

**45th International Conference
ON ORGANIZATIONAL SCIENCE DEVELOPMENT**

Organization and the Longevity Society

**45. mednarodna konferenca
O RAZVOJU ORGANIZACIJSKIH ZNANOSTI**

Organizacija in dolgoživa družba

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University of Maribor

Faculty of Organizational Sciences

**45th International
Conference on Organizational Science Development
Organization and the Longevity Society**

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Organizacija in dolgoživa družba*

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CLASSIFICATION OF EPISODES IN THE BREATHING SIGNAL USING MACHINE LEARNING

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Machine learning methods, which have become increasingly popular in recent years, can be successfully used in the analysis of biomedical signals. Open-source libraries enable the creation of artificial intelligence models using, among others, configurable neural networks. The publication presents an approach to the classification of episodes in the breathing signal using accelerometer and pulse oximeter modules. In particular, it examines the influence of the type of network activation function and time window parameters, i.e. width and offset, on the model sensitivity. With the most optimally selected parameters, it was possible to obtain sensitivity of 85.71% for the detection of episodes in the signal and 100% sensitivity for the classification of calm breathing. The paper also discusses the possibility of creating intelligent sensors by implementing minimized machine learning models on miniature mobile devices with limited hardware resources. Moreover, it proposes a further research path, which is the development of adaptive algorithms able to independently select optimal learning parameters.

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1 Introduction

Artificial intelligence has been an intensively explored phenomenon in recent years, which has resulted in rapid development in this field. One of the paths of artificial intelligence development are generative models, such as language models capable of creating texts or models that generate graphics. As they become increasingly advanced, their level of computational complexity increases and, consequently, the demand for computing power grows. The popularity of artificial intelligence has also allowed for blazing new trails for the most common discriminatory models. At the core of the set of computational methods using machine learning are, among others, classifiers and anomaly detectors. These methods are successfully used in biomedical engineering, both in the field of image analysis - detecting, for example, tumours in magnetic resonance imaging (Kian et al., 2025), management of large databases used in diagnostics (Kwaśniewska et al., 2017), and analysis of continuous signals constituting time series (Backhus et al., 2025), such as, detection of anomalies in the ECG (electrocardiogram) signal (Ruiz-Barroso et al., 2025). A critical issue, particularly prominent in the field of image analysis, is the proper preparation of a training dataset. This process entails a huge demand for memory, and even single poorly prepared sample and data of inappropriate quality affect the accuracy of the entire model (He & Jinzhuo, 2025). Thanks to the selection of appropriate machine learning methods and adequate preparation of a training dataset, it is possible to apply artificial intelligence methods in many areas that have not used these solutions so far.

One of the important areas of artificial intelligence application and verification of the effectiveness of selected methods is the development of open-source libraries, such as TensorFlow. The open-source code allows for further customization of the library code to precisely defined applications and provides great support to the community of people using these libraries in their studies (Alquadah & Moussavi, 2025). The TensorFlow library includes tools for converting created artificial intelligence models to the TensorFlow Lite format. The size of the converted model is significantly reduced; the length of variables is reduced to the minimum necessary to limit the consumption of program memory. TensorFlow Lite makes it possible to optimize computational operations for the most effective use of built-in processor instructions, reducing the number of its cycles necessary to complete the operation,

allowing for the application on single-threaded units with low core clock speeds (Ramadan et al., 2025; Khalid et al., 2026; Ficco et al., 2024).

Reducing the demand for hardware resources opens the way to implementation on miniature, energy-saving, mobile platforms equipped with a microcontroller. SoCs (System-on-a-chip), i.e. systems built in a reduced architecture and integrating all necessary computer components, significantly lower the entry threshold thanks to their wide availability and low cost. Due to their small dimensions and low demand for electric energy, they are used for creating mobile sensor systems (Janik et al., 2019; Wang et al., 2025).

The versatility of this type of devices allows for the implementation of appropriately optimized artificial intelligence models. This means creating the next generation of intelligent sensors and wearable devices operating in accordance with the concept of the Internet of Things (Wang et al., 2023; Janik et al., 2025; Noorali et al., 2025; De Giovanni et al., 2023; Osa-Sanchez et al., 2025), intended for monitoring body parameters, detecting irregularities and alerting about critical conditions.

2 Measurement system and software environment

A measurement system has been built for the acquisition of the signal used for training and testing machine learning models. The system includes a digital accelerometer ADXL345, which natively supports communication via the Inter-Integrated Circuit serial bus (I2C). The MAX30102 heart rate and blood oxygenation (SpO2) sensor module was used as the reference sensor, which also supports communication via the I2C bus. This sensor allows SpO2 data to be compared with data from the accelerometer. The accelerometer sampling rate was set at 25Hz. The values were read using the NodeMCU v3 programmable board, containing the ESP8266 system. Data acquisition was performed using a PC.

The measurement cycle was carried out with the participation of a volunteer. The accelerometer and SpO2 sensor were placed in miniature housings designed and manufactured using 3D printing technology. The sensors in the housings are shown in Figure 1. The accelerometer was placed at the height of the sternum, whereas the SpO2 sensor was placed on the index finger. Measurements from both sensors were recorded concurrently in a lying position.

The open-source TensorFlow library (Abadi et al., 2015) was used to create machine learning models. The native scripting language calling library functions is Python. Anaconda Navigator was used as the platform to run the script interpreter. This platform extends the core Python language to include tools used in the field of Data Science and data analysis.

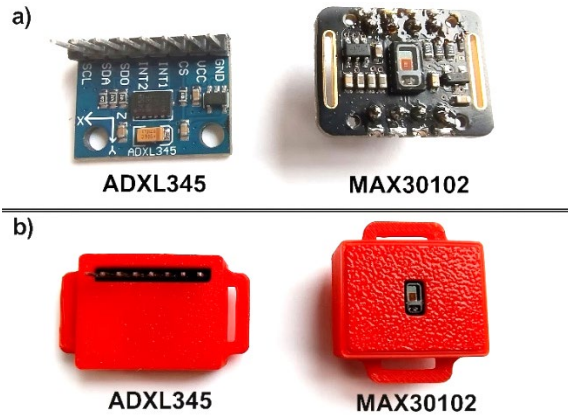


**Figure 1: ADXL345 accelerometer and MAX30102 pulse oximeter a) unit modules,
b) modules in 3D printed housings.**

Source: Own

3 Training dataset

In order to prepare a training dataset, a cycle of calm breathing measurements was carried out, in which specific episodes were introduced: apnoea and faster breathing (approximately twice the frequency of breathing cycles compared to calm breathing). An eleven-minute waveform of the calm breathing signal was selected. It contained 3 apnoea episodes and 3 episodes of faster breathing of different durations. The episodes of faster breathing were as follows:

1 - six breathing cycles with a total duration of 36 s, 2 - two cycles with a total duration of 12 s and 3 - single respiratory cycle with a duration of 6 s.

The results of measurements recorded using an accelerometer are presented

in Figure 2, which shows the raw values for three axes (x, y, z).

Data from the accelerometer were processed with a resolution of 10 bits and a measurement range of $\pm 2G$.

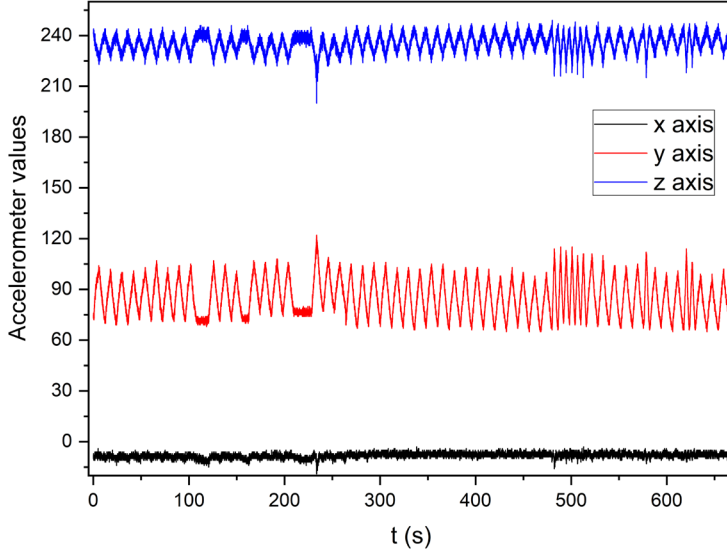


Figure 2: Training dataset - Raw accelerometer values

Source: Own

The waveforms of signal component values for reflected red (R) and infrared (IR) light returned by the SpO2 sensor were filtered. A low-pass filter with a cut-off frequency of 0.8Hz was used. The waveforms of the components coming from the pulse oximeter after filtration are illustrated in Figure 3. Using recorded fragments of signals from the accelerometer and filtered waveforms from the pulse oximeter, a file constituting a training dataset was created. The training data file, where the first line contains the headings of subsequent columns, had the following structure:

- Timestamp (time in ms),
- x, y, z (accelerometer components),
- R (the value of reflected red light returned by the pulse oximeter),
- R_LPF (R value filtered with a low-pass filter with a cut-off frequency of 0.8Hz),
- IR (the value of reflected infrared light returned by the pulse oximeter),

- IR_LPF (IR value filtered with a low-pass filter with a cut-off frequency of 0.8Hz),
- Label – class label to which correctly classified signal fragments are assigned, i.e.: Calm – calm breathing, Apnoea – breath holding, Faster – faster breathing,
- Split – a flag for the division between training and test data.

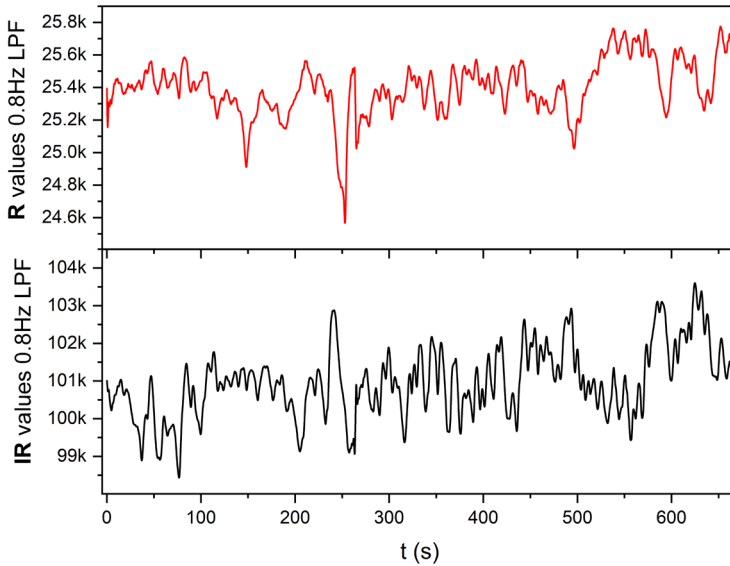


Figure 1: Training dataset - Filtered SpO2 sensor values

Source: Own

4 Machine learning parameters

The Keras sequential classifier model using an artificial neural network with the following structure was used for the TensorFlow model training process:

- Input layer – it accepts signal features sequentially and passes them to the next layer,
- LSTM (Long Short-Term Memory) bidirectional recurrent network layer with 128 units – it is characterized by high efficiency in training patterns taking into account the context,

- Dropout layer with a threshold value of 50% - it randomly drops half of the values stored in nodes to deepen the learning process,
- Dense layer composed of 128 neurons with the ReLU (Rectified Linear Unit) activation function described by (1) – it performs the final classification of the input data portions,
- Output layer with the selected activation function.

The network structure diagram is shown in Figure 4.

100 learning epochs were carried out for each of the training samples, and the selection of validation data was done randomly, selecting 10% of the input dataset.

$$ReLU(x) = \begin{cases} 0 & \text{for } x < 0 \\ x & \text{for } x \geq 0 \end{cases} \dots\dots\dots(1)$$

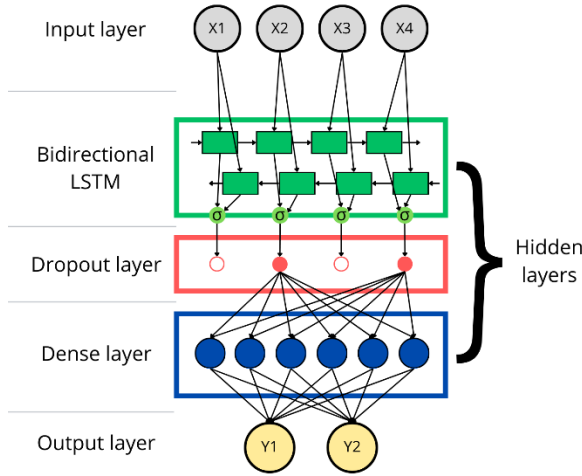


Figure 2: Neural network scheme

Source: Own

4.1 Division of the input data into windows

The time series constituting the input signal is divided into windows. This technique makes it possible to reduce the computational complexity as a smaller fragment of the recorded waveform is subject to classification (Alejandro, 2023). Another aspect

is to facilitate real-time signal analysis. A specific, fixed number of samples, which go to the input of the neural network with each iteration of the classifier, are loaded.

Data windowing introduces two additional parameters: window width and window offset. The data window concept is illustrated in Figure 5. The window width determines how many samples are included in one signal fragment. The offset determines the distance between the beginnings of subsequent windows. This means that in the case of implementing a classifier model or an anomaly detector on a single-threaded system intended to perform real-time classification, the window offset should be equal to its width.

A window offset value smaller than its width allows a certain part of the signal to be covered by several windows, which may contribute to higher model accuracy, especially at larger window width values. However, it requires concurrent classification of the signal and acquisition of its next fragment.

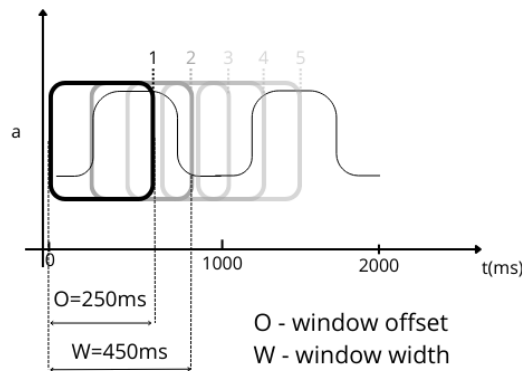


Figure 3: Illustration of window parameters

Source: Own

4.2 Selected window parameters and output layer activation functions

The maximum window width was set at 250 samples, which is approximately a period of calm breathing. The window width was reduced with particular emphasis on intermediate values: 150 samples – approximately the period of faster breathing, 75 samples - approximately half of the period of faster breathing. Table 1

summarizes the selected combinations of window parameters for which training tests of the neural network were carried out and its sensitivity was assessed.

Table 1: Selected window parameters combinations

	Window width (number of samples)										
	8	10	20	30	40	50	75	100	150	200	250
Window offset (number of	4	5	10	10	10	10	15	25	25	25	50
	8	10	20	15	20	25	25	50	50	50	75
				20	30	50	50	75	75	75	100
				30	40		75	100	125	100	125
									150	125	150
										150	175
										175	200
										200	

Source: Own

The normalized softmax exponential function (2) and the sigmoid function (3) were selected as the activation functions of the output layer. A characteristic feature of the softmax function is the summation of all probabilities to the value 1, whereas when the sigmoid function is used, the probability is returned for each class in the range (0,1).

$$\text{softmax}(\mathbf{z})_i = \frac{e^{z_i}}{\sum_{j=1}^K e^{z_j}} \dots \dots \dots (2)$$

where:

$\mathbf{z}$ – vector of real numbers, $\mathbf{z} = (z_1, \dots, z_K) \in R^K$,

K – number of elements of vector $\mathbf{z}$, $K \geq 1$,

$i = 1, \dots, K$.

$$\sigma(x) = \frac{1}{1+e^{-x}} \dots \dots \dots (3)$$

5 Obtained results

Table 2 summarizes the sensitivity results (4) of the model when classifying calm breathing for the softmax and sigmoid activation functions. For the softmax calling function, the mean model sensitivity was $94.13 \pm 5.79\%$. The lowest value was

71.43% for the window width of 200 and the offset of 175. The sigmoid function, in turn, provided a mean sensitivity of $93.97 \pm 5.11\%$ with the lowest score of 76.47% for the window width of 75 and the offset of 75.

$$\text{sensitivity} = \frac{TP}{TP+FN} \dots \dots \dots (4)$$

where:

TP – true positive result,

FN – false negative result.

Table 2: Model sensitivity in calm breathing classification in comparison with the window parameters. White rows represent the softmax function. Grey rows represent the sigmoid function.

		Window width										
		8	10	20	30	40	50	75	100	150	200	250
Window offset	4	96.99%										
		97.89%										
	5		98.11%									
			98.11%									
	8	97.60%										
		98.90%										
	10		96.99%	93.94%	96.18%	93.85%	92.25%					
			95.49%	92.42%	96.95%	95.38%	96.12%					
	15				94.25%			97.65%				
					94.25%			97.65%				
	20			87.88%	89.55%	92.31%						
				90.91%	91.04%	87.69%						
	25						96.15%	84.62%	96.00%	100.00%	93.48%	
							92.31%	94.23%	100.00%	97.92%		
	30				93.18%	90.91%						
					93.18%	90.91%						
	40					90.63%						
						93.75%						
	50						92.31%	92.59%	96.00%	100.00%	95.65%	95.65%
							88.46%	92.59%	92.00%	91.67%	95.65%	90.91%
	75							82.35%	88.24%	93.75%	93.75%	100.00%
								76.47%	100.00%	93.75%	93.75%	93.33%
	100								100.00%	91.67%	92.31%	81.82%
									100.00%	100.00%	84.62%	90.91%
	125									100.00%	100.00%	90.00%
										100.00%	88.89%	100.00%
	150									100.00%	100.00%	100.00%
										100.00%	87.50%	87.50%
	175										71.43%	100.00%
											85.71%	100.00%
	200										100.00%	100.00%
											100.00%	100.00%

Source: Own

Acceptable model sensitivity results ($>50\%$) when classifying both types of episodes were obtained for window widths of $[20, 200]$ and offsets of $[10, 75]$. Significant differences were observed between the tested activation functions, yielding a mean sensitivity of $53.96 \pm 17.71\%$ for the softmax function and $48.58 \pm 15.22\%$ for the sigmoid function within the range of parameters limited by the above intervals. The sensitivity values depending on the window parameters for these intervals are presented in Table 3.

Table 3: Model mean sensitivity in faster breathing and apnoea episodes classification in comparison with the window parameters

		Window width								
		Function	20	30	40	50	75	100	150	200
Window offset	10	softmax	55.36%	77.33%	62.50%	63.33%				
		sigmoid	55.36%	63.33%	59.38%	60.00%				
	20	softmax	41.96%	85.71%	68.75%					
		sigmoid	41.96%	71.43%	61.61%					
	25	softmax				66.67%	75.00%	33.33%	33.33%	50.00%
		sigmoid				66.67%	75.00%	58.33%	41.67%	
	30	softmax		40.00%	75.00%					
		sigmoid		50.00%	58.33%					
	40	softmax			50.00%					
		sigmoid			37.50%					
	50	softmax				50.00%	25.00%	33.33%	16.67%	66.67%
		sigmoid				50.00%	25.00%	33.33%	50.00%	33.33%
	75	softmax					75.00%	50.00%	50.00%	50.00%
		sigmoid					25.00%	25.00%	50.00%	25.00%

Source: Own

6 Conclusions

The conducted research showed the potential to use machine learning methods included in the TensorFlow library for detecting episodes in time series representing biomedical signals. However, the model sensitivity is highly dependent on the window parameters. Dividing the signal into time windows is necessary to enable classification of the signal waveform in real time. Configurability of model and learning process parameters, such as neural network topology, activation functions, learning force or time window parameters, allows the library to be used to analyse signals of various types. Converting models to TensorFlow Lite format is a direct path to implementation on devices with limited resources, such as microcontrollers.

Further optimization of the code in terms of resource use and efficiency will make it possible to obtain miniature, mobile, energy-saving intelligent sensors. An important issue is the correct selection of time window parameters for signal analysis. Their selection was carried out using an iterative method, checking the sensitivity of the model for each of the selected sets of window width and offset values. This process requires a lot of time and computing power, and, consequently, also electric energy.

The solution to the problem of variable parameters in hardware implementations are adaptive methods, which have been successfully developed in many areas (Li et al., 2025; Pielka et al., 2022). Developing an adaptive method so that the algorithm will be able to independently tune the learning parameters to the analysed signal can significantly shorten the learning process, and the resulting models will be more accurate.

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DELOVNA USPEŠNOST SKOZI PRIZMO DIGITALNEGA KADROVSKEGA MANAGEMENTA

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Prispevek na podlagi sodobne znanstvene literature opredeljuje koncept delovne uspešnosti s posebnim poudarkom na razlikah med individualno uspešnostjo, delovno učinkovitostjo in adaptivno uspešnostjo. Z uporabo metode snežne kepe je bila izvedena konceptualna razmejitev med obravnavanimi pojmi ter njihova umestitev v okvir digitalnega kadrovskega managementa. Ugotovitve kažejo, da digitalno delovno okolje pomembno vpliva na kazalnike delovne uspešnosti, oblikuje pričakovanja do zaposlenih ter usmerja razvoj njihovih digitalnih kompetenc. Delovna uspešnost se vse tesneje povezuje z digitalno pismenostjo, adaptivno uspešnostjo in sposobnostjo učinkovitega timskega dela. Digitalno kompetentni zaposleni v digitalnih delovnih okoljih dosegajo boljše rezultate, pri čemer ima pomembno usmerjevalno vlogo tudi digitalni kadrovski management. Ta z organiziranimi usposabljanji sistematično krepi digitalno pismenost zaposlenih ter s tem prispeva k višji individualni in organizacijski uspešnosti v sodobnem digitalnem okolju.

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WORK PERFORMANCE THROUGH THE LENS OF DIGITAL HUMAN RESOURCE MANAGEMENT

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Based on contemporary scientific literature, this paper conceptualises work performance with particular emphasis on the distinctions between individual performance, work efficiency, and adaptive performance. Through a literature review approach, a conceptual delineation of these constructs is provided and situated within the framework of digital human resource management. The findings indicate that the digital work environment has a significant influence on work performance indicators, shapes the expectations placed on employees, and directs the development of their digital competencies. Work performance is increasingly closely associated with digital literacy, adaptive performance, and the ability to work effectively in teams. Digitally competent employees achieve better outcomes in digital work environments, with digital human resource management playing an important guiding role. Through structured training initiatives, digital human resource management systematically strengthens employees' digital literacy, thereby contributing to higher individual and organisational performance in the contemporary digital environment.



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1 Delovna uspešnost v povezavi z digitalno pismenostjo

Delovna uspešnost zaposlenih je osrednji konstrukt sodobnega kadrovskega managementa, saj se nanaša na učinkovito in kakovostno izvajanje delovnih nalog ter prispevek posameznika k doseganju organizacijskih ciljev. V literaturi je opredeljena kot večdimenzionalen pojav, ki poleg rezultatov vključuje tudi vedenjske in prilagoditvene vidike dela (Ángeles López-Cabarcos et al., 2022; Campbell & Wiernik, 2015). Poseben pomen ima adaptivna uspešnost, ki označuje sposobnost zaposlenih za učinkovito prilagajanje spremembam in novim zahtevam, zlasti v digitaliziranih delovnih okoljih (Charbonnier-Voirin & Roussel, 2012). Raziskave poudarjajo, da delovna uspešnost ni odvisna le od individualnih kompetenc, temveč tudi od delovnega okolja, motivacije in organizacijske podpore (Yun et al., 2022). Digitalna transformacija je dodatno okrepila pomen digitalnih kompetenc in digitalne pismenosti, ki pomembno prispevata k višji delovni in adaptivni uspešnosti zaposlenih (Cetindamar et al., 2024; Hermans & Ulrich, 2021). Kljub obsežni literaturi o delovni uspešnosti in digitalni transformaciji organizacij, ostaja pomanjkljivo razumevanje o celostni konceptualni obravnavi vpliva digitalnega kadrovskega managementa na individualno uspešnost zaposlenih. To v naši raziskavi predstavlja raziskovalno vrzel, saj se do sedaj, po našem vedenju ni nobena raziskava obravnavala njune povezave v kontekstu delovne uspešnosti in digitalne pismenosti.

1.1 Digitalni kadrovski management

Digitalni kadrovski management se od klasičnega razlikuje po sistematični uporabi digitalne tehnologije, podatkovno podprtem odločanju in digitaliziranih kadrovskih ter administrativnih procesih, ki povečujejo preglednost in sledljivost kadrovskega dela (Zervas & Stiakakis, 2025). Digitalna tehnologija pri tem ne predstavlja zgolj podpornega orodja, temveč je sestavni del strateškega managementa (Alexandro, 2025). Ta vključuje tudi razvoj digitalne pismenosti zaposlenih, ki v digitalnem okolju delujejo kot povezovalni člen med tehnologijo in delovnimi procesi (Takács & Pogatsnik, 2023). Čeprav je vpeljava digitalnih rešitev praviloma v pristojnosti vodstva in informacijske podpore, kadroviki zagotavljajo operativno in vsebinsko podporo zaposlenim ter skrbijo za skladnost z zakonodajnimi okviri in standardi kot je na primer Digitalni kompetenčni okvir ali Akt o UI (*Akt EU o UI*, 2023; *Okvir digitalnih kompetenc za državljane* | GOV.SI, 2022).

Z okvirji, standardi in zakonodajo kadrovski oddelki organizirajo usposabljanja, spodbujajo učinkovito rabo digitalne tehnologije in uvajanje digitalnih rešitev, ki poenostavljajo delovne procese. Sistematično krepljenje digitalne pismenosti zaposlenih tako prispeva k bolj tekočemu delu, zmanjšanju napak in višji delovni uspešnosti, kar predstavlja osrednji cilj digitalnega kadrovskega managementa (Mahmoud et al., 2025).

2 Metodologija

Raziskava temelji na preliminarnem kvalitativnem raziskovalnem pristopu, katerega namen je razumevanje vpliva digitalnega kadrovskega managementa na individualno uspešnost zaposlenih. Zaradi kompleksnosti obravnavanega pojava in razmeroma novega raziskovalnega področja je bil izbran eksplorativno-deskriptivni raziskovalni dizajn, ki omogoča analizo organizacijskih praks in zaznanih učinkov digitalne transformacije delovnih procesov.

Raziskava izhaja iz dveh raziskovalnih vprašanj, ki sta bili metodološko oblikovani za jasnejšo operacionalizacijo in navezavo na obstoječo znanstveno literaturo:

RV1: Kako digitalni kadrovski management vpliva na individualno uspešnost zaposlenih v organizacijah?

RV2: Ali digitalna pismenost prispeva k višji delovni uspešnosti zaposlenih?

Prispevki so bili zbrani s pomočjo uporabe pristopa snežne kepe (angl. snowball approach), ki omogoča postopno širjenje nabora relevantnih prispevkov na podlagi literature (Brečko, 2005; Johnson, 2014). Izhodiščni nabor literature je bil identificiran z iskanjem v znanstveni bibliografski bazi COBISS.SI, izbrani z namenom sočasnega vpogleda v mednarodni in slovenski znanstveni prostor. Zaradi omejitve na eno bazo je raziskava opredeljena kot preliminarna študija, ki predstavlja teoretično izhodišče za nadaljnje raziskave.

V analizo so bili vključeni izvirni znanstveni članki. Iskanje je zaradi sorodnosti izrazov in različnega opisa konceptov glede na avtorje potekalo z uporabo pojmov delovna učinkovitost, delovna uspešnost, individualna uspešnost in adaptivna uspešnost v kombinaciji s pojmi digitalizacija in digitalni kadrovski management.

Osnovni iskalni niz v angleškem jeziku je tako bil: (“employee efficiency” OR “work performance” OR “job performance” OR “individual performance” OR “adaptive performance”) AND (“digital” OR “digitali*”) AND (“human resource” OR “human resource management” OR “personnel management”).

Na dan 7. 1. 2026 je bilo v bazi COBISS:SI identificiranih 597 zadetkov ob omejitvah na izvirne znanstvene članke, slovenski in angleški jezik ter obdobje 2021–2026. Na podlagi pregleda naslovov in povzetkov, neposredne in posredne literature, je bilo z uporabo metode snežne kepe identificiranih skupno 21 relevantnih znanstvenih prispevkov, povzetih v naslednjem poglavju.

3 Rezultati

Metoda snežne kepe avtorjem preglednih znanstvenih člankov lahko pomaga ugotoviti raziskovalne vrzeli na raziskanem področju, ki jih zanima. Po besedah (Wohlin, 2014) gre za razvrščanje prispevkov v skupine (angl. clustering), ki omogočajo opredeljen začetek iskanja literature. Glede na naše izbrane prispevke smo ugotovili, da je delovna uspešnost povezana z digitalnim kadrovskim managementom in digitalno pismenostjo, kar prikazujemo z odgovorom na RV1 in RV2.

Preko izbranih znanstvenih prispevkov na RV1, odgovarjamo, da digitalni kadrovski management vpliva na individualno uspešnost posledično na delovno uspešnost in učinkovitost. Avtorji na področju managementa namreč v svojih raziskavah obravnavajo digitalizirane delovne procese povezanih z managementom med katerimi so raziskovali odnose med procesi, tehnologijo in zaposlenimi. Povezanost managementa in tehnologije, bodisi digitalne, bodisi umetno inteligenčne (UI) izbranih avtorjev je vodila, da smo prišli do zaključkov, da digitalna tehnologija ne glede na področje kadrovskega managementa vpliva na povečano učinkovitost zaposlenih (Dhiman et al., 2023; Hermans & Ulrich, 2021). Povečana učinkovitost je posledica delovne uspešnosti, ki je v današnjem času v veliki meri odvisna od digitalnih kompetenc zaposlenih (Eraković & Radić-Bojanić, 2023).

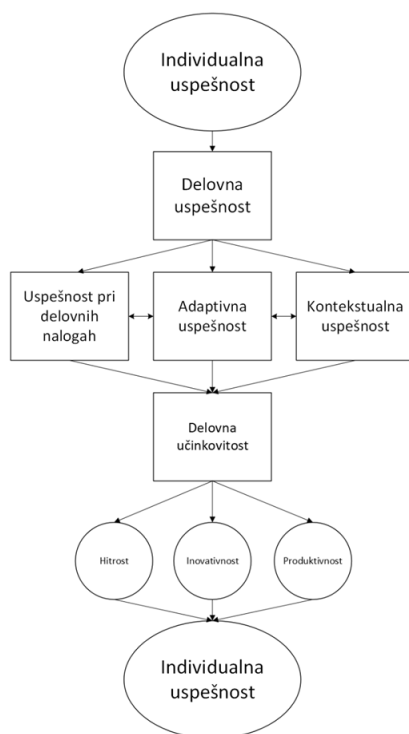
Za razvoj digitalnih kompetenc v organizacijah skrbijo pretežno kadrovski oddelki, ki delujejo kot specializirani delovni timi (London & Sherman, 2021). Znotraj njih, kadroviki opravljajo definirane naloge, od zaposlovanja in administrativne podpore

do kadrovske analitike in strateškega načrtovanja in usposabljanja. Učinkovitost kadrovikov je vse bolj pogojena z njihovimi digitalnimi kompetencami, saj učinkovita raba digitalnih orodij omogoča avtomatizacijo, podatkovno podprto odločanje ter večjo preglednost kadrovskih postopkov. Brez ustreznih kompetenc, posledično digitalne pismenosti bi bila individualna in posledično organizacijska uspešnost bistveno omejena (Pigola et al., 2024). Brez ustreznih digitalnih kompetenc bi bila individualna uspešnost kadrovikov nižja, posledično pa tudi delovanje sodobnega digitalnega kadrovskega managementa v organizacijah ne bi bilo izvedljivo oziroma učinkovito.

Ne glede na zahtevnost in naravo dela morajo kadroviki učinkovito sodelovati, pri čemer digitalna tehnologija predstavlja ključno povezavo in podporo za koordinacijo, izmenjavo informacij in standardizacijo kadrovskih procesov. Sodelovanje omogoča izvedbo digitalnega kadrovskega managementa, zmanjšuje administrativno obremenitev ter kadrovikom omogoča večjo osredotočenost na strateške in razvojne naloge, s čimer kadrovski oddelki delujejo kot zgled učinkovitega timskega delovanja v organizacijah (Alam et al., 2024). Takšen zgled pozitivno vpliva na zavzetost zaposlenih v drugih oddelkih (Minghua, 2022) kar prispeva k boljšim rezultatom, pripadnosti (Berberoglu, 2018), posledično boljši organizacijski klimi in kulturi v oddelkih in organizaciji (Tsoni et al., 2025). Pozitivna organizacijska klima in kultura, podprti z uporabo digitalnih tehnologij, spodbujata tudi inovativnost (Uršič & Čater, 2025) in inovativno uspešnost zaposlenih (Son et al., 2024), izboljšujeta počutje in odnose (Janiukštis et al., 2024) ter zmanjšujeta namero izgorelosti in fluktuacije (Kok et al., 2025; Krajnc & Juvan, 2023). Skupno ti dejavniki pomembno prispevajo k višji delovni učinkovitosti in uspešnosti organizacij.

Za RV2, kjer smo se spraševali, ali digitalna pismenost zvišuje delovno uspešnost, ugotavljamo, da digitalna tehnologija, ki pospešuje kadrovske in druge delovne procese, pomembno prispeva tudi k razvoju digitalnih kompetenc zaposlenih ter krepitvi digitalne pismenosti. Ta predstavlja ključno predpostavko za adaptivno učenje, saj zaposlenim omogoča učinkovito usvajanje novih znanj in prilagajanje tehnološkim spremembam (Yaseen et al., 2025). Razvite digitalne kompetence in višja digitalna pismenost se odražajo tudi v večji adaptivni uspešnosti zaposlenih, saj ti lažje obvladujejo nepredvidene situacije in se odzivajo na spremembe v delovnem okolju (Zervas & Stiakakis, 2025).

Pregled literature kaže, da individualna uspešnost, delovna uspešnost, adaptivna uspešnost in delovna učinkovitost skupaj pojasnjujejo celostno uspešnost zaposlenih pri delu. Gre za medsebojno povezane, a konceptualno ločene konstrukte, katerih razmerja so prikazana na Sliki 1.



Slika 1: Konceptualni model individualne uspešnosti

Vir: Lasten

Slika 1 prikazuje konceptualni model individualne uspešnosti, ki pojasnjuje, zakaj so posamezni zaposleni delovno uspešni in usmerjeno k doseganju lastnih kariernih ciljev in ciljev organizacij (Ramawickrama et al., 2017). Delovna uspešnost se v tem okviru uresničuje, implementira preko uspešnosti pri delovnih nalogah, kontekstualno uspešnost in adaptivno uspešnost, katere so medsebojno povezane ter skupaj oblikujejo delovno učinkovitost zaposlenih.

V digitalnih delovnih okoljih ima adaptivna uspešnost osrednjo vlogo, saj omogoča hitro prilagajanje spremembam v tehnologiji in delovnih procesih ter spodbuja izboljšave in digitalizacijo delovnih nalog (Pulakos et al., 2000). Adaptivna uspešnost, ki temelji na sposobnosti stalnega učenja in sprejemanja novih znanj (Loughlin & Priyadarshini, 2021), v strateških oddelkih vpliva na digitalna usposabljanja, ki zvišujejo digitalno kompetentnost in pismenost (Gabrovšek & Rihtaršič, 2025), kar tudi pritrjuje našemu RV2.

Razvite digitalne kompetence vključujejo informacijsko in podatkovno pismenost, digitalno komunikacijo in sodelovanje, ustvarjanje digitalnih vsebin, razumevanje informacijske varnosti ter reševanje problemov (Cosgrove & Cachia, 2025). Pri tem je potrebo upoštevati etična načela in zasebnost (Keršič & Turkanović, 2025). Takšna digitalna kompetentnost ustvarja pogoje za učinkovit digitalni kadrovske management, ki zaposlenim omogoča višjo delovno in posledično individualno uspešnost, kot je povzeto v prikazu na Sliki 1, ki hkrati prikazuje tudi grafični prikaz odgovorov na RV1 in RV2.

4 Zaključek

Prispevek opredeljuje delovno uspešnost zaposlenih v kontekstu digitalnega kadrovskega managementa ter poudarja, da gre pri individualni uspešnosti za večdimenzionalen konstrukt, ki vključuje delovno uspešnost, adaptivno uspešnost in delovno učinkovitost. Pregled literature potrjuje, da digitalizacija delovnih okolij bistveno spreminja načine dela, kazalnike uspešnosti ter pričakovanja do zaposlenih, pri čemer digitalna pismenost in digitalne kompetence postajajo ključni pogoji za visoko delovno in adaptivno uspešnost in učinkovitost. V tem okviru se digitalni kadrovske management izkazuje kot pomemben mehanizem za sistematičen razvoj digitalnih kompetenc, optimizacijo kadrovske procesov ter podporo timskega sodelovanju in podporo strateškemu odločanju.

Kljub navedenim ugotovitvam ima raziskava določene omejitve. Ker gre za preliminarno študijo, ki temelji na pregledu literature iz omejenega nabora virov in uporabe metode snežne kepe, obstaja možnost selekcijske pristranskosti, prav tako pa rezultati niso neposredno vezani na vse organizacijske kontekste, dejavnosti in velikosti organizacij.

Ob upoštevanju teh omejitev ugotovitve potrjujejo, da vlaganje v digitalna znanja presega raven individualne uspešnosti ter pomembno prispevek dolgoročni organizacijski uspešnosti, inovativnosti in prilagodljivosti, ki bodo v nadaljevanju digitalne transformacije organizacij postajale vedno pomembnejše.

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USTVARJANJE ZNANJA IN NJEGOV VPLIV NA USPEŠNOST PRI DELOVNIH NALOGAH

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Prispevek obravnava problematiko ustvarjanja znanja v javnih organizacijah ter preučuje njegovo povezanost z uspešnostjo pri delovnih nalogah ter izobraževanjem in usposabljanjem zaposlenih. Na podlagi anketne raziskave, izvedene med slovenskimi javnimi uslužbenci, so analizirane povezave med izbranimi spremenljivkami z uporabo korelacijske analize. Rezultati kažejo na statistično značilno pozitivno povezanost med uspešnostjo pri delovnih nalogah in ustvarjanjem znanja, kar potrjuje pomen učinkovitega opravljanja delovnih nalog za razvoj novega znanja v javnem sektorju. Nasprotno povezava med izobraževanjem in usposabljanjem ter ustvarjanjem znanja ni statistično značilna. Ugotovitve prikazujejo, da je uspešnost pri delovnih nalogah pomemben dejavnik razvoja znanja v javnih organizacijah in ponujajo izhodišča za nadaljnje raziskave na tem področju.

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KNOWLEDGE CREATION AND ITS IMPACT ON TASK PERFORMANCE

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The paper examines knowledge creation in public organisations and explores its relationship with task performance as well as employee education and training. Based on a survey conducted among Slovenian public servants, the relationships between the selected variables were analysed using correlation analysis. The results indicate a statistically significant positive relationship between task performance and knowledge creation, confirming the importance of effective task execution for the development of new knowledge in the public sector. In contrast, the relationship between education, training, and knowledge creation is not statistically significant. The findings indicate that task performance is an important factor in the development of knowledge in public organisations., providing a basis for further research in this field.



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1 Ustvarjanje znanja v javnih organizacijah

Ustvarjanje znanja predstavlja osrednjo dimenzijo managementa znanja v organizacijah. Predstavlja prvi element managementa znanja, saj ustvarjeno znanje služi za shranjevanje, prenos in uporabo znanja med zaposlenimi (Alavi & Leidner, 2001). Da se znanje ustvarja mora biti spodbujena ustvarjalnost zaposlenih, ki preko hitrih in jasnih kanalov in povezav pridejo do informacij in podatkov (Omerzel et al., 2010). Z jasnimi informacijami in podatki zaposleni ustvarjajo nove rešitve, izboljšujejo storitve in rešujejo kompleksne težave v organizacijah.

V javnih organizacijah se ustvarjanje znanja razlikuje od ustvarjanja znanja v zasebnih organizacijah predvsem zaradi institucionalnega okvira, službenega interesa in drugih deležnikov. Najbolj izrazito se procesi ustvarjanja znanja pojavljajo v sektorjih, kot so javna uprava, zdravstvo, izobraževanje, varnostni sektor in socialne storitve, kjer je delo intenzivno vezano na strokovno presojo, sodelovanje in izmenjavo izkušenj (Laihonen et al., 2024; Omerzel et al., 2010). Raziskave kažejo, da se novo znanje v teh okoljih pogosto ustvarja skozi reševanje kompleksnih problemov, medsebojnega sodelovanja, projekte ter učenje iz prakse in izrednih situacij.

Ustvarjanje znanja v sodobnih javnih organizacijah je pogosto oteženo zaradi povečane fluktuacije zaposlenih, ki je zaslužna, da implicitno znanje odhaja iz organizacij (Bloodgood & Chen, 2021), omejenega obsega timskega sodelovanja ter nezadostno razvitega sistema mentorstev (Ndatshe et al., 2024; Phaladi & Ngulube, 2024). To doprinese do slabšega medsebojnega sodelovanja, ki je v veliki meri odvisno od organizacijske kulture, katera spodbuja zaupanje in odprtost, kar krepi management uspešnosti (Ellis et al., 2023). Organizacijska kultura je sistematičen in celosten proces načrtovanja, spremljanja, vrednotenja in izboljševanja uspešnosti posameznikov, timov in organizacij kot celote z namenom doseganja strateških ciljev (Sinnaiah et al., 2023). Management uspešnosti v javnih organizacijah krepi uporabniške izkušnje, saj se okrepi učinkovitost storitev javnih uslužbencev (Vignieri & Santoni, 2026). Management uspešnosti zaposlenih po besedah Na-nan et al. (2018) lahko organizacije merijo preko evalvacije uspešnosti, ki sestoji iz upoštevanja predpogojev za doseganje delovne uspešnosti in načrtovanja uspešnosti zaposlenih. Bolj priznan vprašalnik imenovan Vprašalnik za merjenje individualne delovne

uspešnosti je sestavljen iz merjena uspešnosti delovnih nalog, kontekstualne uspešnosti in neželenega delovnega vedenja (Koopmans et al., 2014).

Odraž delovne uspešnosti je torej uspešnost zaposlenih, kar posledično vpliva na njihovo produktivnost (Linna et al., 2010). Ker se produktivnost težje meri od delovne uspešnosti – predvsem iz individualnega vidika, saj je produktivnost objektivni konstrukt, ki temelji na razmerju med delovnim vložkom in izhodom, ocenjevalci lahko ocenjujejo delovno produktivnost delno preko merjenja uspešnosti posameznih delovnih nalog, ki pa je del vprašanj delovne uspešnosti (Koopmans et al., 2014). Tudi sami smo izbrali to spremenljivko, saj se osredotoča na planiranje, mišljenje, zmožnost in sposobnost opravljanja delovnih nalog.

Da so zaposleni delovno uspešni pri opravljanju delovnih nalog, produktivni in delovno uspešni, vpliva več dejavnikov. Eden takšnih je ustrezno usposabljanje in izobraževanje zaposlenih (Hosen et al., 2023). Usposabljanje in izobraževanje sta dva različna pojma, ki pa se v teoriji in praksi prepletata. Izobraževanje temelji na pridobljeni formalni izobrazbi, medtem ko usposabljanje oblikuje in usmerja sposobnosti zaposlenih k konkretnim dejavnostim. Formalno izobraževanje se v večini primerov odvija v otroštvu in mladosti, medtem ko usposabljanje poteka v kasnejšem poklicnem življenju (Vuković & Miglič, 2006).

Izobraževanje in usposabljanje sta ključna za napredek in razvoj tako zaposlenih kot organizacij (Salas et al., 2012). Proces sta del organizacijskega učenja, saj zaposleni pridobijo nova znanja, postanejo motivirani in kakovostnejše opravijo delo.

2 Raziskava

V prispevku prikazujemo izsledke raziskave, za katero je bil povod problem nizkega prenosa znanja med javnimi uslužbenci v tujini (Devi et al., 2024; Singh Sandhu et al., 2011). Z raziskavo tako ugotavljamo povezanost med ustvarjanjem znanja z uspešnostjo pri delovnih nalogah in izobraževanjem in usposabljanjem med slovenskimi javnimi uslužbenci.

Raziskavo smo izvedli med zaposlenimi v slovenskem javnem sektorju, v javnih slovenskih organizacijah. Podatke prikazujemo na vzorcu 50 javnih uslužbencev, ki so rešili našo anketo, ki je vsebovala vprašanja, trditve z omenjenimi tremi spremenljivkami.

Preko tega vzorca smo odgovorili na dve hipotezi:

H1: Uspešnost pri delovnih nalogah je pozitivno povezana z ustvarjanjem znanja med slovenskimi javnimi uslužbenci.

H2: Izobraževanje in usposabljanje je pozitivno povezano z ustvarjanjem znanja med slovenskimi javnimi uslužbenci.

Odgovore na zastavljeni hipotezi smo pridobili z uporabo bivariatne statistične analize, pri čemer je bil statistični test izveden na podlagi povprečnih vrednosti petstopenjskih Likertovih lestvic, uporabljenih pri posameznih konstruktihih spremenljivk.. Prvi konstrukt, uspešnost pri delovnih nalogah smo povzeli po (Koopmans et al., 2014), drugi konstrukt izobraževanje in usposabljanje po Hosen et al. (2023) in tretji konstrukt ustvarjanje znanja, po (Chou & Tsai, 2004).

2.1 Demografija

V raziskavo je bilo vključenih 50 v celoti izpolnjenih anket, pri čemer je sodelovalo 22 moških in 28 žensk, kar je prikazano v tabeli 1.

Tabela 1: Spol

	Število	Odstotki
Moški	22	44
Ženski	28	56
Skupaj	50	100

Vir: lasten

Tabela 2 prikazuje število in deleže anketirancev glede na starost. Največ udeležencev je bilo v starostni skupini od 20 do 30 let, sledila je skupina stara od 31 do 40 let, medtem ko je bilo najmanj anketirancev v starostni skupini od 51 do 60 let.

Tabela 2: Starost

	Število	Odstotki
20-30	20	40
31-40	18	36
41-50	8	16
51-60	4	8
Skupaj	50	100

Vir: lasten

2.2 Hipoteze

Stopnjo povezanosti med spremenljivkami smo izračunali z uporabo bivariatnega Pearsonovega korelacijskega testa. Rezultati povezanosti med uspešnostjo pri delovnih nalogah in ustvarjanjem znanja so prikazani v tabeli 3.

Tabela 3: Korelacija med uspešnostjo pri delovnih nalogah in ustvarjanju znanja

	Uspešnost pri delovnih nalogah (Person correlation, Sig. 1-tailed)	Ustvarjanje znanja (Person correlation, Sig. 1-tailed)
Uspešnost pri delovnih nalogah	0,045 0,379	
Ustvarjanje znanja		0,045 0,379

Vir: lasten

Tabela 3 kaže, da Pearsonov koeficient korelacije znaša 0,379, kar pomeni pozitivno povezanost med spremenljivkama. Z večjo uspešnostjo pri delovnih nalogah se povečuje tudi ustvarjanje znanja. Statistična značilnost enostranskega testa znaša $p = 0,045$, kar je manj od predpisane meje 0,05; zato lahko hipotezo H1 potrdimo.

Tabela 4 prikazuje povezanost med izobraževanjem in usposabljanjem ter ustvarjanjem znanja.

Tabela 4: Korelacija med Izobraževanjem in usposabljanjem ter Ustvarjanjem znanja

	Izobraževanje in usposabljanje (Person correlation, Sig. 1-tailed)	Ustvarjanje znanja (Person correlation, Sig. 1-tailed)
Izobraževanje in usposabljanje	0,234 0,051	
Ustvarjanje znanja		0,234 0,051

Vir: lasten

Tabela 4 prikazuje korelacijo med izobraževanjem in usposabljanjem ter ustvarjanjem znanja ($r = 0,234$), kar pomeni šibko pozitivno povezanost med spremenljivkama. Ker rezultat ni statistično značilen ($p > 0,05$), hipoteze H2 ne moremo potrditi. Na podlagi teh ugotovitev zato ne moremo ne potrditi ne zavrniti trditve, da sta izobraževanje in usposabljanje pozitivno povezana z ustvarjanjem znanja med slovenskimi javnimi uslužbenci.

3 Diskusija

Rezultati kažejo, da je uspešnost pri delovnih nalogah statistično značilno pozitivno povezana z ustvarjanjem znanja. To pomeni, da javni uslužbenci, ki učinkovito opravljajo svoje naloge, pogosteje prispevajo k razvoju novega znanja. Ustvarjanje znanja se tako kaže kot proces, ki izhaja iz kakovostnega izvajanja dela, ne zgolj iz formalnih mehanizmov učenja. V kontekstu raziskovalnega problema to potrjuje, da je uspešnost pomemben dejavnik ustvarjanja znanja v javnih organizacijah.

Ugotovitve so skladne s teorijo managementa znanja (Alavi & Leidner, 2001), ki poudarja, da znanje nastaja skozi delovne procese in reševanje problemov. Nasprotno pa povezava med izobraževanjem in usposabljanjem ter ustvarjanjem znanja ni bila statistično značilna. To delno odstopa od študij, ki poudarjajo neposreden vpliv usposabljanja na uspešnost (Núñez-Cacho Utrilla et al., 2022; Truitt, 2011), hkrati pa sledi ugotovitvam tujih avtorjev, ki so ugotovili, da je stopnja prenosa znanja v javnih organizacijah prenizka (Devi et al., 2024).

Rezultati prispevajo k teoriji iz vidika razumevanja ustvarjanja znanja kot razumevanja uspešnosti, medtem ko za prakso javnega sektorja poudarjajo pomen izboljševanja delovnih procesov in podpore sodelovanju kot temeljev za razvoj organizacijskega znanja.

4 Zaključek

Namen prispevka je bil raziskati povezanost med ustvarjanjem znanja, uspešnostjo pri delovnih nalogah ter izobraževanjem in usposabljanjem zaposlenih v javnih organizacijah. Na podlagi empirične raziskave med slovenskimi javnimi uslužbenci je bilo ugotovljeno, da obstaja statistično značilna pozitivna povezanost med uspešnostjo pri delovnih nalogah in ustvarjanjem znanja, kar potrjuje pomen učinkovitega opravljanja delovnih nalog za razvoj novega znanja v organizacijah.

Nasprotno pa povezava med izobraževanjem in usposabljanjem ter ustvarjanjem znanja ni bila statistično značilna, kar nakazuje, da formalni procesi izobraževanja in usposabljanja sami po sebi še ne zagotavljajo večjega ustvarjanja znanja. To odpira vprašanje kakovosti, vsebine in prenosa pridobljenega znanja v delovno prakso.

Prispevek ima določene omejitve, zlasti glede velikosti vzorca, zato rezultatov ni mogoče posploševati. Kljub temu ugotovitve ponujajo pomembna izhodišča za nadaljnje raziskave, ki bi lahko vključevale večje vzorce ter dodatne individualne in organizacijske spremenljivke, kot so organizacijska kultura, vodenje in podpora znanju v delovnem okolju.

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VPLIV ZRELOSTI PODJETIJ ZA UPORABO ODPRTIH PODATKOV NA NJIHOVO DOSEGANJE CILJEV TRAJNOSTNEGA RAZVOJA - PROTOKOL ZA IZVEDBO ŠTUDIJE PRIMERA

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Odprti podatki predstavljajo nove priložnosti za podjetja, ki lahko z njihovo uporabo krepijo inovacijsko zmogljivost, transparentnost ter trajnostne prakse. Kljub temu, da raziskave kažejo na vpliv uporabe odprtih podatkov k doseganju ciljev trajnostnega razvoja, je to področje slabo raziskano. V raziskavi naslavljamo vpliv zrelosti podjetij za uporabo odprtih podatkov na doseganje ciljev trajnostnega razvoja. Namen prispevka je predstaviti razvoj protokola študije primera, ki bo omogočil sistematično raziskovanje povezav, ter prikazati ustreznost uporabe metode FsQCA za analizo kompleksnih vzročnih konfiguracij, značilnih za organizacijske študije. V prispevku smo zasnovali rigorozno strukturiran protokol študije primera, ki v kombinaciji z metodo FsQCA omogoča sistematično proučevanje vpliva zrelosti podjetij pri uporabi odprtih podatkov na njihovo delovanje v skladu s cilji trajnostnega razvoja, ob zagotavljanju visoke stopnje znanstvene veljavnosti.

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THE IMPACT OF ENTERPRISES OPEN DATA MATURITY ON THE ACHIEVEMENT OF SUSTAINABLE DEVELOPMENT GOALS – A CASE STUDY RESEARCH PROTOCOL

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Open data create new opportunities for enterprises, as their use can enhance innovation capacity, transparency and sustainable practices. Although prior research indicates that the use of open data contributes to the achievement of the Sustainable development goals, this research area remains underexplored. This study addresses the impact of enterprises' maturity for open data use on the achievement of the Sustainable Development Goals. The purpose of this paper is to present the development of a case study research protocol that enables systematic research of connections, and to demonstrate the suitability of the FsQCA method for analyzing complex causal configurations, characteristic for organizational studies. In this paper, we developed a rigorously structured case study protocol which, in combination with the fsQCA method, enables a systematic examination of the impact of enterprises open data maturity for the achievement of SDGs, while ensuring a high level of scientific validity.



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1 Uvod

Odprti podatki (OP) so v zadnjih dveh desetletjih postali eden izmed ključnih elementov digitalne preobrazbe in inovacij v podjetjih. Njihova učinkovita uporaba podjetjem omogoča izboljšanje procesov odločanja, optimizacijo poslovanja ter ustvarjanje dodane vrednosti (Bedini idr., 2014; Blatnik, 2025; Enders idr., 2021; Kljajić Borštnar idr., 2025). Poseben pomen imajo pri krepitvi inovacijskih sposobnosti, saj podjetjem odpirajo dostop do bogatega nabora zunanjih virov, ki omogočajo razvoj novih digitalnih storitev, izboljšav obstoječih produktov in trajnostnih rešitev, kot so nizkoogljične inovacije (Enders idr., 2021, 2022; Jetzek, 2017). Poleg spodbujanja gospodarske rasti OP igrajo ključno vlogo tudi pri povečevanju transparentnosti in odgovornosti podjetij. S tem, ko podjetja razkrivajo svoje podatke, krepijo ugled blagovne znamke ter zaupanje investitorjev in širše skupnosti (Enders idr., 2021, 2022; Smith idr., 2026). V sodobnem poslovnem okolju so OP podatki postali nepogrešljivi za naslavljanje kompleksnih družbenih izzivov in doseganje ciljev trajnostnega razvoja (CTR), saj omogočajo poslovno odločanje na podlagi ažurnih podatkov in s tem oblikovanje trajnostno naravnane poslovne strategije (George idr., 2020; Sussha idr., 2019).

Uspeh pri uresničevanju CTR je lahko odvisen tudi od stopnje zrelosti podjetij za uporabo OP. Zrelost podjetij opredeljuje njihove tehnološke in organizacijske zmogljivosti za vključevanje teh podatkov v vsakodnevne procese (Blatnik idr., 2024). Čeprav OP predstavljajo strateško poslovno sredstvo, se podjetja pogosto srečujejo z organizacijskimi in tehnološkimi ovirami, z ovirami institucionalnega okolja (Blatnik idr., 2024) poleg tega pa tudi s ti. »paradoksom vrednosti OP«, ki opredeljuje, da podjetja oklevajo z naložbami v objavljanje OP zaradi pomanjkanja dokazov o njihovi uporabi, na drugi strani pa posamezniki oklevajo z uporabo OP, saj niso prepričani o trajnosti njihovega objavljanja (Enders idr., 2021). Doseganje višjih stopenj zrelosti podjetjem omogoča preseganje teh ovir z optimizacijo procesov objavljanja, nadgrajevanjem usposobljenosti zaposlenih, izboljšavami podpore poslovnim partnerjem, nadzorovanimi investicijami in strateškim pregledom nad uporabo in objavljanjem OP v podjetju (D'Addario idr., 2025). Podjetja, ki dosegajo višje stopnje zrelosti za uporabo OP imajo zato večje možnosti, da uporabijo ta obilen vir kot ključni dejavnik za doseganje CTR (Jetzek, 2017).

Cilji trajnostnega razvoja, sprejeti v okviru Agende 2030 (United Nations, 2015), predstavljajo celovit svetovni akcijski načrt, katerih namen je izboljšanje kakovosti življenja ljudi, zaščite planeta pred degradacijo, krepitev družbene blaginje, zagotavljanje miru ter vzpostavitvi globalnega partnerstva za doseganje teh ciljev. Raziskave kažejo, da obstaja pozitivna povezava med trajnostno strategijo podjetja in njegovo finančno uspešnostjo, vključno z višjo donosnostjo kapitala in boljšimi donosi delnic (Cek & Eyupoglu, 2020; Whelan idr., 2021) in večjo odpornostjo na pretrese poslovnega sveta (Cek & Eyupoglu, 2020; Enders idr., 2022; Zhou & Zhou, 2021). Trajnostna naravnost podjetjem predstavlja konkurenčno prednost, saj lažje dostopajo do kapitala in zmanjšujejo operativne stroške preko povišanja učinkovitosti virov (Whelan idr., 2021). Trajnostno poročanje je ključno za vzpostavitev zaupanja, povečanje transparentnosti in spodbujanje trajnostnih učinkov (Enders idr., 2022; Smith idr., 2026), poleg tega pa krepi ugled blagovne znamke in zaupanje investitorjev, ki te podatke uporabljajo kot merilo dolgoročne uspešnosti (Enders idr., 2022; Zhou & Zhou, 2021). Pomemben dejavnik predstavlja tudi zavzetost zaposlenih, saj so podjetja z visoko motiviranimi zaposlenimi bolj dobičkonosna, doseganje CTR pa pomaga pritegniti talentirane posameznike generacije, ki v vedno večji meri zahteva družbeno odgovornost (Henisz idr., 2019; Suryanarayana Reddy idr., 2024).

Kljub vse večjemu številu raziskav, ki ločeno obravnavajo zrelost podjetij za uporabo OP ter njihovo doseganje CTR, v literaturi še vedno primanjkuje empiričnih študij, ki bi sistematično analizirale medsebojno povezanost teh dveh področij. Posledično ostaja nepojasnjeno, kako zrelost za uporabo OP vpliva na doseganje CTR v podjetjih in katere kombinacije dejavnikov zrelosti za uporabo OP omogočajo podjetjem, da OP pretvorijo v merljive CTR. Na podlagi tega smo oblikovali raziskovalna vprašanja:

- RV 1: Kako podjetja uporabljajo odprte podatke za doseganje ciljev trajnostnega razvoja?
- RV 2: Kako stopnja zrelosti za uporabo odprtih podatkov podjetja vpliva na uspešnost pri doseganju ciljev trajnostnega razvoja?
- RV 3: Katere kombinacije dejavnikov zrelosti za uporabo odprtih podatkov vplivajo na doseganje ciljev trajnostnega razvoja?

Za ta namen bomo izvedli študijo primera, s katero bomo pridobili podatke, ki jih bo možno analizirati z metodo kvalitativne primerjalne analize na podlagi mehkih množic (Fuzzy set Qualitative Comparative Analysis – FsQCA). V tem delu se bomo osredotočili na pripravo protokola za izvedbo študije primera, ki bo omogočil sistematično in ponovljivo pridobivanje kakovostnih podatkov v realnem poslovnem okolju in procesu izvedbe analize FsQCA.

2 Metodologija

Z uporabo raziskovalne strategije večkratne študije primera bo raziskava omogočila poglobljeno analizo več različnih primerov podjetij z vidika njihove zrelosti za uporabo OP ter stopnje doseganja CTR. Izvedba večkratne študije primera predstavlja kompleksen raziskovalni proces, pri katerem je ključnega pomena zagotovitev zadostne robustnosti, da so izsledki zanesljivi, veljavni in jih je možno posplošiti na populacijo (Annamalah idr., 2025).

Študija primera, kot raziskovalna strategija, omogoča poglobljeno in celostno proučevanje realnega operativnega poslovanja in strateškega odločanja v dejanskem poslovnem okolju podjetja (Annamalah idr., 2025; Yin, 2018). Izbrana metodologija omogoča naslovitev vprašanj »Kako« ali »Zakaj«, kadar vpliv med pojavom (v našem primeru zrelostjo podjetij za uporabo OP) in izidom (doseganje CTR) ni jasen (Yin, 2018). Uporaba večkratne študije primera omogoča poglobljeno razumevanje proučevanega pojava skozi več empiričnih primerov. Tak način omogoča raziskovalcu zajem razlik v organizacijskih in tehnoloških zmožnosti ter strateškega konteksta podjetja, znotraj katerega se oblikujejo prakse uporabe OP in njihovi učinki na trajnostno poslovanje. Poleg tega ta metodologija omogoča vpogled v razumevanje kako podjetja obvladujejo spremembe digitalne transformacije in vključujejo trajnostne prakse v vsakodnevno poslovanje, hkrati pa ohranjajo dobičkonosnost (Annamalah idr., 2025). V tem delu bomo pripravili jasno strukturiran protokol večkratne študije primera, ki bo skupaj z uporabo različnih virov podatkov prispeval k veljavnosti in zanesljivosti raziskave. Takšen pristop omogoča dosledno zbiranje in analizo podatkov, ter krepi kredibilnost ugotovitev pri proučevanju kompleksnih in kontekstno pogojenih pojavov (Quintão idr., 2020).

Analiza pridobljenih podatkov bo izvedena z metodo kvalitativne primerjalne analize na podlagi mehkih množic (FsQCA). Izbrana metoda združuje elemente kvalitativne in kvantitativne analize in se izkazuje za primerno kadar izid ni rezultat enega samega dejavnika, temveč različnih kombinacij več dejavnikov (Pappas & Woodside, 2021). Metoda predvideva obstoj pogojev, ki so v našem primeru dejavniki zrelosti za doseganje OP, za doseganje izida, ki je stanje doseganja CTR. Z uporabo te metode bomo ugotovili, kateri pogoji so nepogrešljivi (ali niso potrebni) za pojav določenega izida ter katere kombinacije pogojev so pomembnejše (ali manj pomembne) od drugih (Pappas & Woodside, 2021). Izvedba pol-strukturiranih intervjujev, s katerimi bomo pridobili kvalitativne podatke o trenutnem stanju glede proučevanega problema v podjetju, je zahteven raziskovalni postopek, zato je izbira FsQCA še posebej primerna, saj omogoča izvedbo analize na podlagi majhnih ali srednje velikih vzorcev (Greckhamer idr., 2018).

3 Rezultati

Na podlagi opredeljenega raziskovalnega okvira smo pripravili protokol večkratne študije primerov in postopek izvedbe analize pridobljenih podatkov.

Metoda pridobivanja podatkov – večkratna študija primerov

S protokolom za izvedbo študije primera se vzpostavijo jasne smernice in pravila za sistematično izvedbo pol-strukturiranih intervjujev ter za zbiranje in analizo podatkov. Protokol določa raziskovalni okvir, postopke zbiranja podatkov, vloge intervjuvancev, postopke priprave terenskega dela in predvideno poročanje o izvedbi študije primera, s čimer zagotavlja metodološko doslednost, primerljivost podatkov in zanesljivo osnovo za nadaljnjo analizo vpliva zrelosti podjetij za uporabo OP na doseganje ciljev trajnostnega razvoja. Za našo raziskavo bomo uporabili smernice za pripravo protokola avtorja Yin (2018), ki zagotavlja celovito obravnavo proučevanja pojava v realnem okolju. V tabeli 1 je predstavljen protokol za izvedbo študije primera.

Tabela 1: Protokol za izvedbo študije primera

Protokol za izvedbo študije primera			
Splošni pregled študije primera	Namen	Preučiti vpliv zrelosti podjetij za uporabo OP na njihovo doseganje CTR.	
	Cilji	Razumeti, kako stopnja zrelosti za uporabo OP vpliva na doseganje CTR.	
	Raziskovalna vprašanja	RV 1: Kako podjetja uporabljajo odprte podatke za doseganje ciljev trajnostnega razvoja? RV 2: Kako stopnja zrelosti za uporabo odprtih podatkov podjetja vpliva na uspešnost pri doseganju ciljev trajnostnega razvoja? RV 3: Katere kombinacije dejavnikov zrelosti za uporabo odprtih podatkov vplivajo na doseganje ciljev trajnostnega razvoja?	
	Raziskovalne predpostavke	Dostop do zadostnega števila reprezentativnih podjetij. Iskreni in verodostojni odgovori udeležencev.	
	Teoretično ozadje	Koncepti zrelosti za uporabo OP. Doseganje CTR v podjetjih. Digitalna transformacija. Zeleni prehod. Trajnostna uspešnost podjetij.	
	Vloga protokola pri izvedbi raziskave	Raziskovalna agenda, ki usmerja zbiranje podatkov ter zagotavlja metodološko doslednost.	
Postopki zbiranja podatkov	Kontaktne osebe za izvedbo terenskega dela	Adrema kontaktnih oseb, pripravljenih za sodelovanje v raziskavi.	
	Načrt zbiranja podatkov	Vrste podatkov	Javno dostopne evidence in poročila podjetij vključenih v raziskavo (trajnostna poročila idr.). Dokumenti podjetja, če jih bodo podjetja pripravljena deliti (strategije digitalne transformacije in trajnostnega razvoja, poslovni podatki podjetij idr.). Pol-strukturirani intervjuji.
		Vloge intervjuvancev	Predstavniki vodstva (podatki o strateških usmeritvah in trajnostnih ciljih). Strokovnjaki za podatke, informatiko ali digitalno preobrazbo. Odgovorni za trajnostno poročanje.
		Dogodki in procesi za opazovanje	Kadar bo izvedljivo bo vključeno opazovanje postopkov zbiranja, uporabe in obdelovanja podatkov, odločanja na podlagi podatkov v povezavi s CTR in notranjih usklajevanj med oddelki.
	Priprava pred izvedbo terenskega dela	Preliminarna ocena stopnje zrelosti podjetja za uporabo OP. Preliminarna ocena doseganja trajnostne usmerjenosti podjetja. Opredelitev relevantnih CTR glede na dejavnost podjetja.	

Protokol za izvedbo študije primera			
Priprava vprašanj	Opis trenutne prakse	Priprava obrazcev za beleženje podatkov za FsQCA.	
		Opis prakse	Opredelitev in opis trenutne uporabe OP v podjetju. Opredelitev in opis trenutnega stanja doseganja CTR v podjetju. Kadrovske vloge, organizacijske enote in tehnologije za izvajanje teh praks. Vključenost OP v trenutne poslovne procese. Vključenost OP v trajnostne prakse.
		Sodelovanje in medorganizacijski vidiki	Sodelovanje znotraj podjetja med oddelki. Sodelovanje z zunanjimi izvajalci in strokovnjaki. Vloga sodelovanja pri uporabi OP za doseganje CTR.
		Nastanek prakse	Kako in zakaj se je pojavila pobuda za uporabo OP v podjetju (interno, vpliv konkurence, trga, zakonodaje)? Kako in zakaj se je pojavila pobuda za doseganje CTR v podjetju?
		Načrtovanje in cilji	Ali je bil vzpostavljen strukturiran načrt pridobivanja in uporabe OP? Kakšni so bili cilji? Ali so bili vzpostavljeni načrti doseganja CTR v podjetju? Kakšni so bili cilji (etična strateška usmerjenost podjetja, konkurenčna prednost, zakonodaja)?
		Inovativnost	Na kakšen način uporabo OP prispeva k novim ali izboljšanim rešitvam? Ali uporaba OP prispeva k CTR rešitvam?
	Vrednotenje inovativne prakse	Načrt vrednotenja	Ali je vzpostavljena formalni ali neformalni sistem za vrednotenje prakse uporabe OP in doseganja CTR? Kdo izvaja vrednotenje (interno, zunanji izvajalci...)?
		Izvedba vrednotenja	Ali je bilo vrednotenje izvedeno (delno, v celoti)? Ali rezultati vrednotenja vplivajo na prakso?
		Merila	Katera merila ali kazalniki se uporabljajo za ocenjevanje učinkov OP (trajnostni, okoljski, poslovni...)? Kateri rezultati so bili zaznani v povezavi z doseganjem CTR?
		Alternativne razlage učinkov	Ali so rezultati mogoče rezultat drugih strategij (tržnih, regulativnih...)?

Protokol za izvedbo študije primera			
			Kako podjetje ocenjuje vlogo uporabe OP v primerjavi z drugimi dejavniki pri doseganju CTR?
Analiza pridobljenih podatkov	Kvalitativne analize	Analiziranje rezultatov poročila o zrelosti podjetij za uporabo OP. Analiziranje rezultatov poročila o doseganju ESG v podjetjih. Analiziranje poslovnih poročil in drugih dosegljivih podatkov podjetij.	
	FsQCA	Strukturiranje podatkov – prepoznavanje in opredelitev pogojev. Definicija želenega izida – doseganje CTR. Identifikacija konfiguracij dejavnikov zrelosti za uporabo OP za doseganje CTR.	
Osnutek poročila	Ciljne skupine	Raziskovalna in strokovna javnost s področja informacijskih sistemov, trajnostnega poslovanja in digitalne transformacije. Odločevalci v podjetjih.	
	Slog poročanja	Analitičen, strukturiran, znanstveno utemeljen. Jasna razmejitev med empiričnimi ugotovitvami in interpretacijo rezultatov.	
	Izvrševanje zakonskih zahtev	Analiza trenutne stopnje izvajanja zahtev, priporočil in spodbud na področjih OP in CTR vseh podjetij. Analiza posameznih izstopajočih praks.	
	Inovativnost prakse	Analiza obravnavane prakse uporabe OP in njene inovativnosti. Analiza inovativnost uporabe OP za doseganje CTR.	
	Doseženi rezultati prakse	Obravnava obstoječih doseženih učinkov uporabe OP za doseganje CTR z vidika zrelosti podjetja za uporabo OP.	
	Priloge	Predstavitev prilog in dostop do podpornih materialov.	

Vir: lasten

Protokol za izvedbo študije primerov predstavlja osrednje metodološko orodje in bo upoštevan pri izvedbi študije vsakega posameznega primera v največjem možnem obsegu. Za vsako vključeno podjetje bomo stremeli k pridobitvi čim več podatkov, predvidenih v načrtu protokola, pri tem pa upoštevamo, da so podjetja različna v različnih vidikih in da zato vse točke mogoče ne bodo relevantne v vseh primerih. Protokol je zasnovan kot iterativen raziskovalni proces, pri katerem posamezne stopnje ne predstavljajo linearnih korakov, temveč medsebojno povezane elemente, ki se lahko na podlagi vmesnih ugotovitev ponovno izvedejo. Stopnji priprave teoretične podlage in intervjujskih vprašanj sta močno prepleteni, saj mora biti vprašalnik usklajen s aktualnimi ugotovitvami na raziskovalnem področju. V stopnjah, ki vključujejo kvalitativno analizo in analizo s FsQCA, lahko pridemo do ugotovitev, ki zahtevajo vračanje k podrobnejši analizi teorije in primerjavi z

obstoječim praksam. Vmesni analitični rezultati prav tako lahko vodijo k reviziji in dopolnitvi empiričnih virov ali prilagoditvi intervjujskih vprašanj v kasnejših primerih. V iterativno logiko protokola je vključeno tudi poročanje, saj lahko rezultati in njihova interpretacija razkrijeta potrebo po dodatni teoretični razlagi.

Pred izvedbo raziskave bo vprašalnik evalviran s pilotno študijo, izvedeno na manjšem številu podjetij. Namen je preverjanje vsebinske razumljivosti, zanesljivosti in ustreznosti pridobljenih rezultatov za uporabo v postopku analize. Tako zasnovan protokol omogoča pridobitev kar najbolj zanesljivih in konsistentnih podatkov, ki bodo predstavljali ustrezno podlago za nadaljnje analize in interpretacijo raziskovalnih ugotovitev.

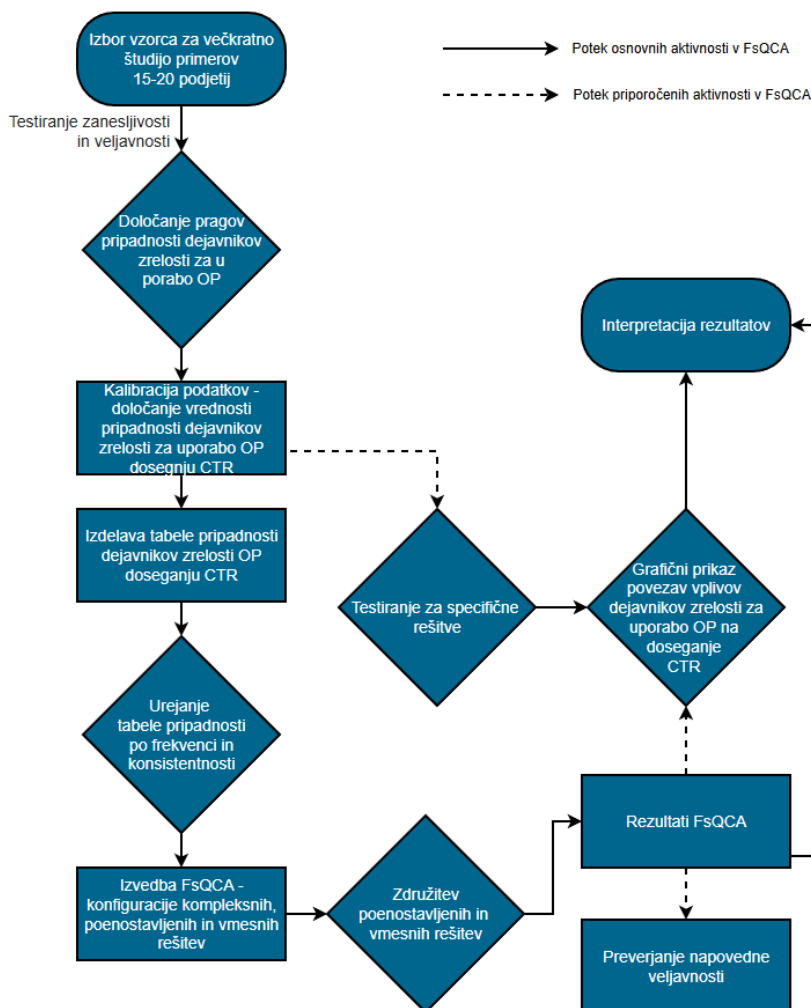
Metoda analize podatkov – FsQCA

Analiza podatkov z metodo FsQCA predstavlja sestavni del večkratne študije primerov in je vsebinsko vključena v protokol izvedbe, vendar pa je zaradi svoje kompleksnosti in specifičnih analitičnih korakov na tem mestu podrobneje predstavljena.

FsQCA za izvedbo zahteva podatke strukturirane na način, da omogočajo analizo kombinacij različnih medsebojno povezanih dejavnikov – pogojev, ki skupaj vodijo do opazovanega izida, v nasprotju z obravnavo posameznega dejavnika ločeno od ostalih. Dejavniki oz. pogoji in cilj oz. izidi so obravnavani kot množice, kar pomeni, da podatki niso uporabljeni v izvorni obliki temveč so pretvorjeni v stopnje pripadnosti množicam (Greckhamer idr., 2018). Pappas & Woodside (2021) posebej izpostavljata, da je izbira te metode za analizo podatkov idealna prav za primere, kjer so podatki pridobljeni s študijo primera, saj omogoča sistematično analizo kombinacij dejavnikov na podlagi kvalitativnih podatkov. Za analizo rezultatov bomo sledili smernicam za izvedbo FsQCA, kot jo navajata avtorja Pappas & Woodside (2021).

Proces analiziranja podatkov v tej raziskavi sledi logiki konfiguracijskega pristopa FsQCA in je zasnovan tako, da omogoča sistematičen prehod od empiričnih podatkov k razlagi kombinacij pogojev – dejavnikov zrelosti za uporabo OP, do vplivov na doseganje izidov – CTR. Podatki za izvedbo analize temeljijo na pol-strukturiranih intervjujih ter analizi interne in javno dostopne dokumentacije

podjetij. Sledi določanje pragov polne pripadnosti, presečišč in nepripadnosti, ki jih bomo določili na podlagi percentilov (95 %, 50 % in 5 %), kot to predlagata Pappas & Woodside (2021). To omogoča pretvorbo izvornih vrednosti v mehke vrednosti.



Slika 1: Postopek izvedbe FsQCA

(Prilagojeno po: Pappas & Woodside, 2021, str. 3)

Najzahtevnejši in tudi najpomembnejši korak FsQCA predstavlja kalibracija podatkov. Pri kalibraciji se surovi podatki pretvorijo v »fuzzy« oz. mehke vrednosti na intervalu med 0 in 1, s čimer se izrazi stopnja pripadnosti posameznih primerov

posameznim množicam. Na podlagi tega se pripravi in ustrezno uredi tabela pripadnosti posameznih pogojev – dejavnikov zrelosti za uporabo OP, izidu – doseganju CTR. Tako pripravljena tabela omogoči izvedbo FsQCA, katere rezultat so konfiguracije kompleksnih, poenostavljenih in vmesnih rešitev. Zaključne korake izvedbe FsQCA predstavljajo interpretacije rezultatov z vračanjem k empiričnim primerom in njihovemu organizacijskemu kontekstu, kar omogoča poglobljeno razumevanje vpliva zrelosti podjetij za uporabo OP na doseganje CTR. Postopek izvedbe FsQCA prikazuje Slika 1.

Zasnovana metodologija pridobivanja podatkov in analize rezultatov omogoča sistematično, rigorozno in relevantno proučevanje raziskovalnega pojava, to je kako zrelost podjetij za uporabo OP vpliva na doseganje CTR.

4 Diskusija

Namen prispevka je utemeljiti izbrano metodologijo – večkratno študijo primerov – za raziskavo vpliva zrelosti za uporabo OP na doseganje CTR in razviti protokol izvedbe metodologije v kvalitativni raziskavi. Poleg tega prispevek utemeljuje uporabo metode FsQCA, za analizo rezultatov raziskave, saj omogoča analizo vplivov na iskani izid na podlagi kvalitativnih podatkov pridobljenih tekom izvedbe večkratne študije primera.

Večkratna študija primera omogoča poglobljeno in celostno proučevanje raziskovalnega problema v realnem organizacijskem in tehnološkem okolju. Izbrana metodologija omogoča prepoznavo raznolikosti med podjetji ter analizo raziskovalnega pojava skozi več empiričnih primerov, kar presega omejitve opazovanja enega samega primera. Zastavljena raziskovalna vprašanja naslavljajo kompleksne in kontekstno pogojene vzročno-posledične povezave, ki jih je možno sistematično nasloviti z izvedbo večkratne študije primera po predvidenem protokolu. Ključno vlogo pri zagotavljanju metodološke ustreznosti ima jasno strukturiran protokol študije primera, ki smo ga za našo raziskavo zasnovali po smernicah Yin (2018). Protokol omogoča natančno definicijo raziskovalnega okolja, opredelitev postopkov zbiranja podatkov, pripravo vprašanj poleg tega pa tudi pripravo osnutka poročila o izvedeni študiji. Na ta način s protokolom opredelimo vse potrebne korake, da zagotovimo zahtevam znanstveno rigoroznega raziskovanja.

Analiza kvalitativnih podatkov, pridobljenih v okviru večkratne študije primera, z uporabo metode FsQCA omogoča prepoznavo nujnih, zadostnih ali nepotrebnih dejavnikov zrelosti za uporabo OP pri doseganju CTR. Ena izmed ključnih prednosti metode FsQCA v pričujoči raziskavi je njena uporaba za analizo kvalitativnih podatkov, ki jih bomo pridobili s izvedbo študije primera. Zbiranje podatkov z analizo dokumentov in izvedbo pol-strukturiranih intervjujev predstavlja metodološko zahteven proces, ki praviloma omejuje število vključenih primerov, zato FsQCA predstavlja posebej primerno analitično orodje, ki omogoča delo z majhnimi vzorci. Rezultati metode presegajo linearne vzročno-posledične razlage s prepoznavo različnih kombinacij dejavnikov, ki skupaj vodijo k doseganju opazovanega izida. S pretvorbo kvalitativnih podatkov v mehke vrednosti FsQCA omogoči sistematično povezovanje empiričnih ugotovitev iz več študij primerov. Interpretacija poenostavljenih in vmesnih rešitev z vračanjem k empiričnim primerom dodatno krepi razumevanje kontekstualnih razlik med podjetji ter potrjuje primernost FsQCA za obravnavo kompleksnih organizacijskih pojavov.

5 Zaključek

V prispevku smo naslovili pomembno raziskovalno vrzel na presečišču zrelosti podjetij za uporabo OP in doseganja CTR, pri čemer smo se osredotočili predvsem na metodološki vidik raziskave. Osrednji namen prispevka je utemeljiti izbiro raziskovanega pristopa z večkratno študijo primera, kot ustrezne raziskovalne strategije ter razviti jasno strukturiran protokol za njeno sistematično izvedbo. Razvit protokol predstavlja pomemben metodološki prispevek, saj omogoča dosledno in primerljivo zbiranje kakovostnih empiričnih podatkov v realnem organizacijskem okolju. Dodatno smo utemeljili uporabo metode kvalitativne primerjalne analize na podlagi mehkih množic kot ustreznega pristopa za analizo kompleksnih in kontekstno pogojenih organizacijskih pojavov, ki niso posledica delovanja posameznega dejavnika, temveč izhajajo iz medsebojnega prepletanja različnih dejavnikov. Metoda FsQCA, ki omogoča, na podlagi kvalitativnih podatkov, pridobljenih z večkratno študijo primerov, identifikacijo različnih konfiguracij dejavnikov zrelosti, ki prispevajo k doseganju CTR, se izkazuje za ustrezno izbiro za izvedbo analize.

Prispevek s tem postavlja trdno metodološko osnovo za nadaljnje empirične raziskave vpliva zrelosti podjetij za uporabo OP na njihovo delovanje v skladu s CTR. Razvit protokol in opisan postopek analize podatkov omogočata njegovo uporabo in nadgradnjo tudi v prihodnjih raziskavah, usmerjenih v razumevanje vloge podatkov pri trajnostni in digitalni preobrazbi podjetij.

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ANALIZA ORGANIZACIJE IN ODZIVNOSTI NA CEPLJENJE PROTI GRIPI V SLOVENIJI IN EVROPI

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Gripa je eden izmed največjih sezonskih izzivov vsako leto. Obolevajo mnogi, a težji potek je značilnejši za starejšo populacijo ter kronične bolnike, majhne otroke, nosečnice in osebe s prekomerno telesno težo. Vsako leto je proti njej na voljo posodobljeno oziroma prilagojeno cepivo. Za cepljenje se odločajo številni, vendar bi odzivnost še zmeraj bila lahko veliko boljša. Cilj pričujočega prispevka je analiza odzivnosti na cepljenje med posameznimi starostnimi skupinami v Sloveniji in Evropi ter pogled v prihodnost, možnosti za napredek in nadaljevanje dobrega dela.

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ANALYSIS OF THE ORGANIZATION AND RESPONSE TO INFLUENZA VACCINATION IN SLOVENIA AND EUROPE

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Influenza is one of the biggest seasonal challenges every year. Many people get sick, but the more severe course is more typical for the elderly population and chronically ill patients, young children, pregnant women and overweight people. Every year, an updated or improved vaccine is available against it. Many people decide to get vaccinated, but the response rate could still be much better. The aim of this article is to analyze the response rate to vaccination among individual age groups in Slovenia and Europe and look to the future, the possibilities for progress and the continuation of good work.



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1 Uvod

Sezonska gripa je velik javnozdravstveni izziv. Četudi je večina simptomatskih primerov blaga, so tisti s hujšim potekom pogosto hospitalizirani, nemalokrat se konča tudi s smrtnim izidom. Globalno se sezonska gripa pojavi pri milijardi ljudi letno, 650 000 ljudi na leto umre. Starejši od 65 let zavzemajo levji delež prizadete populacije, saj predstavljajo več kot 50 % hospitalizacij in več kot 90 % smrti (Gavazzi, idr., 2025).

Cepljenje je najbolj učinkovita metoda zaščite pred okužbo in posledicami virusa influence. Težavo predstavlja predvsem suboptimalen imunski odgovor starejše populacije. Vzrok tiči v starostno povezanem zmanjšanem imunološkem odgovoru in kroničnem vnetju, ki se odraža s povišanimi provnetnimi citokini, ti zmanjšujejo kožno imunost, kar vodi do zmanjšane proliferacije T celic in zmanjšane antigenske stimulacije, na kateri temeljijo cepiva. Dodaten dejavnik, ki zmanjšuje uspešnost cepljenja, je jemanje imunosupresivov, katerih uporaba v zadnjih letih narašča, še posebej med starejšimi. Adjuvantna in visoko dozna cepiva, ki so na voljo, pomagajo pri dotični problematiki, a zaenkrat še niso univerzalno priporočena v evropskih državah. Uporabljajo jih v Avstriji, Nemčiji, Grčiji, Italiji, Združenem kraljestvu, na Irskem in na Nizozemskem. Kljub jasnim priporočilom Svetovne zdravstvene organizacije (WHO), ki kot cilj navaja 75-odstotno precepljenost starejših od 65 let, številne evropske države tega praga ne dosegajo. Precepljenost med državami močno variira, v nekaterih okoljih pa v zadnjih letih celo stagnira ali upada. V Sloveniji ostaja delež cepljenih med najnižjimi v Evropski uniji zlasti v splošni populaciji in med starejšimi kar odpira vprašanja o učinkovitosti obstoječih strategij promocije in dostopnosti cepljenja. Raziskovalna vrzel se tako kaže predvsem v pomanjkanju celovite analize, ki bi povezala epidemiološke podatke o precepljenosti z organizacijskimi pristopi, komunikacijskimi strategijami in primeri dobrih praks iz tujine ter jih umestila v slovenski prostor. Namen pričujočega prispevka je zato analizirati precepljenost proti sezonski gripi med različnimi starostnimi skupinami v Sloveniji ter jo primerjati z izbranimi evropskimi državami, opredeliti ključne dejavnike nizke odzivnosti in predstaviti dokazano učinkovite strategije ter pogled v prihodnost, možnosti za napredek in nadaljevanje dobrega dela (Gavazzi, idr., 2025).

2 Učinkovitost cepiv

Prvo cepivo proti gripi je bilo razvito že leta 1938. To je bil inaktiven pripravek, ki je vseboval en sam sev gripe tipa A, imenovali so ga monovalentno cepivo. Od leta 1940 pa vse do 2010 je tehnologija proizvodnje cepiva ostajala večinoma nespremenjena in je temeljila na vzgoji neaktiviranih virusov v piščančjih jajcih. Zaradi novih sevov influence tipa A je Svetovna zdravstvena organizacija (WHO) leta 1978 uvedla trivalentno cepivo. Leta 2012 so cepivo dodatno nadgradili in uvedli štirivalentno cepivo, to je varovalo pred dvema sevoma influence tipa A in dvema sevoma influence tipa B. Ker se od marca 2020 sev Yamagata influence tipa B ni več pojavil, je WHO predlagal ponovno uvedbo trivalentnega cepiva (Clark, idr., 2024).

Potrebno je izpostaviti, da je cepivo učinkovito zgolj proti trenutno krožečim oblikam gripe. Antigenski premik in odmik namreč ves čas spreminjata obliko gripe in jo na ta način delata odporno proti cepivom. To je razlog, da je potrebno cepivo vsako leto prilagoditi, da ostaja učinkovito in dejansko zaščiti ljudi pred težjo obliko bolezni. WHO vsako leto svetuje, kakšna naj bo vsebina cepiva na severni in južni polobli znotraj njunih sezon gripe. Sezona na severni polobli se pojavlja med oktobrom in februarjem, na južni pa med septembrom in januarjem (Clark, idr., 2024).

Četudi je cepljenje najbolj učinkovit način preprečevanja gripe, je potrebno poudariti, da cepivo ni enako oziroma primerljivo učinkovito v primerjavi z drugimi protivirusnimi cepivi. Na primer cepivo proti ošpicam je več kot 90 % učinkovito, meningokokno cepivo pa zaščiti v kar 100 %, medtem ko je cepivo proti vsem laboratorijsko potrjenim oblikam gripe samo 49 % učinkovito (Clark, idr., 2024).

Zaradi nenehnega spreminjanja in prilagajanja virusa gripe, ki vodi v zmanjšano učinkovitost cepiva, sta potrebna reden nadzor nad krožečimi oblikami virusa in reformulacija cepiva vsako leto. Predviden sev prihajajoče sezone je velikokrat težko določiti, včasih se zgodijo napake in cepivo je v obdobju tiste sezone precej manj učinkovito. Prav tako zmeraj obstaja tveganje pandemije virusa gripe kot posledica incidentov v živalskem svetu in prenosa na ljudi, najpogosteje se to zgodi med pticami. V primeru takšnih dogodkov aktualno cepivo ne zagotavlja nikakršne zaščite oziroma je ta minimalna, zato ti dogodki največkrat vodijo v pandemijo (Clark, idr., 2024).

Zaradi vseh omenjenih dogodkov in scenarijev je potreba po novi generaciji cepiva velika. Optimalno cepivo bi bilo univerzalno in bi zaščitilo pred velikim številom vseh podtipov gripe. Nekaj kandidatov novega univerzalnega cepiva je trenutno v nastajanju. Eden izmed pristopov je uvedba novih antigenskih tarč, povezanih z visoko koncentriranimi in stabilnimi epitopi virusa influence. To ne bi zgolj razširilo področja zaščite, temveč tudi podaljšalo učinkovitost cepiva (Clark, idr., 2024).

3 Metode

Prispevek temelji na pregledu javno dostopne literature in sekundarnih podatkov. Namen pregleda je bil sistematično zbrati in ovrednotiti obstoječe znanstvene članke in poročila o precepljenosti proti sezonski gripi, dejavnikih nizke odzivnosti in strategije izboljšanja precepljenosti v Evropi s poudarkom na Sloveniji.

Literatura je bila pridobljena iz mednarodnih podatkovnih baz (PubMed) in uradnih spletnih virov mednarodnih in nacionalnih institucij z uporabo kombinacij ključnih besed v slovenskem in angleškem jeziku.

Epidemiološki podatki za Slovenijo so zbrani iz javno dostopnih poročil NIJZ, ki podatke o precepljenosti redno objavlja po starostnih skupinah in regijah. Podatki za druge evropske države so pridobljeni iz poročil WHO ter drugih nacionalnih zdravstvenih organizacij in znanstvenih člankov.

Analiza je temeljila na primerjavi deležev precepljenosti med državami, starostnimi skupinami in časovnimi obdobji.

Prispevek ne vključuje primarnega zbiranja podatkov in statističnega modeliranja, saj gre za narativni pregled literature. Posledično so rezultati odvisni od kakovosti in dostopnosti objavljenih virov ter morebitnih razlik v metodologiji zbiranja in analiziranja podatkov med posameznimi državami. Ker gre za uradna epidemiološka poročila in recenzirano literaturo prispevek zagotavlja visoko stopnjo verodostojnosti predstavljenih ugotovitev.

4 Primerjalna analiza evropskih držav

4.1 Neenakosti v precepljenosti in socioekonomski dejavniki

Zaradi povečanega tveganja za okužbo in težji potek bolezni z gripo je Svetovna zdravstvena organizacija (WHO) priporočila cepljenje proti gripi vsem, starim 65 let in več. Večina evropskih držav to priporočilo upošteva, Nemčija, Grčija, Madžarska, Islandija, Nizozemska in Slovaška so priporočeno starostno mejo znižale na 60 let, Irska pa nudi brezplačno cepljenje vsem nad 50 let.

Skupni podatki evropskih držav pravijo, da gripa prizadene 50 milijonov simptomatskih posameznikov letno, med 15 000 in 70 000 jih umre. Podatki iz leta 2024/25 kažejo, da se je aktivnost gripe vrnila na tisto iz časov pred pandemijo COVID-19. Večina evropskih držav je v tem letu poročala srednjo prevalenco gripe med posamezniki nad 65 let, Belgija, Madžarska, Luksemburg, Romunija in Slovenija pa so poročali o visoki do zelo visoki aktivnosti gripe v sezoni 2024/25. Odstopanja med državami je moč pripisati različnim tehnikam in merilom za postavitev diagnoze. Še večja odstopanja med evropskimi državami se pojavijo v precepljenosti populacije, stare nad 65 let, proti sezonski gripi. Najslabša odzivnost je v Črni gori, kjer je cepljenih zgolj 6,5 % starostnikov, na Danskem pa kar 81 %. Kljub vsem dokazom, ki podpirajo uspešnost in varnost cepiva, sta v sezoni 2023/24 zgolj dve državi dosegli mejo precepljenosti, ki jo je zastavila Svetovna zdravstvena organizacija (WHO) – 75 %. Omenjeni državi sta Danska in Irska. Potrebno je poudariti, da so Hrvaška, Francija, Islandija, Italija, Portugalska, Romunija, Španija in Slovenija zabeležile zmanjšano precepljenost, padec je bil več kot 3 % iz sezone 2022/23 v sezono 2023/24. Ponavljajoč trend morebiti označuje spremembo odnosa populacije do cepljenja in oznanja, da bi lahko bilo v prihajajočih letih populacijo precepiti še bolj težavno (Gavazzi, idr., 2025).

Med številnimi razlogi, ki starejše odvrčajo od cepljenja oziroma jim to onemogočajo, so logistične prepreke, neozaveščenost, kje in kdaj se cepiti, ter cena cepiva. Češka raziskava je pokazala, da ima več kot polovica ciljne populacije (54,9 %) težave z razumevanjem informacij glede cepiva, zgolj četrtna omenjenih jih je poiskala pomoč pri razumevanju informacij. V raziskavi so ugotovili tudi, da posamezniki, ki še nikdar niso bili cepljeni proti gripi, bolj negativno dojemajo cepljenje kot tisti, ki so bili cepljeni vsaj enkrat. Pri določenih je razlog ta, da se ne

vidijo kot pripadniki ciljne oziroma ogrožene skupine, saj so "prezdravi", da bi bili ogroženi (Gavazzi, idr., 2025).

Porazdelitev precepljenosti po Evropi je zelo raznovrstna in jo lahko dodatno opredelimo oziroma razdelimo glede na geografsko lokacijo, etnične skupine, socioekonomski položaj, spol, starost in komorbiditete. Etnične raziskave so potrdile, da je delež cepljenih veliko nižji med imigranti in Romi. Ljudje z nižjim socioekonomskim položajem, tisti, ki živijo sami, moški, nižje izobraženi so cepljeni proti gripi v veliko nižjem odstotku kot tisti v zakonski skupnosti, ženske in višje izobraženi (Giezeman-Smits, idr., 2025).

4.2 Posebnosti držav Centralne in Vzhodne Evrope

Regiji Centralne in Vzhodne Evrope imata najslabšo precepljenost proti gripi vsako leto, prav tako imata slabo zavedene vsakoletne podatke o smrtih, povezanih z gripo. Leta 2020 je bilo v Avstriji zabeleženih 3,3 primera smrti na 100.000 prebivalcev, kar je bistveno več kot 0,1 na Slovaškem in < 0,5 na Poljskem, Madžarskem, Srbiji in Romuniji. Raziskava, ki je povzela zdravstveno stanje prebivalstva v omenjenih državah, je potrdila, da imajo te države velik delež starejše populacije s slabšim zdravstvenim stanjem. Z roko v roki glede na obolevnost z gripo in smrti, povezane z njo, gre sklepati, da omenjene države neustrezno beležijo smrti, do katerih pride kot posledica gripe. Da bi izboljšali odzivnost za cepljenje proti gripi, je prvi korak izboljšati beleženje smrtnih izidov. Kot zgled so vzeli Avstrijo, ki ima podobno precepljenost, gostoto prebivalstva, geografsko lego in veliko boljši sistem poročanja. S pomočjo podrobne analize in raznih modelov so izračunali, da ima Srbija največje odstopanje med poročanjem in dejanskimi smrtnimi izidi. Srbija kot država z malim deležem prebivalstva, cepljenega proti gripi, je bila tarča in izziv, kako izboljšati situacijo v celotni Centralni in Vzhodni Evropi. Raziskava je zajemala obdobje med letoma 2014 in 2018 (precepljenost 10,82 %) in se usmerila v leto 2024. Cilj je bil do 2024 doseči 48 % precepljenost med ljudmi, starimi 65 let in več. Glede na podatke, ki so jih imeli v Srbiji, bi, če bi bil cilj dosežen, to pomenilo 4522 manj obiskov zdravnika na primarni ravni, 3490 dni manj hospitalizacij in 2,86 manj smrti na 100.000 prebivalcev. Letna cena bi znašala 2 847 994 evrov. Glede na ekonomsko stanje države in izračune, to ne bi bila stroškovno utemeljena poteza. Če pa podatke Srbije izračunamo po avstrijskem modelu in sklepamo, da je to dejansko stanje smrti in primerov gripe v državi, bi izboljšana precepljenost pomenila 34 397 manj obiskov

zdravnika na primarni ravni, 3707 dni manj hospitalizacij in 19,25 manj primerov smrti na 100.000 prebivalcev. Letna cena bi tako znašala 2 819 147 evrov. Glede na dane podatke bi bila izvedba programa stroškovno smiselna v starostni skupini nad 85 let. Sklepamo lahko torej, da napačno beleženje podatkov v določenih državah vodi do zmotnega stroškovnega izračuna učinkovitosti promocije in izvajanja cepljenja proti gripi (Pitter, idr., 2025).

Kot ena izmed držav Vzhodne Evrope je tudi Ukrajina vključena v kampanje izboljšanja odzivnosti za cepljenje proti gripi. Neizodostno poročanje o smrtnih izdihih ne bi smelo zavajati raziskovalcev in politikov, ko ocenjujejo breme gripe v Ukrajini. Gre za državo z mrzlimi celinskimi zimami, kjer je precepljenost izredno nizka in krhkost starejše populacije izredno visoka. Prizadevanje za visoko precepljenost proti gripi starejše populacije v Ukrajini bi morala biti javnozdravstvena prioriteta in področje, v katerega bi se usmerjal del mednarodne podpore (Pitter, idr., 2025).

4.3 Primer dobre prakse: podaljšana kampanja cepljenja v Franciji

V lanskem letu oziroma sezoni je Francija uvedla podaljšano kampanjo cepljenja proti gripi. Predvideno je bilo, da ta traja od 15. oktobra 2024 do 31. januarja 2025, a so jo podaljšali vse do 28. februarja 2025. Gripa vsako leto prizadene med 2 do 6 milijonov ljudi v Franciji, še posebej starejše in polimorbidne. Brezplačno cepivo so omogočili vsem, starim 65 let in več, mlajšim s kroničnimi boleznimi, nosečnicam, ljudem z ITM (indeksom telesne mase) nad 40, tistim, ki so v neposredni bližini malih otrok, imunokompromitiranim, delavcem in prebivalcem v domovih starejših občanov ter delavcem v svinjski in prašičji industriji. Proti gripi lahko prebivalce cepijo zdravniki, medicinske sestre, babice in farmacevti. Na ta način so omogočili veliko dostopnost do cepiva. Prav tako so ponudili cepljenje proti gripi sočasno s cepljenjem proti COVID-19 (French Government, 2025).

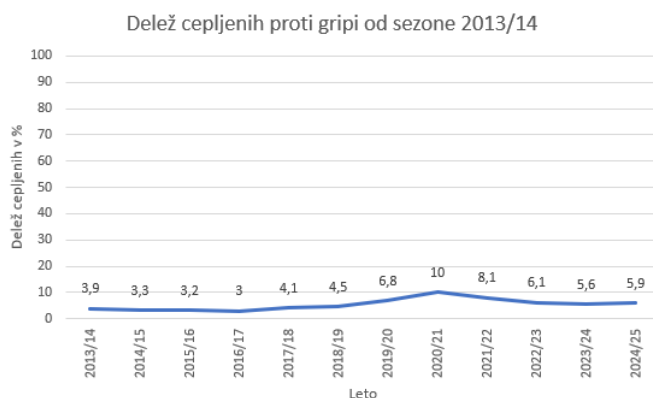
4.4 Precepljenost in organizacija cepljenja v Sloveniji

V Sloveniji vsako sezono za gripo zboli med 5 in 10 % ljudi, to pomeni med 100.000 in 200.000 prebivalcev, zato predstavlja velik javnozdravstveni problem in ima velik vpliv na obolevnost ter umrljivost populacije. Obenem predstavlja tudi ogromen javnozdravstveni izziv, predvsem v smislu preprečevanja širjenja in posledičnega zmanjšanja umrljivosti populacije. Zavedati se moramo, da od 80 do 90 % vseh

smrti, povezanih z gripo, doleti ranljive skupine, predvsem starejše od 65 let. V sklopu lajšanja simptomatike so nam nekoliko v pomoč protivirusna zdravila, ki nekoliko skrajšajo in omilijo potek, če jih bolnik začne jemati prvi ali drugi dan, a žal niso primerna za vse bolnike. Kot že omenjeno, nam najbolj učinkovito zaščito predstavlja vsakoletno cepljenje. Več ljudi kot se cepi, manjša je verjetnost za okužbe in sam pojav bolezni (Cepljenje.info., n.d.).

Lahko rečemo, da je v Sloveniji proti gripi cepljenih premalo ljudi. Po precepljenosti smo na repu držav v Evropski uniji. Za cepljenje se odloča manj kot 10 % prebivalcev. Delež je nekoliko višji glede na predhodno sezono (5,9 % proti 5,6 %), a nižji kot v sezoni 2020/2021, ko je znašal 10 %. V starostni skupini starejših odraslih (stari 65 let ali več) je delež precepljenih nizek. V sezoni 2024/2025 je bilo cepljenih le 18,1 % ljudi, sezono prej 17,6 %, medtem ko je ta delež v sezoni 2020/2021 znašal 27,6 %. Glede na navedene podatke lahko rečemo, da je v Sloveniji delež cepljene populacije daleč pod zastavljenim ciljem Svetovne zdravstvene organizacije (Nacionalni inštitut za javno zdravje, 2024).

Pomembno se je zavedati, da lahko s cepljenjem proti gripi pri otrocih in odraslih, mlajših od 65 let, preprečimo bolezen v 50 do 60 %, pri osebah, starejših od 65 let, je ta odstotek nekoliko nižji. Podatki kažejo, da tudi med cepljenimi, ki zbolijo, s cepljenjem preprečimo hospitalizacijo v približno 40 %, v 40 % sprejem na oddelek za intenzivno zdravljenje in v 50 % smrt (Nacionalni inštitut za javno zdravje, 2024).



Graf 1: Delež cepljenih proti gripi med splošnim prebivalstvom

Vir: Nacionalni inštitut za javno zdravje, 2025

Trend precepljenosti v splošni populaciji v zadnjih sezonah prikazuje Graf 1. Kot je razvidno, se je delež cepljenih po izrazitem porastu v sezoni 2020/2021 ponovno znižal in v naslednjih sezonah ostal pod 6 %, z rahlim porastom v sezoni 2024/2025. Kljub temu precepljenost ostaja nizka in pod priporočili Svetovne zdravstvene organizacije (Nacionalni inštitut za javno zdravje, 2025).

V Sloveniji zbira podatke in izvaja cepljenje Nacionalni inštitut za javno zdravje (NIJZ). Zbrani podatki iz sezone 2024/2025 (1. 10. 2024 do 9. 7. 2025) so pokazali določene zaključke. Podatke o precepljenosti so porazdelili po statističnih regijah (Gorenjska, Goriška, jugovzhodna Slovenija, Koroška, Obalno-kraška, Osrednjeslovenska, Podravska, Pomurska, Posavska, Primorsko-notranjska, Savinjska, Zasavska), po zdravstvenih regijah (Celje, Nova Gorica, Koper, Kranj, Ljubljana, Maribor, Murska Sobota, Novo mesto, Ravne na Koroškem), po skupinah (kronični bolniki, nosečnice, zdravstveni delavci, ostali) in po starostih (6–23 mesecev, 2–18 let, 19–64 let, 65 let in več). Glede na delitev po zdravstvenih regijah je bilo največ ljudi cepljenih proti gripi v Ljubljani (42 954), sledil je Maribor (19 914), kar lahko pripišemo največjemu številu prebivalstva na omenjenih področjih. Najmanj je bilo cepljenih v Ravnah na Koroškem (4707). Glede na skupine je bilo v Sloveniji cepljenih 100 314 "ostalih", 6333 zdravstvenih delavcev, 244 nosečnic in 18 056 kroničnih bolnikov. V porazdelitvi po starosti je bilo največ cepljenih posameznikov starih 65 let in več (84 723), kar nakazuje na pozitivno odzivnost ene izmed glavnih ciljnih skupin cepljenja proti gripi. Sledili so stari med 19 in 64 let (26 753), nato med 2 in 18 let (2961), najmanj je bilo cepljenih 6- do 36-mesečnih otrok (510). Delež cepljenih proti gripi se je v sezoni 2024/2025 v primerjavi s predhodno sezono nekoliko zvišal. Proti gripi se je cepilo 5,9 % prebivalstva Slovenije, v primerjavi s predhodno sezono, ko se je cepilo 5,6 % prebivalstva. Delež cepljenih v starostni skupini 65 let in več se je tudi malce zvišal in je znašal 18,1 % (v sezoni 2023/2024 je bil delež cepljenih 17,6 % v starostni skupini 65 let in več). Nacionalni inštitut za javno zdravje je v dokumentu, v katerem so podali statistične podatke, dodal tudi izjavo, da je cepljenje proti gripi posebej priporočljivo za kronične bolnike, kamor so uvrstili osebe z boleznimi obtočil, dihal, sečil, jeter, metabolnimi boleznimi, nekaterimi živčno-mišičnimi in vezivnimi boleznimi, malignimi obolenji, nekaterimi boleznimi krvi in krvotvornih organov, boleznimi, ki slabijo imunski odziv, in otroke, ki so dalj časa zdravljeni s salicilati. V skladu s tem prispevkom so cepljenje toplo priporočili tudi osebam, starim 65 let in več, otrokom, starim med 6 in 23 mesecev, in nosečnicam. Prav tako so neposredno pozvali zdravstvene delavce

k ozaveščanju populacije in jih pozvali, naj se sami aktivno s cepljenjem zaščitijo proti gripi (Nacionalni inštitut za javno zdravje, 2025).

Najbolj aktualni podatki so za sezono 2025/2026, ko se je v Sloveniji proti gripi (do 8. 12. 2025) cepilo več kot 150.000 prebivalcev, kar je 7,1 % prebivalcev. To je več kot v celotni sezoni v preteklih treh letih. Po starostnih skupinah jih je največ cepljenih med tistimi, ki so stari 80 let ali več (več kot 21 %), sledijo pa tisti, ki so stari med 70 in 79 let (Nacionalni inštitut za javno zdravje, 2025).

Vsako leto poteka cepljenje jeseni od 20. oktobra do konca decembra ali celo januarja. V sezoni 2025/2026 je to brezplačno za vse zavarovane osebe. Pacienti se lahko cepijo pri izbranih zdravnikih, v cepilnih centrih zdravstvenih ustanov in na območnih enotah Nacionalnega inštituta za javno zdravje (NIJZ) (Cepljenje.info., n.d.).

Glede na slabo odzivnost populacije in odločanje za cepljenje proti gripi sta promocija in edukacija prebivalstva ključnega pomena. Ključna sporočila promocije so predvsem varnost, učinkovitost, ciljne skupine in dostopnost. Vsako leto pričnemo s promocijo cepljenja pred sezono gripe z glavnima ciljema povečanja precepljenosti in zmanjšanja bremena gripe na zdravstveni sistem (Nacionalni inštitut za javno zdravje, 2024).

Nacionalni inštitut za javno zdravje je v sezono 2025/2026 vstopil s projektom PREHITIMO GRIPO, ZAŠČITIMO SE ŽE DANES, (10) v sklopu katerega so izdali letake. Slednji so opremljeni z edukativno vsebino o tem, kaj lahko sami storimo, da zmanjšamo okužbe dihal, in o razlogih, zaradi katerih se naj prebivalci odločijo za cepljenje. Poudarijo ogrožene skupine (starejši od 65 let, kronični bolniki, nosečnice, osebe z izrazito prekomerno telesno težo in otroci do 2. leta starosti). Na letaku se nahaja tudi QR koda, ki jo lahko ljudje skenirajo s svojo mobilno napravo in jih vodi do spletne strani NIJZ, na kateri lahko najdejo dodatne informacije o cepljenju, virusu gripe, simptomih in prvih znakih bolezni ter kratke informativne video posnetke, ki so jih pripravili slovenski zdravniki za informiranje svojih pacientov (Nacionalni inštitut za javno zdravje, 2024).

Letake so podkrepili tudi s plakati za promocijo projekta PREHITIMO GRIPO, ZAŠČITIMO SE ŽE DANES, ki tako kot letaki vsebujejo QR kodo, ki prebivalstvo vodi do iste spletene strani kot tista na letakih (Nacionalni inštitut za javno zdravje, 2025).

V svoje promocijsko gradivo je NIJZ vključil tudi predstavitev vseh mitov o gripi in pojasnil strokovno utemeljena dejstva glede bolezni, obvešča o prihodu cepiva in objavlja podatke o neželenih učinkih cepljenja (Nacionalni inštitut za javno zdravje, 2025).

Velik del promocije poleg NIJZ prevzemajo tudi zdravstveni domovi in zdravstveni delavci na primarni ravni. Njihova naloga je predvsem obveščanje o začetku cepljenja in organizacija terminov pri izbranih osebnih zdravnikih (predvsem specialistih pediatrije in družinske medicine). Izbrani zdravniki imajo pomembno vlogo pri pozivanju svojih pacientov k naročanju, pojasnitvi prednosti in odpravljanju morebitnih dvomov pri posameznikih. Prav tako lahko posredno vplivajo na svoje paciente z deljenjem letakov ter izpostavitvijo plakatov, ki jih prejmejo s strani NIJZ (Nacionalni inštitut za javno zdravje, 2024).

5 Strategije izboljšanja precepljenosti

Vsak zadržek oziroma izziv, ki omejuje boljšo odzivnost na cepljenje proti gripi, ima svojo strategijo, kako ga zmanjšati oziroma odpraviti. Pomanjkljivo znanje in informacije najlažje odpravimo z izobraževanjem javnosti in zdravstvenih delavcev, ki naj temelji na dokazih o varnosti, razjasni nerazumljivosti in uporablja empatični način komunikacijskih strategij. Finančni zadržki so odpravljeni z brezplačno dostopnim cepivom. Predlagano je, da se logistične ovire odpravijo, tako da je cepljenje dostopno v lekarnah, mobilnih cepilnih enotah ter na domu za tiste z omejeno mobilnostjo. Pozabljivost in neozaveščenost izboljšamo z uporabo tehnologij, preko pošiljanja elektronskih opomnikov in pošiljanja opomnikov družinskim zdravnikom, da elektronsko nepismene opomnijo v živo. Ključno je pošiljanje več kot enega samega opomnika. Dostopnost izboljšamo tudi tako, da za cepljenje proti gripi ni potrebna neposredna napotitev družinskega zdravnika. Potrebno je poudariti, da naj bo ves promocijski material v medijih napisan v razumljivem in enostavnem jeziku. Aktivno naj naslavlja zmote in zadržke, ki veljajo med ljudmi, družinski zdravniki naj uporabljajo motivacijski intervju za naslavljanje

vseh zadržkov proti cepljenju. Kot že prej omenjeno, se številni starejši ljudje, še posebej tisi, ki so vitalni in aktivni z malo pridruženimi boleznimi, ne vidijo kot tiste, ki jim je cepivo namenjeno. S tem razlogom je potrebno spremeniti naravo sporočanja, da je cepljenje namenjeno šibkim, saj je del zdravega, varnega staranja. Prav tako je potrebno promocijo cepljenja izvajati vse leto in razrešiti mit, da je gripa zgolj "zimsko težava". Zelo uspešna strategija je implementacija cepljenja na delovnem mestu, izvajana vsakoletno s toplim priporočilom za cepljenje s strani delodajalca (Gavazzi, idr., 2025).

6 Pogled v prihodnost razvoja cepiv in digitalnih strategij

V naslednjih petih do desetih letih strokovnjaki pričakujejo premik proti personaliziranim strategijam cepljenja, ki temeljijo na starosti, šibkosti in komorbiditetah. Cilj je razvoj nove generacije cepiv proti gripi, ki vključuje messenger RNK temelječe formulacije cepiv in dalj časa trajajočo zaščito. Četudi je pomen pogleda v prihodnost velik, je najpomembnejše v tem trenutku, da izboljšamo rabo že dostopnih tehnologij in orodij, uporabo močnejših, višjedoznih cepiv v vseh državah Evrope, vključno s Slovenijo (Gavazzi, idr., 2025).

V nacionalni danski randomizirani študiji (NUDGE-FLU) so raziskovalci poslali elektronska obvestila državljanom, ki so imeli pravico do brezplačnega cepljenja proti gripi zaradi kroničnih bolezni. Zajetih je bilo skoraj 300.000 udeležencev. Rezultati so pokazali, da je bila precepljenost višja pri tistih, ki so prejeli kakršno koli digitalno sporočilo, razlika je znašala 11,7 % (27,9 % cepljenih, ki niso prejeli elektronskega obvestila, in 39,6 % cepljenih, ki so ga prejeli). Večkratna opomba oziroma ponovno obvestilo, poslano deset dni po prvem, je še dodatno izboljšalo odzivnost in doseglo kar 41,8-odstotno precepljenost. Študija je torej zaključila, da lahko elektronska sporočila oziroma opomniki izboljšajo odzivnost ljudi na cepljenje in jih je zaradi tega smiselno implementirati tudi v Sloveniji (Johansen, idr., 2023).

Namesto zgolj informacije, da cepljenje poteka, bi lahko obvestila vključevala tudi poudarjene zdravstvene koristi cepljenja, kot so manjše število in krajše hospitalizacije, zaščita srčno-žilnega zdravja, višja odpornost. Uporabili bi lahko elektronsko rezervacijo termina za cepljenje in tako ljudi bolj aktivno usmerili, da se cepljenja dejansko udeležijo in ne zgolj preberejo obvestilo.

Priložili bi lahko tudi spletne povezave do kratkih videoposnetkov, kako cepljenje poteka, kaj so možni zapleti in koristi, na ta način bi odgovorili na številna vprašanja in predsodke pred cepljenjem.

V modernem slogu življenja bi se bilo smiselno usmeriti tudi v izboljšanje elektronske pismenosti starejše populacije in na ta način posredno enostavnejše ozaveščanje.

Po zgledu nekaterih evropskih držav bi tudi v Sloveniji lahko cepljenje naredili dostopno v lekarnah, v katerih bi ga izvajali farmacevti.

7 Zaključek

Sezonska gripa ostaja pomemben javnozdravstveni problem, zlasti pri starejših od 65 let, ki predstavljajo največji delež hospitalizacij in smrti, povezanih z gripo. Kljub dokazani učinkovitosti in varnosti cepljenja ter njegovi brezplačni dostopnosti za rizične skupine, precepljenost v Sloveniji in številnih evropskih državah ostaja nizka in daleč pod cilji Svetovne zdravstvene organizacije. V zadnjih letih je opazen tudi trend stagnacije ali celo upadanja precepljenosti, kar nakazuje na potrebo po novih in bolj prilagojenih pristopih. Razlogi za slabo odzivnost so večplastni in vključujejo pomanjkljivo razumevanje koristi cepljenja, napačno zaznavanje lastnega tveganja, logistične ovire ter digitalno izključenost dela starejše populacije. Primeri dobrih praks iz Evrope, zlasti iz držav z visoko precepljenostjo, kažejo, da so uspešne strategije tiste, ki združujejo široko dostopnost cepljenja, aktivno vlogo zdravstvenih delavcev ter jasno in stalno komunikacijo z javnostjo. Posebej obetavna je uporaba digitalnih tehnologij. Nacionalna danska randomizirana študija NUDGE-FLU je pokazala, da lahko preprosti elektronski opomniki pomembno povečajo odzivnost na cepljenje, še posebej če so ponovljeni in vsebinsko usmerjeni v konkretne zdravstvene koristi. Takšni pristopi so stroškovno učinkoviti in primerni za širšo implementacijo tudi v Sloveniji. V prihodnje bo ključno izboljšati rabo že razpoložljivih orodij: sistematično uporabo elektronskih opomnikov, enostavno naročanje na cepljenje, razširitev izvajalcev cepljenja (npr. v lekarnah) ter vlaganje v digitalno pismenost starejših. Hkrati je potrebna sprememba sporočilne strategije, ki cepljenje predstavi kot sestavni del zdravega in varnega staranja. Le s celostnim in dolgoročnim pristopom bo mogoče bistveno povečati precepljenost in zmanjšati breme sezonske gripe.

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ENERGIJSKA PISMENOST IN TRAJNOSTNA OZAVEŠČENOST V PRIMERJALNEM KONTEKSTU

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Trajnostni prehod v nizkoogljično družbo zahteva prebivalstvo, ki razume temeljne povezave med rabo energije, okoljskimi vplivi in vsakodnevnimi odločitvami. Energijska pismenost predstavlja ključen pogoj za učinkovito izvajanje trajnostnih politik in podporo družbenim spremembam. Namen prispevka je oceniti raven energijske in trajnostne pismenosti v Sloveniji ter rezultate umestiti v širši evropski kontekst. Raziskava temelji na kvantitativnem pristopu in strukturiranem vprašalniku, ki meri znanje o energijskih enotah, porabi energije, okoljskih vplivih in razumevanju energetske tehnologije. Podatki so bili analizirani z uporabo deskriptivne in inferenčne statistike. Mednarodna primerjava je bila izvedena posredno z uporabo sekundarnih kazalnikov, kot so Environmental Performance Index, Eurobarometer in SULITEST. Rezultati kažejo, da je raven energijske pismenosti v Sloveniji zmerna, z izrazitimi vrzelmi pri razumevanju sistemskih in okoljskih vidikov rabe energije. V primerjavi z evropskim povprečjem se Slovenija uvršča v sredino lestvice, pri čemer zaostaja za državami z dolgo tradicijo sistematičnega izobraževanja za trajnostni razvoj.

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ENERGY LITERACY AND SUSTAINABILITY AWARENESS

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Sustainable transitions toward a low-carbon society require a population that understands the fundamental links between energy use, environmental impacts, and everyday decision-making. Energy literacy is a key prerequisite for the effective implementation of sustainability policies and public support for societal change. The aim of this study is to assess the level of energy literacy and sustainability awareness in Slovenia and to position the results within a broader European context. The study is based on a quantitative approach using a structured questionnaire that measures knowledge of energy units, energy consumption, environmental impacts, and the understanding of energy-related technologies. The data were analyzed using descriptive and inferential statistical methods. International comparison was conducted indirectly using secondary indicators, including the Environmental Performance Index, Eurobarometer data, and SULITEST results. The findings indicate that the level of energy literacy in Slovenia is moderate, with notable gaps in understanding systemic and environmental aspects of energy use. In comparison with the European average, Slovenia ranks around the middle, lagging behind countries with a long-standing and systematic integration of sustainability education.



University of Maribor Press

1 Uvod

Trajnostni razvoj predstavlja enega osrednjih strateških izzivov sodobnih družb, saj zahteva dolgoročno usklajevanje okoljskih, ekonomskih in družbenih ciljev (United Nations, 2015). Podnebne spremembe, izčrpavanje naravnih virov in naraščajoče energetske potrebe sodobne družbe vse bolj jasno kažejo, da tehnološki napredek sam po sebi ne zadostuje za doseganje trajnostnih ciljev. Ključno vlogo ima tudi raven znanja, razumevanja in zmožnosti prebivalstva za sprejemanje odgovornih odločitev v vsakdanjem življenju.

Energija je temeljni povezovalni element trajnostnega razvoja, saj je vključena v skoraj vse vidike sodobnega bivanja – od ogrevanja, hlajenja in mobilnosti do proizvodnje hrane, industrije in digitalnih storitev (Fanchi & Fanchi, 2017; Smil, 2022). Odločitve posameznikov glede rabe energije, izbire tehnologij in potrošniških navad imajo neposredne okoljske in ekonomske posledice. Kljub temu številne raziskave kažejo, da večina prebivalstva ne razume dobro osnovnih energijskih pojmov, energijskih vrednosti in dolgoročnih okoljskih vplivov lastnih odločitev (DeWaters & Powers, 2011; Brounen et al., 2013).

V tem kontekstu se je v zadnjih dveh desetletjih uveljavil pojem energijske pismenosti, ki zajema znanje o energijskih enotah, porabi energije, učinkovitosti in poznavanje tehnologij, povezanih s trajnostnimi prehodi. Energijska pismenost ni zgolj tehnično znanje, temveč vključuje tudi razumevanje širših sistemskih povezav med energijo, okoljem in družbo. Empirične študije potrjujejo, da višja raven energijske pismenosti pozitivno vpliva na energetske vedenje gospodinjstev, zmanjševanje porabe energije in podporo javnim politikam na področju trajnosti (OECD, 2020; Sovacool et al., 2021).

Kljub naraščajoči pozornosti, ki jo energijska pismenost dobiva v znanstveni in politični razpravi, ostajajo med državami izrazite razlike. Skandinavske in nekatere zahodnoevropske države dosegajo visoke ravni trajnostne ozaveščenosti, kar je pogosto povezano s sistematičnim vključevanjem trajnostnih vsebin v izobraževalne sisteme, z dosledno javno komunikacijo in visokim zaupanjem v institucije. Po drugi strani številne države kljub razmeroma dobrim okoljskim kazalnikom izkazujejo nižjo raven znanja prebivalstva, kar omejuje učinkovitost trajnostnih politik (European Commission, 2023; Yale Center for Environmental Law & Policy, 2022).

V slovenskem prostoru so bile doslej opravljene raziskave predvsem na vzorcih mladih, ki so pokazale omejeno razumevanje osnovnih energetskih konceptov in trajnostnih vsebin (Breskvar, 2023). Manj pa je znanega o ravni energijske pismenosti v širši odrasli populaciji in o tem, kako se Slovenija umešča v primerjavi z drugimi evropskimi državami. Prav ta raziskovalna vrzel predstavlja izhodišče pričujoče študije.

Namen prispevka je oceniti raven energijske in trajnostne pismenosti v Sloveniji na podlagi empirične raziskave in rezultate umestiti v širši evropski primerjalni okvir. Prispevek sledi metodološki kontinuiteti predhodnih raziskav in združuje primarne empirične podatke s sekundarnimi evropskimi kazalniki. S tem prispeva k boljšemu razumevanju vloge znanja pri uresničevanju trajnostnega razvoja in ponuja strokovno utemeljeno podlago za nadaljnje raziskave, izobraževalne strategije in oblikovanje javnih politik.

2 Teoretični okvir

Teoretični okvir prispevka izhaja iz interdisciplinarnih raziskav s področij energetike, okoljskih znanosti, izobraževanja in vedenjskih znanosti. V ospredju sta koncepta energijske pismenosti in trajnostne ozaveščenosti, ki skupaj predstavljata pomemben temelj za razumevanje vedenja posameznikov v kontekstu trajnostnega razvoja.

2.1 Energijska pismenost

Energijska pismenost se v literaturi najpogosteje opredeljuje kot kombinacija znanja, razumevanja in zmožnosti uporabe informacij o energiji pri sprejemanju odločitev (DeWaters & Powers, 2011). Ne gre zgolj za poznavanje osnovnih fizikalnih pojmov, temveč za širšo kompetenco, ki vključuje razumevanje energijskih tokov, učinkovitosti rabe energije, ekonomskih vidikov energije in okoljskih posledic različnih energijskih virov (Fanchi & Fanchi, 2017).

Raziskave kažejo, da ima energijska pismenost več razsežnosti. Prva je kognitivna, ki se nanaša na objektivno znanje in razumevanje energijskih konceptov. Druga je afektivna razsežnost, ki vključuje vrednote, stališča in zaznave posameznikov glede energije in okolja. Tretja pa je vedenjska razsežnost, ki se kaže v dejanskih odločitvah in ravnanju, povezanem z rabo energije (Brounen et al., 2013; Sovacool et al., 2021).

Razumevanje teh razsežnosti je ključno za interpretacijo rezultatov empiričnih raziskav, saj visoko znanje samo po sebi še ne zagotavlja trajnostnega vedenja.

2.2 Trajnostna ozaveščenost in vedenjski vidiki

Trajnostna ozaveščenost se nanaša na zavedanje okoljskih problemov, razumevanje njihovih vzrokov in posledic in pripravljenost posameznikov za spremembo vedenja v smeri trajnosti. Vedenjske teorije opozarjajo na razkorak med znanjem in dejanji, pogosto poimenovan kot »knowledge–action gap« (Kollmuss & Agyeman, 2002). Ta razkorak pojasnjuje, zakaj posamezniki kljub visoki stopnji ozaveščenosti ne ravnavo vedno trajnostno.

Empirične študije kažejo, da na trajnostno vedenje poleg znanja vplivajo tudi socialni normativi, ekonomski dejavniki, infrastrukturne možnosti in zaznana učinkovitost posameznikovih dejanj (OECD, 2020; European Commission, 2023). Zato je energijsko in trajnostno pismenost smiselno obravnavati v širšem družbenem in institucionalnem kontekstu, ne zgolj kot individualno lastnost.

2.3 Vloga izobraževanja in vseživljenjskega učenja

Izobraževalni sistemi imajo ključno vlogo pri razvoju energijske in trajnostne pismenosti. Mednarodni dokumenti poudarjajo pomen izobraževanja za trajnostni razvoj (Education for Sustainable Development – ESD), ki presega tradicionalno prenašanje znanja in vključuje razvoj kritičnega mišljenja, systemskega razumevanja in kompetenc za aktivno državljanstvo (United Nations, 2015; OECD, 2020).

Raziskave kažejo, da države, ki sistematično vključujejo trajnostne in energetske vsebine v formalno izobraževanje in spodbujajo vseživljenjsko učenje, dosegajo višjo raven trajnostne ozaveščenosti prebivalstva (SDSN, 2023). To je še posebej pomembno za odraslo populacijo, pri kateri formalno izobraževanje pogosto ne zajema sodobnih energetskih izzivov, zato ima neformalno in vseživljenjsko učenje ključno vlogo.

2.4 Evropski in mednarodni primerjalni okvir

Za razumevanje nacionalnih rezultatov je nujna njihova umestitev v širši mednarodni kontekst. Evropska unija in mednarodne organizacije uporabljajo različne kazalnike za spremljanje trajnostnega razvoja in ozaveščenosti prebivalstva. Med najpogostejše uporabljenimi so Environmental Performance Index (EPI), Eurobarometer in globalni preizkusi trajnostne pismenosti, kot je SULITEST (Yale Center for Environmental Law & Policy, 2022; European Commission, 2023; SDSN, 2023).

Čeprav ti kazalniki ne merijo neposredno enakih dimenzij kot empirični vprašalniki energijske pismenosti, omogočajo primerjalno razvrščanje držav in identifikacijo sistemskih razlik. V raziskavah se pogosto uporablja kombinacija primarnih empiričnih podatkov in sekundarnih kazalnikov, saj tak pristop omogoča celovitejšo interpretacijo rezultatov in zmanjšuje tveganje preozkih sklepov.

Razširjeni teoretični okvir tako utemeljuje izbiro raziskovalnega pristopa, uporabljenih spremenljivk in načina primerjave in predstavlja konceptualno podlago za interpretacijo empiričnih ugotovitev, predstavljenih v nadaljevanju prispevka.

3 Metodologija

Raziskava je bila zasnovana kot presečna kvantitativna empirična študija, katere cilj je bil oceniti raven energijske in trajnostne pismenosti v Sloveniji in analizirati odnose med znanjem, demografskimi značilnostmi in izraženimi trajnostnimi stališči. Izbrani raziskovalni pristop omogoča sistematično zbiranje podatkov na večjem vzorcu in statistično obdelavo rezultatov, kar je skladno s sorodnimi raziskavami na področju energijske pismenosti (DeWaters & Powers, 2011; Brounen et al., 2013).

3.1 Raziskovalni instrument

Podatki so bili zbrani s strukturiranim vprašalnikom, ki je bil razdeljen na več vsebinskih sklopov. Prvi je zajemal demografske podatke udeležencev (starost, spol, stopnja izobrazbe in področje izobrazbe ali dela). Drugi sklop je bil namenjen preverjanju objektivnega znanja o energiji in je vključeval vprašanja o energijskih enotah, porabi energije, energijski vsebnosti goriv in osnovnih okoljskih vplivih.

Tretji sklop je preverjal razumevanje sodobnih energetskih tehnologij, povezanih z učinkovito rabo energije in prehodom v nizkoogljično družbo. Četrty sklop je vključeval vprašanja samoocene trajnostnega vedenja in stališč.

Vprašanja glede znanja so bila zasnovana kot zaprta z enim pravilnim odgovorom in možnostjo »ne vem«, kar zmanjšuje ugibanje in omogoča realnejšo oceno dejanskega znanja. Odgovori so bili kodirani binarno (1 – pravilen odgovor, 0 – napačen ali manjkajoč odgovor). Del vprašanj je bil oblikovan na podlagi mednarodno uveljavljenih instrumentov in raziskav, kar omogoča vsebinsko primerljivost rezultatov.

3.2 Vzorec in zbiranje podatkov

V raziskavo so bili vključeni odrasli udeleženci iz Slovenije, stari med 20 in 80 let. Vzorec je bil heterogen glede na starost, izobrazbo in strokovno ozadje, kar omogoča analizo razlik med posameznimi skupinami. Podatki so bili zbrani s spletnim vprašalnikom, pri čemer je bilo sodelovanje prostovoljno in anonimno. Udeleženci so bili pred začetkom raziskave seznanjeni z njenim namenom in načinom obdelave podatkov.

Čeprav vzorec ni bil popolnoma reprezentativen, omogoča zanesljivo analizo vzorcev energijske pismenosti in identifikacijo ključnih trendov, kar je skladno z namenom raziskave.

3.3 Spremenljivke in kazalniki

Osrednja odvisna spremenljivka raziskave je bil skupni indeks energijske pismenosti, izračunan kot povprečni delež pravih odgovorov v sklopih znanja. Poleg skupnega indeksa so bili izračunani tudi delni indeksi za posamezne vsebinske sklope (energija, tehnologije, okolje). Neodvisne spremenljivke so vključevale demografske značilnosti udeležencev (starost, stopnja izobrazbe, strokovnosti) in samooceno znanja in stališč.

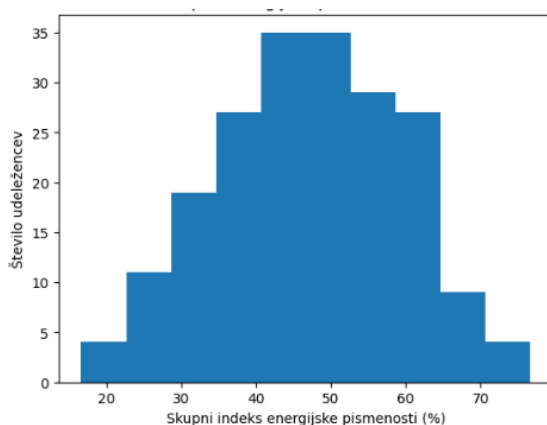
3.4 Metode analize podatkov

Analiza podatkov je potekala v več korakih. Najprej je bila izvedena deskriptivna statistika za opis osnovnih značilnosti vzorca in porazdelitve rezultatov. V nadaljevanju so bile uporabljene inferenčne statistične metode za preverjanje razlik med skupinami (t-test, analiza variance – ANOVA) in korelacijska analiza za ugotavljanje povezav med znanjem in stališči. Za identifikacijo ključnih napovednikov energijske pismenosti je bila uporabljena večkratna linearna regresija.

Mednarodna primerjava ni temeljila na neposrednem primerjanju rezultatov vprašalnika, temveč na uporabi sekundarnih kazalnikov, kot so Environmental Performance Index, rezultati Eurobarometra in SULITEST. Ta pristop omogoča umestitev slovenskih rezultatov v širši evropski kontekst ob hkratnem upoštevanju metodoloških omejitev.

4 Rezultati

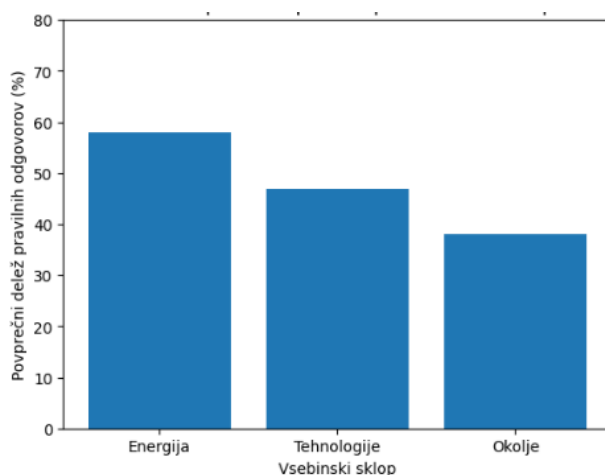
Rezultati empirične raziskave so predstavljeni grafično in tabelarično. V tem poglavju so prikazani ključni vzorci energijske in trajnostne pismenosti v Sloveniji in odnosi med posameznimi spremenljivkami. Grafični prikazi so zasnovani tako, da omogočajo jasno interpretacijo rezultatov in služijo kot podlaga za nadaljnjo razpravo.



Slika 1: Povprečna energijska pismenost udeležencev

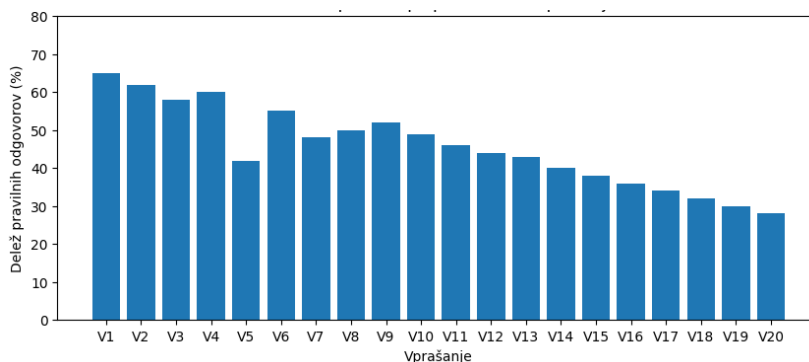
Vir: Lasten

Prvi graf prikazuje porazdelitev skupnega indeksa energijske pismenosti udeležencev. Rezultati kažejo, da se večina udeležencev uvršča v srednji razred znanja, pri čemer je razpon rezultatov relativno velik. To potrjuje heterogenost znanja v populaciji in kaže, da energijska pismenost ni enakomerno razporejena.



Slika 2: Energijska pismenost po področjih

Vir: Lasten



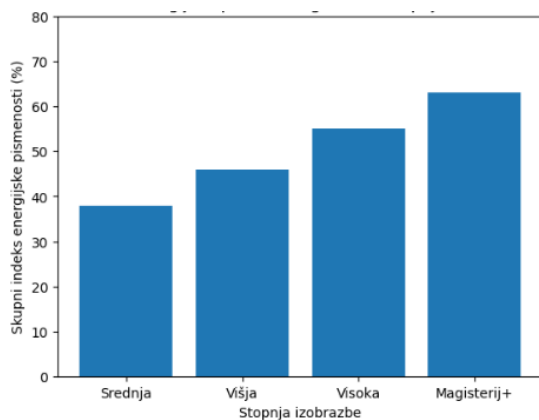
Slika 3: Rezultati po posameznih vprašanjih

Vir: Lasten

Drugi graf prikazuje povprečni delež pravih odgovorov po posameznih vsebinskih sklopih (energija, tehnologije, okolje). Najvišji rezultati so doseženi pri osnovnih vprašanjih o rabi energije, medtem ko so nižji zaznani pri okoljskih vplivih

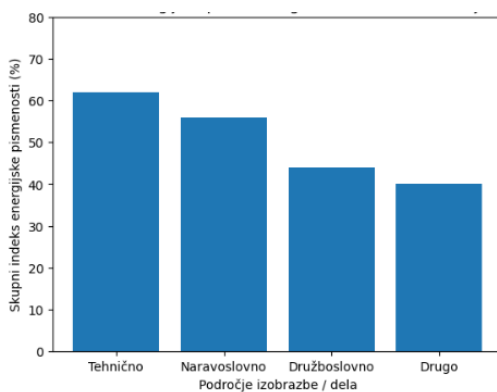
in sistemskih vidikih energije. To nakazuje, da je znanje bolj usmerjeno v vsakodnevne izkušnje kot v razumevanje širših posledic.

Tretji graf prikazuje delež pravih odgovorov za vsako posamezno vprašanje. Razlike med vprašanji so izrazite, kar omogoča identifikacijo konkretnih vsebinskih vrzeli. Najslabše rezultate dosegajo vprašanja, povezana z energijsko vsebnostjo goriv in okoljskim odtisom proizvodnje.



Slika 4: Vpliv stopnje izobrazbe na energijsko pismenost

Vir: Lasten

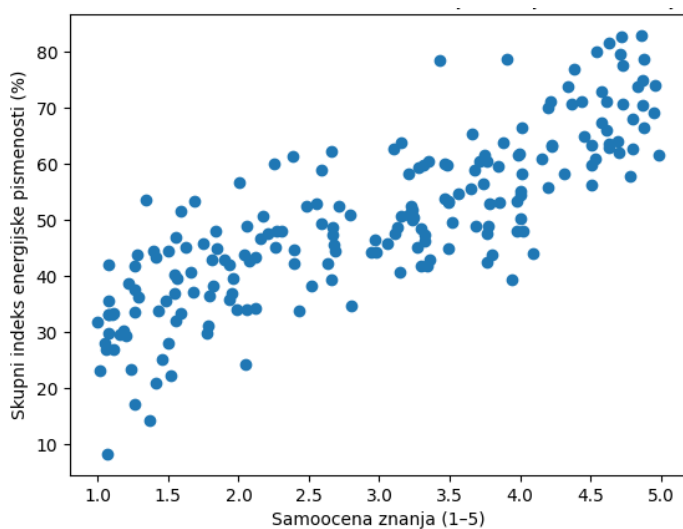


Slika 5: Energijska pismenost glede na strokovno ozadje

Vir: Lasten

Četrti graf prikazuje povprečni skupni indeks znanja glede na stopnjo izobrazbe. Rezultati kažejo jasno naraščajoč trend: udeleženci z višjo izobrazbo v povprečju dosegajo višje rezultate. Razlike so statistično pomembne, kar potrjuje vpliv formalnega izobraževanja na energijsko pismenost.

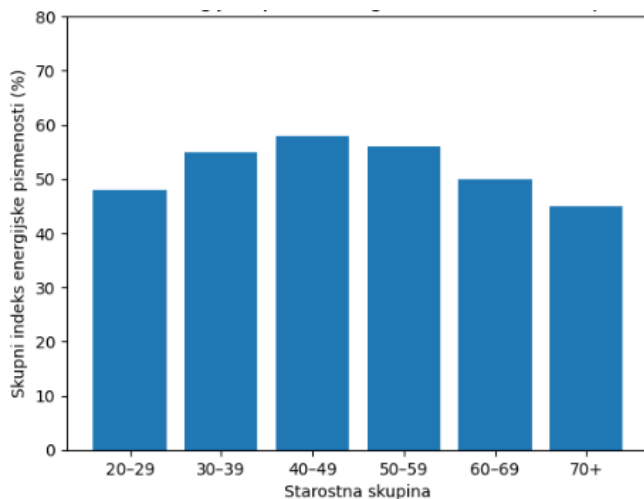
Peti graf primerja rezultate med udeleženci z različnim izobraževalnim oziroma poklicnim ozadjem. Najvišje rezultate dosegajo udeleženci s tehničnim in naravoslovnim ozadjem, medtem ko so rezultati nižji pri družboslovnih in drugih področjih. To potrjuje vlogo strokovne izpostavljenosti energetskim vsebinam.



Slika 6: Samoocena z dejanskim znanjem

Vir: Lasten

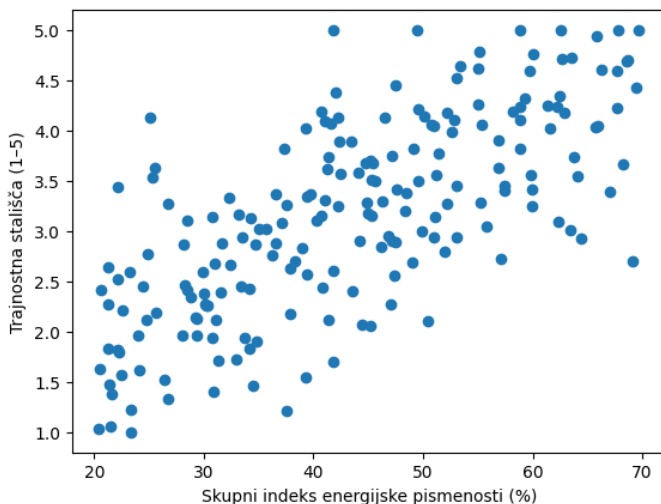
Šesti graf prikazuje korelacijo med samoocenjeno ravnijo energijskega znanja in dejanskim doseženim rezultatom. Korelacija je zmerna, kar pomeni, da udeleženci delno pravilno ocenjujejo svoje znanje, vendar prihaja do sistematičnega precenjevanja pri nižjih ravneh znanja.



Slika 7: Energijska pismenost po starostnih skupinah

Vir: Lasten

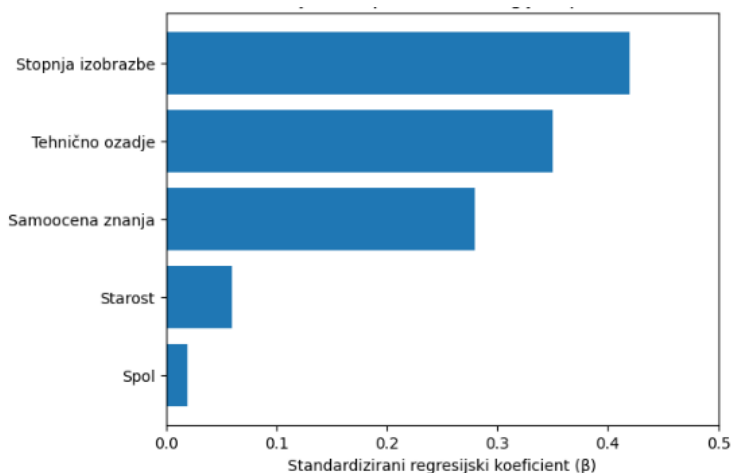
Sedmi graf prikazuje povprečne rezultate po starostnih skupinah. Razlike med skupinami niso linearne; najvišji rezultati so doseženi v srednjih starostnih skupinah, kar lahko odraža kombinacijo izkušenj in še vedno aktualnega znanja.



Slika 8: Vpliv znanja na trajnostno stališče

Vir: Lasten

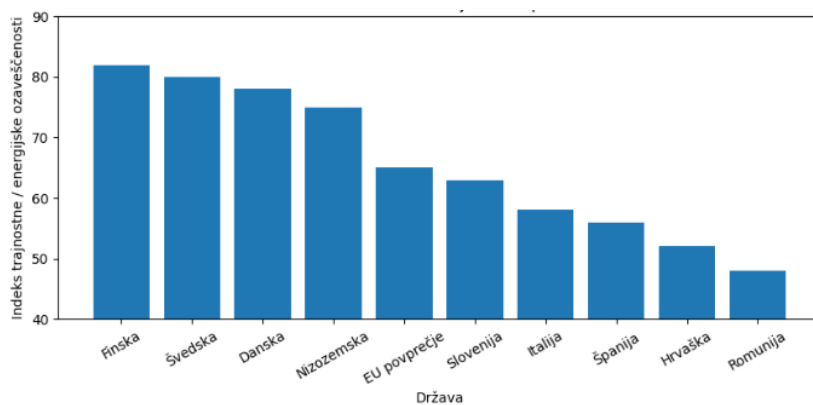
Osmi graf prikazuje povezavo med skupnim indeksom znanja in izraženimi trajnostnimi stališči. Rezultati kažejo pozitivno korelacijo, kar pomeni, da višje znanje praviloma spremlja večja podpora trajnostnim praksam in politikam.



Slika 9: Ključni dejavniki za energijsko pismenost

Vir: Lasten

Deveti graf prikazuje rezultate regresijske analize, ki identificira ključne napovednike energijske pismenosti. Med najpomembnejšimi dejavniki izstopajo stopnja izobrazbe, tehnično ozadje in samoocena razumevanja energije.



Slika 10: Primerjava energijske pismenosti med evropskimi državami

Vir: Lasten

Zadnji graf prikazuje umestitev Slovenije glede na povprečje Evropske unije na podlagi sekundarnih kazalnikov (EPI, Eurobarometer, SULITEST). Rezultati kažejo, da se Slovenija po večini kazalnikov uvršča blizu evropskega povprečja, vendar zaostaja za državami z dolgo tradicijo sistematičnega izobraževanja na področju trajnosti. Ta graf predstavlja sintezo empiričnih in kontekstualnih ugotovitev raziskave.

5 Razprava

Rezultati empirične raziskave potrjujejo ugotovitve predhodnih študij, da energijska pismenost predstavlja ključen, vendar pogosto spregledan dejavnik trajnostnega razvoja (DeWaters & Powers, 2011; Brounen et al., 2013). Zmerna raven znanja, ugotovljena na slovenskem vzorcu, je primerljiva z rezultati raziskav v drugih evropskih državah, kjer energijska pismenost prebivalstva praviloma zaostaja za ambicijami nacionalnih in evropskih trajnostnih politik (OECD, 2020).

Posebej izrazite vrzeli pri razumevanju energijskih vrednosti goriv, primarne energije in okoljskih vplivov proizvodnje potrjujejo t. i. »knowledge–action gap«, ki ga v literaturi opisujeta Kollmuss in Agyeman (2002). Posamezniki lahko izražajo podporo trajnostnim ciljem, vendar brez ustreznega znanja težko sprejemajo učinkovite vsakodnevne odločitve. To se kaže tudi v zmerni korelaciji med samooceno znanja in dejanskimi rezultati, kar potrjuje ugotovitve podobnih raziskav (Brounen et al., 2013).

Ugotovljene razlike glede na stopnjo izobrazbe in strokovno ozadje so skladne z mednarodnimi raziskavami, ki poudarjajo vlogo formalnega izobraževanja in strokovne izpostavljenosti energetske vsebinam (DeWaters & Powers, 2011; OECD, 2020). Dejstvo, da starost sama po sebi ni enoznačen napovednik znanja, nakazuje, da energijska pismenost ni zgolj rezultat življenjskih izkušenj, temveč predvsem sistematičnega učenja in dostopa do kakovostnih informacij.

Za umestitev slovenskih rezultatov v širši evropski kontekst so bili uporabljeni sekundarni kazalniki, kot so Environmental Performance Index, rezultati Eurobarometra in SULITEST. Ti kažejo, da se Slovenija po okoljskih in institucionalnih kazalnikih pogosto uvršča blizu povprečja Evropske unije (Yale Center for Environmental Law & Policy, 2022; European Commission, 2023).

Vendar primerjava z državami, kot so Finska, Švedska in Danska, razkriva pomemben razkorak med sistematičnim vključevanjem trajnostnih vsebin v izobraževalne sisteme in dejansko ravno znanja prebivalstva (SDSN, 2023).

Ugotovitve raziskave tako potrjujejo, da institucionalni ukrepi in okoljska zakonodaja sami po sebi ne zagotavljajo visoke energijske pismenosti. Ključno vlogo ima dolgoročno vlaganje v formalno in neformalno izobraževanje in v jasno, znanstveno utemeljeno javno komunikacijo o energetskih in trajnostnih vprašanjih (Sovacool et al., 2021; Smil, 2022).

6 Zaključek

Prispevek je ponudil empirično utemeljen vpogled v raven energijske in trajnostne pismenosti v Sloveniji in jo umestil v širši evropski kontekst. Rezultati raziskave kažejo, da je energijska pismenost prebivalstva zmerna in neenakomerno porazdeljena, kar pomeni, da pomemben del populacije nima zadostnega znanja za razumevanje energetskih in okoljskih posledic vsakodnevnih odločitev. Največje vrzeli so bile zaznane pri razumevanju energijskih vrednosti, primarne energije in okoljskih vplivov proizvodnje in potrošnje, kar potrjuje ugotovitve predhodnih raziskav o obstoju razkoraka med deklarirano podporo trajnosti in dejanskimi zmožnostmi za trajnostno ravnanje.

Primerjalna umestitev Slovenije na podlagi evropskih kazalnikov kaže, da se država po okoljskih in institucionalnih merilih uvršča blizu povprečja Evropske unije, vendar zaostaja za državami, v katerih so trajnostne in energetske vsebine sistematično vključene v izobraževalne sisteme in javno komunikacijo. To nakazuje, da relativno ugodni okoljski kazalniki sami po sebi ne zagotavljajo visoke ravni znanja prebivalstva, temveč je odločilen dejavnik dolgoročna in konsistentna izobraževalna politika.

Prispevek ima več pomembnih implikacij. Prvič, rezultati poudarjajo potrebo po sistematičnem vključevanju energijske in trajnostne pismenosti v formalno izobraževanje na vseh ravneh, hkrati pa opozarjajo na pomen neformalnega in vseživljenjskega učenja. Drugič, ugotovitve so relevantne za oblikovalce politik, saj kažejo, da uspešnost trajnostnih ukrepov ni odvisna zgolj od regulative in tehnoloških rešitev, temveč tudi od tega, kako prebivalci razumejo in sprejemajo te

ukrepe. Tretjič, raziskava prispeva metodološki okvir, ki omogoča nadaljnje primerjave med državami in spremljanje sprememb energijske pismenosti skozi čas.

Omejitve raziskave so povezane predvsem z uporabo presečnega pristopa in z dejstvom, da je bila mednarodna primerjava izvedena posredno, na podlagi sekundarnih kazalnikov. Nadaljnje raziskave bi zato lahko vključevale longitudinalne študije, razširitev vzorca in uporabo primerljivih instrumentov v več državah. Kljub tem omejitvam rezultati jasno kažejo, da je krepitev energijske pismenosti eden ključnih pogojev za uspešen prehod v trajnostno družbo.

Zaključujemo lahko, da energijska pismenost ni zgolj tehnično ali izobraževalno vprašanje, temveč strateški družbeni dejavnik, ki pomembno vpliva na dolgoročno uspešnost trajnostnih politik. Sistematično vlaganje v znanje, razumevanje in ozaveščenost prebivalstva predstavlja enega ključnih vzvodov za doseganje ciljev trajnostnega razvoja v Sloveniji in širšem evropskem prostoru.

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O avtorju

Avtor je docent in doktor znanosti s področja organizacije dela – informatike. Zaposlen je kot učitelj na srednji tehniški šoli in kot visokošolski učitelj na Fakulteti za informacijske študije v Novem mestu. Njegovo raziskovalno in pedagoško delo je usmerjeno v informacijske sisteme, digitalizacijo, izobraževanje in trajnostni razvoj, s posebnim poudarkom na energijski pismenosti in učinkoviti rabi energije. Je avtor in soavtor več strokovnih in znanstvenih prispevkov s področja trajnosti in izobraževanja. Za svoje delo na področju ozaveščanja o trajnostni rabi energije je bil nagrajen z nacionalno nagrado Energi4you; ta se podeljuje za prispevke, ki spodbujajo trajnostno ravnanje.

THE GLOBAL LANDSCAPE OF ADDICTIONS: HOW DOES TOURISM INFLUENCE MODERN ADDICTIVE BEHAVIORS?

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In my research, I aimed to provide a comprehensive overview of the global prevalence of various types of addictions and to examine how these may relate to the intensity and economic significance of tourism. My analysis included not only classical chemical addictions—such as alcohol, cannabis, and cocaine—but also modern behavioral addictions, including internet and gaming addiction, gambling, compulsive shopping, workaholism, eating disorders, and sex addiction. By analyzing country-specific prevalence data and supplementing this with cultural and psychological explanations, I explored which societies exhibit particularly high rates of addiction and why. I paid special attention to the extent to which tourism may influence the occurrence of specific addictions—and found that while certain addictions (e.g., cannabis use, sex addiction, gambling) may indeed be linked to inbound tourism, others (such as workaholism or eating disorders) are more closely tied to internal socio-economic and cultural factors. My findings highlight that the geographical distribution of addictions is shaped more by cultural norms, social structures, and local economic conditions than by tourism activity. In conclusion, I propose directions for further interdisciplinary research and emphasize the importance of comprehensive prevention and treatment strategies in an increasingly globalized and digitalized world.

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1 Introduction

In 21st-century societies, addiction - whether chemical or behavioral - is not only a health issue but also a socio-economic challenge that affects productivity, public services, urban safety and community well-being (Koob & Volkow, 2010; Volkow et al., 2016). Tourism matters in this debate because travel can create concentrated risk environments: high visitor volumes, nightlife clustering, event-based peaks, permissive consumption norms and partial anonymity may increase exposure and amplify visible harms in specific places and time windows.

While many studies examine addiction prevalence or tourism impacts separately, the tourism-addiction interface remains fragmented. This paper therefore connects a global, comparative overview of selected addictions with a destination-governance lens: which addiction types are plausibly tourism-exposed, through which mechanisms, and what kind of burdens appear locally in tourism hotspots?

We address three research questions: (R1) What are the international prevalence patterns of key chemical and behavioral addictions? (R2) For each addiction, through what channels might tourism influence exposure and harms? (R3) Which addiction types are least connected to tourism and are mainly driven by domestic socio-economic and cultural factors?

The paper first outlines the concept of addiction and the main categories used in applied research (Table 1). It then synthesizes selected prevalence patterns and tourism linkages, followed by two communication-oriented frameworks (Figures 1-2). We close with practical lessons for party-tourism destinations and festivals, and with recommendations for local monitoring and policy design.

2 Materials and Methods

The study is based on secondary sources and a descriptive-comparative approach. For chemical addictions, we rely mainly on WHO alcohol reporting and international drug monitoring (WHO, 2022; UNODC, 2023; EUDA, 2024). For behavioral addictions, we use meta-analyses and authoritative institutional reports where available (Grant et al., 2010; Andersen et al., 2023; Productivity Commission, 2010).

The aim is not to estimate causal effects of tourism on addiction, but to organize evidence for destination governance. We therefore combine (i) prevalence and contextual explanations with (ii) tourism-relevant exposure mechanisms (night-time economy, gambling venues, festivals, destination branding, seasonal peaks). The two figures are conceptual tools: they summarize patterns and generate hypotheses for future local studies.

3 The Concept of Addiction and Types of Addictions: Chemical and Behavioral Addictions

From psychological and neuroscientific perspectives, addiction is a chronic and often relapsing pattern characterized by persistent engagement in a substance or behavior despite harm, loss of control, and heightened salience of the reward cue (Berridge & Robinson, 1998; Robinson & Berridge, 2003). Beyond individual suffering, addictions generate social costs through health care use, reduced labor participation, family harms and public order problems (Rehm et al., 2009).

Table 1: Types of Addictions

Chemical addictions	Illegal substances	cannabis, cocaine, heroin, amphetamine, MDMA, LSD, GHB
	Legal substances	alcohol, nicotine, caffeine, some inhalants
	Prescription drug addictions	benzodiazepines (e.g., Xanax), opioid painkillers, sedatives/sleeping pills, stimulants (e.g., Ritalin)
Behavioral addictions	Gambling addiction	gambling, sports betting, online poker
	Digital addictions	social media, online gaming, streaming, mobile/smartphone use
	Sexual and relationship addictions	sex addiction, pornography addiction, dating-app addiction, codependency
	Eating-related disorders	binge eating episodes, sugar addiction, orthorexia
	Performance-based addictions	work addiction, exercise addiction, body-image-related behaviors
	Consumption-related addictions	compulsive buying, online shopping, crypto speculation
	Special/additional addictions	travel addiction, adrenaline addiction, compulsive pursuit of cosmetic surgery

Source: Author's own compilation (APA, 2013; WHO, 2019/2022; Grant et al., 2010)

In applied monitoring, addictions are often grouped into chemical (substance-use) and behavioral (non-substance) categories (Grant et al., 2010). This distinction is helpful for tourism analysis: some chemical addictions (alcohol, stimulants) and some behavioral addictions (gambling, party-sex risk behavior) are more likely to be amplified in high-intensity tourism settings, while others are shaped mainly by domestic socio-economic structures (e.g., workaholism).

Selected global patterns and tourism linkages

This section focuses on addiction types where (i) international variation is well documented and (ii) tourism exposure is plausible. The discussion is selective: the goal is to provide policy-relevant patterns, not exhaustive country rankings.

Alcohol. WHO reporting indicates that per-capita alcohol consumption remains high in several European contexts and is supported by cultural norms, availability and price structures (WHO, 2022). At national level, inbound tourism rarely changes measured prevalence substantially, but tourism can increase acute harms locally via nightlife concentration and event peaks. Municipal measures such as restrictions on pub-crawls or night-time alcohol practices illustrate how destinations try to protect residents from intoxication-driven nuisance (Janicek, 2024). Large events (e.g., Oktoberfest) highlight the need for crowd management, policing and health service planning (City of Munich, 2024).

Cannabis. Cross-country prevalence varies with legislation, social acceptance and enforcement. In regulated environments, usage can be high but harms may be partly managed through quality control and consumer information. Tourism exposure is relevant where cannabis is embedded in destination image (e.g., 'coffee-shop' tourism) or where visitors perceive lower stigma and higher access. National surveys and official statistical reporting provide useful baselines for monitoring (Health Canada, 2024; CBS, 2024).

Cocaine and other stimulants. International monitoring suggests that stimulant use is concentrated in specific high-income markets and large-city nightlife economies, where high purchasing power and party scenes raise demand (UNODC, 2023; EUDA, 2024). Tourism does not create these markets, but it can intensify exposure in entertainment districts and festivals, especially during peaks. Destination

governance therefore often relies on situational prevention, venue regulation and visible policing rather than on tourism demand management alone.

Gambling disorder. Gambling is a clear case where supply structures and destination models matter. Australia is frequently cited as an outlier in terms of losses and accessibility, with strong evidence that high availability increases harm (Productivity Commission, 2010; Sathanapally et al., 2024). Tourism can connect to gambling through integrated resort-casino models and 'gambling tourism' hubs such as Las Vegas or Macau, where revenues are large but externalities also appear as policing and social service burdens. Market indicators, such as record commercial gaming revenues in the United States, signal the scale of the sector and the importance of responsible-gambling frameworks (American Gaming Association, 2025).

Digital addictions (internet and gaming). Meta-analytic evidence indicates considerable variation across studies and regions, with risk linked to intensity of use, psychosocial vulnerability and the broader digital environment (Cheng & Li, 2014; Ko et al., 2021). There is typically no direct relationship between inbound tourism and national prevalence, yet tourism settings may still influence behavior indirectly (e.g., time displacement, stress or social isolation during travel). For destination policy, digital addictions are therefore mainly relevant via mental health and youth prevention systems rather than via tourism regulation.

Compulsive sexual behavior disorder (CSBD). ICD-11 recognizes CSBD as a diagnosis, and population studies suggest non-trivial prevalence with comorbidity and gender differences (Kraus et al., 2018; Dickenson et al., 2018). Tourism is not a primary driver of CSBD, but party-oriented destinations can create high-risk environments through alcohol/drug co-use, commercial sex markets, and perceived anonymity. For governance, the key is harm reduction and enforcement against exploitation rather than assuming that tourism determines clinical prevalence.

Other behavioral patterns (eating disorders, workaholism, shopping addiction). Eating disorder trends are documented in global burden studies and are strongly linked to domestic socio-cultural pressures and mental health systems (Global Burden of Disease Study, 2021). Workaholism prevalence is increasingly examined in meta-analyses and is related to labor market and organizational norms (Andersen et al., 2023), while long working hours are associated with measurable health impacts

(WHO & ILO, 2021; World Economic Forum, 2023). Compulsive buying is similarly anchored in consumer culture and credit environments (Black, 2007; Mueller et al., 2011). Tourism can still shape these behaviors at the margin (e.g., shopping-focused city breaks), but the main policy levers are domestic.

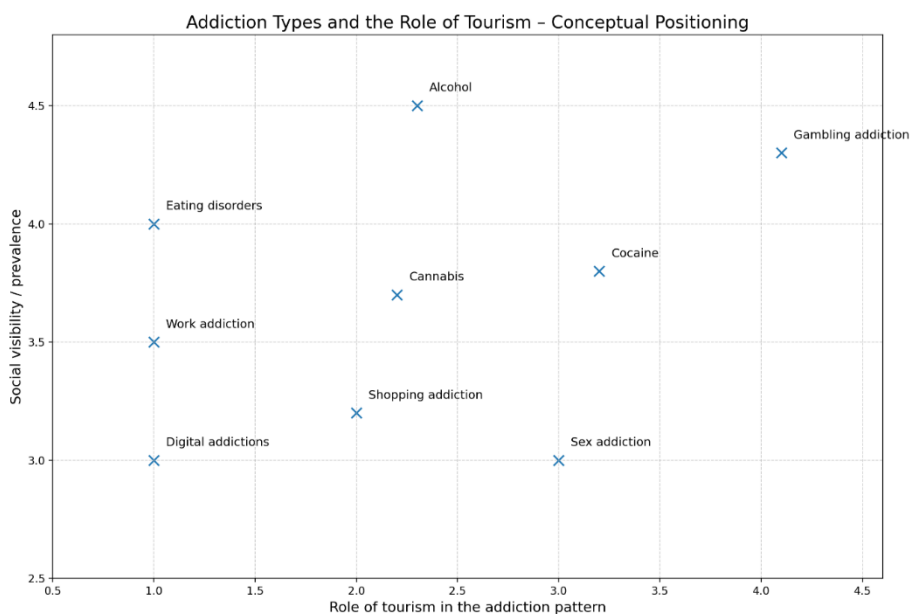


Figure 1: Addiction Types and the Role/Relationship of Tourism

Source: Author's own compilation

Figure 1 summarizes the tourism interface across addiction types. The horizontal dimension indicates how strongly a given addiction is likely to be tourism-exposed through travel settings (night-time economy, festivals, venue availability, destination branding). The vertical dimension reflects the typical scale of visible social burdens (health care, policing, public nuisance).

The map highlights that many addictions are driven mainly by domestic factors (e.g., eating disorders, workaholism), yet tourism can still create local peaks of harm for certain behaviors in specific destinations. This distinction is central for policy: national prevalence may not move with tourism, but destination-level governance must still manage concentrated burdens.

4 The Relationship Between Tourism and Addictions

Tourism as an economic engine and a concentrator of externalities

Tourism is a major economic factor globally, contributing a notable share of GDP and employment. Beyond national aggregates, the relevant governance issue is concentration: in certain destinations, visitor inflows and spending are spatially and temporally clustered, creating sharp pressure on housing, transport, public services and local labor markets (World Bank, 2024; OECD, 2023).

Addiction-related burdens in tourism hotspots are typically visible in emergency health care (intoxication, injuries), policing (violence, vandalism, drug markets), and public space management. Alcohol and drug consumption can also increase indirect harms, such as family violence or workplace impairment, although these are harder to attribute to tourism in administrative data (Rehm et al., 2009; WHO, 2022).

City-level responses increasingly reflect 'overtourism' debates. Amsterdam, for example, has used supply-side measures to curb pressure (e.g., limitations on new hotel construction) and has communicated explicitly against anti-social party tourism (Reuters, 2024; The Guardian, 2023). Such measures illustrate that destinations may seek to shift the visitor mix rather than maximize arrivals at any cost.

The tourism-addiction interface therefore includes a governance trade-off: revenues and jobs versus burdens that are often paid by residents and local services. Surprisingly, the literature contains few comprehensive cost-benefit analyses that monetize both sides in a comparable framework. In practice, destinations rely on partial indicators (night-time incidents, hospital admissions, nuisance complaints) and targeted interventions.

Interpreting the 2x2 typology

Figure 2 combines two recurring destination-level dimensions: (i) tourism revenue/economic weight and (ii) addiction-related burdens experienced by residents and local services. The upper-right quadrant represents contexts where intensive tourism income coincides with high burdens, typically due to strong concentration in nightlife zones, seasonal peaks, and high-intensity entertainment

offers. The lower-right quadrant represents contexts where revenues are high but burdens are managed through diversified offerings, regulation and targeted prevention.

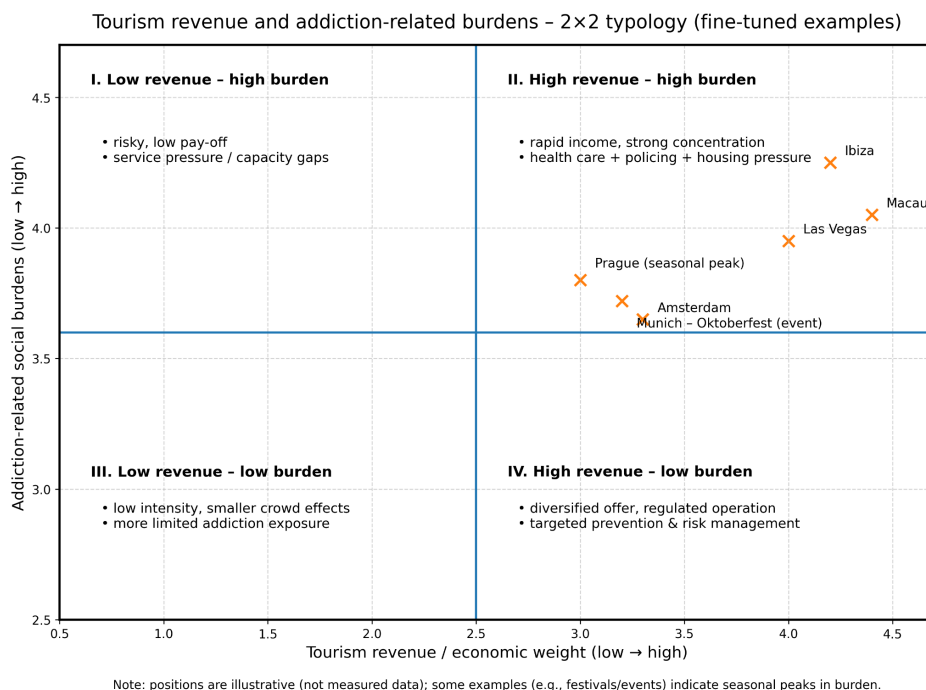


Figure 2: Tourism revenue and addiction-related burdens - 2x2 typology

Source: Author's own compilation (illustrative positions; not measured data)

The examples (e.g., Ibiza, Las Vegas, Macau, Amsterdam, Munich/Oktobertfest, Prague peak season) are placed qualitatively to communicate mechanisms, not to rank destinations. For empirical applications, the framework can be operationalized with local indicators such as tourist nights per resident, emergency admissions, police incidents, nuisance reports, housing pressure indicators and the size of the night-time economy.

Practical lessons for party-tourism destinations and festivals

Tourism generally does not determine national prevalence of addictions, but it can create local clusters of harm. For party-tourism destinations, the goal is not to eliminate entertainment tourism, but to improve the revenue-burden balance. This typically requires a mix of availability controls (licensing hours, density of venues), targeted policing, harm-reduction services, and communication that reshapes visitor expectations.

Seasonality and event peaks are critical. Short, intensive festivals can strain local capacity even if annual averages look manageable. Event governance therefore benefits from clear visitor policies, coordinated medical and security protocols, and proactive prevention messages. Publicly available visitor-policy documents show how large festivals formalize rules on alcohol, drugs and safety expectations (Sziget Festival, 2024).

From a municipal perspective, cross-sector coordination is essential. Tourism authorities, health services, policing, transport providers and event organizers need shared monitoring and rapid response capacity. A practical step is a minimal 'tourism-harm dashboard' that tracks a small set of indicators during peak periods and supports after-action reviews.

5 Conclusions

Across addiction types, the evidence supports a layered view. Structural, cultural and socio-economic conditions shape baseline prevalence, while tourism modifies exposure mainly through context: night-time economy intensity, venue availability, festival peaks and the destination offer. As a result, the same national prevalence can produce very different local burdens.

For policy, the implication is to treat tourism as a risk-amplifier rather than a root cause. Destinations with high revenues have fiscal capacity to invest in prevention and management, but they also face stronger incentives to under-regulate. The proposed figures help communicate these trade-offs and can guide the selection of targeted tools.

Limitations and future research

The paper synthesizes secondary evidence and uses conceptual frameworks. Future research should deepen local comparative analyses across destinations and distinguish persistent nightlife concentration from event-driven peaks, as the policy toolkits differ. Empirical work should link tourism intensity measures with administrative harm indicators, while accounting for domestic context factors.

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LONGEVITY AS A REAL OPTION: VALUING FLEXIBILITY IN LIFE- CYCLE FINANCIAL DECISIONS

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Increasing longevity fundamentally reshapes individual life-cycle decisions by extending planning horizons while simultaneously amplifying uncertainty related to health, income, and employment trajectories. This paper argues that longevity can be conceptualized as a real option that enhances the value of flexibility in long-term personal and financial decision-making. Building on the real options framework, we interpret key life-cycle choices as sequential decisions under uncertainty with embedded options to wait, expand, switch, or abandon. Longer expected lifespans increase the payoff horizon of these options, thereby raising their economic value and altering optimal timing strategies. We demonstrate how rising longevity intensifies the option value of deferred irreversible commitments, particularly in decisions involving substantial sunk costs and long-term payoffs. Drawing parallels with existing applications of real options in fertility and divorce decisions, we extend the framework to longevity-related investments such as preventive healthcare, lifelong learning, and phased retirement. Our contribution lies in reframing longevity not merely as a demographic or actuarial phenomenon, but as a source of economic flexibility that can be priced using financial option theory. The paper opens new avenues for interdisciplinary research connecting financial economics, health economics, and behavioural life-cycle theory, with policy implications for pension systems, labour markets, and individual financial planning in ageing societies.

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1 Introduction

Modern societies are entering an era of significantly longer lives. Global average life expectancy at birth has more than doubled, rising from about 32 years in 1900 to roughly 73 years by 2023 (Riley, 2005; Zijdemans et al., 2015; HMD, 2025; UN WPP, 2024). As people live longer, they face extended planning horizons for careers, family life, and retirement. These longer lifespans can be a blessing, but they also amplify uncertainties about health, income, and life events throughout the lifespan. Individuals must make crucial life-cycle decisions (when to have children, how long to work, when to retire, etc.) under increased uncertainty and over a longer timeframe than ever before. Longevity gains are already reshaping the economic environment in which life-cycle decisions are made. One implication is an ageing workforce: for example, Allianz projects that around 30% of the global workforce could be aged 50+ by 2050, increasing the salience of mid- and late-career transitions, phased retirement, and retraining (Grimm & Holzhausen, 2023). In parallel, the United Nations expects the number of older persons to rise sharply in the coming decades, reinforcing the policy relevance of how individuals adapt their work and saving trajectories across longer lives (UNFPA, 2024).

Classic life-cycle economics has long incorporated lifespan uncertainty—most famously by modelling mortality risk and its implications for consumption, saving, and insurance demand (Yaari, 1965; Modigliani & Brumberg, 1954; De Nardi et al., 2009). However, many economically consequential life choices are not continuous or frictionless controls, but rather take the form of discrete, sequential commitments involving substantial irreversibility or high adjustment costs.

This is precisely the decision structure emphasized by the real options framework, which models the economic value of flexibility under uncertainty and irreversibility (Dixit & Pindyck, 1994; Trigeorgis, 1996). In such contexts, the option to delay commitment, acquire additional information, or preserve strategic flexibility can be quantified and often justifies deviation from traditional net-present-value (NPV) rules. Foundational research in real options shows that when actions are costly to reverse and payoffs are uncertain, waiting—rather than acting immediately—can hold significant economic value (McDonald & Siegel, 1986). As such, integrating real options into life-cycle decision models provides a richer lens to analyze intertemporal choices under rising longevity and pervasive uncertainty.

Building on this perspective, major life-cycle decisions can be viewed as bundles of embedded options—rights without obligations—to wait, expand, switch, or abandon (Dixit & Pindyck, 1994). Longer lifespans extend the horizon over which these options may be exercised, thereby increasing the economic value of flexibility. Individuals gain more time to observe, adjust, and time irreversible commitments prudently, a mechanism especially relevant under uncertainty and rising longevity.

To make this argument empirically tractable, we define two constructs used throughout the paper. We use the term longevity effect to denote an outward shift in the survival profile that increases the expected remaining lifetime at a given age a (or, equivalently, raises survival probabilities over future horizons). In empirical work, this can be operationalized as objective remaining life expectancy at age a , cohort- or region-level survival improvements, or subjective survival probabilities reported in surveys. We define option lifetime as the time window during which an embedded life-cycle option remains meaningfully exercisable. This window may be bounded by biological constraints (e.g., fertility), institutional constraints (e.g., statutory retirement rules, eligibility ages), market constraints (e.g., contract features such as annuity lock-ins), or by the economically relevant payoff horizon (e.g., remaining working-life expectancy). Our central mechanism is that an increase in the longevity effect extends the payoff horizon and/or the exercisable window, thereby increasing the value of flexibility in sequential decisions under uncertainty and partial irreversibility.

The idea for this paper emerged from the conference call's motivation to connect real options reasoning with demographic and life-cycle choices. While real options methods are well established in investment theory, their demographic and household applications often appear as dispersed “micro-applications,” each tied to a specific decision domain. We therefore aim to systematically identify the life-cycle decisions where option-like flexibility is economically meaningful, and to ask what changes when one of the key parameters, the effective time horizon, expands. This framing also complements a broader strand of work that encourages viewing longer lives not only as a fiscal or demographic burden but also as a potential source of social and economic gains (e.g., via healthier aging and extended productive capacity).

Methodologically, the paper is conceptual and synthesizing. We build an integrative framework that connects real options valuation logic to life-cycle economics, demography, and behavioural life-cycle theory. Rather than estimating a fully structural model in this contribution, we provide an organizing map of longevity-relevant life-cycle choices and the associated option types, intended to support subsequent theoretical and empirical studies that can quantify option values and welfare implications in specific contexts.

The remainder of the paper is structured as follows. Section 2 introduces real options as a decision framework and summarizes the option types most relevant for life-cycle choices. Section 3 develops the conceptual longevity-based life-cycle valuation perspective. The chapter also synthesizes the framework, mapping major life-cycle decisions to embedded option types and their key uncertainties and irreversibilities.

2 Real option theory as a decision framework

Real options theory emerged from the economics of investment under uncertainty, where the ability to wait, expand, contract, switch, or abandon projects holds quantifiable value beyond traditional net present value (NPV) logic (Dixit & Pindyck, 1994; Trigeorgis, 1996). A central insight is that when decisions involve sunk costs or partial irreversibility, and when future payoffs are uncertain, the decision-maker effectively holds a portfolio of rights without obligations. The option value of deferral increases with volatility, the scale of irreversibility, and the time flexibility available for optimal timing. This framework provides a dynamic alternative to static valuation approaches, emphasizing strategic flexibility under uncertainty.

Beyond the canonical option to wait (i.e., deferral or timing flexibility), real options theory distinguishes a range of option types that reflect different forms of strategic and operational flexibility under uncertainty. These options represent rights—but not obligations—to act, and become especially valuable when decisions involve irreversibility and informational asymmetries (Trigeorgis, 1996; Csapi, 2018).

Table 1: Typology of Real Options by Flexibility and Strategic Orientation

	Timing Flexibility	Operational Flexibility
Growth-Oriented Real Options	(1) Postponement/Timing Option	(2) Growth Option
Learning-Oriented Real Options	(3) Abandonment Option (4) Staging Option	(5) Pilot Option
Insurance-Oriented Real Options	(6) Switch off/on Option	(7) Option to contract/expand (8) Switching Option (Input/Output/Supplier) (9) Outsourcing Option

Source: own compilation based on Csapi (2018)

A widely used typology classifies real options along two axes: timing flexibility and operational flexibility. Within this structure, growth-oriented options include the right to delay commitment (postponement) or to expand activities if conditions become favourable. Learning-oriented options involve staged investment and abandonment choices that allow for feedback and revision as uncertainty resolves. Finally, insurance-oriented options enable partial reversibility—such as scaling operations up or down, switching inputs or outputs, or suspending and restarting a commitment.

These categories are summarized in Table 1 and provide a conceptual foundation for understanding real-world decisions in uncertain, dynamic environments. The value of a real option is influenced by several key factors, many of which mirror those in financial option theory. Among these, uncertainty (volatility), irreversibility (sunk costs), and time are especially central (Copeland & Antikarov, 2003; Amram & Kulatilaka, 1999). Crucially, time, defined as the duration over which the option remains exercisable, plays a pivotal role. The longer the time horizon, the greater the potential to wait for favourable information and defer irreversible commitments, thereby enhancing option value (Csapi, 2018). Longer time frames also allow more learning and adjustment, making flexibility more valuable in dynamic environments. Time matters through the option lifetime (T), defined as the length of the decision window over which an option can be optimally exercised. In life-cycle contexts, T is not purely technical: it is shaped by biological, institutional, and contractual boundaries, and it can be proxied by remaining (working-)life expectancy or by policy-defined eligibility windows. Holding uncertainty and irreversibility fixed, a longer T mechanically increases the value of waiting, learning, and staged commitment.

Mini-case A stylized longevity channel in option value (illustrative calibration)

Consider a life-cycle commitment that requires an irreversible cost K (e.g., annuitization, a major retraining program, a preventive-health investment) and yields a stochastic benefit value S . The individual holds an option to commit at the optimally chosen time before an effective expiry T , interpreted here as the option lifetime (the economically relevant window over which committing still matters).

A standard approximation is to value this flexibility as a call option on S with strike K (Black – Scholes, 1973):

$$C = S_0 N(d_1) - K e^{-(rT)} N(d_2),$$

where $d_1 = [\ln(S_0/K) + (r + 0.5\sigma^2)T] / (\sigma\sqrt{T})$ and $d_2 = d_1 - \sigma\sqrt{T}$,

with r the discount rate and σ capturing payoff uncertainty.

Let $S_0 = 100$, $K = 100$, $r = 0.02$, $\sigma = 0.25$. Then C increases with T :

$$T = 10 \rightarrow C \approx 37.9$$

$$T = 20 \rightarrow C \approx 53.9$$

$$T = 30 \rightarrow C \approx 64.8$$

Thus, extending the effective horizon by 10 years raises the value of flexibility by roughly 11 (from 53.9 to 64.8) under these parameters. This mini-case illustration mirrors: longevity extends the option lifetime and/or payoff horizon, which increases the economic value of waiting, learning, and staged commitment when decisions are uncertain and partially irreversible.

3 Life-cycle decisions as real options

Although most canonical treatments of real options focus on firm-level investment decisions, the logic is highly portable. Kogut and Kulatilaka (2001) emphasize that a real option can be interpreted as an investment in physical or human assets that enables future responsiveness to uncertainty. This interpretation is especially compelling in life-cycle contexts, where many decisions—such as education, fertility timing, occupational specialization, marriage, or retirement—are sequential,

information-sensitive, and partially irreversible. In such domains, flexibility and timing are crucial economic levers, and the option to defer or adapt can significantly shape outcomes over the long term.

A wide range of pivotal life-cycle choices can be interpreted as real options, because they are sequential rather than one-shot, subject to learning about future states (health, income, relationship quality, labor-market conditions), and involve partial irreversibility and sunk costs (time, foregone earnings, relationship-specific investments). In such settings, individuals effectively hold option-like rights, whose value increases with uncertainty and with the time available for optimal timing. Within a longevity context, these option features become even more salient. A longer expected life increases the “runway” for learning and adjustment, thereby raising the economic value of prudent timing and staged commitment: individuals can wait longer before exercising irreversible choices, expand only when the state improves, switch paths when comparative advantages evolve, and abandon unfavourable commitments earlier without forfeiting the possibility of building value elsewhere over a longer remaining horizon.

Mapping real-life cycle decisions, like fertility timing, retirement, human capital accumulation onto the framework of Table 1 reveals how rising longevity tends to extend the option horizon, thereby increasing the value of flexibility across these domains. In what follows, we examine each of these real option categories in greater depth, focusing on how longevity enhances their relevance and payoff structure in sequential household and life-cycle contexts.

3.1 Fertility Timing

Childbearing decisions exhibit a real option structure. Prospective parents face uncertainty regarding income, employment security, partnership stability, and long-term health, while the timing of childbirth remains, to some extent, discretionary. In such contexts, the option to wait represents a valuable form of flexibility, allowing individuals to defer an irreversible commitment until uncertainty resolves. Bhaumik and Nugent (2005) formalize this logic by distinguishing two opposing effects: a positive insurance effect, where higher uncertainty incentivizes earlier fertility as a hedge against future instability, and a negative option-value effect, where uncertainty increases the value of delay. Using the natural experiment of German reunification,

they find that in an environment with a robust welfare safety net—where the insurance motive is plausibly muted—the option-value effect dominates. Their empirical results show that heightened uncertainty was associated with delayed or foregone fertility.

This finding supports the broader argument that as expected lifespan increases, the temporal horizon for exercising such options lengthens, raising the economic value of postponement. In the fertility domain, this means that individuals with longer planning horizons can rationally delay childbearing to better align with future information—such as improved labor market prospects, partner stability, or health status—without sacrificing the opportunity entirely. The real option to wait becomes more valuable precisely because longevity allows for more flexibility in life-cycle sequencing under uncertainty.

3.2 Retirement timing choices

Retirement and decumulation decisions are prototypical examples of timing problems under uncertainty. The canonical “option value of work” framework conceptualizes continued employment as preserving the right—but not obligation—to retire at a future date, while wages and pension entitlements evolve stochastically (Stock & Wise, 1990). In this model, the value of working an additional year stems not only from accrued benefits but from maintaining flexibility in the face of uncertain future states.

Retirees often treat the decision of when and how much to annuitize their savings as a real option, due to the largely irreversible nature of annuity purchases. Converting a lump sum into a guaranteed lifetime income is typically a one-time, irreversible choice – once wealth is annuitized, it cannot be readily taken back or reallocated. This irreversibility means there is value in waiting to annuitize, similar to holding an option until more information is available. In other words, delaying annuitization preserves financial flexibility and the ability to adapt to new information (such as changes in health status or interest rates. Milevsky and Young (2001) interpret annuitization as an irreversible financial commitment with an embedded real option. Although immediate annuitization may offer actuarially fair value, deferral can be optimal because it preserves exposure to higher expected returns and provides time to learn about investment markets and personal health

status. The annuity purchase resembles a real option in that delaying its exercise has measurable value, especially when volatility and uncertainty are high.

3.3 Human capital, career (re)investment, and lifelong learning

Human-capital theory implies that the timing of skill investment depends on the horizon over which returns can be recouped: a longer remaining work life raises incentives to invest in training and education (Ben-Porath, 1967). A longevity-driven extension follows directly: if longer lives translate into longer potential working lives (or longer periods over which skills generate returns), then retraining, reskilling, and career switching can be interpreted as option-like investments whose value rises with the extended payoff horizon. Recent evidence is consistent with this horizon channel. Pension reforms that increase the residual working horizon causally raise training participation among older workers, suggesting that extending the expected work horizon shifts optimal training incentives upward (Brunello & Comi, 2015; Chinetti, 2024; Fürstenau et al., 2023). Empirically, the adult-learning literature further indicates that returns to adult and vocational qualifications exist but vary substantially across routes, populations, and institutional settings—an environment where postponement, staging, and switching strategies become especially decision-relevant (Bratsberg et al., 2020; Blundell et al., 2021; Leuven, 2005). In this paper, we accordingly treat lifelong learning, mid-career retraining, and career transitions as option-like strategies that preserve adaptability to uncertain labour-market and health trajectories.

3.4 Health investment decisions

A longer life span changes the intertemporal calculus of investing in oneself through education and health, because these choices typically require upfront, partly sunk costs (time, tuition, effort) with uncertain future returns. In human-capital models, a longer horizon over which benefits can be realized strengthens incentives to invest and to re-invest later in life (Ben-Porath, 1967). In parallel, health-capital theory treats health and preventive care as investments that produce “healthy time,” implying that expected longevity and uncertainty about future health states shape optimal prevention and related expenditures (Grossman, 1972; Muurinen, 1982). This decision environment naturally supports an option-based interpretation.

Individuals may stage investments, scale them up when signals become favourable, or stop further investment when expected returns deteriorate.

On the health front, preventive care can be viewed as a sequence of adjustable investments with uncertain payoffs, where gradual commitment and updating are economically rational. The compression of morbidity hypothesis emphasizes that postponing morbidity relative to longevity can reduce lifetime disability and associated costs, raising the expected returns to prevention (Fries, 1980). Valuation work in health economics further shows that mortality reductions and longevity improvements generate very large welfare gains, underscoring the potentially high payoff to successful prevention over long horizons (Murphy & Topel, 2006). Consistent with a “hedging” mechanism under uncertainty, evidence also indicates that greater subjective uncertainty about longevity is associated with lower probabilities of unhealthy lifestyles, suggesting that uncertainty can shift behaviour toward prevention (Dormont et al., 2018).

3.5 Marriage and divorce decisions

Marriage and divorce can be framed as sequential commitments under uncertainty, where entry and exit costs create partial irreversibility and therefore an “option value” of waiting and flexibility. Treating marriage as a long-horizon partnership investment highlights how the expected duration of the relationship amplifies both the gains from a good match and the losses from a bad match. Legal regimes matter because they change the effective irreversibility of marriage: the move from mutual-consent to unilateral/no-fault divorce can be interpreted as introducing a more readily exercisable exit option, reshaping incentives in marriage markets. In a search-and-learning framework, divorce-law liberalization alters marriage rates, selection into marriage, and divorce outcomes because it changes outside options and bargaining positions (Rasul, 2006). Empirically, the US unilateral-divorce reforms are associated with a short-run spike in divorce that largely reverses over time, consistent with a one-time regime shift rather than a permanent level effect (Wolfers, 2006), and they also shift intra-household bargaining and measured family distress (e.g., domestic violence and female suicide), consistent with an expanded exit threat affecting behavior within marriage (Stevenson & Wolfers, 2006). Overall, longer horizons plausibly heighten the salience of both timing (when to commit) and exit

flexibility (when to leave), strengthening the relevance of an option-based interpretation of family decisions.

Having introduced the relevant option categories, Table 2 provides a structured synthesis that operationalizes the conceptual framework. It maps core life-cycle decisions onto dominant option types and makes the framework empirically tractable by pairing each mapping with a testable longevity effect and an observable behavioral implication.

Table 2: A Comparative Matrix of Life-Cycle Real Options under Increasing Longevity

Life-Cycle Decision	Option Type	Longevity Effect	Empirical Implications
Fertility Timing	Option to Wait	Extends reproductive planning window, increases value of waiting under uncertainty	Delayed childbearing in high uncertainty contexts
Retirement Timing	Option to Wait / Expand / Switch	Extends work horizon, raises value of deferring or staging retirement	Rising trend of phased retirement, delayed annuitization
Human Capital Investment	Option to Expand / Switch	Lengthens payoff period, increases incentive to retrain or re-enter education	More mid-life reskilling programs, career switches
Health Investment	Option to Expand	Greater healthspan improves returns to preventive investments	Healthier behaviors, demand for wellness programs
Marriage and Divorce	Option to Wait / Abandon	Extended time horizon increases flexibility in relationship decisions	Later-life divorce and remarriage patterns

Source: Authors' own compilation

The Table 2 does not present new empirical findings, but serves a methodological function by offering a structured classification of key life-cycle decisions as real options influenced by increasing longevity. It synthesizes earlier conceptual discussions into a comparative matrix, highlighting how different decision domains exhibit distinct types of embedded optionality in response to longer life horizons.

From an analytical perspective, this framework establishes a common typology through which future empirical studies can be organized and tested. It provides a basis for operationalizing longevity effects on behavior using life-cycle financial data, survey instruments, or simulation models.

On the implication side, the table reinforces the practical relevance of viewing longevity as a generator of economic flexibility. The option-enhancing effects of extended life expectancy manifest in recognisable behavioural patterns: delayed childbearing, staggered retirement, midlife reskilling, and adaptive health behaviours, among others. Recognizing these as outcomes of expanded decision horizons enables more targeted design of retirement systems, adult learning incentives, public health campaigns, and family policy timing mechanisms. By bridging conceptual modeling with real-world implications, this typology strengthens the case for longevity-aware economic planning and supports the broader reframing of aging societies as option-rich environments rather than solely demographic burdens.

3.6 Operationalization and testable hypotheses

Our framework can be tested by linking measurable longevity proxies to observable timing, participation, and switching outcomes in domains where decisions are sequential and partially irreversible. At the individual level, longevity can be proxied by subjective survival probabilities or health expectations; at the cohort/region level, by remaining life expectancy at age a or survival improvements over time. Option lifetime (T) can be proxied by remaining working-life expectancy, policy-defined eligibility windows (e.g., retirement ages, pension rules), or contract-defined lock-in horizons (e.g., annuity features). Uncertainty can be proxied by income volatility, job-loss risk, health-risk indicators, or macro uncertainty measures, while irreversibility can be proxied by sunk monetary/time costs or adjustment-cost indices.

For a given life-cycle domain, a reduced-form specification can be expressed as:

$$\text{Outcome}_{\{i,t\}} = \alpha + \beta \text{ Longevity}_{\{i,t\}} + \gamma \text{ Uncertainty}_{\{i,t\}} + \delta (\text{Longevity} \times \text{Uncertainty})_{\{i,t\}} + \theta \text{ Irreversibility}_{\{i,t\}} + \text{controls} + \epsilon_{\{i,t\}},$$

where outcomes include timing (delay/acceleration), staged participation (phased retirement), switching (career changes), or commitment (annuitization, marriage entry/exit).

Hypotheses.

The core predictions are:

H1 Higher expected remaining lifetime increases the value of waiting, leading to later exercise of irreversible options (e.g., delayed annuitization, delayed retirement, delayed fertility), *ceteris paribus*.

H2 The delay effect of longevity (H1) is stronger when uncertainty is higher ($\delta > 0$).

H3 The longevity-driven option effect is stronger in domains with higher sunk costs or higher adjustment costs.

H4 Greater longevity increases investment in flexibility-enhancing actions such as reskilling and career switching, especially when the remaining work horizon expands through policy reforms.

H5 Greater longevity increases preventive-health investment when prevention yields benefits over long horizons, with stronger effects when expected healthspan rises.

These hypotheses map directly to the decision domains summarized in Table 2 and provide a clear empirical agenda for future work using administrative data, survey panels, or policy reforms as sources of exogenous variation in horizon length.

4 Conclusion

Longevity, once considered purely a demographic or actuarial variable, can fruitfully be viewed as a real option that imbues individuals with greater flexibility in their life-cycle decisions. Longer expected lifespans increase the time horizon and uncertainty of life outcomes, which in turn raises the economic value of strategies that preserve flexibility – such as delaying irreversible decisions and keeping the option to adapt. We saw how this perspective illuminates a range of choices: from fertility and marriage (waiting for the right time or the right partner, with exit options in case of mismatch), to retirement and work (deferring retirement, phasing out of work gradually, or re-entering if needed), to health and education investments (staging and adjusting them as new information arrives). By integrating longevity risk and health

uncertainty into a real options valuation framework, we gain a richer understanding of why people make the timing choices they do, and how they can be supported in making optimal decisions. Rather than viewing increased longevity as simply a fiscal challenge (more old people to support) or an actuarial adjustment, it becomes a source of economic value – if individuals and societies are flexible enough to capture it.

This reframing opens several interdisciplinary avenues. In financial economics, it suggests new ways to price and hedge longevity-related risks (for example, valuing the option component of pensions or insurance products that allow adjustments based on lifespan outcomes). In health economics, it underscores the importance of preventive care and health flexibility (treating health capital as something that one can invest in gradually, with options to adjust behaviors). In labor economics and education, it calls for models where human capital accumulation is ongoing and option-driven, not just front-loaded in youth. It also aligns with behavioral life-cycle theory by considering how real people might deviate from purely rational models – sometimes failing to exercise valuable options (like delaying unhealthy consumption) due to biases, which policy could aim to correct.

Overall, treating longevity as a real option highlights policies like adaptive retirement ages, incentives for continued learning, and robust health programs as ways to empower individuals in an aging society. If society adapts creatively – turning longer lives into opportunities for prolonged productivity and fulfillment – then longevity can be “an engine for sustainable, inclusive growth” rather than a crisis. In practical terms, that means moving toward a life-cycle framework that values resilience and optionality: helping people keep their options open as they navigate the uncertainties of a very long life. The payoff is not only individual well-being but also fiscal and economic health, as more people aging well can continue contributing to society. In conclusion, longevity should be seen not merely as a burden to manage, but as a form of capital – an expanded portfolio of years – whose value can be unlocked through flexibility, timely choices, and supportive policy. By pricing and managing this real option wisely, both individuals and societies can better thrive in the era of 100-year lives.

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TEHNOLOGIJA IN UMETNA INTELIGENCA V PODPORO DOLGOŽIVI DRUŽBI: ORGANIZACIJSKI IN ZDRAVSTVENI IZZIVI TER PRILOŽNOSTI

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Demografsko staranje in podaljševanje življenjske dobe preoblikujeta organizacijske strukture, delovne procese ter zdravstvene in dolgotrajne oskrbovalne sisteme. Dolgoživa družba zahteva prehod od reaktivnega k proaktivnemu upravljanju tveganj, virov in kompetenc. Umetna inteligenca (UI) ter sodobne informacijsko-komunikacijske tehnologije omogočajo zgodnje zaznavanje poslabšanj zdravja, podporo odločanju, optimizacijo razporejanja ter zmanjšanje administrativnih bremen, vendar le ob premišljeni sociotehnični implementaciji. Prispevek sintetizira stanje raziskav o uporabi UI v zdravstvu, dolgotrajni oskrbi in delovnem okolju ter obravnava ključne tehnologije (IoT, napovedna analitika, robotika, digitalne platforme). Posebna pozornost je namenjena organizacijskim izzivom: interoperabilnosti, upravljanju podatkov, pristranskosti, starostni diskriminaciji ter skladnosti z GDPR in EU AI Act. Na podlagi pregleda literature je razvit praktičen organizacijski okvir implementacije UI, ki povezuje sistemski inženiring, organizacijske znanosti in zdravstvene discipline ter predlaga kazalnike za vrednotenje kliničnih, organizacijskih in etičnih učinkov.

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TECHNOLOGY AND ARTIFICIAL INTELLIGENCE IN SUPPORT OF A LONGEVITY SOCIETY: ORGANISATIONAL AND HEALTHCARE CHALLENGES AND OPPORTUNITIES

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Demographic ageing and increasing life expectancy are transforming organisational structures, work processes, and healthcare and long-term care systems. A longevity society requires a shift from reactive to proactive management of risks, resources, and competencies. Artificial intelligence (AI) and modern information and communication technologies enable early detection of health deterioration, decision support, workflow optimisation, and reduction of administrative burden, provided they are implemented within a sociotechnical framework. This paper synthesises current research on AI in healthcare, long-term care, and the workplace, addressing key technologies such as IoT, predictive analytics, robotics, and digital platforms. Particular attention is given to organisational challenges, including interoperability, data governance, bias and age discrimination, and compliance with the GDPR and the EU AI Act. Based on a literature review, a practical organisational framework for AI implementation is proposed, linking systems engineering, organisational sciences, and health disciplines, together with indicators for evaluating clinical, organisational, and ethical impacts.



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1 Uvod

Demografsko staranje prebivalstva predstavlja enega najpomembnejših strukturnih trendov sodobnih družb. OECD v poročilu o starostno vključujočih delovnih mestih poudarja, da se starostna raznolikost hitro povečuje in da organizacije potrebujejo politike, ki podpirajo daljše delovno življenje, vseživljenjsko učenje ter prilagoditve delovnih mest (OECD, 2023). Hkrati se v evropskem prostoru krepi potreba po posodobitvi zdravstvenih in oskrbovalnih sistemov, saj narašča število oseb z večkratnimi kroničnimi stanji, funkcionalnimi omejitvami ter potrebo po kontinuirani podpori.

Dolgoživa družba ni zgolj družba starejših, temveč družba, v kateri se prepletajo različne generacije z raznolikimi potrebami, zmožnostmi in pričakovanji. Organizacije se zato soočajo z večplastnimi izzivi: kako ohraniti produktivnost in inovativnost ob starajoči se delovni sili, kako prilagoditi delovna mesta in procese, kako zagotoviti dostopne in kakovostne zdravstvene ter oskrbovalne storitve ter kako preprečiti socialno in digitalno izključenost starejših.

V tem kontekstu tehnologija in umetna inteligenca igrata dvojno vlogo. Po eni strani omogočata avtomatizacijo, optimizacijo procesov in podporo odločanju; po drugi strani pa lahko, če nista ustrezno zasnovani, poglobljata neenakosti in krepiata starostno diskriminacijo. Neves idr. (2023) opozarjajo na pojav sociotehničnega starizma, kjer tehnološke obljube spremljajo starostne anksioznosti in implicitne predpostavke o zmožnostih starejših uporabnikov. Zato vprašanje ni več, ali bodo organizacije uporabljale UI, temveč kako jo bodo implementirale na način, ki bo podpiral cilje dolgožive družbe.

Prispevek se umešča v razpravo o razvoju organizacijskih znanosti v kontekstu dolgožive družbe in si zastavlja tri cilje: (1) sintetizirati stanje raziskav o UI v zdravstvu, dolgotrajni oskrbi in delovnem okolju; (2) opredeliti organizacijske izzive in priložnosti ter (3) predlagati praktičen okvir implementacije UI, ki povezuje sistemsko-inženirski pristop (arhitektura sistemov, integracija tehnologij, podatkovni tokovi) z zdravstvenim in organizacijskim vidikom (dobro počutje, kakovost oskrbe, delovna sposobnost, kultura in upravljanje sprememb).

2 Pregled stanja raziskav

2.1 Uporaba umetne inteligence v oskrbi starejših in zdravstvu

Raziskave na področju uporabe UI v oskrbi starejših in zdravstvu so v zadnjem desetletju doživele izrazit porast. UI se uporablja pri spremljanju zdravstvenega stanja, zgodnjem zaznavanju tveganj, podpori kliničnemu odločanju, triaži, optimizaciji poteka dela ter organizaciji oskrbe v domačem in institucionalnem okolju. Komentar v reviji *The Lancet Healthy Longevity* izpostavlja potencial UI za izboljšanje dolgotrajne oskrbe starejših, ob sočasnih opozorilih glede dokazov iz realnega okolja in potrebe po varnem uvajanju (*The Lancet Healthy Longevity*, 2022).

Nosljive naprave, pametni senzorji in sistemi interneta stvari (IoT) omogočajo neprekinjeno spremljanje vitalnih znakov, telesne aktivnosti in okoljskih dejavnikov, kar prispeva k zgodnjemu odkrivanju poslabšanja zdravstvenega stanja in lahko zmanjša število hospitalizacij. Bibliometrična analiza na področju geriatrične oskrbe potrjuje hitro rast uporabe UI pristopov, zlasti v kombinaciji s senzoriko in digitalnimi podatkovnimi viri, vendar opozarja na razkorak med raziskovalnimi prototipi in rutinsko klinično rabo (Wang et al., 2023).

Kljub obetavnim rezultatom številne študije navajajo, da je večina dokazov še vedno omejena na pilotske projekte ali nadzorovana okolja. Gottschlich idr. (2024) poudarjajo, da socialni in asistivni sistemi lahko prispevajo k večji neodvisnosti in socialni interakciji, vendar se učinki pogosto zmanjšajo, če tehnologija ni integrirana v dnevne rutine, organizacijske protokole in vloge osebja. Pri implementaciji je zato ključen pristop, ki hkrati obravnava tehnologijo, ljudi in procese..

2.2 Umetna inteligenca, staranje in družba

Poleg zdravstvenega vidika raziskave vse pogosteje obravnavajo širše družbene in organizacijske posledice uporabe UI v kontekstu staranja. Koncept sociotehničnega starizma opozarja, da tehnologije niso nevtralne, temveč odražajo vrednote, predpostavke in pristranskosti svojih snovalcev, hkrati pa se lahko uporabljajo v družbenih praksah, ki utrjujejo stereotipe o starosti (Neves idr., 2023). Starizem je oblika diskriminacije, ki utemeljuje in vzdržuje neenakosti med družbenimi

skupinami različnih starosti; v digitalnem okolju se lahko kaže kot slaba dostopnost storitev, neustrezni uporabniški vmesniki ali pristranski podatkovni nizi.

V delovnem okolju se raziskave osredotočajo na sprejemanje tehnologije med starejšimi zaposlenimi, vpliv avtomatizacije na delovna mesta ter prilagoditve organizacijskih praks. Aisa (2023) ugotavlja, da avtomatizacija ne vodi nujno v izrinjanje starejših delavcev, temveč lahko ob ustreznih prilagoditvah prispeva k podaljševanju delovne aktivnosti, zmanjševanju fizičnih obremenitev in ohranjanju delovne sposobnosti. Vendar so učinki odvisni od investicij v usposabljanje, preoblikovanja delovnih nalog in pravične porazdelitve koristi.

2.3 Organizacijski vidiki in spremembe

Organizacijske znanosti poudarjajo, da je uspeh uvajanja UI v dolgoživi družbi odvisen predvsem od organizacijskega konteksta. Chang (2023) predlaga socio-ekološki model, ki upošteva individualne, organizacijske in družbene dejavnike prilagajanja starejših delavcev na tehnološke spremembe. Ključni elementi vključujejo podporno vodstvo, prilagodljive delovne pogoje, dostop do izobraževanja, preprečevanje diskriminacije in pozitivno organizacijsko kulturo.

V zdravstvenih in oskrbovalnih organizacijah je uvajanje UI pogosto povezano s preoblikovanjem delovnih vlog, odgovornosti in procesov. Scoping pregled o uvajanju z UI podprtih robotov v domovih za dolgotrajno oskrbo izpostavlja ovire, kot so pomanjkanje kompetenc, etični pomisleki, stroški, nedorečeni protokoli odgovornosti in strah pred zmanjšanjem človeškega stika (Wong, Wong & Wong, 2024). Empirične študije, objavljene v JMIR Aging, dodatno kažejo, da sprejemanje UI pri starejših odraslih pomembno določajo zaznane koristi, občutek nadzora, zaupanje ter jasnost glede uporabe in delitve podatkov (Wong, 2025).

3 Tehnološke rešitve in organizacijski okvir

3.1 Ključne tehnologije v podporo dolgoživi družbi

Tehnološki portfelj dolgožive družbe je raznolik in vključuje strojno učenje, senzoriko, robotiko, komunikacijske platforme ter podporne informacijske sisteme. Za organizacije je pomembno, da tehnologije razumejo kot komplementarne

gradnike in ne kot posamične »produkte«, saj se učinki pokažejo šele ob integraciji v delovne procese, ustreznem upravljanju podatkov ter oblikovanju storitev, ki so uporabniku prijazne in dostopne.

Prenosne naprave, senzorji in IoT (ambient assisted living). Razvoj nosljivih naprav (npr. pametne ure, senzorji srčnega utripa), okoljskih senzorjev (zaznava gibanja, odpiranja vrat, kakovost zraka) in IoT platform omogoča prehod od epizodičnega spremljanja k kontinuiranemu spremljanju tveganj v domačem in institucionalnem okolju. Takšni sistemi so posebej relevantni pri zgodnjem odkrivanju funkcionalnega upada in dogodkov, kot so padci, dehidracija ali poslabšanje kroničnih stanj. Bibliometrični pregled raziskav v geriatrični oskrbi potrjuje hitro rast uporabe UI v kombinaciji s senzoriko, vendar opozarja na potrebo po validacijah v realnih okoljih (Wang et al., 2023).

Strojno učenje, napovedna analitika in klinični podporni sistemi. Napovedna analitika, ki izkorišča podatke iz elektronskih zdravstvenih zapisov, senzorike in samo-poročanih kazalnikov (PROMs), omogoča razvoj modelov za oceno tveganja (npr. verjetnost padca, rehospitalizacije, poslabšanje srčnega popuščanja). V dolgoživi družbi je ključno, da se taki modeli ne obravnavajo kot »črna skrinjica«, temveč kot del klinično-organizacijskega procesa: kdo model uporablja, pri katerih odločitvah, kako se rezultat interpretira in kako se ukrepa. V praksi to pomeni formalizacijo pragov ukrepanja, protokolov eskalacije ter spremljanje lažnih alarmov.

Robotika, asistivne tehnologije in socialni roboti. V oskrbi starejših se robotika pojavlja v treh dominantnih vlogah: (1) fizična pomoč (premikanje, dvigovanje), (2) podpora rehabilitaciji (vodena vadba, biofeedback) in (3) socialna podpora (spodbujanje interakcije, zmanjševanje osamljenosti). Literatura poudarja obetavne učinke na neodvisnost in socialno interakcijo, vendar izpostavlja potrebo po realnih organizacijskih validacijah in jasni opredelitvi odgovornosti (Gottschlich idr., 2024; The Lancet Healthy Longevity, 2022).

Digitalne platforme in »pametno delovno mesto« za starosti prijazno organizacijo. V organizacijah z dolgoživo delovno silo se UI uveljavlja pri avtomatizaciji administrativnih bremen (npr. vnos podatkov, razporejanje), podpora usposabljanju (mikro-učenje, prilagojene vsebine) ter optimizaciji delovnih procesov (odkrivanje

ozkih grl, priporočila). Ključno je, da se rešitve oblikujejo po načelih starosti prijaznega dizajna in z vključevanjem uporabnikov, sicer lahko povečajo kognitivno obremenitev in odpor do uporabe.

3.2 Od tehnologije k sistemu: sociotehnična perspektiva

Raziskave o staranju in tehnologiji opozarjajo, da tehnologija ne deluje v vakuumu. Sociotehnični starizem se lahko pojavi, ko so sistemi implicitno zasnovani za »povprečnega« uporabnika in s tem marginalizirajo starejše (Neves idr., 2023). Zato mora biti zasnova UI rešitev obravnavana kot sociotehnični sistem, kjer tehnologija (algoritmi, UI, senzorji) deluje skupaj z ljudmi (uporabniki, osebje, vodstvo), procesi (workflow) določajo dejansko rabo, organizacijska kultura in pravila pa odločajo o sprejetju in trajnosti.

V praksi to pomeni, da je tehnično »dobro delujoč« model lahko organizacijsko neuspešen, če na primer podvaja delo osebja, generira preveč alarmov (alarm fatigue) ali ni jasne odgovornosti, kdo ukrepa ob zaznanem tveganju. Zaradi tega je priporočljivo, da se tehnološki projekti vodijo kot programi organizacijske spremembe: z analizo procesov, preoblikovanjem vlog, načrtom usposabljanja in merjenjem učinkov.

3.3 Referenčna arhitektura UI-rešitve v oskrbi in organizaciji

Za povečanje prenosljivosti (scalability) in zmanjšanje tveganj pri uvajanju UI je smiselno uporabljati referenčno arhitekturo. Predlagana arhitektura vključuje šest plasti:

1. Zajem podatkov: nosljive naprave, IoT, klinični sistemi, ankete, opazovanja.
2. Integracija in interoperabilnost: standardizacija formatov, API povezave, semantična uskladitev.
3. Shranjevanje in upravljanje podatkov: kakovost, sledljivost, upravljanje dostopa, politike hrambe.
4. Analitika/UI: napovedni modeli, detekcija anomalij, priporočilni sistemi.
5. Uporabniška plast: aplikacije za starejše, nadzorne plošče (dashboards) za osebje, opozorila.

6. Procesna in organizacijska plast: protokoli ukrepanja, odgovornosti, usposabljanje, audit.

Arhitektura je skladna s sistemskim inženiringom (integracija plasti) in zdravstvenim vidikom (klinična smiselnost, varnost in odgovornost). V izvedbi je pomembno, da se že v fazi načrtovanja opredeli, kateri podatki so res potrebni za odločanje in kateri predstavljajo dodatno breme ali povečujejo tveganja zasebnosti.

3.4 Interoperabilnost kot pogoj za učinek

Brez interoperabilnosti UI sistemi pogosto ostanejo »otok« in ne vplivajo na realne procese. Kot ključni standard za izmenjavo zdravstvenih podatkov se v praksi uveljavlja HL7 FHIR (Fast Healthcare Interoperability Resources), ki omogoča modularno in API-usmerjeno izmenjavo zdravstvenih informacij (HL7, n.d.; HealthIT.gov, 2024). Interoperabilnost je v dolgoživi družbi pomembna zaradi kontinuitete oskrbe (prehodi med domom, patronažo, ambulantno, bolnišnico in domom za starejše) in zaradi organizacijske učinkovitosti (manj podvajanja, manj administrativnega bremena, boljši pregled nad tveganji).

Z organizacijskega vidika interoperabilnost ni le tehnično vprašanje standardov, temveč tudi vprašanje dogovorov o odgovornostih, kakovosti podatkov in upravljanja sprememb. Učinkovitost UI v praksi pogosto omejujejo razlike v kodirnih sistemih, nepopolni vnosi, neusklajene definicije kazalnikov in omejitve dostopa do podatkov. Zato je priporočljivo oblikovati »podatkovni slovar« (data dictionary) in dogovoriti minimalni nabor podatkov, ki jih organizacije izmenjujejo v procesu oskrbe.

3.5 Upravljanje podatkov, zasebnost in regulativa

Organizacije v EU morajo rešitve UI zasnovati skladno z varstvom osebnih podatkov in specifičnimi zahtevami za zdravstvene podatke. Osnovni pravni okvir je Splošna uredba o varstvu podatkov (GDPR; European Union, 2016). Za UI je z organizacijskega vidika ključno, da se že v fazi zasnove definira pravna podlaga obdelave (npr. privolitev ali obdelava v okviru zdravstvene oskrbe), načelo minimizacije podatkov, politike dostopa (role-based access), sledljivost odločitev (audit trail) in upravljanje incidentov.

Dodatno je pomemben regulativni okvir za UI v EU. Evropska komisija navaja, da je EU AI Act začel veljati 1. avgusta 2024, z fazno uveljavitvijo: prepovedane prakse in obveznosti AI pismenosti od 2. februarja 2025, obveznosti za general-purpose AI (GPAI) od 2. avgusta 2025 in polna uporabnost 2. avgusta 2026, ob določenih izjemah (European Commission, 2024; European Commission, n.d.). To je za organizacije kritično, ker se del zdravstvenih UI rešitev lahko uvršča med visokotvegane sisteme, kar vpliva na dokumentiranje, nadzor, upravljanje življenjskega cikla in dokazovanje skladnosti.

Na ravni upravljanja priporočamo vzpostavitev UI-governance: imenovanje lastnika rešitve (business owner), odgovorne osebe za podatke (data steward), opis življenjskega cikla modela (model lifecycle), postopek za spremembe (change control) ter redne preglede pristranskosti, učinkovitosti in varnosti.

3.6 Uporabniška izkušnja in starosti prijazen dizajn

Za uspeh UI v dolgoživi družbi so ključni ergonomija, dostopnost in uporabnost. Standard ISO 9241-210:2019 opredeljuje načela in aktivnosti na človeka osredotočenega oblikovanja (human-centred design) skozi celotni življenjski cikel interaktivnih sistemov (ISO, 2019). Za starejše uporabnike in starejše zaposlene to v praksi pomeni: večjo berljivost, jasne povratne informacije, konsistentno navigacijo, zmanjšanje kognitivne obremenitve (npr. prioritizacija alarmov), prilagoditve za senzorne in motorične omejitve ter vključevanje uporabnikov v testiranje (co-design) in iterativni razvoj.

Raziskave o sprejemanju UI pri starejših dodatno kažejo, da sta zaupanje in občutek nadzora nad podatki ključna za sprejetje. Jasno komuniciranje, kaj sistem počne, katere podatke uporablja in kako se obravnavajo napake, je zato organizacijska naloga (Wong, 2025).

4 Izzivi in priložnosti za organizacije v dolgoživi družbi

4.1 Priložnosti

UI in IKT lahko v dolgoživi družbi ustvarijo strateške priložnosti na treh med seboj povezanih ravneh: (1) ravni posameznika (uporabnika/pacienta in zaposlenega), (2)

ravni organizacije (procesi, kakovost, produktivnost) in (3) ravni sistema (zdravstveni in socialnovarstveni sistemi). WHO v okviru UN Decade of Healthy Ageing (2021-2030) poudarja, da je za izboljšanje kakovosti življenja starejših potrebno usklajeno delovanje sistemov, okolij in storitev, pri čemer ima digitalna podpora pomembno vlogo pri dostopu, koordinaciji in spremljanju (WHO, 2021; WHO, 2023).

Prva priložnost je izboljšanje zdravstvenih in oskrbovalnih izidov z zgodnjim zaznavanjem tveganj. Senzorski sistemi in napovedni modeli omogočajo proaktivne intervencije (npr. ob povečani verjetnosti padca ali poslabšanja kronične bolezni), kar lahko zmanjša število urgentnih obiskov in rehospitalizacij. V dolgotrajni oskrbi to podpira cilj »staranja na domu« (ageing in place) in večjo avtonomijo.

Druga priložnost je razbremenitev osebja in optimizacija poteka dela. Digitalna orodja lahko zmanjšajo administrativno breme (vnos podatkov, poročanje, razporejanje), izboljšajo usklajevanje timov in omogočijo boljšo razporeditev virov. V kontekstu pomanjkanja kadra v oskrbi je to relevantno tudi za zmanjšanje izgorelosti.

Tretja priložnost je razvoj starosti vključujočih delovnih mest. OECD (2023) izpostavlja, da lahko starostno raznolike organizacije povečajo odpornost in prenos znanja, če sistematično podpirajo vseživljenjsko učenje, prilagoditve delovnih mest, fleksibilnost in medgeneracijsko sodelovanje. UI lahko pri tem podpira personalizirano učenje, mentorstvo in prilagoditev delovnih nalog glede na zmožnosti, ne glede na starost.

4.2 Izzivi

Kljub potencialnim koristim uvajanje UI v dolgoživi družbi odpira več tipov izzivov. Digitalna pismenost in sprejemanje tehnologije. Starejši uporabniki niso homogena skupina; razlike v zdravju, izobrazbi, socialni podpori in izkušnjah z digitalnimi tehnologijami vplivajo na sprejetje. Kvalitativne študije kažejo, da so pogosti pomisleki povezani z zasebnostjo, strahom pred napakami, občutkom nadzora ter zamenjavo človeškega stika (Wong, 2025). Pristranskost, starostna diskriminacija in pravičnost. UI modeli lahko ojačajo neenakosti, če so trenirani na nereprezentativnih podatkih ali če uporabljajo proxy spremenljivke, ki korelirajo s starostjo. Posledice

so lahko nepravilne odločitve (npr. v triaži, zavarovalništvu ali kadrovanju) in zmanjšanje zaupanja. Varnost, zasebnost in skladnost. Zdravstveni podatki so posebej občutljivi, zato morajo organizacije izvajati načela privacy-by-design in security-by-design ter zagotoviti skladnost z GDPR (European Union, 2016). V EU AI Act je poseben poudarek na upravljanju visoko-tveganih sistemov, dokumentaciji, nadzoru in AI pismenosti, kar zahteva dodatne kompetence in procese (European Commission, 2024; European Commission, n.d.). Interoperabilnost in tehnična dolgoročnost. Brez standardizacije (npr. FHIR) in dogovorov o podatkih lahko UI rešitve povzročijo fragmentacijo, podvajanje dela in težave pri prenosu med organizacijami. Poleg tega je pomembno načrtovanje vzdrževanja modelov (model drift), posodobitev in varnostnih popravkov. Organizacijska kultura in upravljanje sprememb. Uvajanje UI pogosto sproži odpor zaradi strahu pred nadzorom, spremembami vlog in odgovornosti. Empirične ugotovitve v literaturi o avtomatizaciji kažejo, da je sprejemanje tesno povezano z občutkom kompetentnosti, podporo vodstva in smiselnostjo uporabe v realnih nalogah (Aisa, 2023; Chang, 2023).

4.3 Organizacijski kompromisi: učinkovitost proti kakovosti, avtomatizacija proti avtonomiji UI

UI lahko izboljša učinkovitost, vendar lahko tudi nehote poveča administrativno delo (npr. dodatno vnašanje podatkov), zmanjša avtonomijo zaposlenih (če se UI obravnava kot »avtoriteta«) in sproži pojav alarm fatigue v kliničnih okoljih. Zato mora organizacija opredeliti, kje UI podpira odločanje in kje UI odloča, ter vzpostaviti protokole, ki ohranjajo odgovornost, strokovno presojo in možnost izjem.

V zdravstvenem okolju je priporočljivo ohraniti načelo, da je UI podporni sistem, ki izboljšuje informiranost, ne pa nadomestilo za klinično presojo. V delovnem okolju pa je treba paziti, da optimizacijski algoritmi (npr. razporejanje) ne ustvarjajo nevidnih pritiskov ali nepravilne porazdelitve obremenitev.

4.4 Kompetence in upravljanje sprememb kot primarni dejavnik uspeha

Učinkovita implementacija UI zahteva kombinacijo digitalnih, organizacijskih in etičnih kompetenc. Poleg tehničnih znanj (osnove podatkov, razumevanje delovanja modelov, kibernetska varnost) so ključne kompetence upravljanja sprememb: komunikacija, vključenost deležnikov, preoblikovanje procesov in razvoj kulture učenja. OECD (2023) poudarja, da so ukrepi za vseživljenjsko učenje in prilagoditev delovnih mest temelj starostno vključujočih organizacij.

Za zmanjšanje odpora je priporočljivo: (1) vključevanje uporabnikov in zaposlenih v sooblikovanje, (2) jasna opredelitev koristi in meja uporabe, (3) načrt usposabljanja po vlogah in (4) iterativna uvedba z merjenjem učinkov ter prilagajanjem.

5 Praktični okvir za organizacije: priporočila za implementacijo UI

5.1 Strategija in vizija

Implementacija UI naj izhaja iz jasne strategije in vizije, povezane z dolgoročnimi cilji organizacije v kontekstu dolgožive družbe. Namesto tehnološko vodenih projektov (»kupimo rešitev«) je priporočljiv problemsko voden pristop: opredelitev procesa ali izida, ki ga želimo izboljšati, opredelitev deležnikov, tveganj in meril uspeha. Strategija naj opredeli tudi meje avtomatizacije, načela odgovornosti ter način zagotavljanja pravičnosti in nediskriminacije.

5.2 Vključevanje deležnikov in sooblikovanje (co-design)

Vključevanje deležnikov je ključni pogoj sprejetja. V zdravstvu to pomeni sodelovanje kliničnega osebja, oskrbovalcev, IT strokovnjakov, vodstva in predstavnikov uporabnikov (starejših). V podjetjih to vključuje kadrovsko službo, vodje procesov, sindikate/odbor delavcev in predstavnike starejših zaposlenih. Co-design zmanjšuje tveganje, da bi sistem ustvarjal dodatno breme ali neustrezno uporabniško izkušnjo, hkrati pa povečuje občutek nadzora in legitimnost tehnologije (ISO, 2019; Wong, 2025).

5.3 Digitalna pismenost, usposabljanje in podpora

Organizacije naj razvijejo program digitalne pismenosti in usposabljanja po vlogah. Učinkovit pristop vključuje: (1) uvodno usposabljanje (osnove uporabe in namen sistema), (2) scenarijsko učenje na realnih primerih (npr. kako ukrepati ob alarmu), (3) superuporabnike (key users) kot notranje mentorje in (4) stalno podporo ter osvežitvene vsebine. Pri starejših uporabnikih so pomembni enostavni vodiči, možnost osebne podpore ter oblikovanje, ki zmanjšuje kognitivno obremenitev (ISO, 2019).

5.4 Prilagoditev procesov in ergonomija delovnega mesta

UI je učinkovita, če je integrirana v procese. Pred uvedbo je smiselno izvesti procesno analizo (npr. mapping workflow) in opredeliti, kje UI dodaja vrednost. Pri tem je treba preprečiti podvajanje vnosa podatkov ter zagotoviti, da UI izhodi (opozorila, priporočila) vodijo v jasne nadaljnje korake. V delovnih okoljih se to povezuje z ergonomijo (fizično in kognitivno), prilagoditvijo delovnih nalog, fleksibilnimi oblikami dela in starosti prijaznimi informacijskimi sistemi.

5.5 Tehnološka infrastruktura, interoperabilnost in kibernetika varnost

Tehnološka infrastruktura mora omogočati zanesljiv zajem, integracijo in varno obdelavo podatkov. Ključne zahteve so: interoperabilnost (npr. FHIR za zdravstvene podatke), upravljanje identitet in dostopov, šifriranje, varnostne kopije, spremljanje incidentov in upravljanje ranljivosti. Pri uvajanju UI v oskrbi je priporočljivo tudi načrtovanje delovanja ob izpadih (fallback procedures) in redno testiranje zanesljivosti.

5.6 Etika, upravljanje in merjenje učinka

Etika in upravljanje sta nujna, ker UI posega v odločitve, ki vplivajo na zdravje, varnost in dostojanstvo. Organizacije naj vzpostavijo UI-governance okvir, ki vključuje: odgovornosti, dokumentacijo, oceno vplivov (npr. DPIA, kjer je relevantno), postopke za pritožbe, preglednost komunikacije do uporabnikov in redne revizije modelov. EU AI Act uvaja dodatne obveznosti za določene tipe

sistemov, zato je potrebno spremljati klasifikacijo rešitve in implementirati zahtevane kontrole (European Commission, 2024; European Commission, n.d.).

Merjenje učinka naj presega tehnične metrike (npr. AUC) in vključuje klinične ter organizacijske izide, zadovoljstvo uporabnikov in pravičnost. Predlagani kazalniki so predstavljeni v poglavju 8.

5.7 Model zrelosti implementacije umetne inteligence (AI maturity)

Za sistematično uvajanje UI je uporaben 5-stopenjski model zrelosti:

1. Ad hoc: pilotski projekti brez integracije v procese.
2. Upravljanje: osnovni protokoli, lastništvo, začetno izobraževanje.
3. Integrirano: interoperabilnost, integracija v workflow, merjenje učinkov.
4. Optimizirano: stalno izboljševanje, audit, obvladovanje pristranskosti, upravljanje model drift.
5. Transformativno: UI kot strateški vzvod, inovacije storitev, sistemska sinergija in širitev na partnerske organizacije.

5.8 Upravljanje pristranskosti (bias) in pravičnost

V dolgoživi družbi so starostne pristranskosti posebej problematične. Organizacije naj uvedejo preverjanje reprezentativnosti podatkov (starostne skupine), metrike pravičnosti (npr. primerjava občutljivosti/specifičnosti po starosti), periodične preglede učinka po podskupinah ter postopke za pritožbe in človeški pregled v kritičnih odločitvah (Neves idr., 2023). Pri kadrovskih algoritmih je priporočljivo tudi pravno in etično pregledovanje kriterijev, ki bi lahko delovali kot proxy za starost.

6 Metodološke implikacije za raziskave in evalvacijo

Raziskovanje UI v kontekstu dolgožive družbe zahteva interdisciplinarne metodološke pristope. Tehnološko usmerjene študije (npr. razvoj modela na retrospektivnih podatkih) je potrebno dopolniti z evalvacijo v realnih okoljih, kjer imajo ključno vlogo organizacijski dejavniki.

Priporočljive so longitudinalne raziskave, ki spremljajo dolgoročne učinke tehnologije na uporabnike in organizacije (npr. spremembe v stopnji hospitalizacij, funkcionalnem statusu, zadovoljstvu osebja). Pomembne so tudi kvalitativne metode (intervjuji, fokusne skupine, etnografsko opazovanje), ki osvetljujejo izkušnje starejših, skrbnikov in zaposlenih ter razloge za sprejetje ali odpor.

V praksi je pogosto primeren mešani pristop (mixed methods) in okvir implementacijske znanosti, ki pojasnjuje, zakaj se inovacije v praksi primejo ali ne. Realistične evalvacije (realist evaluation) so posebej uporabne, ker ne iščejo le odgovora »ali deluje«, temveč »kaj deluje, za koga in v katerih pogojih«. Kadar randomizirane kontrolirane raziskave (RCT) niso izvedljive, so primerne kvazi-eksperimentalne zasnove (pred/po, kontrolne enote, interrupted time series).

Posebej pomembno je razločevanje med tehnično veljavnostjo (natančnost modela), klinično veljavnostjo (ali izboljša klinično odločanje) in organizacijsko veljavnostjo (ali spremeni procese in rezultate brez nesorazmernih stranskih učinkov). V vseh fazah evalvacije je priporočljivo spremljati tudi pravičnost po starostnih in drugih relevantnih podskupinah.

7 Razprava

UI v dolgoživi družbi se pogosto obravnava kot odgovor na kadrovske in finančne pritiske, vendar literatura opozarja, da se učinki pojavijo šele, ko so izpolnjeni sociotehnični pogoji: interoperabilnost, kompetence, jasna odgovornost, upravljanje sprememb in etično upravljanje (The Lancet Healthy Longevity, 2022; Chang, 2023). To pomeni, da organizacije ne bi smele začeti z vprašanjem »kateri model kupimo«, temveč z vprašanjem »kateri proces želimo izboljšati in kako bomo merili učinek«.

V delovnem okolju je tveganje, da avtomatizacija poglobi starostne razlike v kompetencah ali posredno podpira diskriminatorne prakse (npr. selekcija kadrov, algoritmi ocenjevanja uspešnosti). Zato je pomembna transparentnost kriterijev, možnost človeškega pregleda in spremljanje učinkov po starostnih skupinah. V oskrbi starejših je tveganje »tehnološkega nadzora«, kjer se avtonomija zmanjšuje zaradi pretirane instrumentacije vsakdanjega življenja. Meja med varnostjo in zasebnostjo je občutljiva in zahteva dogovor o namenu, minimalnem naboru podatkov in jasnih pravilih dostopa (European Union, 2016).

Razprava tudi kaže, da digitalna pismenost ni le individualna lastnost, temveč organizacijska odgovornost: če organizacija uvaja UI, mora ustvariti okolje, kjer je učenje normalizirano, podprto in prilagojeno različnim generacijam (Aisa, 2023; OECD, 2023). Pri tem so učinkovite prakse, kot so medgeneracijsko mentorstvo, superuporabniki in vgrajeni »trenutki učenja« v sam sistem.

Na ravni javnih politik je pomembno, da digitalne rešitve podpirajo cilje zdravega staranja. WHO poudarja pomen sistemskih ukrepov (integrirana oskrba, starosti prijazna okolja, boj proti starizmu), pri čemer je digitalno zdravje en od pospeševalcev, če je implementirano pravično in varno (WHO, 2021; WHO, 2023).

8 Kazalniki uspeha in vrednotenje učinkov

Merjenje uspeha UI v dolgoživi družbi mora vključevati klinične, organizacijske, uporabniške in etične kazalnike. Predlagan je večnivojski sklop kazalnikov:

(a) Kazalniki na ravni uporabnika/pacienta (outcomes): stopnja padcev in »near-falls« (kadar se meri), število urgentnih obiskov in rehospitalizacij, funkcionalni status (npr. ADL/IADL), kakovost življenja (standardizirani vprašalniki), zaznana varnost in zaznana avtonomija.

(b) Kazalniki na ravni organizacije: čas osebja na administrativnih nalogah, delež pravočasno izvedenih intervencij po alarmu, čakalne dobe, fluktuacija kadra, absentizem, zadovoljstvo zaposlenih, stroškovni kazalniki (npr. strošek na oskrbni dan) in kazalniki kakovosti storitev.

(c) Kazalniki etike, varnosti in pravičnosti: stopnja lažnih alarmov in alarm fatigue, incidenti varnosti podatkov, skladnost z internimi protokoli, metrike pravičnosti po starosti (npr. razlika v občutljivosti modela), delež primerov s človeškim pregledom v visoko-tveganih odločitvah, ter kazalniki razumevanja in zaupanja uporabnikov.

Organizacije naj kazalnike določijo že v fazi načrtovanja in jih povežejo z odločanjem o nadaljnji širitvi ali spremembah rešitve (model zrelosti iz poglavja 5.7).

9 Zaključek

Ključna ugotovitev prispevka je, da UI v dolgoživi družbi ni primarno tehnološki projekt, temveč organizacijska transformacija, ki zahteva upravljanje sprememb, interoperabilnost, kompetence ter regulativno in etično skladnost. UI lahko okrepi neodvisnost starejših, izboljša kakovost oskrbe in omogoči starosti prijaznejše delovno okolje, vendar le, če je implementirana kot del sociotehničnega sistema in merjena z izidi, ki so relevantni za uporabnike in organizacije (The Lancet Healthy Longevity, 2022; Chang, 2023).

Za nadaljnje raziskave je smiselno okrepiti empirične študije implementacije UI v realnih organizacijskih kontekstih (npr. v Sloveniji) ter razviti primerljive kazalnike za oceno učinkov na uporabnike, osebje in sisteme. Posebej pomembno je tudi raziskovanje pravičnosti, zaupanja in oblikovanja storitev, ki ohranjajo dostojanstvo ter avtonomijo starejših.

10 Scenariji implementacije (praktični primeri)

V tem poglavju sta predstavljena dva ilustrativna scenarija, ki kažeta, kako lahko organizacije strukturirano uvedejo UI v kontekstu dolgožive družbe. Scenarija sta namenjena ponazoritvi korakov, vlog in meritev; ne predstavljata edinih možnih pristopov.

10.1 Scenarij A: preprečevanje padcev v domu za starejše. Organizacija uvede kombinacijo okoljskih senzorjev in nosljivih naprav za zaznavo tveganja padcev, s sistemom opozoril za osebje. Ključni koraki vključujejo: (1) procesno analizo (kje nastanejo padci, kdo ukrepa), (2) definicijo pragov alarmov in protokola eskalacije, (3) usposabljanje osebja in superuporabnike, (4) integracijo podatkov v obstoječi informacijski sistem, (5) spremljanje lažnih alarmov in obremenitve osebja, ter (6) periodično preverjanje pravičnosti po starostnih in funkcionalnih podskupinah.

10.2 Scenarij B: starosti prijazno delovno mesto v podjetju z dolgoživo delovno silo. Podjetje uvede UI podprt sistem za načrtovanje usposabljanj in prilagoditev delovnih nalog, ki temelji na kompetenčnem profilu in preferencah zaposlenih. Ključni koraki vključujejo: (1) opredelitev ciljev (ohranjanje kompetenc, zmanjšanje poškodb, prenos znanja), (2) vzpostavitev etičnih pravil (prepoved uporabe za

diskriminatorne odločitve), (3) vključitev predstavnikov zaposlenih v sooblikovanje, (4) pilotiranje v eni enoti, (5) merjenje učinkov (absentizem, zadovoljstvo, uspešnost usposabljanj) in (6) širitev ob doseženih pragovih uspeha.

11 Omejitve prispevka

Prispevek temelji na pregledni sintezi literature in institucionalnih virov ter ne vključuje lastne empirične študije. Posledično je treba predlagani organizacijski okvir razumeti kot priporočilni model, ki ga je potrebno prilagoditi specifičnemu kontekstu organizacije (pravni okvir, informacijska zrelost, kadrovske zmožnosti, kultura). Dodatno se področje UI hitro razvija, zato je priporočljivo redno posodabljanje praks glede na nove regulativne smernice, standardizacijske dokumente in empirične dokaze.

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VSEBINSKI, PODATKOVNI IN PROCESNI MODEL IZVEDBE ANALIZ PODATKOV

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V prispevku predstavljamo metodologijo za standardizirano izvajanje analiz podatkov, ki podjetjem omogoča bolj zanesljivo, pregledno in učinkovito analitično delo. Pristop temelji na enotni vsebinski zasnovi, podatkovnem modelu ter jasno strukturiranem procesu, ki analitikom zagotavlja doslednost in sledljivost, uporabnikom pa boljše razumevanje rezultatov. Z opredelitvijo ključnih podatkovnih elementov in njihovih povezav podatkovni model omogoča, da so analize zgrajene na preverjenih, primerljivih in ustrezno dokumentiranih informacijah. Poseben poudarek namenjamo vprašanju kakovosti podatkov, ki pomembno oblikuje zanesljivost analitičnih zaključkov in odločitev, ki izhajajo iz njih. Metodologija vključuje celoten potek analiz podatkov, od oblikovanja zahtevka in izbire podatkovnih virov do preverjanja kakovosti, priprave algoritma, ovrednotenja rezultatov ter končne ugotovitve. S takšnim pristopom organizacija pridobi robusten analitični okvir, ki podpira razvoj naprednih podatkovnih rešitev ter izboljšuje strateško in operativno odločanje.

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CONTENT, DATA, AND PROCESS MODELS FOR PERFORMING DATA ANALYSES

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Keywords:

data analysis,
data analysis development
process,
data model, data reliability,
analytical methodology,
business analytics

This paper presents a methodology for the standardized execution of data analyses, enabling organizations to perform more reliable, transparent, and efficient analytical work. The approach is based on a unified content framework, a data model, and a clearly structured process that ensures consistency and traceability for analysts while improving end users' understanding of the results. By defining key data elements and their relationships, the data model ensures that analyses are built on verified, comparable, and properly documented information. Special emphasis is placed on data quality, which critically shapes the reliability of analytical conclusions and the decisions derived from them. The methodology covers the entire data analysis lifecycle—from request formulation and selection of data sources to data quality verification, algorithm preparation, result validation, and final presentation of findings. Such an approach provides organizations with a robust analytical framework that supports the development of advanced data solutions and enhances both strategic and operational decision-making.



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1 Uvod

V podjetjih se dnevno ustvarja ogromna količina podatkov, od meritev v poslovnih procesih do informacij o sredstvih in obratovalnih pogojih (Davenport, 2006). Kljub bogatim virom ostaja ključni izziv, kako iz podatkov pravočasno in zanesljivo pridobiti informacije za podporo odločanju. Odgovor na ta izziv je strukturirana analiza podatkov, ki zagotavlja, da so podatki preverjeni, razumljeni in pripravljeni za obdelavo, kar jim daje dodatno vrednost. Tak pristop ni le izvedba izračunov, temveč standardiziran način razmišljanja o analizah: od njihovega oblikovanja in izbire podatkov do preverjanja kakovosti in razumljive predstavitve rezultatov. Prispevek temelji na študiji (Bokal idr., 2020; Lustig idr., 2010), ki povezuje vsebinski, podatkovni in procesni vidik analitičnega dela.

S strukturiranim pristopom se rešuje pogosta težava, ko se isti problem v podjetju rešuje na več načinov z različnimi rezultati. Standardizirana analiza uvaja strukturo za ponovljiv proces dela, uporabnikom pa zagotavlja zanesljive in sledljive rezultate.

V prispevku obravnavamo celovit model, ki se uporablja pri pripravi analiz in prikazov. Pokažemo, kako jasna opredelitev vsebine in enotna struktura postopka vodita do natančnejših in doslednejših rezultatov. Na konkretnem primeru iz prakse prikažemo, kako takšen pristop poenostavi pripravo analiz, zmanjša možnost napačnih interpretacij in izboljša učinkovitost odločanja v podjetju.

2 Teoretične osnove standardiziranega pristopa k podatkovni analitiki

V podjetjih se podatki zbirajo iz številnih različnih virov, kar ustvarja okolje z veliko količino informacij, a neenakomerno kakovostjo. Ker je od kakovosti odvisna učinkovitost uporabe podatkov v praksi, je ključno zagotoviti njihovo enotno obravnavo, dosledno preverjanje in zanesljivo interpretacijo pri odločanju. Strukturirana analiza podatkov je nastala kot odgovor na ta izziv. Njen namen je vzpostaviti standardiziran način razmišljanja o analitičnih postopkih, ki omogoča preglednost, ponovljivost in skladnost z vsebinskimi cilji. S tem presega klasično analitiko, saj ustvarja celovit okvir, v katerem je vnaprej jasno, kaj analiziramo, zakaj je to pomembno in kako zagotoviti primernost podatkov za obdelavo.

2.1 Strukturirani pristop

Strukturirana analiza podatkov je celovit proces, ki povezuje vsebinski, podatkovni in procesni vidik dela. Vsebinski del določa smisel analize z vidika uporabnika, podatkovni del se ukvarja z razpoložljivostjo in kakovostjo podatkov, procesni del pa določa zaporedje korakov izvedbe. Takšen pristop zagotavlja enotno strukturo analiz ne glede na njihovo vsebino, kar omogoča primerljivost rezultatov, njihovo integracijo v širše podatkovno okolje podjetja ter zmanjšuje tveganje napačnih interpretacij (Rizzi, 2009).

Analitični postopek poteka kot jasno opredeljeno zaporedje dejavnosti. Najprej se opredeli zahteva uporabnika in opiše problem, nato pa se oblikujejo cilji in vsebinska vprašanja. Sledi preverjanje kakovosti podatkov (popolnost, pravilnost, časovna ustreznost in konsistentnost), saj je kakovost izračuna neposredno odvisna od vhodnih podatkov. Po preverjanju analitik določi logiko obdelave, ki vključuje izračune in filtracije s sprotim preverjanjem smiselnosti. Zaključni del predstavlja priprava prikazov, prilagojenih uporabniku. Ključna prednost procesa je visoka sledljivost, saj je vsak prikaz mogoče povezati z vhodnimi podatki in postopkom obdelave (Mahnic, 2013).

Kljub prednostim ima model določene omejitve. Metodologija ne more nadomestiti manjkajočih informacij, preverjanje podatkov pa je lahko pri velikih naborih časovno zahtevno. Proces je odvisen od ažurnosti virov, učinkovitost pristopa pa od organizacijske zrelosti in pripravljenosti zaposlenih na standardizirani način dela, saj celovitost metodologije pride do izraza le, če jo dosledno uporabljajo analitiki in tudi naročniki analiz.

2.2 Obstoječi standardi in tehnološke rešitve

V praksi obstajajo številna orodja in programske rešitve, ki podpirajo posamezne faze analize podatkov, kot so zbiranje in shranjevanje podatkov, njihova obdelava, upodobitev ter poročanje rezultatov. Takšna orodja analitikom omogočajo učinkovitejšo izvedbo izračunov in pripravo prikazov, vendar se večinoma osredotočajo na tehnično izvedbo analiz ali na podporo odločanju v obliki končnih poročil in nadzornih plošč.

Poleg konkretnih programskih rešitev, kot sta npr. Great Expectations za preverjanje kakovosti ali Apache Atlas za sledljivost podatkov (Moses idr., 2022), obstajajo tudi

metodološki okviri, ki opisujejo faze analitičnega procesa. Najbolj razširjen med njimi je standard CRISP-DM (Cross-Industry Standard Process for Data Mining)(Shearer, 2000), ki poudarja pomen razumevanja problema, priprave podatkov ter interpretacije rezultatov.

Ti pristopi prispevajo k večji sistematičnosti analitičnega dela, vendar pogosto ne opredeljujejo natančno strukture podatkov in njihove kakovosti v povezavi s posameznimi analizami (Batini & Scannapieco, 2016; Henderson idr., 2024). Skupna značilnost večine obstoječih pristopov je, da obravnavajo vsebinski, podatkovni in procesni vidik analize ločeno ali implicitno, brez enotnega modela, ki bi te vidike jasno povezal. Posledično je sledljivost med vsebinskim namenom analize, uporabljenimi podatki in končnimi prikazi pogosto omejena, kar lahko oteži razumevanje rezultatov in njihovo ponovljivo uporabo v praksi. Predstavljeni pristop v tem prispevku zato ne nadomešča obstoječih orodij, temveč jih dopolnjuje z jasno strukturiranim vsebinskim, podatkovnim in procesnim modelom, ki omogoča, da so analize zasnovane, izvedene in interpretirane na enoten in sledljiv način.

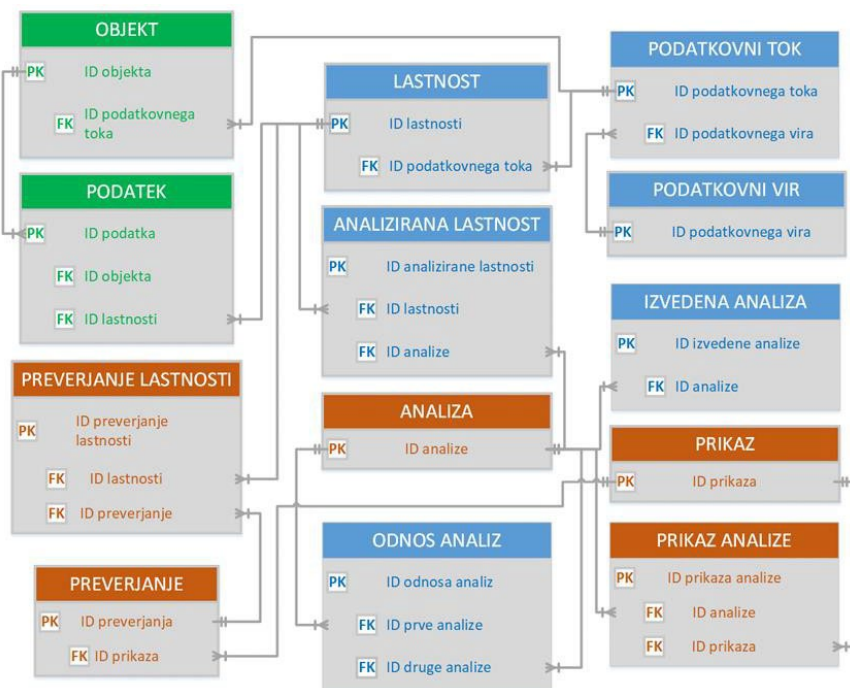
3 Podatkovni in procesni model

Podatkovni in procesni model predstavljata hrbtenico analitičnega delovanja, saj opredeljujeta elemente analize in povezave med njimi. Model analitiku omogoča razumevanje potrebnih podatkov, njihove organizacije, lastnosti in poteka v postopku. Takšen pristop zagotavlja preglednost, enoznačno interpretacijo rezultatov ter razvoj modularnih in nadgradljivih analiz, primernih za vključitev v sistem digitalnega dvojčka elektroenergetskega omrežja.

V središču podatkovnega modela je podatkovni model analize (slika 1), ki določa cilje, pričakovane rezultate, vire podatkov in logiko obdelave. Vsaka analiza je povezana z izvedeno analizo, ki predstavlja dejanski potek obdelave na konkretni podatkovni množici v določenem času. Razlikovanje med obema entitetama omogoča večkratno uporabo iste vsebinske zasnove v različnih obdobjih, kar povečuje ponovljivost in sledljivost.

Model vključuje tudi entiteto prikaz (slika 1), ki zajema način predstavitve rezultatov. Prikaz ni le vizualna komponenta, temveč zaključni element logične verige. Model zagotavlja, da vsak prikaz temelji na jasnih pravilih in je povezan z ustrezno izvedeno analizo, kar omogoča povratno sledljivost nazaj do vhodnih podatkov. Ta povezljivost je ključna za verodostojnost, saj uporabnik natančno vidi, kako je rezultat nastal.

Pomemben del modela so entitete, povezane s podatki in njihovimi lastnostmi (slika 1). Podatek je opredeljen z izvorom, časovno pripadnostjo in kakovostjo (popolnost, rednost, pravilnost, konsistentnost) (Tayi & Ballou, 1998). Model določa način preverjanja teh lastnosti, kar analitiku omogoča razumevanje omejitev virov še pred izvedbo in bistveno zmanjšuje tveganje napačnih rezultatov.



Slika 1: Shema entitetnega modela podatkovne strukture, ki povezuje ključne gradnike analize

Vir: (Bokal idr., 2020)

Procesni model dopolnjuje podatkovni del z natančnim opisom poti podatka od vstopa v analizo do končnega prikaza (Bratuša, 2019). Opredeljuje ključne korake: razumevanje zahteve, oblikovanje zasnove, preverjanje podatkov, priprava algoritma, izvedba in interpretacija. Ta standardizacija omogoča primerljivost dela različnih analitikov in združljivost rezultatov.

Modela skupaj ustvarjata stabilen okvir, ki zmanjšuje možnosti napak in poenostavlja komunikacijo. Analitik se lahko osredotoči na vsebino problema, saj struktura zagotavlja transparentno in sledljivo izvedbo po preverjenih pravilih.

4 Proces izdelave analiz

Proces izdelave analiz je zasnovan tako, da omogoča pregledno, ponovljivo in vsebinsko utemeljeno izvajanje vseh analiz v organizaciji. Temelji na enotni metodologiji, ki povezuje uporabniško zahtevo, podatkovne preveritve in analitično obdelavo v jasno zaporedje korakov (slika 2). S tem se zagotavlja, da je vsaka analiza izvedena na enak način, ne glede na tematiko ali zahtevnost, rezultati pa so vedno sledljivi, primerljivi in pripravljeni za uporabo pri odločanju. Namen procesa ni le tehnična izvedba analize, temveč ustvarjanje okolja, kjer analitik in naročnik delujeta usklajeno, podatki pa so obravnavani tako, da odražajo dejansko stanje in omogočajo zanesljive zaključke.

4.1 Pregled procesa priprave analiz

Priprava analize se začne z razumevanjem vsebinskih ciljev, ki jih postavi naročnik. Analitik najprej oblikuje splošno predstavo o tem, kaj želimo ugotoviti, kateri podatki bodo potrebni in katere omejitve lahko pričakujemo. Ta pregled služi kot orientacija za nadaljnje korake in zagotavlja, da je analiza zasnovana na jasnem problemu. Pregled procesa omogoča, da se že v začetku prepoznajo morebitni izzivi, kot so omejitve podatkov, časovni okvir ali zahtevnost interpretacije.

4.2 Zahtevek

Zahtevek predstavlja formalizirano opredelitev analize. V njem naročnik navede namen analize, ključna vprašanja ter pričakovane rezultate. Dobro oblikovan zahtevek usmerja analitika, saj pojasni, kaj je bistvo analize in zakaj je ta potrebna. V

tej fazi se vzpostavi skupno razumevanje ciljev, kar zmanjša možnost napačnih interpretacij in zagotavlja, da analiza ostane osredotočena na dejanske potrebe uporabnika.

4.3 Vir podatkov

Ko je zahtevek jasen, analitik določi, iz katerih virov bodo podatki črpani. Podatki v podjetjih prihajajo iz številnih sistemov, zato je pomembno razumeti njihovo zanesljivost, izvor in strukturo. Pri izboru vira analitik oceni, ali podatki odražajo realno stanje in ali so dovolj podrobni za namen analize. Ta korak je ključen, saj pravilna izbira vira neposredno vpliva na kakovost nadaljnjih rezultatov.

4.4 Preverjanje kakovosti podatkov

Preverjanje kakovosti podatkov je osrednji element. Analitik pregleda, ali so podatki popolni, pravilni, časovno skladni in notranje konsistentni. Namen preverjanja ni izločanje podatkov, temveč razumevanje njihovih omejitev in vplivov na analizo. S tem se omogoča, da je interpretacija rezultatov realistična in da morebitne pomanjkljivosti ne vodijo do napačnih zaključkov. Kakovost podatkov določa zanesljivost celotne analize, zato je ta korak obravnavan skrbno in sistematično.

4.5 Algoritem analize

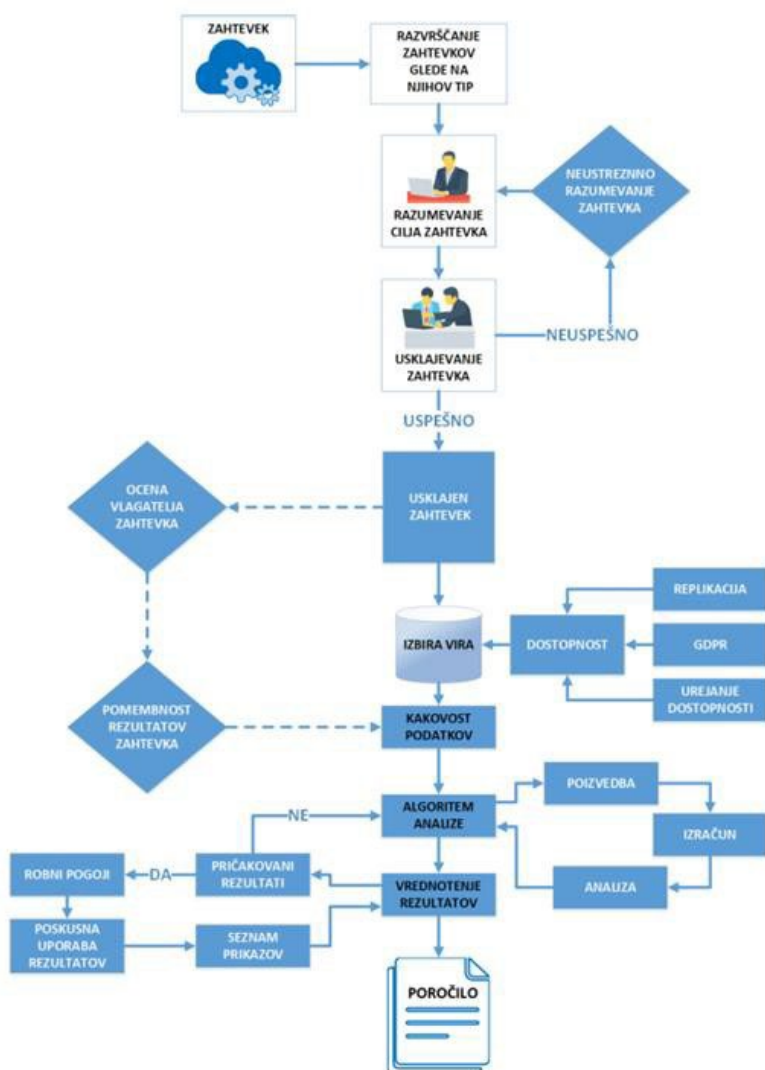
Ko so podatki preverjeni, analitik pripravi logično zasnovo algoritma. Na abstraktni ravni algoritem določa postopke, s katerimi bodo podatki obdelani, merila, ki bodo uporabljena pri vrednotenju, ter pravila, ki vodijo do končnega rezultata. Pri tem je pomembno, da je logika enostavna za razumevanje, sledljiva in ponovljiva. Dobro zasnovan algoritem omogoča dosledne rezultate ter lažje posodobitve, če se analiza v prihodnosti ponavlja ali nadgrajuje.

4.6 Preverjanje rezultatov algoritma

Po izvedbi izračunov analitik preveri, ali rezultati smiselno odražajo stanje, ki ga analiza obravnava. Preverjanje vključuje pregled vmesnih vrednosti, zaznavanje morebitnih anomalij ter oceno, ali so zaključki v skladu s pričakovanji. Namen tega koraka je zagotoviti, da so rezultati ne le pravilno izračunani, temveč tudi vsebinsko

razumljivi in uporabni. Če se pojavijo odstopanja, se analitik vrne korak nazaj in preveri logiko algoritma in tudi kakovost vhodnih podatkov.

4.7 Poročilo analize



Slika 2: Standardiziran proces izdelave analiz podatkov

Vir: (Bokal idr., 2020)

Zaključni rezultat procesa je poročilo, ki združuje vse ključne elemente analize. Poročilo predstavlja potek dela, glavne ugotovitve in interpretacije ter jasno nakaže omejitve, ki vplivajo na končno razumevanje rezultatov. Pripravljeno mora biti tako, da ga razumeta tako analitik in tudi uporabnik, ki ni neposredno sodeloval v postopku. Poročilo ima pomembno vlogo pri zagotavljanju sledljivosti, saj omogoča, da se analiza kadarkoli ponovno preveri ali izvede z enako logiko na novih podatkih.

5 Stopnje in vpliv (ne)kakovostnih podatkov

Kakovost podatkov je eden najpomembnejših dejavnikov, ki določajo zanesljivost in uporabnost analize. V praksi podatki nikoli niso popolni, zato mora pristop analize zagotoviti, da so omejitve podatkov prepoznane, pravilno dokumentirane in smiselno upoštevane pri interpretaciji rezultatov. Za razumevanje zanesljivosti analize je zato ključno, da podatke ne obravnavamo zgolj kot številčne vrednosti, temveč kot elemente z lastnostmi, ki vplivajo na njihovo interpretacijo in analitično vrednost (Batini & Scannapieco, 2016). Te lastnosti tvorijo različne stopnje kakovosti, ki omogočajo, da analitik oceni, kako močno lahko zaupa izračunanim rezultatom.

Podatki z visoko stopnjo kakovosti so popolni, pravilni in časovno skladni, kar pomeni, da jih je mogoče neposredno uporabiti pri izračunih. Rezultati, ki temeljijo na takšnih podatkih, imajo visoko stopnjo verodostojnosti, saj analitik lahko sklepa, da odražajo dejanske razmere. Kadar so podatki delno nepopolni ali vključujejo manjša odstopanja, je treba njihovo kakovost označiti kot srednjo. Takšni podatki še vedno omogočajo izvedbo analize, vendar mora analitik natančno navesti, kako morebitne vrzeli vplivajo na razumevanje rezultatov. Podatki z nizko stopnjo kakovosti so tisti, ki vsebujejo več napak, so nepopolni ali niso dovolj natančni za namen analize. Tudi takšni podatki niso brez vrednosti, vendar zahtevajo previdnost in lahko vodijo do večje stopnje negotovosti.

Vpliv nekovostnih podatkov postane najbolj očiten pri interpretaciji rezultatov. Tudi tehnično pravilno izvedena analiza ne more zagotoviti zanesljivih zaključkov, če temeljni podatki niso ustrezni. Zato je eden ključnih elementov tega pristopa, da se vsak podatek obdela skupaj z oceno kakovosti, ki analitiku omogoča razumeti, kako podatkovne omejitve vplivajo na obseg in natančnost rezultatov. Na ta način se zmanjšuje tveganje napačnih odločitev, ki bi temeljile na preveč optimistični

interpretaciji ali napačnih predpostavkah. Poleg tega ocena kakovosti podatkov uporabniku omogoča realnejše razumevanje rezultatov, saj mu jasno pokaže, kje so meje zanesljivosti analize.

Stopnje kakovosti podatkov imajo pomembno vlogo tudi pri dolgoročni rabi analiz v organizaciji. Tak pristop omogoča, da se podatki ne obravnavajo enkratno, temveč se sčasoma izboljšujejo preko ponavljajočih se procesov preverjanja. Z vsako izvedbo analize podjetje bolje razume, kje prihaja do največjih vrzeli, in lahko usmerja napore v izboljšave. Takšen krožni proces povečuje zanesljivost podatkovnega okolja in omogoča razvoj bolj naprednih analitičnih pristopov. Kakovost podatkov torej ni le pogoj za dobro analizo, temveč tudi gonilo stalnega izboljševanja analitičnega ekosistema.

Razumevanje kakovosti podatkov je zato bistveno za pravilno interpretacijo rezultatov in za dolgoročno zanesljivost analitičnih postopkov. Tak pristop zagotavlja, da je ta vidik vedno vključen v proces, kar omogoča bolj premišljeno uporabo analiz v podporo tehničnim in strateškim odločitvam.

6 Zaključek

Standardizirani pristop k podatkovni analitiki je celovit in zanesljiv okvir za pripravo, izvedbo in predstavitev analiz v podjetjih. Z vzpostavitvijo enotnega vsebinskega, podatkovnega in procesnega modela analize omogoča dosleden način dela, ki analitikom zagotavlja večjo preglednost, ponovljivost in sledljivost, uporabnikom pa večje zaupanje v rezultate. Standardizirani postopki od zahteve do poročila ustvarjajo okolje, kjer vsaka analiza temelji na preverjenih podatkih, jasno opredeljenih ciljih in razumljivo predstavljenih rezultatih. Tak pristop ne izboljšuje le kakovosti posameznih analiz, temveč tudi celotno podatkovno kulturo v podjetju.

Poseben pomen metodologije izhaja iz poudarjanja kakovosti podatkov kot ključnega elementa analitičnega dela. Z upoštevanjem stopenj njihove zanesljivosti in njihovih omejitev se rezultati interpretirajo realistično in odgovorno, kar zmanjšuje tveganje napačnih odločitev. Pristop omogoča, da se sčasoma izboljšuje tudi samo podatkovno okolje, saj sistematično preverjanje podatkov usmerja pozornost na področja, kjer so potrebne izboljšave. Standardizirana analiza tako ne

deluje le kot posamezen analitični postopek, temveč kot dolgoročen mehanizem za dvig kakovosti podatkov in podporo strateškemu razvoju organizacije.

S predstavljenim modelom pripravljenosti podatkov, procesnim potekom analize in metodologijo poročanja takšna analiza prispeva k večji preglednosti, učinkovitosti in strokovnosti delovanja. Rezultati analiz postanejo bolj primerljivi, postopki bolj predvidljivi, sodelovanje med naročniki in analitiki pa bolj usklajeno. V kontekstu nenehno rastoče količine podatkov in vse večjih zahtev po njihovi zanesljivi uporabi se tak pristop izkaže kot nepogrešljiv del analitičnega okolja podjetja.

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DIGITAL APPROACHES TO LOWER-LIMB PROSTHESIS OPTIMIZATION

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Lower-limb prosthesis optimization remains a complex clinical challenge, as gait compensations and alignment-related deviations are often difficult to identify through only visual assessment. This paper demonstrates how integrated digital gait assessment can provide objective, clinically relevant insight into prosthesis-related movement patterns. A laboratory study was conducted using marker-based motion capture, ground reaction force measurement, and treadmill-based plantar pressure analysis to characterize gait kinematics, kinetics, and load distribution during walking and stance. The results reveal multi-segment compensations involving pelvic control, transverse-plane knee motion, ankle–foot function, and asymmetric weight-bearing strategies. To extend descriptive findings toward mechanistic understanding, an OpenSim-based musculoskeletal modeling workflow is introduced as a decision-support pipeline for joint-level interpretation. Together, the results illustrate how complementary digital methods can support evidence-based prosthesis fitting and alignment decisions, while highlighting a practical pathway toward scalable, technology-assisted rehabilitation workflows.

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1 Introduction

Lower-limb amputation remains a major and growing rehabilitation challenge, driven by chronic vascular conditions, diabetes, aging populations, trauma, and conflicts. While the global epidemiology varies by region and cause, recent burden-of-disease analyses show that traumatic amputations alone represent a substantial and persistent health burden worldwide (Yuan, Bei, et al., 2023). At the same time, national projections illustrate that limb loss prevalence is expected to increase markedly in the coming decades, largely due to vascular disease and diabetes trends (Rivera, Julio A., et al. 2024).

Beyond the initial surgical outcome, long-term mobility depends heavily on the prosthesis–user interface and the user’s ability to regain stable, efficient gait. However, walking with a lower-limb prosthesis is commonly associated with deviations in spatiotemporal and kinetic gait characteristics, compensatory strategies, elevated metabolic demand, and secondary musculoskeletal issues (Lathouwers et al., 2023).

Residual limb discomfort is also a critical barrier to prosthesis use: systematic evidence indicates a high prevalence of residual limb pain after lower-extremity amputation, which can directly limit daily function and prosthesis tolerance (List et al., 2021). These challenges translate into a practical clinical problem: many users do not achieve consistently symmetric, confident gait patterns, and prosthetic optimization often requires iterative adjustments that are time-consuming and expertise-intensive.

In response, digital health and rehabilitation engineering increasingly leverage portable sensing and computational modeling to provide more accessible, quantitative insight. Wearable inertial measurement units (IMUs) have become a particularly promising pathway because they are relatively low-cost, unobtrusive, and can enable gait monitoring beyond laboratory environments. Recent reviews have highlighted that inertial sensing can support objective gait characterization in individuals with limb loss, with applications spanning movement analysis, fall–risk–related metrics, and technology-assisted prosthetic development (Demeco et al., 2023). Complementary to sensing, musculoskeletal modeling and simulation offers a structured way to interpret movement data mechanistically - linking observable

kinematics and external forces to internal quantities such as joint moments, joint reaction forces, and muscle–tendon loading (Seth et al., 2011).

Importantly, the choice and integration of digital methods affects clinical workflows, resource allocation, and the scalability of evidence-based prosthetic services. This paper positions these trends within a practical research question relevant to modern rehabilitation services: How can digital assessment and biomechanical modeling technologies be integrated to support evidence-based optimization of lower-limb prostheses while remaining feasible for broader clinical use?

2 Digital technologies for prosthesis optimization

Digital approaches for lower-limb prosthesis optimization can be grouped into (chapter 2.1) laboratory-grade quantitative gait analysis (typically combining optical motion capture with force measurement), (chapter 2.2) portable and wearable sensing for point-of-care or real-world monitoring, and (chapter 2.3) biomechanical modeling and simulation for biomechanical interpretation.

2.1 Optical motion capture and laboratory-based quantitative gait analysis

Marker-based optical motion capture (MoCap) systems are widely regarded as reference methods for three-dimensional gait analysis and are frequently used as a benchmark for evaluating emerging motion assessment technologies. In prosthetics research, MoCap is commonly applied to capture detailed kinematic data and is often combined with force plates to enable the estimation of joint moments, joint reaction forces, and other kinetic variables relevant to prosthetic alignment and gait compensation (Baker, 2013; Nolasco, L. A., et al., 2023).

For individuals with lower-limb amputation, laboratory-based gait analysis provides high-resolution insight into asymmetries, compensatory strategies, and prosthesis–user interactions under controlled conditions. Such analyses have been shown to support a deeper understanding of how prosthetic components, alignment, and user adaptation influence gait mechanics and functional performance (Gailey et al., 2008; Lathouwens et al., 2023). As a result, MoCap-based systems are frequently described

as the most comprehensive approach for quantitative gait assessment in prosthetic research settings.

Despite these advantages, several studies highlight substantial barriers to the routine clinical implementation of optical motion capture. These include the need for dedicated laboratory infrastructure, extensive setup time related to marker placement and system calibration, and the requirement for highly trained personnel to acquire and interpret data (Muro-de-la-Herran et al., 2014; Wishaupt, R., et al., 2024).

2.2 Wearable sensing and IMU-based gait analysis

Wearable sensing, most notably through inertial measurement units (IMUs), has become a central focus in contemporary gait assessment because it enables portable, relatively low-cost, and scalable measurements beyond specialized laboratories. Recent evidence syntheses emphasize that IMU-based systems can capture clinically meaningful gait information while reducing operational barriers such as infrastructure requirements, long setup times, and the need for dedicated gait-lab personnel (Prisco et al., 2025).

Across rehabilitation and prosthetics contexts, IMUs are typically used to derive:

- temporal gait events (e.g., heel strike and toe-off),
- spatiotemporal indicators (e.g., cadence, step/stride time, stance/swing timing),
- in multi-sensor configurations, estimates of segment/joint kinematics.

IMU deployments range from multi-sensor full-body solutions (often used to approximate joint kinematics) to minimal sensor setups intended primarily for gait event detection and temporal parameter monitoring. Recent work in prosthesis-user cohorts demonstrates that IMU-based pipelines can be validated against optical motion capture and then applied to quantify gait parameters relevant to prosthesis use and alignment evaluation (Han et al., 2024).

2.3 Biomechanical modeling and simulation for prosthesis optimization

Biomechanical modeling and simulation provides a complementary pathway to experimental gait assessment by linking observable movement to internal biomechanical quantities that are difficult to measure directly in vivo (e.g., joint moments, joint reaction forces, and muscle–tendon loading). Contemporary musculoskeletal simulation platforms enable researchers and clinicians to perform inverse kinematics/dynamics analyses and explore mechanistic “what-if” scenarios relevant to rehabilitation decision-making and device configuration (Seth et al., 2011).

In the context of lower-limb prosthetics, simulation is increasingly used to examine how prosthetic configuration, alignment, and limb-loss related constraints may influence gait mechanics and compensatory strategies. Recent studies have introduced and shared OpenSim-based models specifically tailored to amputee populations (e.g., transfemoral limb loss and osseointegration scenarios), supporting both inverse-dynamics analyses and predictive/optimal-control simulations (Raveendranathan et al., 2023; Miller et al., 2024; Carloni, R., et al., 2024).

3 Methodology

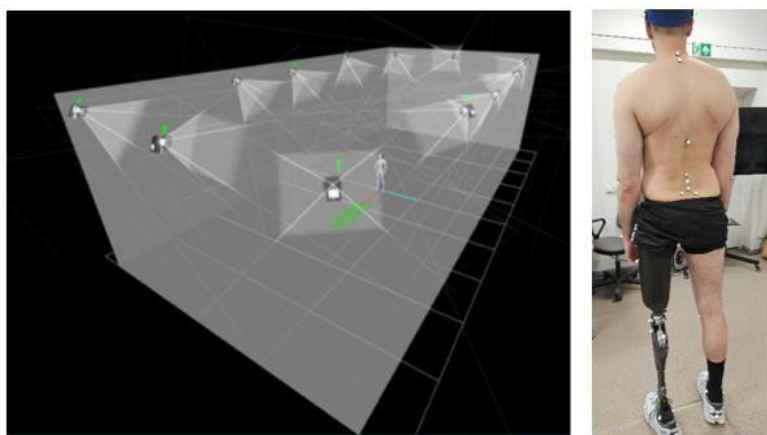


Figure 1: Laboratory gait analysis setup (optical cameras and force plates) and subject with markers attached

Source: Own

In the study of biomechanical gait characteristics, a subject with a left above-knee amputation (male, 28 years old, body mass 85 kg, height 1.95 m) volunteered to participate. Gait trials were repeated six times with 1 minute break between them.

Three-dimensional kinematic data were collected using a marker-based optical motion capture system (Qualisys) comprising 12 Oqus 7 cameras operating at a sampling frequency of 120 Hz. Markers were attached to anatomically important parts of the body according to the recommendations of the Rizzoli Orthopedic Institute. Ground reaction forces were synchronously recorded using two AMTI force plates.

In addition, treadmill-based gait analysis was performed using a Rehawalk HP Cosmos treadmill combined with a Zebris FDM-T pressure measurement system, which integrates a plantar pressure sensor matrix operating at 120 Hz. This setup enabled complementary assessment of foot–ground interaction and load distribution during prosthetic gait. Furthermore, a musculoskeletal modeling workflow is under development using OpenSim to enable model-based interpretation of gait data, with particular focus on joint reaction force–oriented analysis.

As this investigation represents a single-subject demonstration study, results are reported descriptively without inferential statistical testing. The focus is placed on illustrating the type and depth of biomechanical information that can be obtained using digital gait assessment technologies and how such information may support prosthesis fitting and alignment decisions. From an organizational perspective, this workflow reduces subjective interpretation and supports structured, repeatable clinical decision-making.

4 Results

4.1 Laboratory gait analysis results

A single-subject laboratory gait assessment at self-selected walking speed revealed a consistent pattern of prosthesis-side compensations and alignment-related deviations. In the frontal plane, the pelvis demonstrated reduced prosthesis-side pelvic elevation, indicating a contralateral pelvic drop and limited hip stabilization during stance on the prosthetic limb.

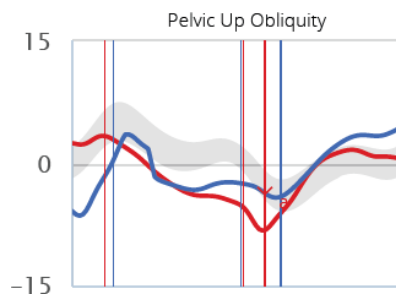


Figure 2: Pelvic obliquity per gait cycle (the blue curve represents the healthy limb, while the red curve represents the prosthetic limb)

Source: Own

At toe-off, pelvic obliquity reached -8.23° on the prosthesis side compared to 3.40° on the healthy limb. The grey shaded band represents ± 1 standard deviation from the mean normative value derived from a control group of 18 healthy adults. This pattern is clinically relevant because reduced frontal-plane pelvic control may contribute to whole-body compensation strategies, including increased reliance on the healthy limb and upper-body adjustments during gait.

Lower-limb joint kinematics further indicated reduced bilateral hip internal rotation, suggesting limited transverse-plane mobility or constrained movement strategies during walking. At the knee, the prosthesis-side knee exhibited increased internal rotation, a deviation that is more plausibly related to prosthetic alignment and transverse-plane control.

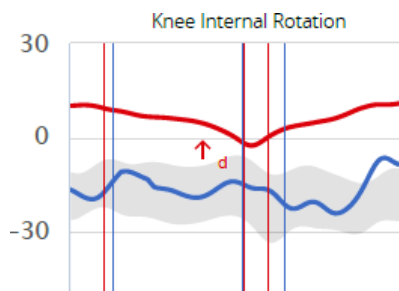


Figure 3: Knee internal rotation per gait cycle (the blue curve represents the healthy limb, while the red curve represents the prosthetic limb)

Source: Own

At the ankle–foot level, sagittal-plane kinematics revealed asymmetry in push-off behavior. At toe-off, the healthy limb demonstrated substantial plantarflexion (-28.2°), whereas the prosthetic side reached only 3.6° , indicating an absence of active push-off mechanics on the prosthetic limb. This reduced plantarflexion capacity is consistent with the functional characteristics of prosthetic ankle–foot systems and likely contributes to altered propulsion and compensatory loading patterns. Also, the prosthetic limb exhibited limited rotational variability, with values of approximately 3° across the gait cycle, while the sound limb showed a pronounced peak internal rotation of 11.35° . This pattern suggests increased reliance on transverse-plane adjustments of the intact limb to maintain forward progression and overall gait stability.

Kinetic outputs complemented these observations. Internal hip valgus moments were within normative limits bilaterally, indicating generally adequate hip loading capacity under the tested condition. However, the healthy limb demonstrated a reduced internal knee valgus moment, which may reflect altered load distribution and highlights the importance of strength and control capacity on the intact side in unilateral prosthesis users.

Table 1: Summary of key gait deviations identified by laboratory gait analysis

Feature	Parameter	Observed pattern	Interpretation
Pelvic motion	Pelvic obliquity	Decreased prosthesis-side pelvic elevation	Reduced hip stabilization during stance on the prosthetic limb
Hip kinematics	Hip internal rotation	Decreased bilaterally	Limited transverse-plane hip mobility during gait
Knee kinematics (prosthetic limb)	Knee internal rotation	Increased	Alignment- or control-related transverse-plane deviation
Ankle kinematics (prosthetic limb)	Ankle dorsiflexion	-28.2° (healthy) vs 3.6° (prosthetic)	Limited ankle–foot function and absence of active push-off
Hip kinetics	Internal hip valgus moment	Within normal limits bilaterally	Adequate frontal-plane hip loading capacity
Upper-body kinematics	Shoulder flexion	Increased bilaterally	Forward-flexed posture and trunk compensation
Spatiotemporal	Step length	0.76 vs 0.89 m (Shorter on healthy limb)	Asymmetric stepping following prosthetic stance
Spatiotemporal	Stance time	65.9% vs 58.8% (Increased prosthetic stance)	Stability-oriented gait

4.2 Plantar pressure and stance analysis

Treadmill-based stance and plantar pressure analysis provided additional insight into static load distribution and postural control characteristics during standing. The Zebris stance assessment revealed a clear asymmetric load distribution between limbs, with higher total loading observed on the healthy limb compared to the prosthetic limb. Average force distribution indicated that the prosthesis side contributed approximately 41% of the total load, whereas the healthy limb bore approximately 59%, reflecting a protective unloading strategy of the prosthesis side during stance. Segmental analysis of plantar loading further demonstrated marked asymmetry in foot loading patterns. On the prosthesis side, load was concentrated almost exclusively in the forefoot region, 100% load, with negligible contribution from the backfoot. In contrast, the healthy limb exhibited a more physiologically distributed load between forefoot and backfoot regions, indicating more effective rearfoot support and weight acceptance.

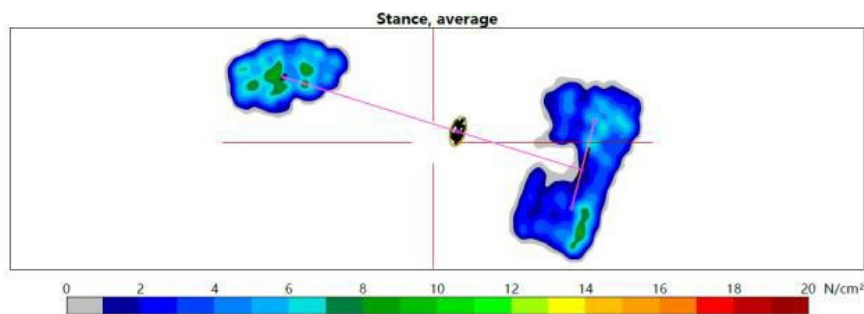


Figure 4: Plantar pressure distribution during stance (left side represents prosthetic limb)

Source: Own

These results demonstrate how pressure-based assessment can reveal clinically relevant information about prosthesis-side unloading and balance control that is not directly observable from kinematic analysis alone.

4.3 OpenSim-based workflow for biomechanical interpretation

Building on the laboratory-derived kinematic and kinetic datasets, an OpenSim-based musculoskeletal modeling workflow is being established to support the mechanistic interpretation of prosthesis-related gait deviations. The workflow is

designed to integrate motion capture kinematics and ground reaction forces to enable joint-level analysis with a particular focus on joint reaction force (JRF)–oriented interpretation.

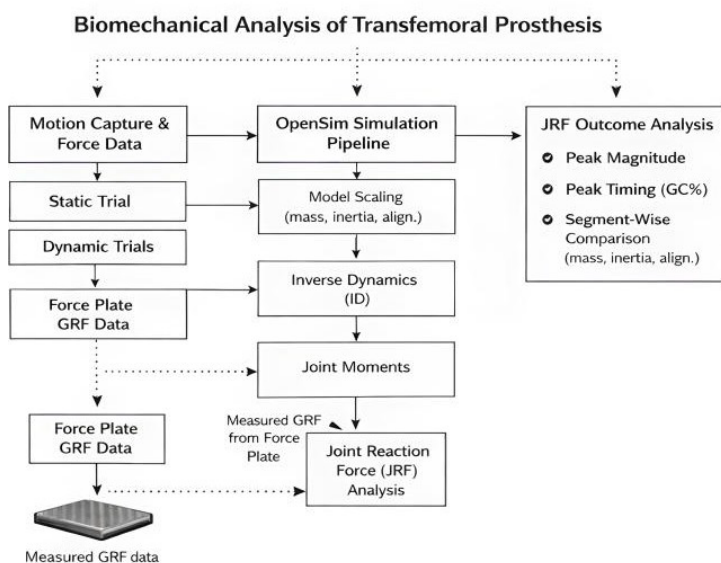


Figure 5: OpenSim simulation integration workflow

Source: Own

This workflow-oriented approach positions modeling not as a replacement for laboratory assessment, but as a decision-support extension that can help translate descriptive gait metrics into biomechanically meaningful insights relevant to prosthesis optimization.

5 Discussion and Conclusion

This study demonstrates how laboratory-grade digital gait assessment can provide detailed and clinically meaningful insight into prosthesis-related gait behavior. Motion capture analysis revealed multi-segment compensations associated with prosthesis side stance control and transverse-plane alignment, while plantar pressure assessment highlighted asymmetric weight-bearing strategies and altered foot–ground interaction during static conditions. Together, these findings illustrate that

prosthesis-related adaptations manifest across kinematic, kinetic, and balance-related domains, underscoring the limitations of observation-based assessment alone.

Beyond the descriptive findings, the results support a digitally informed approach to lower-limb prosthesis optimization. High-resolution laboratory assessment enables objective identification of alignment and control-related deviations, while complementary pressure-based measures provide additional context regarding load distribution and postural strategies. The OpenSim-based workflow presented as a progress outcome further extends these results toward mechanistic interpretation, offering a pathway to translate observable gait patterns into joint-level loading hypotheses relevant to fitting and alignment decisions.

Several limitations should be acknowledged. The results are based on a single participant and a single walking condition, and are therefore not intended for generalization. Nevertheless, the study's strength lies in demonstrating the type and depth of information that can be obtained using integrated digital assessment methods. Future work will focus on applying the presented workflow across larger cohorts, incorporating scalable sensing solutions, and advancing musculoskeletal modeling toward validated, clinically feasible decision-support tools for evidence-based prosthesis optimization.

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IMPLEMENTING ARTIFICIAL INTELLIGENCE IN THE PUBLIC SECTOR: BETWEEN NATIONAL STRATEGY AND LOCAL CHALLENGES

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Implementing artificial intelligence requires institutional capacity, yet mismatches across public-sector tiers are often neglected. The central government typically has stronger capacity, centralised information systems, larger budgets, and direct access to national digital strategies, which increases AI readiness. In contrast, local government is fragmented and resource-constrained; AI readiness is reduced by non-interoperable systems, shortages of experts, and dependence on external vendors. National strategies often lack concrete municipal support mechanisms (shared platforms, targeted funding, training), leaving smaller municipalities reactive. This paper reviews and examines stakeholder inclusion in AI implementation and identifies key adoption factors. The analysis assumes both national and local digital strategies that specify rationales (service quality, process optimisation, transparency), employee training on ethics and digital skills, funding models, mechanisms to enhance municipal agility, and active involvement of citizens, experts, and other stakeholders. An exploratory case study was conducted using document analysis and focus groups, with interaction intensity assessed across the collaborative process.

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1 Introduction

AI is increasingly positioned as a tool for improving public services and internal efficiency, yet implementation capacity differs substantially across parts of the public sector (van Noordt & Misuraca, 2022; Wirtz et al., 2019). Central administrations typically have stronger institutional capacity, more centralised information systems, larger budgets, and closer access to national digital strategies. At the same time, municipalities often operate with fragmented systems, tighter resources, and limited specialist expertise, which can leave local implementation reactive and uneven (Mergel et al., 2019; Wirtz et al., 2019).

Prior research on public-sector AI highlights a persistent strategy to implementation gap, where high-level commitments are not matched by local enabling conditions such as interoperable systems, specialised expertise, training, and predictable financing. In Slovenia, this gap is visible in the contrast between centralised national ambitions and the operational realities of municipalities, particularly smaller ones that depend more heavily on external vendors and ad hoc solutions. These dynamics raise a governance question: how do stakeholder inclusion and collaboration shape AI implementation trajectories, and which mechanisms are required to move from isolated experimentation toward accountable, routinised adoption? Therefore, this paper examines stakeholder inclusion in municipal AI implementation and identifies key adoption factors that condition progress throughout the collaborative process, capturing how coordination patterns, capacity constraints, and support mechanisms affect implementation at the local level.

1.1 National and Local Digital Strategies for AI Implementation

The digital transformation of Slovenia's public sector is currently guided by an ambitious dual-track approach that seeks to reconcile high-level national strategic objectives with the practical, often constrained, realities of local governance (Ministry of Digital Transformation [MDT], 2025; Aristovnik et al., 2025). While the National Program for Artificial Intelligence 2030 (NpUI 2030) outlines a vision for Slovenia to become an active co-shaper of the global AI landscape, local municipalities face significant hurdles in moving from ad hoc tool use to systemic integration (MDT, 2025; Aristovnik et al., 2025).

The core of Slovenia's digital strategy is the NpUI 2030, which serves as an upgrade to the 2025 framework and focuses on technological, data, and linguistic sovereignty (MDT, 2025). This strategy is designed to ensure that Slovenia is not merely a consumer of global AI commercial products, but a developer of solutions tailored to its own cultural and legal context. A central pillar of this sovereignty is the GaMS model, a large language model specifically trained on Slovenian language corpora to preserve national identity in the digital era (MDT, 2025).

The national strategy is anchored by ten leading principles, including responsibility, safety, and public interest, which aim to foster public trust in digital services (MDT, 2025). Administratively, the strategy introduces a centralised governance model led by the Ministry of Digital Transformation, supported by a Permanent AI Forum and an AI Observatory to monitor progress through Key Performance Indicators (KPIs). These bodies are tasked with ensuring that 80% of key public services are executed digitally by 2030, a goal harmonised with the Digital Slovenia 2030 (DSI 2030) framework (MDT, 2023).

Despite the clear national roadmap, the existing empirical evidence suggests a significant implementation gap at the local level. Research among municipal employees reveals that although individual motivation is high, organisational readiness remains low. Slovenian municipalities, which are predominantly small to medium-sized organisations, often lack the financial resources and technical infrastructure found in larger state institutions (Aristovnik et al., 2025).

Financial constraints are cited by 55% of organisations as a primary barrier to AI adoption, alongside a lack of access to high-quality, interoperable data (Digital Innovation Hub Slovenia [DIH], 2025). At the local level, this is compounded by bureaucratic rigidity and the absence of clear internal guidelines for recording AI use, raising concerns about the transparency and accountability of administrative procedures (Aristovnik et al., 2025).

To address these challenges, the NpUI 2030 introduces six horizontal building blocks (HG) designed to provide the necessary support structures for both national and local entities (MDT, 2025).

The six horizontal building blocks are:

- Technological Sovereignty: Developing national capacities to reduce dependence on foreign commercial providers and strengthening national AI know-how.
- Infrastructural Support: Building the necessary computing (HPC) and data infrastructure to support AI development.
- Data Availability: Ensuring access to high-quality data for training and implementing AI models.
- Regulatory Framework: Establishing legal rules, ethical standards, and regulatory sandboxes for safe and trustworthy AI.
- Language Technologies: Protecting and developing the Slovenian language in the context of digital and AI tools.
- Human Resources, Skills, and Talent: Enhancing competencies, fostering education, and developing talent to support AI.

Table 1: Comparison of National Strategic Goals vs. Local Operational Realities

Strategic Dimension	Strategic Dimension	Local Municipal Reality
Governance	Centralised leadership via MDT and Inter-ministerial Group.	Fragmented; lack of designated AI officers or formal local guidelines (Aristovnik et al., 2025).
Technology Use	Systemic "mainstreaming" of predictive and autonomous AI.	Isolated use; 92% dominance of generative tools for basic text tasks (Aristovnik et al., 2025).
Skills & Training	Systematic training of 500+ servants/year; AI literacy for all.	High competence gap; 41% of staff report zero access to AI training (Aristovnik et al., 2025).
Infrastructure	Access to sovereign HPC (SLAIF) and national cloud.	Predominant use of public clouds; only 6% currently use HPC (DIH, 2025).
Transparency	Mandatory labelling of AI content; FRIA assessments.	Low visibility; only 22% of municipalities clearly label AI content (Aristovnik et al., 2025).
Data Access	Creation of sectoral data spaces (Health, Gov, etc.).	62% of organisations lack access to adequate data for AI development (DIH, 2025).

Source: Author's own work

1.2 Research Objectives

The paper investigates how municipalities organise AI implementation as a collaborative process and which conditions shape progress from intention and early experimentation toward more structured adoption. The analysis is anchored in stakeholder inclusion and interaction dynamics, and it considers how strategic and support arrangements affect municipal implementation capacity.

Study has three main objectives. First, it targets at identifying the key stakeholder groups involved in municipal AI implementation and specify their roles across the implementation process. Second, it focuses at assessing the intensity of stakeholder interactions and coordination patterns, to determine where these patterns enable or constrain implementation. Third, it tries to isolate the main adoption factors in municipalities, including organisational capacity constraints and the adequacy of enabling mechanisms (for example, shared platforms, financing, and training support).

Following, our study is guided by the following research questions:

- RQ1. Which stakeholders are involved in municipal AI implementation, and how are their roles and responsibilities configured across the process?
- RQ2. How do interaction intensity and coordination patterns among stakeholders influence municipal AI implementation trajectories?
- RQ3. Which factors most strongly shape municipal AI adoption, and how adequate are the enabling mechanisms available to support municipalities?

2 Methodology

This study employs focus groups, a research technique that collects data through group interaction on a topic defined by the researcher (Morgan, 1996). The method is suitable for examining how shared meanings and organisational cultures shape managers' attitudes and behaviours toward municipal AI implementation and stakeholder inclusion (Rabiee, 2004). Participants were selected via purposive sampling to ensure comparable role-related characteristics and direct familiarity with the municipal context, supporting open discussion within a relatively homogeneous setting (Wilkinson, 1998). Each session was moderated and supported by note-

taking to capture non-verbal dynamics and the “group effect” (Morgan, 1996). Data were analysed through thematic coding and synthesised into theme-based summaries with illustrative statements; salient terms were additionally visualised using a word-frequency word cloud.

As this is still and ongoing study, the empirical setting consists of a single exploratory case in one large municipality in Slovenia with top- and middle-level municipal managers, selected because they combine strategic oversight with operational responsibility. This positioning makes them well placed to address the study’s objectives and RQ1–RQ3 concerning stakeholder roles, coordination and interaction intensity, and key adoption factors and enabling mechanisms.

In line with the exploratory case study design, focus group findings were complemented with document analysis to reconstruct the formal implementation context and triangulate reported practices with strategic and governance arrangements (Yin, 2018; Bowen, 2009). The document set included national and municipal digitalisation strategies, policy guidance, and relevant internal or public reports (Bowen, 2009). Interaction intensity in the collaborative process of municipal AI implementation was assessed across actors by examining interaction frequency, coordination depth, and the degree of institutionalisation through routines and formal roles (Ansell & Gash, 2008; Emerson & Nabatchi, 2015).

The focus group sample comprised 30 participants from one large municipality in Slovenia, participating in two focus groups conducted in January 2026. Participation was voluntary.

The participant profile was as follows:

- 10 were male and 20 females.
- Age was primarily 40–49 (13 participants), followed by 30–39 (9) and 50–59 (6), with 2 participants under 30 and none over 60.
- Educational attainment was predominantly tertiary: 14 participants held a university degree, and 13 held a master’s degree/specialisation, while 3 reported post-secondary non-tertiary education.

- In terms of professional background, overall work experience was concentrated in the mid to high ranges: 2 participants had less than 5 years of experience, 5 had 5–10 years, 13 had 11–20 years, 7 had 21–30 years, and 1 had more than 30 years (2 missing responses).
- Time in the current position was most commonly within five years (13 participants), with 5 reporting less than one year, 3 reporting 6–10 years, 7 reporting 11–20 years, and 1 reporting more than 20 years (1 missing response).
- Organisational tenure was reported as less than 1 year (4), 1–5 years (9), 6–10 years (5), 11–20 years (10), and more than 20 years (2).
- Most participants held a managerial role (19), while 9 did not (2 missing responses).
- Self-assessed ICT competence was uniformly average or above: 12 participants reported average skills, 13 good, and 5 very good.
- Participants most frequently reported working in spatial planning/environment/utilities (10), general affairs / HR / legal (8), finance/budget/procurement (7), economy/development / EU projects (5), and social affairs (culture, education, social services) (1). Six participants selected other units, including the mayor's office/city council, protocol and international cooperation, traffic control, and inspectorate/municipal warden services.

3 Results

First, participants described the primary purpose of current AI-related activity in operational terms, emphasising faster case handling, process optimisation, and reduced routine manual work. AI was also reported as supporting drafting and analytical tasks (for example, preparing materials and synthesising information). In addition, transparency and accessibility were mentioned as relevant public value aims associated with AI-enabled improvements.

Second, accounts regarding formalisation and organisational direction varied. Some participants reported that strategic framing is under development at the municipal level, while others indicated limited visibility of formal guidance in their everyday work. Several statements described current AI use as predominantly unit-level or individually driven, rather than coordinated through an organisation-wide approach.

Third, participants reported uneven support for capability. Skills development was most often described as self-directed, including learning by doing and participation in external seminars, with mixed perceptions of internal support. Some participants reported not being aware of any organised training. Ethics, data protection, and regulatory considerations were repeatedly cited as relevant areas, with responses indicating that their operationalisation is not uniform across organisational units.

Table 2: Themes, primary findings, and illustrative statements

Theme	Main findings	Illustrative statements
Aims of AI-related activity	Reported aims focused on speed, process optimisation, workload relief, and support for drafting/analysis; transparency and accessibility were also mentioned.	“Increase productivity/efficiency.” “Faster handling of cases.” “Support in preparing materials and analysing data.”
Formalisation and direction	Reports differed on whether guidance exists; several indicated limited visibility and reliance on individual initiative.	“With limited resources and gradually.” “Financial resources are limited, so free tools are used.” “I think there is one licence available.”
Capability support	Skill development was reported as mostly self-directed; some reported no organised training; internal support varied.	“At the individual level.” “I am not aware that we have training.” “Seminars and trainings on one’s own initiative.”
Resourcing and procurement	Resources were reported as limited; the rollout was described as gradual; reliance on free tools or existing subscriptions, and limited licences, was noted.	“With limited resources and gradually.” “Financial resources are limited, so free tools are used.” “I think there is one licence available.”
Stakeholder involvement	Involvement was reported as primarily internal; external actors were included selectively (experts/vendors) and, less consistently, citizens/state.	Employees are strongly involved.” “Employees and external experts.” “Partly also citizens and the state.”

Source: Author's own work

Fourth, resourcing and procurement were reported as constraints to implementation. Participants referred to gradual roll-out, limited budgets, the use of free tools or AI features embedded in existing subscriptions, and limited licence availability. These responses were typically framed as shaping the pace and scope of AI-related initiatives.

Fifth, participants reported that stakeholder involvement is concentrated primarily within the municipality. Employees, managers, and internal support functions (notably IT and legal) were most consistently referenced. External actors were described as involved more selectively, most commonly external experts and vendors, and less consistently citizens and the state, with involvement varying by topic and implementation phase.

Table 2 summarises the themes, the corresponding main findings, and illustrative participant statements. The distribution of key terms across the response corpus is visualised in Figure 1, which highlights the prominence of concepts related to organisational actors, capability development, and process-oriented implementation aims.



Figure 1: Word cloud of key terms in focus group responses

Source: Author's own work

As shown in Figure 1, the most salient terms relate to organisational stakeholders (e.g., employees), capacity-building instruments (e.g., training), cross-level enabling actors (e.g., the state), and operational implementation domains (e.g., processes and services), which is consistent with the thematic patterning summarised in Table 3.

4 Discussion and implications

The findings indicate an implementation pathway in which early, practice-driven AI use is progressing alongside limited institutionalisation of governance, training, and coordination. This pattern clarifies the paper's central contribution: municipal AI adoption is not explained by "readiness" in a narrow technical sense, but by the interplay between stakeholder configuration (who participates and with what responsibilities), interaction intensity (how collaboration is organised and sustained), and enabling conditions (what supports or constrains the move from experimentation to routinised use). The results provide an empirical basis for specifying "adequate enabling mechanisms" for municipalities as those that reduce person-dependence, routinise responsible use, strengthen procurement and oversight capacity, and improve interoperability and shared infrastructure (Ansell & Gash, 2008; Hickok, 2024; van Noordt & Misuraca, 2022).

Theoretically, the study advances a process-oriented view of municipal AI adoption that integrates collaborative governance logics with public-sector AI implementation scholarship. By treating implementation as a multi-actor coordination problem rather than a single-organisation technology decision, this approach shows how interaction intensity and the institutionalisation of coordination routines can be conceptualised as mechanisms that translate strategic intent into implementation trajectories (Ansell & Gash, 2008; Emerson & Nabatchi, 2015). In doing so, the paper adds granularity to established accounts of AI diffusion in government by identifying how coordination structures shape whether municipalities remain in fragmented experimentation or progress toward accountable, repeatable practices (van Noordt & Misuraca, 2022).

Practically, the results imply that municipalities should treat AI implementation as an interdisciplinary organisational change effort with explicit ownership, defined roles across internal functions (service units, IT, legal, HR, procurement), and routinised procedures for permissible use, documentation, and accountability. At the same time, the findings underscore that national-level support must be operationally usable at the municipal level. Shared platforms, structured competence development (including ethics and compliance), and predictable financing mechanisms can reduce fragmentation and mitigate vendor-dependence, while interoperability support and

common standards address a key barrier to scaling AI beyond narrow use cases (European Commission, 2024b; Hickok, 2024).

The findings suggest that municipal AI implementation in this case is advancing through a predominantly operational logic, where perceived benefits are tied to incremental process improvements and individual or unit-level use. This pattern is consistent with broader evidence that public-sector AI uptake often begins with low-risk, productivity-oriented applications. It only later shifts toward more formalised organisational adoption once governance, capacity, and integration requirements become salient (van Noordt & Misuraca, 2022). From an implementation perspective, this sequencing matters because early uptake can create a sense of progress while leaving institutional foundations underdeveloped, thereby increasing variation across units and limiting the municipality's ability to scale beyond informal or discretionary use.

The resourcing pattern reported by participants is also consistent with the broader finding that public organisations often face limited discretionary budgets for AI, uncertainty about how to measure value creation, and difficulties embedding AI investment into standard planning cycles, which collectively reinforce gradual roll-out and uneven diffusion. In municipal contexts, these constraints can further intensify reliance on existing subscriptions, free tools, and vendor-led options, which heightens the importance of procurement capacity and contract governance. The public procurement literature warns that AI procurement can amplify information asymmetries and shift control toward suppliers unless municipalities have sufficient capability to specify requirements, manage risk, and maintain accountability (Hickok, 2024).

Finally, the reported pattern of stakeholder involvement, which is strong internally and selective externally, has implications for the adequacy of enabling mechanisms available to municipalities. If municipal AI adoption is shaped by uneven capability development and limited resourcing, then support mechanisms need to be evaluated for their operational usability at the local level, not just for their formal availability.

To sum up, the study suggests that municipal AI adoption is best understood as a coordination and capacity-building challenge embedded in multi-level governance, rather than merely a technological upgrade. Strengthening interaction intensity

through institutionalised collaboration, alongside targeted enabling mechanisms that address skills, procurement oversight, and interoperability, appears central to moving municipalities from fragmented experimentation toward accountable implementation and sustainable public value creation (Ansell & Gash, 2008; van Noordt & Misuraca, 2022).

5 Concluding reflections

Paper addresses three main research questions. For RQ1, the stakeholder configuration reported by participants places internal actors at the centre of implementation, with employees, managers, and internal support functions (notably IT and legal) described as the most consistently involved groups. This is consistent with public administration accounts of AI implementation as a compliance-intensive, socio-technical change process in which operational units, legal assurance, and technical support jointly determine what can be adopted and under which constraints (Mergel et al., 2024; Straub et al., 2023). The more selective role of external actors, especially vendors and external experts, also reflects a typical capacity pattern in which municipalities draw on market and expert support when internal capability is limited, which can influence the distribution of decision rights and practical control during implementation (Hickok, 2024).

For RQ2, the reported variation in strategic visibility and the prominence of unit-level or individual initiative can be interpreted as a coordination structure with uneven interaction intensity across organisational segments. Collaborative governance scholarship emphasises that implementation trajectories depend not only on actor presence but on how interaction is organised and institutionalised through routines, shared procedures, and stabilised roles (Ansell & Gash, 2008; Emerson & Nabatchi, 2015). Where coordination is not routinised, collaboration becomes episodic and person-dependent, increasing fragmentation and creating discontinuities in implementation between experimentation, formalisation, and scaling. This aligns with more recent evidence that AI changes bureaucratic work in ways that are contingent on organisational context and coordination arrangements, producing divergent outcomes across units within the same administration (Giest & Klievink, 2024).

For RQ3, the findings point toward a bundle of adoption conditions that jointly shape municipal trajectories: capability development, responsible-use operationalisation, and resource constraints. The prevalence of self-directed learning and uneven training provision closely aligns with system-level assessments that identify skills gaps and limited structured guidance as persistent constraints, especially when organisations attempt to move from ad hoc use to repeatable, accountable processes. Importantly, participants' emphasis on ethics, data protection, and regulatory considerations indicates that "readiness" is not reducible to tool access; it requires role-specific procedures for permissible use cases, documentation standards, escalation routes, and accountability allocation, which the public-sector literature treats as central to legitimacy and risk management in AI-enabled work (Mergel et al., 2024; Straub et al., 2023).

Several limitations of the paper should be considered. First, the study is still ongoing and is thus based on an exploratory single-case design in one large municipality, which limits statistical generalisability and may under-represent constraints faced by smaller municipalities with lower capacity, although it helps getting an insight into theory-building perspective. Second, the evidence is derived from focus group accounts and short written responses, which reflect perceptions at a particular time point and do not directly measure actual AI use, performance outcomes, or longitudinal changes in governance routines. Third, the participant group consisted of top and middle management; perspectives from frontline employees, IT specialists, legal officers, vendors, and citizens were not systematically captured, although these actors were discussed as relevant stakeholders. Following, these limitations will be addressed in the further stages of research through comparative, longitudinal, and multi-actor research designs.

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ZMANJŠANJE INCIDENCE BOLNIŠNIČNIH OKUŽB

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Bolnišnične okužbe v Sloveniji predstavljajo naraščajoč problem na področju kakovosti in varnosti tako za paciente kakor zaposlene ter posledično stroške, ki ob tem nastajajo. Incidenca bolnišničnih okužb je povezana izolacijskimi ukrepi pacientov in z njimi povezanimi ukrepi za preprečevanje prenosa okužb. V terciarnem zavodu smo izvedli 4429 dezinfekcij v obdobju enega leta z uporabo sodobne naprave. Na enem izmed oddelkov smo izvedli primerjalno analizo izvedbe dezinfekcije, vezano na postopke pred čiščenjem, po ročnem čiščenju in dezinfekciji ter po uporabi sodobnih naprav. Ugotovili smo, zelo močno rast večkratno odpornih bakterij pred čiščenjem; v štirih primerih slabo rast in v enem močno rast po ročnem čiščenju in dezinfekciji, po uporabi sodobne naprave ni bilo zaznanih rasti večkratno odpornih bakterij. Glede na ugotovitve in prevalenco se managementu postavlja pomembno vprašanje, ali je nakup sodobne opreme strošek ali investicija. Zaključimo lahko, da je to investicija tudi v zagotavljanje kakovostne in varne zdravstvene oskrbe za paciente in zaposlene.

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REDUCING THE INCIDENCE OF NOSOCOMIALLY AFFECTED INFECTIONS

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Hospital infections in Slovenia constitute a growing problem in the field of quality and safety for both patients and employees, and consequently for the associated costs. The incidence of hospital infections is also related to patient isolation, and other measures to prevent the transmission of infection. At a tertiary institution, we performed 934 disinfections over 1 year using a modern device. In one of the departments, we conducted a comparative analysis of disinfection procedures performed before cleaning, after manual cleaning and disinfection, and after the use of modern devices. We observed substantial growth of multidrug-resistant bacteria before cleaning; poor growth in four cases; and strong growth in one case after manual cleaning and disinfection. After using a modern device, no growth of multidrug-resistant bacteria was detected. When it comes to the cost of hospital infections and their prevalence, management faces an important question: Is the purchase of modern equipment a cost or an investment? We can conclude that this is an investment, including in the provision of high-quality, safe healthcare for patients and employees.



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1 Uvod

Breme okužb, povezanih z bolnišnično oskrbo, postaja globalni problem in pomemben problem zdravstvene varnosti. Gre za okužbe, pridobljene med zdravljenjem zaradi zdravstvenih ali kirurških stanj, ki v času sprejema niso bile prisotne. To še poslabšuje pojav virulentnih in visoko tveганиh bakterijskih sevov (Monegro et al., 2020).

Ocenjuje se, da se v Evropski uniji in Evropskem gospodarskem prostoru (EU/EGP) vsako leto pojavi več kot 3,5 milijona primerov okužb, povezanih z bolnišničnimi boleznimi, kar povzroči več kot 90 tisoč smrti in ustreza približno 2,5 milijona let življenja, kar po ocenah presega kumulativno breme drugih okužb, vključno z gripo in tuberkulozo v EU/EGP (ECDC, 2026). Po podatkih Svetovne zdravstvene organizacije (WHO, 2022) 7 od 100 bolnikov v državah z visokimi dohodki in 15 od 100 v državah z nizkimi in srednjimi dohodki med zdravljenjem pridobi vsaj eno bolnišnično okužbo. To niso redki dogodki – so pogosti, preprečljivi zapleti, ki ogrožajo paciente in preobremenjujejo zdravstvene sisteme.

Najpogostejša vrsta okužb, povezanih z zdravstveno oskrbo, ob sprejemu je bila okužba mesta kirurškega posega (25,7 %). Prevalenca pacientov z vsaj eno okužbo, povezano z zdravstveno oskrbo, se je gibala med 4,4 % v primarnih bolnišnicah in 7,7 % v terciarnih bolnišnicah. Najvišja je bila pri bolnikih na intenzivni negi, in sicer 20,5 %, v primerjavi s 6,4 % za vse druge specialnosti skupaj (ECDC, 2024). Prevalenca okužb, povezanih z zdravstveno oskrbo, v slovenskih bolnišnicah za akutno oskrbo je bila leta 2017 precejšnja, zlasti na oddelkih za intenzivno nego. Preprečevanje in obvladovanje okužb, povezanih z zdravstveno oskrbo, je pomembna prednostna naloga javnega zdravja. Razviti je treba nacionalni nadzor okužb, povezanih z zdravstveno oskrbo, na oddelkih za intenzivno nego, da bi podprli preprečevanje in obvladovanje okužb, ki temeljijo na dokazih (Klavs et al., 2019).

Glavni izzivi, povezani z bolnišničnimi okužbami, so pomanjkljivosti pri higieni rok, neustrezna uporaba protimikrobnih zdravil, nepravilno ravnanje z invazivnimi pripomočki in neupoštevanje institucionalnih protokolov. Učinkovite strategije preprečevanja vključujejo stalno usposabljanje zaposlenih, izvajanje dezinfekcijskih postopkov, racionalno uporabo antibiotikov in aktivni nadzor s strani bolnišničnih

odborov za nadzor okužb. Vloga zaposlenih v zdravstveni negi, kliničnega farmacevta in ostalih zdravstvenih delavcev je prav tako poudarjena kot ključni element pri zmanjševanju tveganj. Raziskava ugotavlja, da čeprav so izzivi bolnišničnih okužb splošno prepoznani, je vrzel med teorijo in prakso precejšnja. Učinkovito preprečevanje zahteva interdisciplinarne ukrepe, stalno izobraževanje in stalno spremljanje (da Costa et al., 2025).

ECDC ocenjuje, da javne bolnišnice zaradi okužb, povezanih z zdravstveno oskrbo, izgubijo do 6 % proračuna. To so viri, ki bi sicer lahko bili namenjeni zaposlovanju dodatnega osebja, vlaganju v napredno oskrbo ali izboljšanju izidov zdravljenja. Preprečevanje okužb ni le medicinska odgovornost, je finančna nujnost (OECD, 2019). Ocenjuje se, da je do 50 % okužb, povezanih z zdravstveno oskrbo, mogoče preprečiti. Uporaba ukrepov za preprečevanje in obvladovanje okužb v zdravstvenih ustanovah je bistvenega pomena za preprečevanje okužb, povezanih z zdravstveno oskrbo (ECDC, 2026).

Namen prispevka je predstaviti problematiko bolnišničnih okužb v Sloveniji kot pomemben izziv na področju kakovosti in varnosti zdravstvene obravnave ter osvetliti njihov vpliv na paciente in zdravstvene delavce.

2 Metodologija

Izvedena je bila presečna retrospektivna statistična raziskava na podlagi primerjalne analize dezinfekcij v obdobju enega leta v terciarnem zavodu.

2.1 Opis vzorca

Izvedena je bila presečna retrospektivna statistična raziskava, v katero je bilo v terciarnem zavodu v obdobju enega leta vključenih 4429 izvedenih dezinfekcij v 26 različnih enotah, vključno z operacijskimi dvoranami, negovalnimi oddelki in oddelki intenzivne terapije.

2.2 Zbiranje podatkov

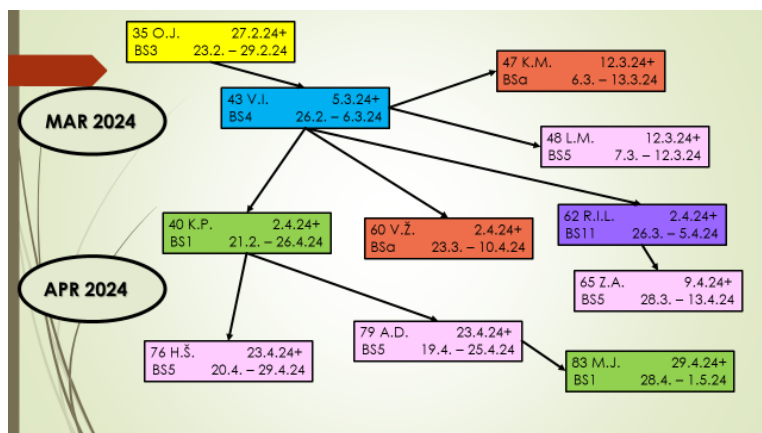
Podatke smo zbirali v sistemu SPOT, ki online spremlja naprave, nameščene v zavodu. Spremlja podatke o številu dezinfekcij in času, ki je bil opravljen. Podatke smo prav tako zbirali z odvzemi brisov površin.

2.3 Statistična analiza

Narejena je bila opisna statistika. Za raven statistične pomembnosti smo uporabili $p < 0,05$. Statistična analiza je bila izvedena s programom SPSS 28.0 (IBM Corp, ZDA).

3 Rezultati

Z analizo podatkov smo ugotovili, da je bilo v letu 2025 število dezinfekcij 4429 ($\bar{x} = 5,8$ na dan), čas izvajanja med 2 in 45 ($\bar{x} = 17$) minutami. Izvajali smo sledljivost prenosov v celotnem letu (slika 1), kjer smo ugotovili prenose.



Slika 1: Primer spremljanja prenosov

Vir: Lasten

Po izvedenih dezinfekcijah smo v enem od primerov izvedli odvzem brisov (slika 2) na 12 različnih mestih in potrdili, da je pred čiščenjem prisotna tudi zelo močna, močna in slaba rast VOM (večkratno odporni mikroorganizmi). Po ročnem čiščenju

in dezinfekciji smo ugotovili močno in slabo rast. Po uporabi sodobne dezinfekcije v vseh primerih ni bilo zaznati rasti VOM.

Vzorčena površina v BSS	Pred čiščenjem	Po ročnem čiščenju in dezinfekciji	Po
Stranica postelje	Močna rast.	Ni bilo zaznane rasti.	Ni bilo zaznane rasti.
Pipa (spodnja stran)	Slaba rast. Izolat: Enterococcus faecium.	Ni bilo zaznane rasti.	Ni bilo zaznane rasti.
Milnik	Močna rast.	Močna rast.	Ni bilo zaznane rasti.
Stikalo za luč	Ni bilo zaznane rasti.	Ni bilo zaznane rasti.	Ni bilo zaznane rasti.
Obposteljna mizica	Ni bilo zaznane rasti.	Ni bilo zaznane rasti.	Ni bilo zaznane rasti.
Kljuka (senčna stran)	Ni bilo zaznane rasti.	Ni bilo zaznane rasti.	Ni bilo zaznane rasti.
Površina na vratih za kljuko	Ni bilo zaznane rasti.	Slaba rast.	Ni bilo zaznane rasti.
Etažer	Zelo močna rast.	Slaba rast.	Ni bilo zaznane rasti.
Temperaturna tabla	Ni bilo zaznane rasti.	Ni bilo zaznane rasti.	Ni bilo zaznane rasti.
Spodnji del držala izvlečne mizice	Ni bilo zaznane rasti.	Slaba rast. Izolat: Enterococcus faecium.	Ni bilo zaznane rasti.
Trapez	Zelo močna rast. Izolat: Enterococcus faecium.	Slaba rast. Izolat: Enterococcus faecium.	Ni bilo zaznane rasti.
Klicna naprava	Slaba rast. Izolat: Enterococcus faecium.	Slaba rast. Izolat: Enterococcus faecium, Enterococcus faecalis.	Ni bilo zaznane rasti.

Slika 2: Prikaz porasta VOM po različnih oblikah čiščenja in/ali dezinfekcije

Vir: Lasten

4 Razprava

Večkratno odporni mikroorganizmi (VOM) predstavljajo resno in naraščajočo grožnjo varnosti pacientov, pri čemer Svetovna zdravstvena organizacija (WHO) protimikrobno odpornost opredeljuje kot eno največjih globalnih zdravstvenih kriz sodobnega časa (WHO, 2022). V raziskavi smo ugotovili, kot potrjuje tudi WHO, da je poleg neposrednega prenosa z osebe na osebo izjemnega pomena tudi bolnišnično okolje kot ključen rezervoar patogenov, saj so številni VOM sposobni dolgotrajnega preživetja na neživih površinah ter ohranjajo kužnost tudi po večkratni izpostavljenosti suboptimalnim čistilnim postopkom (WHO, 2016).

WHO v svojih smernicah jasno navaja, da je učinkovita in dosledna dezinfekcija okolja nepogrešljiv del celostnih programov preprečevanja in obvladovanja okužb, zlasti v okoljih z visoko prevalenco VOM (WHO, 2016). Naši podatki so pokazali, da so tradicionalni, pretežno ročni postopki dezinfekcije časovno zahtevni, kadrovsko obremenjujoči in izrazito podvrženi variabilnosti, povezani s človeškim

dejavnikom, kar WHO prepoznava kot pomembno omejitev pri zagotavljanju ponovljive mikrobiološke varnosti (WHO, 2016).

V tem kontekstu predstavljajo sodobni dezinfekcijski postopki pomemben kakovostni preskok. Povprečen čas dezinfekcije se je z uvedbo sodobnih tehnologij skrajšal na približno 17 minut v primerjavi s preteklimi postopki, ki so zahtevali tudi do tri ure. Tako izrazito časovno skrajšanje ni zgolj organizacijska prednost, temveč ima neposredne epidemiološke posledice. WHO poudarja, da daljši čas nedostopnosti prostorov pogosto vodi v odstopanja od priporočenih izolacijskih ukrepov, zlasti v pogojih kadrovske in prostorske preobremenjenosti (WHO, 2022).

Standardizirani in časovno učinkoviti postopki zmanjšujejo tveganje za neustrezno ali nepopolno dezinfekcijo, ki jo WHO navaja kot enega ključnih dejavnikov za vztrajanje okoljskega rezervoarja VOM (Boyce, 2016; WHO, 2016). Zmanjšanje intervala med odpustom enega pacienta in sprejemom naslednjega, ob hkratnem zagotavljanju visoke ravni dekontaminacije, bistveno zmanjša možnost navzkrižnega prenosa mikroorganizmov, kar je zlasti pomembno pri patogenih z dokazano odpornostjo in omejenimi terapevtskimi možnostmi.

Z vidika zdravstvenega osebja WHO opozarja, da je skladnost z ukrepi tesno povezana z njihovo izvedljivostjo v praksi (WHO, 2016; Han et al., 2025). Dolgotrajni in kompleksni postopki povečujejo tveganje za odstopanja od protokolov, medtem ko sodobne dezinfekcijske tehnologije zmanjšujejo delovno obremenitev, izboljšujejo ponovljivost postopkov in omogočajo boljšo integracijo v klinične delovne prakse. Posledično se poveča skladnost z ukrepi, kar WHO izrecno navaja kot pogoj za učinkovito obvladovanje VOM (WHO, 2022).

WHO dodatno izpostavlja, da so okužbe, povezane z zdravstveno oskrbo, ki jih povzročajo VOM, povezane z daljšo hospitalizacijo, večjo umrljivostjo in znatno višjimi stroški zdravljenja (WHO, 2016). V tem okviru sodobna dezinfekcija ne predstavlja zgolj stroška, temveč ekonomsko utemeljen preventivni ukrep, ki lahko dolgoročno prispeva k zmanjšanju bremena protimikrobne odpornosti na ravni zdravstvene ustanove in celotnega sistema (Sheikh et al., 2024).

Na podlagi smernic WHO in predstavljenih ugotovitev je mogoče utemeljeno zaključiti, da sodobni, časovno učinkoviti in standardizirani dezinfekcijski postopki predstavljajo ključen podporni ukrep pri preprečevanju širjenja večkratno odpornih mikroorganizmov. Skrajšanje časa dezinfekcije z več ur na nekaj minut ob hkratnem zagotavljanju visoke učinkovitosti bistveno prispeva k večji varnosti pacientov, boljši skladnosti s preventivnimi ukrepi ter trajnostnemu obvladovanju protimikrobne odpornosti v zdravstvenih ustanovah.

Možnost nadaljnjih raziskav analizirati dejavnike, ki vplivajo na pojavnost bolnišničnih okužb, vključno z osnovnimi boleznimi pacientov, izvajanjem izolacijskih ukrepov ter učinkovitostjo preventivnih strategij za preprečevanje prenosa okužb v bolnišničnem okolju.

5 Zaključek

Ozaveščanje je prvi korak k zmanjšanju incidence bolnišničnih okužb. Vlaganje v tehnologije, ki temeljijo na dokazih, podpira programe okoljske higiene in pomaga zapolniti vrzel, ki jo pušča ročno čiščenje. Pametni, avtomatizirani sistemi zagotavljajo doslednost, dosežejo senčne površine in zmanjšujejo mikrobo obremenitev z merljivimi, potrjenimi rezultati. Ko so tveganja tako visoka in posledice tako resnične, napredna površinska dezinfekcija ni več luksuz. To je odgovornost.

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About the authors

Mojca Dobnik - Z več kot dvajsetletnimi izkušnjami v Univerzitetnem kliničnem centru Maribor deluje na področju zdravstvene nege, vodenja in izobraževanja. Poklicno pot je začela na anesteziologiji, nadaljevala kot strokovna vodja zdravstvene nege na Oddelku za revmatologijo ter kasneje in še vedno na vodstvenih in svetovalnih funkcijah v UKC Maribor in Ministrstvu za zdravje RS, kjer je bila leta 2022 vršilka dolžnosti generalne direktorice Direktorata za zdravstveno nego. Je docentka in predavateljica na več fakultetah, aktivna raziskovalka ter mentorica študentom. Aktivno sodeluje v strokovnih združenjih, komisijah in delovnih skupinah na nacionalni ravni. Prejela je najvišje priznanje Zbornice zdravstvene in babiške nege Slovenije za uspešno delo, je članica uredniškega odbora Obzornika zdravstvene nege.

Mateja Lorber - Mateja Lorber je dekanica in izredna profesorica na Univerzi v Mariboru, Fakulteti za zdravstvene vede. Pred tem je bila zaposlena v Univerzitetnem kliničnem centru Maribor. Njen interes raziskovanja je področje gerontologije, obvladovanja kroničnih bolezni, managementa in vodenja ter raziskovanja na področju zdravstvene nege. Svoja dela predstavlja na mednarodnih srečanjih in konferencah ter objavlja znanstvene članke v domačih in tujih znanstvenih revijah. Prejela je tudi najvišje priznanje Zbornice zdravstvene in babiške nege Slovenije za uspešno delo in prispevek k izvajanju programov na področju zdravstvene nege. Je glavna in odgovorna urednica revije Obzornik zdravstvene nege.

PRIMERJAVA BIPOLARNIH IN UNIPOLARNIH OCENJEVALNIH LESTVIC V ŠTUDENTSKIH EVALVACIJAH POUČEVANJA

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Prispevek empirično proučuje vpliv unipolarnih in bipolarnih ocenjevalnih lestvic na rezultate študentskih evalvacij poučevanja. V okviru pilotne raziskave sta dve primerljivi skupini študentov z uporabo različnih ocenjevalnih lestvic ocenjevali enake trditve o pedagoškem procesu. Analize porazdelitev ocen, povprečnih vrednosti in deležev odgovorov v najvišjih kategorijah kažejo, da uporaba bipolarne lestvice pri večini vprašanj vodi do statistično značilno večjega zgoščanja odgovorov v zgornjem delu lestvice ter izrazitejšega učinka stropa. Ugotovitve potrjujejo teoretična predvidevanja o vplivu polarnosti lestvic na odzivno vedenje anketirancev ter kažejo, da izbira ocenjevalne lestvice vpliva na variabilnost in interpretabilnost rezultatov evalvacij. Prispevek osvetljuje metodološke posledice izbire ocenjevalne lestvice in odpira razpravo o njeni ustreznosti v kontekstu visokošolskih evalvacijskih praks.

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A COMPARISON OF BIPOLAR AND UNIPOLAR RATING SCALES IN STUDENT EVALUATIONS OF TEACHING

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This paper empirically examines the effects of unipolar and bipolar rating scales on the outcomes of student evaluations of teaching. In a pilot study, two comparable groups of students evaluated identical items using different rating scales. Analyses of score distributions, mean values, and top-category response shares indicate that the use of a bipolar scale leads to a statistically significantly higher concentration of responses at the upper end of the scale for most items, reflecting a more pronounced ceiling effect. The findings support theoretical expectations regarding the influence of scale polarity on response behaviour and demonstrate that rating format selection affects score variability and result interpretability. The paper discusses the methodological implications of rating scale choice and contributes to the ongoing debate on appropriate evaluation practices in higher education.



University of Maribor Press

1 Uvod

Študentske evalvacije poučevanja (angl. *Student Evaluations of Teaching* – SET) predstavljajo osrednji element zagotavljanja kakovosti pedagoškega dela v visokem šolstvu in enega ključnih virov povratnih informacij o učinkovitosti poučevanja. Kljub njihovi razširjeni uporabi se pogosto domneva, da je izbira numerične ocenjevalne lestvice zgolj tehnična odločitev brez bistvenih posledic za rezultate. Vendar psihometrijske raziskave in študije pristranskosti v odzivanju kažejo, da se anketiranci na bipolarne (npr. od -2 do $+2$) in unipolarne (npr. od 1 do 5) lestvice odzivajo različno. Predhodne analize poročajo o sistematičnih vzorcih odzivanja, zlasti o izogibanju negativnim kategorijam pri bipolarnih lestvicah, kar vodi v zgoščanje odgovorov v zgornjem delu skale, zmanjšano variabilnost ocen ter pojav izrazitega učinka zgornje meje oziroma t. i. učinka stropa (angl. *ceiling effect*). Slednje se pokaže še posebej izrazito pri ocenjevanju oseb (Höhne et al., 2020; Höhne et al., 2021; Menold, 2023; Steinberg in Rogers, 2020; Nemani et al., 2025).

Namen prispevka je empirično proučiti, ali in v kolikšni meri tip ocenjevalne lestvice vpliva na ocene pedagoškega procesa in pedagoškega osebja ter osvetliti metodološke in praktične posledice izbire ocenjevalnega formata za visokošolske institucije.

2 Teoretična izhodišča in pregled sorodnih raziskav

Iz vidika polarnosti delimo ocenjevalne lestvice na *unipolarne* in *bipolarne*. Pri unipolarnih lestvicah (npr. od 1 do 5) vse vrednosti izražajo različno stopnjo iste lastnosti, pri čemer nevtralna referenčna točka ni nujno eksplicitno opredeljena, medtem ko bipolarne lestvice (npr. od -2 do $+2$) vključujejo jasno določeno sredinsko nevtralno vrednost (0) ter omogočajo razlikovanje med negativnim in pozitivnim polom ocenjevanja.

Čeprav se ocenjevalne lestvice v praksi pogosto obravnavajo kot nevtralen tehnični element pri izvedbi mnenjske raziskave, pregled literature pokaže, da značilnosti lestvic neposredno vplivajo na kakovost in verodostojnost zajetih podatkov ter veljavnost merjenja (DeCastellarnau, 2018). Ključno teoretično izhodišče predstavlja ugotovitev, da anketiranci numeričnih vrednosti ne uporabljajo le za beleženje odgovora, temveč kot vir informacij za interpretacijo pomena vprašanja (Schwarz,

1999; Schwarz et al., 1991). Ilustrativen primer tega mehanizma predstavlja študija (Schwarz et al., 1991), v kateri so avtorji primerjali vpliv lestvice na samooceno uspešnosti v življenju. Rezultati so pokazali izrazit učinek numeričnih vrednosti: medtem ko je na bipolarni lestvici (–5 do +5) le 13 % anketirancev izbralo vrednosti v spodnji polovici razpona, je na formalno ekvivalentni unipolarni lestvici (0 do 10) vrednosti v spodnji polovici izbralo kar 34 % vprašanih. Analize so potrdile, da razlika izhaja iz spremenjene semantične interpretacije pola »sploh ne uspešen«. V kombinaciji s številko 0 so anketiranci ta opis razumeli kot »odsotnost izjemnih dosežkov«, medtem ko so ga v kombinaciji s številko –5 interpretirali kot »prisotnost izrazitih neuspehov«.

Ta pojav Cabooter et al. (2016) podrobneje pojasnjujejo z učinkom simetrije (angl. *symmetry effect*). Sklicevaje se na Gannon in Ostroma (1996) utemeljujejo, da format lestvice sproži proces aktivacije kategorij. Pri unipolarnih lestvicah anketiranci aktivirajo le eno kategorijo, kar pušča interpretacijo spodnjega dela lestvice dvoumno. V takšnih primerih se anketiranci pogosto oprejo na t. i. hevrstiko »sredina pomeni tipično« (angl. *Middle Means Typical Heuristic*; Tourangeau et al., 2000) in se zatekajo k srednjim vrednostim, ki jih dojemajo kot varno, normativno izbiro. Nasprotno pa bipolarne lestvice (z dvema eksplicitnima poloma) aktivirajo obe nasprotni kategoriji (npr. »slabo« in »dobro«). Lestvica se percipira kot simetrična, kjer leva stran jasno označuje negativno, desna pa pozitivno valenco. Ta jasna simetrična delitev sproži dva komplementarna psihološka mehanizma, ki skupaj vodita do izrazite pozitivne pristranskosti:

1. Odpor do izgube (angl. *Loss Aversion*): V skladu s teorijo vedenjske ekonomije (Tversky in Kahneman, 1991) anketiranci dojemajo negativne numerične vrednosti na levi strani simetrične lestvice (npr. –2) kot obliko kaznovanja ali izgube. Ker imajo izgube na posameznika večji psihološki učinek kot enakovredni dobički, se anketiranci podzavestno izogibajo izbiri odgovorov v negativnem spektru, da ne bi povzročili »škode« ocenjevani osebi.
2. Težnja k strinjanju (angl. *Agreeableness*): Hkratna jasna ločitev »dobrega« od »slabega« aktivira socialno normo vljudnosti. Ker imajo ljudje naravno težnjo k strinjanju in vzdrževanju pozitivnih odnosov, simetrična valenca odgovorov še dodatno okrepi pritisk k izbiranju pozitivnih ocen (Cabooter et al., 2016).

Sinergija teh dveh učinkov pojasnjuje, zakaj empirične raziskave pri bipolarnih lestvicah dosledno zaznavajo višjo stopnjo pozitivne asimetrije v primerjavi z unipolarnimi lestvicami, kjer je spodnji pol semantično bolj dvoumen (Cabooter et al., 2016).

Empirično relevantnost teh mehanizmov v specifičnem okolju študentskih evalvacij potrjujejo rezultati Sedlmeierja (2006), ki je v svoji študiji ugotovil, da so ocene pedagogov podvržene močnemu učinku stropa, kjer se velika večina odgovorov zgošča na pozitivnem delu lestvice. Rezultati te študije kažejo, da manipulacija formata ocenjevalne lestvice statistično značilno vpliva na premik povprečne ocene (angl. *mean shift*). Izkaže se, da uporaba ocenjevalnih lestvic, ki spodbujajo pozitivno pristranskost (kot so bipolarne lestvice s simetričnim pozitivnim polom), umetno zviša povprečne ocene vseh ocenjevanih pedagogov. Avtor ob tem ugotavlja, da takšen premik ne poveča nujno variance med dobrimi in slabimi pedagogi, temveč le zamakne celotno porazdelitev navzgor, kar institucijam otežuje identifikacijo dejanske kakovosti poučevanja.

Problem merske neinvariantnosti pa ni omejen le na izobraževanje. Sorodne ugotovitve so bile potrjene tudi na drugih področjih, od merjenja dohodkovne neenakosti (Höhne et al., 2021) do dinamičnih analiz psiholoških stanj in obnašanja (Nemani et al., 2023), kar potrjuje robustnost zaznanih metodoloških učinkov.

3 Empirična raziskava

3.1 Zasnova raziskave

Učinek ocenjevalne lestvice smo želeli empirično preveriti. Osnovna ideja je bila ta, da se dvema primerljivima skupinama anketirancev ponudi enak anketni vprašalnik, pri čemer ena skupina na vprašanja odgovarja na unipolarni, druga skupina pa na analogni bipolarni lestvici. Na podlagi izsledkov v literaturi in izkušenj smo postavili naslednje raziskovalne hipoteze:

H1: Pri več kot polovici vprašanj iz anketnega vprašalnika bo porazdelitev ocen med obema skupinama statistično značilno različna.

H2: Pri več kot polovici vprašanj iz anketnega vprašalnika bo povprečna ocena v skupini, ki uporablja bipolarno lestvico, statistično značilno višja kot v skupini, ki uporablja unipolarno lestvico.

H3: Pri več kot polovici vprašanj iz anketnega vprašalnika bo razlika v povprečnih ocenah med obema skupinama srednja ali visoka (Cohen's $d \geq 0,5$).

H4: Pri več kot polovici vprašanj iz anketnega vprašalnika bo delež odgovorov v najvišji kategoriji statistično značilno višji pri uporabi bipolarne ocenjevalne lestvice kot pri uporabi unipolarne lestvice. Učinek stropa bo torej bolj izrazit v skupini, ki uporablja bipolarno ocenjevalno lestvico.

3.2 Izvedba raziskave

Pilotna študija je bila izvedena med študenti Fakultete za organizacijske vede Univerze v Mariboru (FOV UM). Kot ciljno populacijo smo izbrali študente, ki so v študijskem letu 2025/26 vpisani v 1. letnik rednega študija na enega od VS študijskih programov 1. stopnje (OMIS, OMKIS ali IPS) in imajo v predmetniku predmet Osnove matematike v organizacijskih vedah. Glede na podatke v akademskem informacijskem podsistemu (AIPS) obsega izbrana populacija 208 študentov. V raziskavi, ki je bila izvedena v sklopu zaključnega kolokvija pri izbranem predmetu v decembru 2025, je sodelovalo vseh 80 študentov, ki so se kolokvija udeležili.

Vprašanja za anketni vprašalnik smo povzeli iz ankete o pedagoškem delu in obremenitvi študentov, ki jo UM vsako študijsko leto izvaja na vseh članicah z namenom pridobitve povratne informacije o kakovosti izvedbe študijskega procesa. V sklopu te ankete so študenti pozvani, da na lestvici od -2 do 2 izrazijo strinjanje z vnaprej podanimi trditvami. Trditve, ki smo jih vključili v našo raziskavo, so naslednje:

T1: Visokošolski učitelj/sodelavec predava zanimivo, razumljivo, vključuje sodobne metode poučevanja, uporablja ustrezno literaturo, spodbuja razmišljanje in intelektualno radovednost.

T2: Visokošolski učitelj/sodelavec spodbuja in upošteva pobude študentov, svetuje in usmerja pri opravljanju študijskih obveznosti.

T3: Visokošolski učitelj/sodelavec je ob dogovorjenem času (vaje, govorilne ure, e-pošta idr.) dostopen in odziven.

T4: Študent pridobi ustrezna pričakovana znanja, spretnosti in veščine, ki naj bi jih poznal, obvladal in razumel.

Sodelujoči v raziskavi so bili razdeljeni v 2 skupini, A in B. **Skupini A** je bila za ocenjevanje strinjanja s podanimi trditvami T1 – T4 predložena unipolarna lestvica (1 - zelo slabo, 2 - slabo, 3 - povprečno, 4 - dobro, 5 - zelo dobro). **Skupina B** pa je uporabljala analogno bipolarno lestvico (–2 - zelo slabo, –1 - slabo, 0 - povprečno, 1 - dobro, 2 - zelo dobro), ki je tudi uradna ocenjevalna lestvica v študentskih anketah za ocenjevanje kakovosti pedagoškega dela na UM. Raziskava je za obe skupini potekala sočasno, pri čemer sodelujoči niso vedeli, da se na anketnih vprašalnikih uporabljajo različne ocenjevalne lestvice, niti kateri skupini pripadajo.

Da bi lahko preverili in utemeljili primerljivost obeh skupin, smo anketni vprašalnik dopolnili še s kontrolnim vprašanjem:

V5: Kako v splošnem ocenjujete celotno izvedbo predmeta?

Pri tem vprašanju je bila v obeh skupinah uporabljena unipolarna lestvica (1 - zelo slabo, 2 - slabo, 3 - povprečno, 4 - dobro, 5 - zelo dobro).

4 Rezultati

4.1 Vzorčni rezultati

Struktura vzorca sodelujočih v raziskavi glede na pripadnost posamezni skupini je prikazana v tabeli 1.

Tabela 1: Struktura vzorca glede na pripadnost posamezni skupini

Skupina	Frekvenca	Odstotek
A – unipolarna	39	49 %
B – bipolarna	41	51 %

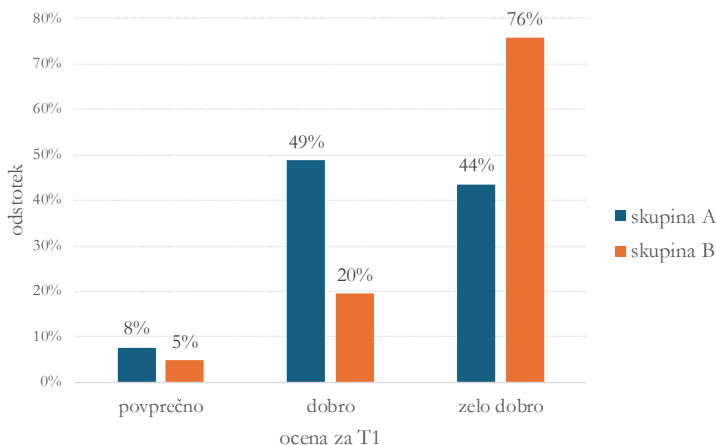
V nadaljevanju podajamo odgovore obeh skupin anketiranih (A – unipolarna in B – bipolarna) v smislu strinjanja s posameznimi trditvami (T1 – T4).

Porazdelitev ocen strinjanja s trditvijo T1 je za obe skupini predstavljena v tabeli 2, grafično pa je prikazana na sliki 1.

Tabela 2: Porazdelitev ocen za strinjanje s trditvijo T1

Skupina A			Skupina B		
Ocena	Frekvenca	Odstotek	Ocena	Frekvenca	Odstotek
1 - zelo slabo	0	0 %	-2 - zelo slabo	0	0 %
2 - slabo	0	0 %	-1 - slabo	0	0 %
3 - povprečno	3	8 %	0 - povprečno	2	5 %
4 - dobro	19	49 %	1 - dobro	8	20 %
5 - zelo dobro	17	44 %	2 - zelo dobro	31	76 %
Skupaj	39	100 %	Skupaj	41	100 %

Iz tabele 2 je razvidno, da se v obeh skupinah čez 90% odgovorov nahaja v zgornjih dveh kategorijah (4 in 5 oz. 1 in 2), medtem ko najnižji dve kategoriji (1 in 2 oz. -2 in -1) sploh nista zastopani. Slika 2 nadalje pokaže, da je delež ocen v najvišji kategoriji pri skupini B (bipolarna) občutno višji kot pri skupini A (unipolarna).

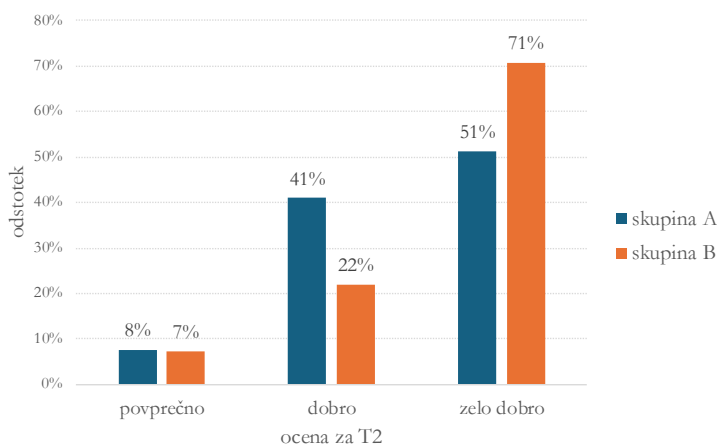


Slika 1: Grafični prikaz porazdelitve ocen za strinjanje s trditvijo T1 za obe skupini

Porazdelitev ocen strinjanja s trditvijo T2 je za obe skupini podana v tabeli 3, grafično pa je prikazana na sliki 2.

Tabela 3: Porazdelitev ocen za strinjanje s trditvijo T2

Skupina A			Skupina B		
Ocena	Frekvenca	Odstotek	Ocena	Frekvenca	Odstotek
1 - zelo slabo	0	0 %	-2 - zelo slabo	0	0 %
2 - slabo	0	0 %	-1 - slabo	0	0 %
3 - povprečno	3	8 %	0 - povprečno	3	7 %
4 - dobro	16	41 %	1 - dobro	9	22 %
5 - zelo dobro	20	51 %	2 - zelo dobro	29	71 %
Skupaj	39	100 %	Skupaj	41	100 %



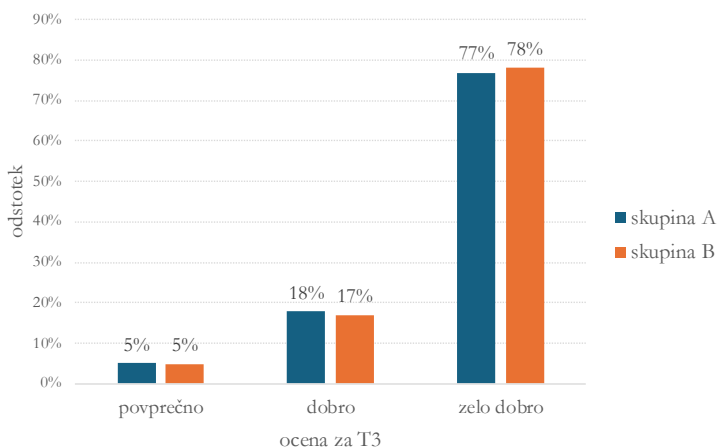
Slika 2: Grafični prikaz porazdelitve ocen za strinjanje s trditvijo T2 za obe skupini

Podobno kot pri rezultatih strinjanja s trditvijo T1 se tudi tu pokaže, da se v obeh skupinah čez 90% odgovorov nahaja v zgornjih dveh kategorijah, delež ocen v najvišji kategoriji pa je tudi tokrat pri skupini B višji kot pri skupini A.

Tabela 4: Porazdelitev ocen za strinjanje s trditvijo T3

Skupina A			Skupina B		
Ocena	Frekvenca	Odstotek	Ocena	Frekvenca	Odstotek
1 - zelo slabo	0	0 %	-2 - zelo slabo	0	0 %
2 - slabo	0	0 %	-1 - slabo	0	0 %
3 - povprečno	2	5 %	0 - povprečno	2	5 %
4 - dobro	7	18 %	1 - dobro	7	17 %
5 - zelo dobro	30	77 %	2 - zelo dobro	32	78 %
Skupaj	39	100 %	Skupaj	41	100 %

Porazdelitev ocen strinjanja s trditvijo T3 je razvidna iz tabele 4, njen grafični prikaz pa je na sliki 3.



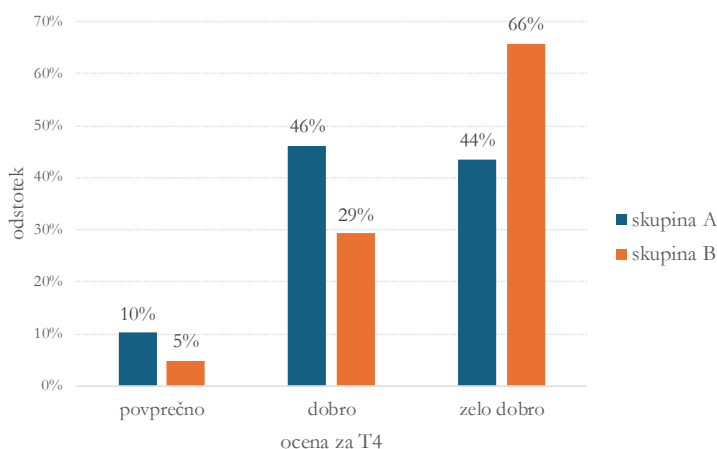
Slika 3: Grafični prikaz porazdelitve ocen za strinjanje s trditvijo T3 za obe skupini

Iz tabele 4 in slike 3 lahko razberemo, da so v primeru ocenjevanja strinjanja s trditvijo T3 rezultati v obeh skupinah zelo podobni in primerljivi.

Tabela 5 in slika 4 prikazujeta porazdelitev ocen strinjanja z zadnjo trditvijo, T4.

Tabela 5: Porazdelitev ocen za strinjanje s trditvijo T4

Skupina A			Skupina B		
Ocena	Frekvenca	Odstotek	Ocena	Frekvenca	Odstotek
1 - zelo slabo	0	0%	-2 - zelo slabo	0	0%
2 - slabo	0	0%	-1 - slabo	0	0%
3 - povprečno	4	10%	0 - povprečno	2	5%
4 - dobro	18	46%	1 - dobro	12	29%
5 - zelo dobro	17	44%	2 - zelo dobro	27	66%
Skupaj	39	100%	Skupaj	41	100%



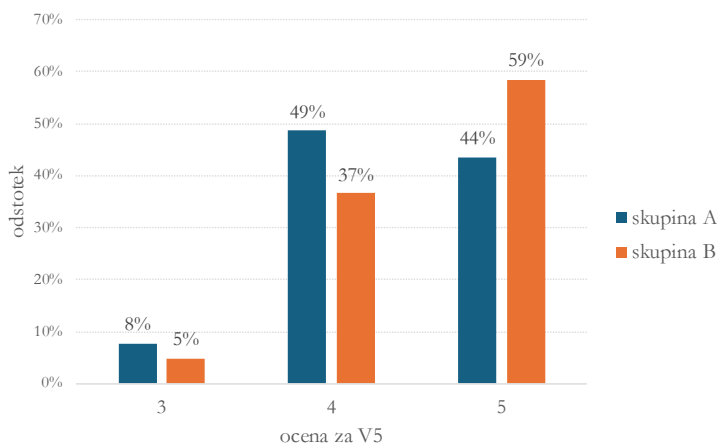
Slika 4: Grafični prikaz porazdelitve ocen za strinjanje s trditvijo T4 za obe skupini

Podobno kot pri prejšnjih trditvah, se tudi v tem primeru izkaže, da je v obeh skupinah čez 90 % v zgornjih dveh kategorijah. Delež ocen v najvišji kategoriji je tudi tokrat pri skupini B znatno višji kot pri skupini A.

Zadnje vprašanje (V5) je bilo kontrolno, zato je bila za obe skupini uporabljena enaka ocenjevalna lestvica. Porazdelitev odgovorov obeh skupin podaja tabela 6, grafično pa so prikazani na sliki 5. Vzorčni rezultati nakazujejo, da se odgovori na kontrolno vprašanje med obema skupinama nekoliko razlikujejo. Ali so te razlike statistično značilne, pa bomo preverili z ustreznimi statističnimi testi v naslednjem poglavju.

Tabela 6: Porazdelitev odgovorov na kontrolno vprašanje V5

Ocena	Skupina A		Skupina B	
	Frekvenca	Odstotek	Frekvenca	Odstotek
1 - zelo slabo	0	0 %	0	0 %
2 - slabo	0	0 %	0	0 %
3 - povprečno	3	8 %	2	5 %
4 - dobro	19	49 %	15	37 %
5 - zelo dobro	17	44 %	24	59 %
Skupaj	39	100 %	41	100 %



Slika 5: Grafični prikaz porazdelitve odgovorov na kontrolno vprašanje V5 za obe skupini

4.2 Analiza raziskovalnih hipotez

Vse statistične analize smo izvedli s programom IBM SPSS Statistics 31.

Za namen preverjanja primerljivosti skupin A in B, smo za kontrolno vprašanje V5 izvedli test razlike populacijskih povprečij pri 5 % stopnji značilnosti testa. Pri tem smo najprej interpretirali rezultat Levenovega testa, na podlagi katerega smo lahko predpostavili enakost varianc v obeh skupinah ($p = 0,772 > 0,05$). Skladno s to ugotovitvijo smo nadalje odčitali dvostransko p -vrednost t -testa za razliko populacijskih povprečij in dobili 0,198. Ker je dvostranski $p = 0,198 > 0,05$, statistično značilnih razlik v povprečni oceni odgovorov na kontrolno vprašanje V5 med skupinama ne moremo potrditi. S tem smo dokazali, da sta skupini primerljivi.

Da smo lahko za potrebe analize raziskovalnih hipotez H1 - H4 rezultate obeh skupin med seboj primerjali, smo morali najprej ocenjevalni lestvici uskladiti. To smo naredili tako, da smo vse odgovore skupine B (za vse 4 trditve T1 – T4), ki so bili podani na bipolarni lestvici, linearno pretvorili na unipolarno lestvico ($-2 \rightarrow 1$, $-1 \rightarrow 2$, ipd.).

Nadalje smo izračunali opisne statistike za vsa vprašanja anketnega vprašalnika (T1 – T4 in V5) za obe skupini. Rezultati za skupino A (unipolarna lestvica) so podani v tabeli 7, za skupino B (bipolarna lestvica po linearni pretvorbi) pa v tabeli 8. Razvidno je, da so vzorčna povprečja v vseh kategorijah vprašalnika za skupino B nekoliko višja. Največjo razliko med povprečnima ocenama vidimo pri trditvi T1, kjer je absolutna razlika med povprečnima ocenama 0,35, najmanjšo razliko pa pri trditvi T3, kjer je absolutna razlika enaka 0,01.

Tabela 7: Opisne statistike za vprašanja anketnega vprašalnika – skupina A (unipolarna lestvica)

	T1	T2	T3	T4	V5
N	39	39	39	39	39
Povprečje	4,36	4,44	4,72	4,33	4,36
Mediana	4	5	5	4	4
Modus	4	5	5	4	4
St. odklon	0,628	0,641	0,560	0,662	0,628
Min.	3	3	3	3	3
Maks.	5	5	5	5	5

Tabela 8: Opisne statistike za vprašanja anketnega vprašalnika – skupina B (bipolarna lestvica po linearni pretvorbi)

	T1	T2	T3	T4	V5
N	41	41	41	41	41
Povprečje	4,71	4,63	4,73	4,61	4,54
Mediana	5	5	5	5	5
Modus	5	5	5	5	5
St. odklon	0,559	0,623	0,549	0,586	0,596
Min.	3	3	3	3	3
Maks.	5	5	5	5	5

Za namen preverjanja razlike v porazdelitvi ocen na populaciji (H1) smo izvedli neparametrični Mann-Whitney test pri stopnji značilnosti 0,05. Rezultati testa so pokazali, da statistično značilne razlike v porazdelitvi ocen med obema lestvicama lahko potrdimo pri trditvah T1 ($p = 0,006 < 0,05$) in T4 ($p = 0,045 < 0,05$), medtem ko razlike v porazdelitvi ocen pri T2 ($p = 0,105 > 0,05$) in T3 ($p = 0,905 > 0,05$) niso statistično značilne. Hipotezo H1 lahko torej potrdimo le delno.

Za preverjanje hipoteze H2 smo izvedli enostranski test razlike populacijskih povprečij, s katerim smo testirali, če je populacijsko povprečje ocen pri uporabi bipolarne lestvice (skupina B, po ustrezni linearni pretvorbi) višje kot pri uporabi unipolarne lestvice (skupina A). Rezultati so pokazali, da lahko pri 5 % stopnji značilnosti testa statistično značilno višje povprečne ocene pri uporabi bipolarne lestvice potrdimo pri trditvah T1 ($p=0,005<0,05$) in T4 ($p=0,026<0,05$), medtem ko pri trditvah T2 ($p=0,082>0,05$) in T3 ($p=0,456>0,05$) tega ne moremo trditi. Če izvedemo test pri 10 % stopnji značilnosti, pa lahko statistično značilno višje povprečne ocene pri uporabi bipolarne lestvice potrdimo tudi pri trditvi T2. Rezultati testov torej nakazujejo, da lahko hipotezo H2 potrdimo.

V sklopu preverjanja hipoteze H3 smo za vse štiri trditve izračunali vrednosti Cohenovega koeficienta d. Velikost učinka, izražena s Cohenovim koeficientom d, je bila za vse štiri trditve srednja (med 0,55 in 0,63). Izračunane vrednosti kažejo, da med obema skupinama obstajajo zmerne, a praktično pomembne razlike v povprečnih ocenah trditev. Ugotavljamo torej, da izbira lestvice vpliva na izide merjenja. Hipotezo H3 potrdimo.

Za potrebe analize hipoteze H4 smo pri posameznih trditvah primerjali delež odgovorov v najvišji kategoriji (delež vrednosti »5« za skupino A in delež vrednosti »2« za skupino B). Vzorčni deleži odgovorov v najvišji kategoriji za posamezne trditve za obe skupini so prikazani v tabeli 9.

Tabela 9: Vzorčni deleži odgovorov v najvišji kategoriji

	Skupina A (delež vrednosti »5«)	Skupina B (delež vrednosti »2«)
T1	0,44	0,76
T2	0,51	0,71
T3	0,77	0,78
T4	0,44	0,66

Razvidno je, da so vzorčni deleži pri vseh trditvah višji pri skupini B. Z izjemo trditve T3 so razlike občutne. Pri stopnji značilnosti testa 5 % smo izvedli test deleža, ki je potrdil statistično značilne razlike pri trditvah T1 ($p=0,002<0,05$), T2 ($p=0,038<0,05$) in T4 ($p=0,023<0,05$), pri trditvi T3 pa rezultat testa ni bil statistično značilen ($p=0,453>0,05$). Efekt stropa je torej izražen pri 3 od 4 testiranih trditev, kar pomeni, da hipotezo H4 lahko potrdimo.

5 Zaključek

Pričujoča raziskava potrjuje teoretična predvidevanja iz psihometrične in metodološke literature, da tip ocenjevalne lestvice pomembno vpliva na odzivno vedenje anketirancev v študentskih evalvacijah poučevanja. Empirični rezultati kažejo, da uporaba bipolarne ocenjevalne lestvice sistematično povečuje koncentracijo odgovorov v najvišjih kategorijah in krepi učinek stropa, s čimer vpliva na porazdelitev ocen in zmanjšuje njihovo diskriminativnost. Rezultati analize nadalje kažejo, da je vpliv izbire ocenjevalne lestvice izrazitejši pri postavkah, ki temeljijo na subjektivni in vrednostni presoji pedagoškega dela (T1, T2), medtem ko je pri trditvi T3, ki se nanaša na relativno objektivno in vedenjsko opazno značilnost (dostopnost in odzivnost), ta vpliv bistveno manj izrazit. To nakazuje, da učinek polarnosti ocenjevalne lestvice ni univerzalen, temveč je pogojen tudi z naravo merjenega konstrukta, pri čemer so subjektivne evalvacije bolj dovzetne za odzivne pristranskosti, povezane s formatom ocenjevalne lestvice.

Z vidika visokošolskih institucij to pomeni, da izbira ocenjevalne lestvice ne sme biti zgolj tehnična odločitev, temveč metodološka izbira, ki neposredno vpliva na veljavnost, primerljivost in interpretabilnost evalvacijskih rezultatov. Ugotovitve zato odpirajo prostor za razmislek o morebitni prilagoditvi ali ponovni presoji uporabljene ocenjevalne lestvice, zlasti v kontekstih, kjer se rezultati evalvacij uporabljajo za spremljanje kakovosti poučevanja in podpora institucionalnemu odločanju.

Rezultate naše raziskave je seveda treba interpretirati ob upoštevanju njenih omejitev, saj temelji na pilotni študiji z relativno majhnim vzorcem, omejenim na en predmet in eno visokošolsko institucijo. Kljub temu ugotovitve ponujajo pomembne indikacije metodoloških učinkov izbire ocenjevalne lestvice, ki jih je smiselno preveriti v obsežnejših in longitudinalnih študijah.

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SUCCESSFUL AGING AT WORK: ORGANIZATIONAL STRATEGIES AND EMPLOYEE EXPERIENCES IN PUBLIC AND PRIVATE SECTOR

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Successful aging at work (SAW) has become a critical challenge for contemporary organizations. This study examines SAW from two complementary perspectives: organizational practices aimed at supporting aging employees (SAW strategies) and employees' maturation, development, and growth through aging in organizational contexts (SAW experiences). Using survey data from 456 employees in Slovenia, we compare public and private sector organizations and examine the relationship between SAW strategies and experiences. Results show that SAW strategies are widely implemented, with no significant differences between sectors. While the strategy–experience correlation is stronger in private sector organizations, SAW experiences are significantly more positive in public sector organizations. The possibility to remain employed in an organization as long as desired is most strongly associated with SAW experiences, which suggests that job security plays an integral role in supporting positive aging trajectories and acts as a foundation that enables employees to adapt, develop, and thrive as they age.

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1 Introduction

The aging of the world's population represents one of the most significant demographic transformations of the 21st century, bringing unprecedented challenges for organizations worldwide (OECD, 2025). The rapidly aging workforce is fundamentally changing the composition of labour markets (Kooij et al., 2020; OECD, 2025). In this context, organizations face the dual challenge of retaining older workers' valuable experience while adapting workplace practices to support longer, healthier working lives (Beier et al., 2022; Rudolph & Zacher, 2022). Understanding how employees can age successfully at work - maintaining and even enhancing their capabilities, motivation, and well-being across the working lifespan, has therefore become a strategic imperative for organizational sustainability, workforce retention, and long-term performance (Dimovski et al., 2022; Zacher et al., 2018; Taneva & Peng, 2024).

1.1 Successful aging at work: theoretical framework

Successful aging at work (SAW) is an emerging concept rooted in contemporary interpretations of organizational and lifespan developmental theories (Beier et al., 2022). Kooij (2015) defined SAW as the sustainable maintenance of an individual's work ability, health, and motivation across the working life cycle. Zacher (2015) expanded this conceptualization by noting that SAW encompasses not only maintenance of current functioning but also development and growth. Unlike traditional deficit-focused perspectives on aging, which emphasize productivity decline and diminishing capabilities, SAW emphasizes employees' capacity for improvement, adaptation, and continued contribution throughout their careers (Debelak et al., 2024; Kooij et al., 2020; Zacher et al., 2018).

Taneva & Yankov (2020) distinguished two complementary, measurable dimensions of SAW. The first dimension concerns organizational strategies for successful aging (SAW strategies): workplace policies, practices, and conditions that facilitate employees' continued engagement and development. The second dimension involves employee experiences of successful aging (SAW experiences): individuals' subjective perceptions of age-related growth in work-related competencies and psychological resources.

SAW strategies include access to continuous training and skill development opportunities, recognition and respect for employees' contributions, flexibility in work arrangements, supportive supervision and feedback, job autonomy and decision-making freedom, and organizational openness to negotiating individualized work arrangements that match employees' evolving needs (Olson & Shultz, 2019; Taneva & Yankov, 2020; Taneva & Peng, 2024; Zacher et al., 2018; Pak et al., 2020; Boehm et al., 2020; Bal, 2015; Taneva & Arnold, 2017). They provide the contextual resources and opportunities that enable employees to maintain, adapt, and further develop their capabilities as they age (Kooij et al., 2014, 2020; Olson & Shultz, 2019).

On the other hand, SAW experiences reflect positive changes in individuals' functioning at work throughout aging (Taneva & Yankov, 2020; Zacher et al., 2018). Taneva et al. (2016) and Taneva & Yankov (2020) link SAW experiences with increased confidence stemming from accumulated knowledge and adaptations, enhanced ability to manage workplace relationships, greater comfort in raising issues and expressing opinions, improved capacity to solve complex problems, development of more meaningful workplace relationships, enhanced conflict resolution skills, increased emotional regulation (remaining calm and optimistic under pressure), greater adaptability to workplace changes, and heightened self-awareness regarding personal strengths and limitations.

1.2 Organizational context and the SAW strategy–experience link: background and research gap

Aging can lead to notable developmental gains, and not merely losses in workplace contexts (Rudolph & Zacher, 2022; Kooij et al., 2020; Olson & Shultz, 2019). SAW experiences contribute to both employees' well-being and performance (Taneva & Arnold, 2017; Zacher, 2015). In theory, SAW strategies should positively influence SAW experiences, but empirical evidence regarding this relationship is still developing (Olson & Shultz, 2019; Beier et al., 2022). Age-friendly HR practices, supportive supervision, job autonomy, and opportunities for development are generally associated with positive outcomes (Cui et al., 2025; Pak et al., 2020; Kooij et al., 2014; 2020; Zacher, 2018). However, the strategy–experience link and overall SAW approaches and outcomes vary across organizational contexts (Kooij, 2015; Zacher, 2015; Taneva & Arnold, 2017; Egdell et al., 2020).

Substantial differences in organizational structures, management practices, employment stability, and mission orientations between public and private sectors are widely recognized (Perry & Rainey, 1988). Private sector organizations face competitive pressure and are therefore more agile, providing more flexibility and initiatives for development and performance, but also lower employment security, while public sector organizations typically provide stable employment, have more traditional management approaches and seniority models that favour older workers, but may be less developmentally oriented or motivationally engaging (Calo et al., 2013; Walker et al., 2021; Macassa, et al., 2024). Sector characteristics may influence both organizational practices and individuals' aging trajectories, shaping the conditions for SAW (Quinn et al., 2019; Villajos et al., 2020).

Despite growing theoretical interest in SAW, several gaps remain in the literature. Empirical measurement and analysis of SAW strategies and experiences is limited (Pak et al., 2019). There is a lack of examination of the relationship between organizational strategies and employee experiences (Cui et al., 2025; Debelak et al., 2024), and how it may vary across contexts (Boehm et al., 2021; Egdell et al., 2020).

To achieve positive SAW experiences, SAW strategies must be tailored to organizational context and employees' needs (Kooij et al., 2020; Zacher et al., 2018; Taneva et al., 2016). This motivates us to explore how SAW strategies and experiences are perceived by employees in different sectoral contexts, and how specific strategies translate into employees' experiences.

1.3 Research objectives

This study addresses contemporary practical challenges of managing an aging workforce and theoretical gaps with three objectives: (1) to examine the relationship between organizational strategies and employee experiences of successful aging at work, (2) to investigate whether public and private sector employees differ in their perceptions of SAW strategies and experiences, and (3) to explore which specific organizational strategies are most strongly associated with positive SAW experiences, and whether these associations vary by sector. Accordingly, we pose three research questions:

- RQ1: Are there differences between public and private sector employees in perceived organizational strategies for successful aging at work (SAW-S) and experienced successful aging at work (SAW-E)?
- RQ2: Which specific organizational strategies and employee experiences show significant differences between sectors, and what is the magnitude of these differences?
- RQ3: How do organizational strategies relate to employee experiences of successful aging, and do these relationships differ between public and private sector contexts?

To answer these research questions, we conducted a quantitative survey study and analysed responses from a sample of Slovenian employees across public and private sector organizations, using the validated SAW scales developed by Taneva and Yankov (2020). This study contributes to the emerging SAW literature by providing empirical evidence on the implementation of SAW strategies, employees' experiences of successful aging, the strategy–experience link, and sectoral differences.

2 Methods

This study examines whether SAW strategies and experiences differ between public and private sector employment, and how organizational strategies relate to employee experiences. We employed a quantitative research design using a questionnaire survey approach, a method appropriate for collecting structured data from a defined population and systematically examining relationships among variables (Creswell & Creswell, 2017). The data were gathered through two online surveys administered in Slovenia between May and September 2025. All participants were informed of the research purpose, anonymity, and voluntary participation before completing the questionnaire.

Data collection resulted in a total sample of 557 participants. The sample comprised 494 employees with valid sector information (238 private sector: 48.2%; 256 public sector: 51.8%). The sample was approximately evenly distributed between genders (55.7% female, 44.2% male), with moderate age distribution (age data were available for 506 participants: 90.8%). The largest proportion of the sample was aged 40-49 (28.9%), followed by under 30 (24.9%), 30-39 (22.9%), and 50-59 (22.5%).

Education levels varied, with the largest proportion holding university degrees (42.6%), followed by lower education levels (secondary and professional combined, 35.5%) and higher degrees (master's and doctoral combined, 21.9%) based on 507 valid responses.

SAW was measured using full scales from Taneva and Yankov (2020), which include 10 items for SAW strategies (SAW-S) and 10 items for SAW experiences (SAW-E). Participants rated each item on a 5-point Likert scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). Respondents could also select "I don't know" (coded as 0) or "Not relevant" (coded as -1) - these responses were excluded from the final analysis, together with data of respondents that had missing responses.

Data were analysed using SPSS 29. We first examined descriptive statistics to characterize the sample and verify that measures showed adequate variability. Both scales demonstrated good internal consistency (Cronbach's $\alpha = 0,914$ for SAW-S and $\alpha = 0,908$ for SAW-E). To test whether successful aging differs between employment sectors, we conducted independent samples t-tests comparing public and private sector employees on both composite scores and individual items. T-tests were chosen because they provide a straightforward test of mean differences between two groups. Composite scores for both SAW strategies and experiences were calculated as the mean of valid responses. We calculated effect sizes using Cohen's d to assess the practical significance of differences, using benchmarks of 0.2 (small), 0.5 (medium), and 0.8 (large). Item-level analyses were conducted in addition to composite comparisons to identify specific strategies and experiences that might show sectoral variation even if overall scores do not differ. To examine how organizational strategies relate to employee experiences, we conducted Pearson correlation analyses. Given the exploratory nature of this study and the focus on identifying patterns of associations rather than causal relationships, bivariate correlations were deemed appropriate. Correlations were calculated between each SAW strategy item and the SAW-E composite score for the full sample and separately for each sector. This approach allows us to identify which strategies are most strongly associated with successful aging experiences.

3 Results

There were 456 valid responses used for the SAW analysis. As shown in Table 1, participants reported moderate-to-high levels of organizational strategies. The highest mean was observed for the item "Stay as desired" ($M = 3.81$, $SD = 1.00$), while the lowest was for "Openness to negotiation" ($M = 3.13$, $SD = 1.15$).

Table 1: Descriptive Statistics for SAW Strategies Items

Item		1	2	3	4	5	M	SD
saws_1 (Access to training)	N	28	44	137	181	66	3.47	1.05
	%	6.1	9.6	30	39.7	14.5		
saws_2 (Stay up-to-date)	N	27	42	119	202	66	3.52	1.04
	%	5.9	9.2	26.1	44.3	14.5		
saws_3 (Recognition/respect)	N	22	45	123	199	67	3.54	1.02
	%	4.8	9.9	27	43.6	14.7		
saws_4 (Stay as desired)	N	18	22	107	193	116	3.81	1.00
	%	3.9	4.8	23.5	42.3	25.4		
saws_5 (Flexibility)	N	49	75	109	158	65	3.25	1.20
	%	10.7	16.4	23.9	34.6	14.3		
saws_6 (Quick feedback)	N	34	56	114	182	70	3.43	1.12
	%	7.5	12.3	25	39.9	15.4		
saws_7 (Freedom in decision)	N	17	40	134	189	76	3.59	.99
	%	3.7	8.8	29.4	41.4	16.7		
saws_8 (Supervisor support)	N	32	49	124	168	83	3.49	1.12
	%	7	10.7	27.2	36.8	18.2		
saws_9 (Openness to negotiation)	N	52	71	146	140	47	3.13	1.15
	%	11.4	15.6	32	30.7	10.3		
saws_10 (Flexible supervisors)	N	41	77	142	145	51	3.19	1.12
	%	9	16.9	31.1	31.8	11.2		

Note. N = 456 valid responses; 101 cases excluded due to missing data. Frequencies show response distribution for each Likert scale point. Percentages calculated from valid N for each item. Scale: 1 = Strongly disagree, 5 = Strongly agree.

Regarding employee experiences (Table 2), the results indicate a generally positive perception of aging at work. Employees felt most confident due to their knowledge ($M = 3.97$, $SD = 0.81$) and their ability to solve complex tasks ($M = 3.89$, $SD = 0.80$). Overall, the means for experiences were higher than those for organizational strategies.

Table 2: Descriptive Statistics for SAW Experiences Items

Item		1	2	3	4	5	M	SD
sawe_1 (Confident due to knowledge)	N	4	18	76	246	112	3.97	.81
	%	0.9	3.9	16.7	53.9	24.6		
sawe_2 (Better manage relationships)	N	4	22	121	233	76	3.78	.81
	%	0.9	4.8	26.5	51.1	16.7		
sawe_3 (Dare to raise issues)	N	6	23	109	226	92	3.82	.85
	%	1.3	5	23.9	49.6	20.2		
sawe_4 (Solve complex tasks)	N	6	12	99	246	93	3.89	.8
	%	1.3	2.6	21.7	53.9	20.4		
sawe_5 (Meaningful relationships)	N	6	29	152	203	66	3.64	.85
	%	1.3	6.4	33.3	44.5	14.5		
sawe_6 (Resolve conflicts)	N	9	19	122	237	69	3.74	.84
	%	2	4.2	26.8	52	15.1		
sawe_7 (Calm and focused)	N	4	34	148	212	58	3.63	.83
	%	0.9	7.5	32.5	46.5	12.7		
sawe_8 (Calm and optimistic)	N	6	26	103	236	85	3.81	.85
	%	1.3	5.7	22.6	51.8	18.6		
sawe_9 (Adapt to changes)	N	5	19	120	244	68	3.77	.79
	%	1.1	4.2	26.3	53.5	14.9		
sawe_10a (Aware of strengths/limits)	N	3	16	109	247	81	3.85	.77
	%	0.7	3.5	23.9	54.2	17.8		

Note. N = 456 valid responses; 101 cases excluded due to missing data. Frequencies show response distribution for each Likert scale point. Percentages calculated from valid N for each item. Scale: 1 = Strongly disagree, 5 = Strongly agree.

To address the first research question (RQ1), we first compared SAW results between the public and private sectors. Levene's test indicated that equal variances could be assumed for all variables. As presented in Table 3, the composite-level analysis revealed no statistically significant differences between the sectors.

Table 3: Descriptive Statistics and T-test Results for SAW Composite Scores by Sector

		N	M	SD	t	df	p	Cohen's d
SAW Experiences	Full sample	456	3.80	.60				
	Private sector	238	3.76	.60	-1.551	440	.122	-.148
	Public sector	204	3.85	.58				
SAW Strategies	Full sample	456	3.46	.81				
	Private sector	238	3.46	.82	.015	440	.988	.001
	Public sector	204	3.46	.79				

Note. 101 cases excluded due to missing SAW data.

Public and private sector employees reported identical levels of SAW strategies ($M = 3.46$, $p = .988$). Public sector employees reported slightly higher overall experiences ($M = 3.85$) compared to the private sector ($M = 3.76$), but this difference was not statistically significant ($p = .122$). These results indicate that at the overall level, both sectors provide similar levels of organizational support and that employees in both contexts report comparable aging experiences. Next, we examined individual items to identify specific strategies and experiences that might differ between sectors (RQ2). Table 4 presents the results for SAW strategies, and Table 5 presents results for SAW experiences.

Table 4: Item-Level Comparison of SAW Strategies by Sector

Item	Private M (SD)	Public M (SD)	t	df	p	Cohen's d
saws_1 (Access to training)	3.45 (1.04)	3.56 (1.01)	-1.075	440	.283	-.103
saws_2 (Stay up-to-date)	3.58 (1.00)	3.52 (1.05)	.574	440	.567	.055
saws_3 (Recognition/respect)	3.52 (1.03)	3.59 (1.00)	-.787	440	.432	-.075
saws_4 (Stay as desired)	3.71 (1.02)	3.96 (.94)	-2.669	440	.008**	-.255
saws_5 (Flexibility)	3.29 (1.21)	3.23 (1.18)	.600	440	.549	.057
saws_6 (Quick feedback)	3.49 (1.11)	3.41 (1.12)	.750	440	.453	.072
saws_7 (Freedom in decision)	3.68 (.95)	3.52 (1.01)	1.685	440	.093	.161
saws_8 (Supervisor support)	3.45 (1.13)	3.56 (1.10)	-1.023	440	.307	-.098
saws_9 (Openness to negot.)	3.21 (1.16)	3.08 (1.13)	1.204	440	.229	.115
saws_10 (Flexible supervisors)	3.23 (1.11)	3.17 (1.13)	.556	440	.578	.053

Note. N = 442 (Private sector = 238, Public sector = 204). 101 cases excluded due to missing SAW data and 14 for missing sector data. All p-values two-tailed. *Significant differences ($p < .05$). **Significant differences ($p < .01$).

Table 5: Item-Level Comparison of SAW Experiences by Sector

	Private M (SD)	Public M (SD)	t	df	p	Cohen's d
sawe_1 (Knowledge confidence)	3.71 (.81)	3.87 (.76)	-2.105	440	.036*	-.201
sawe_2 (Manage relationships)	3.83 (.81)	3.84 (.89)	-.130	440	.897	-.012
sawe_3 (Raise issues)	3.82 (.78)	4.01 (.75)	-2.727	440	.007**	-.260
sawe_4 (Complex tasks)	3.66 (.78)	3.66 (.89)	-.018	440	.986	-.002
sawe_5 (Meaningful relations)	3.74 (.81)	3.78 (.82)	-.513	440	.608	-.049
sawe_6 (Resolve conflicts)	3.60 (.84)	3.66 (.80)	-.831	440	.406	-.079
sawe_7 (Calm and focused)	3.75 (.86)	3.88 (.81)	-1.621	440	.106	-.155
sawe_8 (Calm and optimistic)	3.78 (.77)	3.76 (.79)	.169	440	.866	.016
sawe_9 (Adapt to changes)	3.77 (.76)	3.95 (.75)	-2.523	440	.012*	-.241
sawe_10a (Aware of strengths)	3.76 (0.76)	3.95 (.75)	-2.523	440	.012*	-.241

Note. N = 442 (Private sector = 238, Public sector = 204). 101 cases excluded due to missing SAW data and 14 for missing sector data. All p-values two-tailed. *Significant differences ($p < .05$). **Significant differences ($p < .01$).

Among organizational strategies, only one significant difference emerged (Table 4): public sector employees reported significantly higher support for staying as long as desired ($p = .008$, $d = -0.26$). In contrast, several significant experiential differences were identified (Table 5). Public sector employees reported significantly higher scores in raising issues ($p = .007$, $d = -0.26$), adapting to changes ($p = .012$, $d = -0.24$), being aware of strengths and limits ($p = .012$, $d = -0.24$), and being confident due to knowledge ($p = .036$, $d = -0.20$).

To examine how organizational strategies relate to employee experiences (RQ3), Pearson correlation analyses were conducted. The results in Table 6 show that all ten SAW strategies as well as SAW-S composite score are significantly and positively correlated with the SAW-E composite score across the full sample and in both sectors ($p < .01$).

Table 6: Pearson Correlation Analysis between SAW Strategies (Independent) and SAW-E Composite (Dependent) - full sample and sector side-by-side comparison

	Pearson Correlation coefficient (r)		
	Full Sample	Private Sector	Public Sector
saws_1 (Access to training)	.341	.310	.338
saws_2 (Stay up to date)	.331	.346	.309
saws_3 (Recognition/respect)	.425	.405	.438
saws_4 (Stay as desired)	.444	.433	.379
saws_5 (Flexibility)	.316	.269	.358
saws_6 (Quick feedback)	.393	.429	.370
saws_7 (Freedom in decision)	.421	.432	.378
saws_8 (Supervisor support)	.379	.386	.356
saws_9 (Openness to negotiation)	.330	.357	.292
saws_10 (Flexible supervisors)	.337	.347	.285
SAW-S Composite value	.491	.485	.471

Note: N = 456 (full sample), 238 (private sector), 204 (public sector). All correlations significant at $p < .01$ (two-tailed).

The composite SAW-S score showed a strong correlation with SAW-E in full sample ($r = .491$, $p < .01$) and both the private ($r = .485$) and public ($r = .471$) sectors. When comparing sectors, the pattern of associations remained consistent, with some variation in the strength of specific correlations between strategies and experiences (bold in Table 6).

4 Discussion

The primary objective of this study was to investigate the nuances of SAW across the public and private sectors in Slovenia. While the composite scores initially resulted in a high level of similarity, detailed item-level analysis and correlation patterns reveal a more complex landscape of how organizational support translates into employee experiences.

4.1 Sectoral Differences in Strategies and Experiences

Regarding RQ1, findings indicate a surprising level of uniformity in SAW strategies. This supports the notion that both public and private sector organizations universally implement age management practices (Macassa et al., 2024). However, public sector employees reported significantly higher organizational support for staying as long as desired ($p = .007$, $d = -0.26$). This supports that the public sector is perceived to offer greater job security and long-term stability (Quinn et al., 2019; Villajos et al., 2020). Interestingly, a marginal trend ($p = .093$) showed that private sector employees might feel slightly more freedom in decision-making, potentially reflecting the less bureaucratic and hierarchical nature of private enterprises (Perry & Rainey, 1988).

In contrast to the strategic landscape, several significant experiential differences emerged, all favouring the public sector (RQ2). Public sector employees reported significantly more positive experiences in being confident due to accumulated knowledge, daring to raise issues, adapting to workplace changes, and being aware of their strengths and limitations. Effect sizes for these differences were small, indicating meaningful though not large sectoral variations. These findings support the observations that the public sector environment may foster conditions more conducive to positive experiences of aging at work. Employment stability in public sector allows older workers to be more confident and focus on competence rather than career survival, whereas the private sector's higher performance pressure may impact SAW experiences negatively (Taneva & Arnold, 2018; Egdell et al., 2020; Quinn et al., 2019; Walker et al., 2021; Villajos et al., 2020; Macassa et al., 2024).

4.2 Relationships Between Strategies and Experiences

The correlation analysis for RQ3 highlights the mechanism behind SAW experiences. Composite scores for organizational strategies (SAW-S) and employee experiences (SAW-E) showed a moderate positive correlation ($r = .491$, $p < .001$), confirming the overall relationship between organizational support and successful aging outcomes. Results show that the sectors differ in which types of organizational strategies are more strongly associated with positive aging experiences. In the private sector, strategies emphasizing flexibility ($r = .269$ vs. $.358$), feedback ($r = .429$ vs. $.370$), and autonomy ($r = .432$ vs. $.378$) show stronger associations with positive experiences. Conversely, in the public sector, recognition ($r = .438$ vs. $.405$) and employment security ($r = .433$ vs. $.379$) are more strongly linked to overall SAW experiences. These results align with the proposition that increasing organizational support through SAW strategies is likely to enhance SAW experiences (Kooij et al., 2014, 2020; Pak et al., 2020; Zacher, 2015).

For the full sample, the perceived possibility to maintain employment shows the highest correlation ($r = .444$) with overall positive SAW experiences. This result is consistent with Conservation of Resources theory (Hobfoll et al., 2018). Older workers generally report significant declines in perceived job security, with these concerns being especially pronounced in less secure sectors (Walker et al., 2021). SAW experiences appear more positive in the public sector, likely because job security acts as a psychological foundation (Villajos et al., 2020; Quinn et al., 2019). This implies that job security is a key predictor of successful aging; when tenure is secure, employees are mentally freed to engage in development and maintain positive social relations (Taneva & Arnold, 2017).

Interestingly, the composite SAW-S to SAW-E correlation is slightly stronger in the private sector ($r = .485$) than in the public sector ($r = .471$), suggesting that despite lower absolute levels of some experiences, private sector organizations may achieve somewhat more efficient translation of SAW strategies into SAW experiences. This may reflect more direct linkages between formal policies and actual practices in less bureaucratic environments or more individualised age management approaches of private sector (Calo et al., 2013; Egdell et al., 2020), though the public sector's advantage in SAW experiences (based on T-test results) indicates that other

contextual factors (particularly employment security) shape the nature of aging experiences beyond the immediate impact of formal policies.

4.3 Theoretical and Practical Implications

This study demonstrates that despite both sectors providing similar levels of strategic support, the public sector environment facilitates more positive individual experiences, while in the private sector, the strategies are translated into experiences more effectively. Our findings extend the understanding of SAW by highlighting the importance of sector context. Importantly, the results show that job security is not just a benefit but a catalyst for successful aging. In practice, private sector organizations must realize that without a sense of stability, their initiatives may be insufficient to sustain a high-performing, multi-generational workforce. To bridge this gap, they should implement longevity bonuses, clear career paths for older employees or other mechanisms that enhance perceived employment security. On the other hand, public sector organizations should leverage their stability, and further support successful aging by empowering employees to raise issues and adapt to change, while maintaining robust feedback loops that older workers find vital for their success (Pak et al., 2020; Bal, 2015; Kooij et al., 2014). Overall, increasing organizational support through SAW strategies is likely to enhance successful aging regardless of context (Kooij et al., 2014, 2020; Pak et al., 2020; Zacher, 2015). By actively involving older workers in the design of SAW strategies, organizations can ensure long-term employment sustainability, ultimately supporting a high-performing, multi-generational workforce (Egdell et al., 2020; Villajos et al., 2020).

4.4 Limitations and Future Research

The study is limited by its cross-sectional design and self-report nature of data. Future research should utilize longitudinal designs to observe these dynamics over time (Rudolph & Zacher, 2022). We also propose moving beyond simple correlations by using hierarchical multiple regression to test the predictive power of SAW strategies while controlling for other variables. Furthermore, future studies should employ latent profile analysis to identify specific organizational types (e.g., Security-Focused vs. Development-Focused) and analyse how patterns of strategy implementation influence the aging process of their workforce, helping to tailor interventions to specific organizational contexts. Lastly, identifying clusters of

individuals with similar SAW experiences would bring insights into how to tailor SAW interventions to specific employee profiles.

5 Conclusion

This study demonstrates that while public and private sectors in Slovenia provide similar strategic support, the public sector environment facilitates more positive individual experiences of aging. Employment stability in the public sector allows older workers to be more confident and focus on competence rather than career survival, whereas the private sector's higher performance pressure may impact SAW experiences negatively, despite possibly more efficient strategies. The findings suggest that SAW strategies are not a one-size-fits-all solution; their success depends on the sectoral context and the foundational sense of job security they provide. To truly foster successful aging, organizations must move beyond a purely formal or symbolic implementation of age-related practices and shift towards a holistic strategy that integrates developmental efforts with psychological safety. Aligning strategies with evolving individual needs and sector-specific characteristics is crucial.

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NEPOTISM: IS IT REALLY AS BAD AS IMAGINED? EXPLORING ITS POSSIBLE IMPACTS ON SOCIOEMOTIONAL WEALTH IN HUNGARIAN FAMILY BUSINESSES

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This research paper investigates the conceptual leadership phenomena of nepotism in a family business context. By identifying the antecedents of nepotism, namely machiavellianism and paternalism, the authors attempt to establish a solid context for examining its impact in family business succession. With applying the morally different concepts of reciprocal- and entitled nepotism an empirical attempt is demonstrated to capture the impact of nepotism on socioemotional wealth (SEW) in family businesses (FBs). Using a qualitative, interpretivist approach, two Hungarian FBs where the CEO title has been inherited are analysed through semi-structured interviews with three stakeholders: the predecessor, the successor, and a non-family employee. The findings suggest that reciprocal nepotism can strengthen SEW by fostering emotional bonds, organizational identity, and succession continuity. These insights contribute to the discourse on ethical succession planning and sustainable entrepreneurship in FBs. This research paper aims to provide deeper empirical insights, integrating stakeholder quotations, and positioning the findings within contemporary debates on family business succession and governance.

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1 Introduction

Family businesses constitute a dominant organizational form worldwide and play a particularly significant role in transition economies such as Hungary, where an estimated 60-80% of firms can be classified as family-owned or family-controlled enterprises (Csákné Filep, 2012a; Huszák et al., 2021). Despite their economic importance, family businesses face a critical vulnerability during generational succession. Empirical evidence suggests that nearly two-thirds of family firms fail to survive the transition from the first to the second generation (Ward, 1987). While succession failure is often attributed to inadequate strategic or financial planning, research increasingly highlights emotional, relational, and identity-based factors as primary sources of tension. As Heidrich et al. (2018) conceptualise successor readiness across three main dimensions: human capital, socio-emotional wealth transfer and successor potential.

One particularly controversial phenomenon in this context is nepotism. In mainstream management literature, nepotism is typically framed as an unethical practice that undermines meritocracy and organizational performance (Bloom & Van Reenen, 2007; Cialdini, 1996; Kets de Vries, 1996), also has negative effect on society (Weber, 1958). In family businesses, however, nepotism is not only widespread but often institutionally expected. The appointment of family members to leadership roles may serve functions related to trust, identity preservation, and dynastic continuity (Le Breton-Miller & Miller, 2006; Finelli, 2011). This raises an important question: Is nepotism inherently harmful in family businesses? Is it really as bad for the organization as naturally assumed? Or can it contribute positively to socioemotional outcomes during succession?

This paper addresses this question by examining nepotism through the lens of **socioemotional wealth (SEW)** and by distinguishing between **entitlement-based nepotism** and **reciprocal nepotism** (Jaskiewicz et al., 2009). By integrating qualitative evidence from Hungarian family businesses undergoing intra-family succession, the study contributes to a more nuanced understanding of nepotism as a context-dependent governance mechanism. This approach is in line with earlier family business studies that stress the need for a process and context focused understanding of organizational phenomena.

2 Theoretical Background

2.1 Family Business Succession as a Socioemotional Process

Family businesses are commonly characterized by shared ownership structures, active family involvement in management, and the intra-family transfer of leadership roles (Kása et al., 2019). In such organizations, the influence of the owning family or families is evident not only in ownership but also across leadership, managerial, and operational domains (Mandl, 2008; Csákné, 2012b). A defining feature of family enterprises is familiness (Chrisman et al., 2005), which includes unique resources coming from family involvement and simultaneously involves both advantages and constraints. Family values and norms affect the organization at all levels, shaping decision-making processes, governance practices, and everyday operations.

Succession constitutes one of the most critical phases in the life cycle of a family business (Sharma et al., 1997), with significant implications for both its socioemotional wealth (SEW) (Gómez-Mejía et al., 2007) and strategic orientation. Succession in family businesses represents more than a leadership transition; it is a deeply emotional process involving the reconfiguration of roles, identities, and power structures (Handler, 1994; Lansberg, 1999). Incumbent leaders often struggle with letting go of control, while successors face the pressure of meeting family expectations and preserving the founder's legacy. Prior research in Hungary confirms that unresolved emotional tensions and communication failures are among the primary causes of unsuccessful succession (Mosolygó-Kiss et al., 2022).

2.2 Nepotism in Family Businesses

The two theoretical leadership antecedent notions of nepotism are paternalism and machiavellianism. **Paternalistic leadership** seems to appear as an inherent phenomena of FBs, especially in the early stages of organizations' life cycle. Founders of family businesses often expected to become paternalistic by the very nature and culture of FBs. Paternalistic leadership appears as a hierarchical relationship where the leader guides the professional and personal lives of subordinates in a parent-like manner, expecting loyalty and deference in return. These leaders often aim to create a perceived family atmosphere at work. While not considered as democratic and partner based, paternalism considered to have three

different types with leadership layers, such as authoritarian, benevolent, and moral (Aycan, 2006).

A morally more questionable phenomena related to nepotism is **machiavellianism**, which considered as one dimension of the dark triad (machiavellianism-narcissism-psychopathy). Machiavellianism describes people who are manipulative and prone to exploit others, motivated by personal gain (Book et al., 2015; Jones & Paulhus, 2014). This latter phenomena is related to nepotism through the (ab)use of resources in FBs, such as social networks.

Nepotism refers to preferential treatment based on family ties rather than objective merit. While widely criticized also in non-family organizational contexts, nepotism is a common practice and structurally embedded in family firms (Cruz et al., 2011; Gersick et al., 1997; Jaskiewicz et al., 2009).

Jaskiewicz et al. (2009) distinguish between two morally different forms. On the one hand, **entitlement-based nepotism**, where family members receive positions or privileges based solely on kinship, often leading to competence deficits and organizational tension. On the other hand, **reciprocal nepotism**, where preferential treatment is accompanied by expectations of competence, commitment, and reciprocal contribution. This distinction allows nepotism to be examined not as a uniform negative phenomenon but as a relational and moral practice embedded in family logic.

2.3 Socioemotional Wealth and the FIBER Model

Socioemotional wealth refers to the non-financial value that family owners derive from their firms, including emotional attachment, identity, and the desire for dynastic continuity (Gómez-Mejía et al., 2007). Berrone et al. (2012) operationalized SEW through the **FIBER model**, which divides these values into five main categories:

- Family control and influence – the family's role in strategic decision-making.
- Identification of family members with the firm – the degree to which family members identify with the business.

- Binding social ties – the strength of internal and external relational networks.
- Emotional attachment – the intensity of emotional bonds.
- Renewal of family bonds through dynastic succession – the aspiration for dynastic continuity and succession as value transmission.

The FIBER model provides a comprehensive framework for analysing how nepotism and succession interact to shape emotional and relational outcomes in family firms.

3 Methodology

3.1 Research Design

The study employs a **qualitative, interpretivist case study approach**, suitable for exploring complex socioemotional phenomena and capturing multiple stakeholder perspectives. This approach is consistent with prior family business research that highlights the importance of process-oriented and context-sensitive analysis.

3.2 Sample and Data Collection

The study examines two nationally operating, larger than micro-sized Hungarian family businesses (Table 1.) from different industry segments with undergoing intra-family succession. In both cases, the CEO position was transferred from the predecessor to a family successor. Both firms were founded in the early 1990s, with business roots extending across three generations. Interviewees representing different generations were comparable in age, occupied equivalent positions within their respective family businesses, and possessed similar levels of higher education. In both cases, succession occurred within the family; however, the cases illustrate distinct pathways through which successors entered the family business.

Data were collected through **semi-structured interviews** (approx. 60 minutes each) with three stakeholders: the predecessor, the successor, and a non-family employee per firm (Table 2.). This triangulation enabled the examination of nepotism and SEW beyond the family's internal narrative.

Table 1: Characteristics of case companies

	Case 1.	Case 2.
Company profile	Manufacturer and (importer) distributor of building materials	(Importer) Distributor and service provider of technological machinery for (mainly) wood industry
Firm size	SME	SME
Market	national	national
Year founded	1992	2010* *the original company was founded cca. 30 years ago
Family ownership	100%	100%
Revenue (2024)	1 619 million HUF	754 million HUF
Number of employees (2024)	9	5** ** There are more employees within the group.
Generations of the same profession	3	3
Generations actively involved	2	2
Number of adult children	2	2
Children involved	1	1
Management among generations	shared	shared
Ownership among generations	shared	shared
Decision making among generations	shared	shared

Source: Prepared by the authors

Table 2: Characteristics of interviewees

	Case 1.	Case 2.
Predecessor	– male over 65, CEO – founder of current company – related professional background – started his career as entrepreneur in related company before this FB	– male over 65, CEO – founder of current company – related professional background – Started his career as entrepreneur in this FB
Successor	– male over 30, CEO – second son of predecessor – related professional background – started his career in this FB – joined the company in 2016	– female over 30, CEO – second daughter of predecessor – not-related professional background – started her career as entrepreneur, not in FB – joined the company in 2016

	Case 1.	Case 2.
Non-Family Employee	– male over 50, sales manager – work for more than 5 years at the FBs – related professional background and education	– male over 50, head of service – work for more than 10 years at the FBs – related professional background and education

Source: Prepared by the authors

3.3 Data Analysis

Interview transcripts were analysed using **thematic analysis**, guided by the FIBER dimensions and the conceptual distinction between reciprocal and entitlement-based nepotism. Coding focused on emotional expressions, identity narratives, perceptions of fairness, and legitimacy of succession.

4 Findings

4.1 Nepotism as Reciprocal Commitment

In both cases, nepotism manifested primarily as **reciprocal nepotism**. Successors were expected to acquire formal education, external or internal work experience, and firm-specific knowledge; also they were expected to achieve gradual milestones before assuming leadership roles. Preferential treatment was legitimised through demonstrated competence and long-term commitment.

Predecessor Case 1.: “If I had seen that it wasn’t working, I would never have insisted that someone from the family take over the company.”

Predecessor Case 2.: “We had external consultants. We always discussed our long-term strategic goals with them and made a plan that showed, that after a five-year preparation phase, we would gradually hand the task.”

4.2 Family Control and Trust

However, trust rooted in family ties facilitated gradual delegation, the transfer of control was emotionally challenging for predecessors and still there are some challenging issues in case of financial decisions in Case 2..

Predecessor Case 2.: “Two strong personalities, the two women (other Predecessor and the Successor), and there are all kinds of emotional tensions... But it hasn't been such a big problem yet.”

Nepotism functioned as a **trust mechanism**, reducing perceived succession risk and reinforcing family control.

Predecessor Case 1.: “I allow him (the Successor) to make mistakes ... I always let him, and even when he wasn't the managing director, I allowed him to carry out a well-thought-out plan or process.”

Predecessor Case 2.: “I didn't want to change her (the Successor) opinion completely. If I had done it slightly differently, would that matter at all?”

4.3 Identification and Emotional Attachment

Successors exhibited strong identification with the firm, often framing leadership as a moral obligation tied to family legacy.

Successor Case 1.: “I was actually born into this whole family business.” ... “(Now) 70% of my life revolves around this”

Successor Case 2.: “I thought of it (the FB) as cultural heritage. ... I think that this kind of tradition somehow permeates??? the entire company and the people who work here. So, for me, this is a tremendous value, and I think it will remain so.”

Furthermore, emotional attachment deepened alongside rising pressure and an expanding sense of responsibility during succession.

Successor Case 1.: “However, I also feel the pressure that what has been achieved so far is only the bare minimum.”

Successor Case 2.: “Since this (working in FB) is a dynamic that operates with greater emotional amplitude among family members, it is undoubtedly twice as stressful.”

4.4 Binding Social Ties and Organisational Legitimacy

Non-family employees initially accepted nepotistic succession as a natural way of FB generational transition, but ultimately expressed deeper approval when competence and transparency were evident. In the eyes of non-family employees intra-family succession represents the guarantee of business continuity.

Non-Family Employee Case 1.: “He has worked hard so far.” “Everything will continue, and the company will definitely remain in business.”

Non-Family Employee Case 2.: “We have known her since childhood. She knows the company well and wants to continue running it. She has lots of ideas.”

Reciprocal nepotism mitigated legitimacy loss by ensuring that family-based appointments were consistent with professional standards.

4.5 Dynastic Renewal and Identity Integration

Succession was interpreted as both continuity and renewal. While core values were preserved, and nurturing the legacy is a key priority for the next generation.

Successor Case 2.: “For us, it's a legacy thing, because my grandfather was involved in it, and I wouldn't be happy if it were lost. Actually, that was my motivation, because I thought that, on some level, it's in our blood, that it's a super-super good business and a very lovable thing.”

Successor Case 1.: “I really want to get the best out of myself mentally, not just to do my job, but to contribute to the company.”

Successors introduced modernization efforts, illustrating that dynastic succession does not exclude strategic change.

Successor Case 1.: “I definitely want to make some more changes in the next three to five years.”

Successor Case 2.: “If we don't modernise, digitalise, etc., etc., then we won't remain competitive in the market. So I have every opportunity to develop a lot and improve greatly.”

5 Discussion

Table 3: FIBER dimension in the examined in the examined companies

Company	Role	F – Control	I – Identification	B – Binding Ties	E – Emotional Attachment	R – Renewal
Case 1.	Predecessor	Strong control, cautious decision-making, focus on stability	The business as a life's work, strong founder identity	Traditional partner relationships, international business networks	Strong attachment, letting go based on rationality	Cautious renewal, value preservation
Case 1.	Successor	Increasing operational control, more agile decision-making	Experience-based identification, determined mindset	Team- and HR-oriented ties, development of new relationships	High need for conformity, strong emotional involvement	Modernization, expansion
Case 2.	Predecessor	Retention of financial control, structured transfer	Multi-generational industry identity, professional legacy	Long-term supplier relationships, professional networks	Deep emotional attachment to the firm, perception as a life's work	Deliberate renewal, value-based transfer
Case 2.	Successor	Expanding leadership role, strengthening operational control	Strong identification with a modern, branding-based narrative	Strong team relationships, modern internal culture	Performance pressure, affection-based motivation	Innovation, digitalization, scalability competence-based dynastic renewal

Source: Prepared by the authors

The findings challenge the dominant narrative of nepotism as inherently problematic or even detrimental for the business. In line with SEW theory, nepotism – when reciprocal and competence-based – can serve as a mechanism for preserving emotional value, identity, and continuity. However, the emotional burden placed on successors highlights the fragile balance between privilege and pressure. While the answers of third party stakeholders confirmed the statement of Csizmadia et al. (2016) as intergenerational ownership transfer is considered the most natural mode of succession in family firms.

The study also confirms that SEW dimensions are **dynamic**, evolving throughout the succession process rather than remaining static assets (Table 3.).

This research demonstrates that nepotism in family businesses should be understood as a morally differentiated and **context-dependent phenomenon**. Findings confirmed the presence of unique **family dynamics**, where family members deal with emotional ties, differing ambitions, while preserving relationships alongside business goals. Generational transition is accompanied by emotional, relational, and identity-related challenges. However, by integrating family preference with competence-based expectations, in case of **reciprocal nepotism** the risk of legitimacy loss can be reduced. Moreover, nepotism can facilitate access to highly committed family-based human capital and a loyal, cost-efficient workforce (Firfiray et al., 2018). As in the surveyed cases both successors were dedicated and personally motivated, attaining the necessary work experience and knowledge before taking the role of CEO. They were accepted by the organisation as well. In addition, the predecessors have objective expectations and clear requirements towards the applicant for the next leader, also have several-year-long plan in head with fixed milestones for the succession process. These attributes may endow family firms with a competitive advantage, suggesting that nepotistic practices can positively influence firm performance (Bellow, 2003; Ford & McLaughlin, 1986). Furthermore, outcomes of the study confirm the positive influence of intra-family succession on family socioemotional wealth.

However, it cannot be generalised for every case, as FBs and nepotistic decisions may differ. For instance, as previous literature shows, that hiring nepots with low formal qualifications runs greater risk for companies (Lee et al., 2003; Pérez-González, 2006). Nevertheless, the practice of granting preferential treatment to family members solely based on kinship rather than merit has long been the subject to critical inspection. Significant part of literature claims that nepotism may undermine the long-term sustainability and economic performance of family enterprises (Dyer, 2006; Schulze et al., 2001). While reciprocal nepotism can enhance socioemotional wealth during succession, entitlement-based expectations risk emotional strain and legitimacy loss (Firfiray et al., 2018; Jaskiewicz et al., 2009).

The findings contribute to ethical succession planning and expand SEW theory by integrating context dependent nepotism as a possible positive relational governance mechanism.

6 Conclusion

This study contributes to the understanding of nepotism as a leadership-related phenomenon within family business succession by demonstrating that its effects are neither uniformly negative nor inherently dysfunctional. By distinguishing between entitlement-based and reciprocal forms of nepotism and situating them within broader antecedents such as paternalism and machiavellian tendencies, the findings underscore the contextual and moral complexity of nepotistic practices. Drawing on qualitative evidence from two Hungarian family businesses undergoing intra-family leadership transfer, the analysis reveals that reciprocal, competence-based nepotism can reinforce key dimensions of socioemotional wealth, including emotional attachment, organizational identification, and continuity of succession. The inclusion of multiple stakeholder perspectives further highlights how legitimacy and governance outcomes are shaped by perceived fairness and professionalism. Overall, the study enriches ongoing debates on ethical succession and sustainable entrepreneurship in family businesses by offering empirically grounded insights into the socioemotional dynamics underpinning family-based leadership transitions.

6.1 Limitations

While the socioemotional wealth (SEW) framework has significantly advanced the understanding of non-financial goals in family firms, it has also attracted criticism regarding its conceptual clarity and empirical operationalization arguing that the concept is overly broad. FIBER scale of Berrone et al. (2012) have their own limitations. Concerns have been emerged by scholars in the recent academic discourse among others by Brigham and Payne (2019). Furthermore, Debicki et al. (2016) developed another scale (SEWi); also Hauck et al. (2016) modified FIBER scale to REI scale.

General concerns remain that the FIBER dimensions may vary in relevance depending on firm context, size, or generational stage (Miller & Le Breton-Miller, 2014). Furthermore, the reliance on self-reported survey data in SEW measurement raises questions about social desirability bias and the ability of respondents to accurately assess intangible socioemotional priorities. These general concerns can be applied as a limitation of this research paper as well.

Though limited in scope, this study is part of a longer-term research initiative. Its purpose is to establish key theoretical and empirical insights that will inform and support a more extensive exploration of the effect that different types of nepotisms have on the FIBER scale dimensions of SEW in FBs in subsequent phases.

Although it goes beyond the scope of the research topic, according to the findings of the interviews, an emerged topic and recommended further area of research could be the pressure on successors and achieving a healthy work-life balance while managing a family business with the pressure of maintaining and expanding family legacy.

6.2 Theoretical and Practical Implications

This paper aimed to give a deeper understanding of how reciprocal nepotism and its effects on SEW elements in family businesses are studied empirically through the lens of different stakeholder perspectives. On the one hand the main academic contribution of the research paper that it applies the FIBER scale empirically and explores reciprocal nepotism within the SEW framework. On the other hand, the practical implication is to provide actionable insights into ethical and effective succession planning in FBs as the research aimed to discover how reciprocal nepotism contributes to family firm sustainability and legacy.

Moreover, with the help of complex perspective by including the lens of non-family member employees, also empirical analysis could be made on how corporate context and type of nepotism affect the acceptability of nepotism and impact of it on employee performance and loyalty in family business settings. This new holistic approach can motivate other researcher for analysing the phenomena of nepotism in FBs in a more holistic way with contextual perspective.

6.3 Future Research Possibilities

This study should be interpreted in light of certain limitations. First, the present research constitutes **one component of a broader research project** that aims to examine and critically compare the **two distinct forms of nepotism (entitlement and reciprocal nepotism)**. Accordingly, the current analysis does not explore their potentially divergent mechanisms and outcomes.

As a result, the findings reflect an incomplete understanding of phenomena related to nepotism, lacking a comparison of the finer distinctions in the impact of entitlement-based and reciprocity-based nepotism practices on individual attitudes, behavior, or organizational outcomes. Future phases of the research project will address this limitation through a more refined conceptualization and empirical operationalization of nepotism, allowing for a comparative assessment of these two forms and their differing theoretical and practical implications.

Secondly, although this issue extends beyond the immediate scope of the study, the interview findings highlight the need for a deeper examination of succession processes and their associated socioemotional dynamics in family firms, as well as for extending the research timeframe to capture long-term outcomes. At the same time, successors experienced increased pressure to balance modernization efforts with the preservation of tradition, reflecting an emotional dynamic that consistent with broader research on socioemotional wealth and family business governance.

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REASON TO BELIEVE: DYNAMIC FAMILINESS AND THE CONTINUITY OF FAMILY-OWNED WINERIES

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This study investigates which intangible resources underpin continuity in family-owned wineries. Integrating the resource-based view (RBV) with dynamic capabilities theory (DCT), we develop the concept of dynamic familiness, defined as the set of family-specific resource elements and routines that remain functional only when they are deliberately transmitted, maintained, and continuously renewed. The analysis draws on an existing qualitative database comprising semi-structured interviews and case studies of Hungarian family-owned wineries. Resource elements were first grouped into RBV categories and then assessed along a continuity-oriented dimension that distinguishes between resources that require conscious reproduction and those that are relatively stable and can be sustained through formal transfer. The findings suggest that tacit knowledge, relational networks, culture and identity, and renewal-oriented routines are pivotal for continuity, whereas physical and financial capital, although necessary, are insufficient on their own to secure continuity over time.

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1 Introduction

The continuity of family businesses is a recurring topic in the scholarly literature. Numerous empirical studies indicate that a substantial proportion of family firms do not survive the first or second generational transition (Sharma et al., 2003; Miller & Le Breton-Miller, 2006). Discontinuity has often been explained through formal factors such as ownership structures, governance mechanisms, and financial or legal conditions. At the same time, increasing attention has been directed toward intangible and difficult-to-formalize resources — such as tacit knowledge, organizational culture, shared identity, and relational networks — as potential foundations of continuity (Habbershon & Williams, 1999; Zellweger et al., 2012).

According to the resource-based view of the firm (RBV), one of the primary sources of inter-firm heterogeneity lies in differences in the composition and quality of resources; sustained competitive advantage is grounded in resources that are valuable, rare, difficult to imitate, and non-substitutable (Barney, 1991). Within the family business literature, the concept of familiness extends this logic by introducing family-specific content: the interaction between family and business gives rise to a distinctive bundle of resources and capabilities that manifests differently from those found in other organizational forms (Habbershon & Williams, 1999; Zellweger et al., 2012). However, these perspectives tend to reflect an implicitly static understanding of resources, even though generational succession and environmental change may alter both the value and functioning of resources over time.

In this respect, dynamic capabilities theory (DCT) offers a complementary perspective to the RBV by linking continuity not merely to the possession of resources, but to their renewal, reconfiguration, and alignment with changing environments (Teece, Pisano & Shuen, 1997; Teece, 2007, 2014). Within this framework, a distinction is commonly drawn between ordinary capabilities that support day-to-day activities and dynamic capabilities that enable adaptation through the reconfiguration of resources (Winter, 2003; Teece, 2014). In the context of family businesses, this raises the question of whether elements of familiness should be viewed not as given endowments, but as resources whose value and effects evolve over time and may be particularly sensitive to shifts in roles, responsibilities, and decision-making routines.

Gjergji et al. (2025) argue that findings related to ordinary and dynamic capabilities in family business research are often inconsistent, and that the literature only partially uncovers the mechanisms through which family involvement leads to divergent long-term outcomes. From a continuity perspective, this suggests that identifying intangible resources alone is insufficient; it is also necessary to examine the transmission, maintenance, and renewal mechanisms through which these resources remain viable over time.

Our previous analysis (Heidrich & Vajdovich, in press) demonstrated that the dual nature of familiness-related resources is not static, meaning that the same resource may exert different — either enabling or constraining — effects across generational stages and phases of the firm's life cycle. Building on these insights, the present study examines which intangible elements of familiness remain functional over time. To this end, based on existing qualitative material, we distinguish resource elements according to whether their persistence requires conscious reproduction through transmission, maintenance, and renewal, or whether they are more likely to retain their functionality through formal transfer alone. This distinction is then applied as an interpretive framework for understanding continuity.

The empirical context is provided by Hungarian family-owned wineries, where terroir embeddedness, reputation, regional networks, and the simultaneous management of tradition and innovation make the stakes of preserving intangible resources particularly visible. The study does not rely on new data collection; instead, it reinterprets the authors' existing interview and case study database within a modified theoretical framework (Vajdovich, 2024), aligned with a winery-specific resource perspective (Heidrich & Vajdovich, in press).

The central research question addresses which RBV-type resources in family-owned wineries exhibit a dynamic character, that is, require active maintenance and renewal, and how this distinction contributes to understanding why continuity depends on conscious transmission and ongoing renewal for certain resources, while others may persist through formal transfer alone (Teece, 2007; Gjergji et al., 2025). This distinction provides a continuity-oriented operationalization of familiness by explicitly linking RBV resource categories to the temporal reproduction mechanisms emphasized by dynamic capabilities theory.

2 Literature background

2.1 Dynamic capabilities

The dynamic capabilities perspective places sustained adaptability and strategic renewal at the center of analysis, emphasizing that firms do not merely possess resources but are able to recombine and reconfigure them over time in alignment with changing environments (Teece, Pisano & Shuen, 1997; Helfat et al., 2007). In this context, capabilities are understood as socially complex organizational routines that determine how effectively inputs are transformed into outputs (Collis, 1994). Building on this logic, the literature distinguishes between ordinary and dynamic capabilities: the former support value creation and efficiency in day-to-day operations, while the latter enable strategic change and renewal (Winter, 2003; Helfat & Winter, 2011).

Teece (2007) conceptualizes dynamic capabilities through a process logic of sensing, seizing, and reconfiguring, spanning the interpretation of environmental change, the formulation of responses, and the reconfiguration of resources and routines. Ordinary and renewal-oriented capabilities are not mutually exclusive alternatives but complementary elements. Organizational performance depends on how routines of everyday operation are connected to and coordinated with routines of renewal (Teece, 2014; Helfat & Winter, 2011).

Within the family business literature, however, the application of the ordinary–dynamic distinction and the role of their combination remain insufficiently clarified in several respects (Gjergji et al., 2025). This justifies an empirical focus not only on identifying resources, but also on capturing the routines and reproduction mechanisms that keep these resources viable over time.

2.2 RBV and familiness

According to the resource-based view, differences in firm performance stem from resource heterogeneity, and sustained competitive advantage is associated with resources that are valuable, rare, difficult to imitate, and non-substitutable (VRIN) (Barney, 1991). This logic is particularly relevant in the study of family businesses, as the interconnection between family and firm can generate distinctive resource and

capability configurations that manifest differently from those found in other organizational forms and may therefore constitute unique sources of competitive advantage (Habbershon & Williams, 1999).

This configuration is captured by the concept of familiness, defined as the bundle of resources and capabilities arising from the interaction between the family and the business (Habbershon & Williams, 1999). The literature identifies elements such as tacit knowledge, trust-based relationships and reputation, as well as shared identity and values-based culture as core components of familiness (Habbershon & Williams, 1999; Zellweger et al., 2012). From a continuity perspective, however, the key issue is not merely whether these resources are present or exhibit VRIN characteristics, but through which reproduction mechanisms they remain functional across generations, including transmission, maintenance, and renewal.

3 Methodology

The empirical foundation of the study consists of a database created during our previous qualitative research, comprising semi-structured interviews and related case studies conducted in ten Hungarian family-owned wineries. The empirical material was collected as part of one author's doctoral research, which examined generational succession and continuity in family businesses using qualitative methods (Vajdovich, 2024). The present study does not involve new data collection; instead, it reinterprets this interview and case study material within a modified analytical framework.

The choice of the wine industry as the research setting is justified by its sector-specific characteristics. Wine production is simultaneously capital-intensive and strongly reliant on intangible elements such as tacit knowledge, reputation, and regional networks, while the concurrent management of tradition and innovation is particularly salient during generational transitions. This context is therefore well suited to a qualitative examination of the transgenerational transfer of family-specific resources and the conditions of continuity.

The analysis applied a **two-step classification of resources**. In the first step, identified resources were grouped according to traditional RBV categories: human capital, social capital, financial capital, and physical capital (Barney, 1991). This classification built on our earlier resource framework, which synthesized the

resources of family-owned wineries and their manifestations in organizational practice (Heidrich & Vajdovich, in press).

In the second step, each resource element was assessed along an additional analytical dimension, examining **whether its persistence requires conscious transmission, maintenance, and renewal (dynamic character), or whether it can be considered relatively stable and transferable through formal mechanisms alone (relatively stable character)** (Teece, Pisano & Shuen, 1997; Teece, 2007, 2014).

This assessment was based on **three interrelated criteria**, which jointly informed the classification of each resource element: (a) the extent to which the value of the resource depends on individual or organizational change; (b) the degree to which the resource requires conscious transmission, maintenance, or reconfiguration to persist; and (c) the manner in which the resource contributes to maintaining continuity during generational transitions (see Figure 1). Accordingly, the analysis applies an RBV-based categorization of resource elements in the first step, and in the second step evaluates their **transmission sensitivity and continuity relevance** along a dynamic–stable dimension.

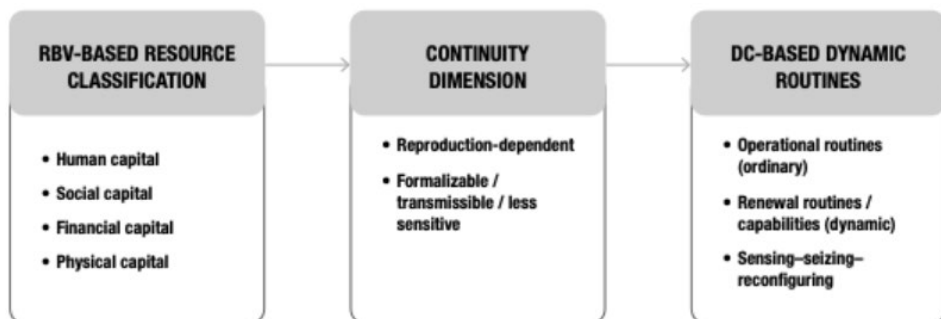


Figure 1: Three-step analytical framework

Source: Own editing

The classification of resources according to their dynamic or relatively stable character emerged from an inductive analytical process. The categorization was developed based on recurring patterns identified in the narratives of the interviews and case studies.

4 Results

Based on the empirical data collected, we distinguished resource elements within the RBV categories (human, social, financial, and physical capital) that exhibit different patterns with respect to continuity. Along the continuity dimension, we distinguished between resource elements that require reproduction to remain functional — that is, those dependent on conscious transmission, maintenance, and renewal — and those that are more readily transferable through formal mechanisms and are therefore less sensitive. The dynamic capabilities perspective is applied as an interpretive framework to capture how resources are enacted through ordinary and renewal-oriented routines (Winter, 2003; Teece, 2007; Teece, 2014) (see Table 1).

Table 1: Continuity-oriented classification of resource elements

RBV resource category	Resource element / sub-dimension	Continuity-oriented character	Observed reproduction mechanisms
Human capital	Tacit knowledge, routines, decision-making patterns Renewal capabilities (innovation, reconfiguration)	Requires reproduction	Joint work, mentoring, gradual involvement Joint innovation decisions, experimentation, technological integration
Social capital (external) (internal/cognitive)	External relational networks, reputation Culture, identity, traditions	Requires reproduction	Successor introduction, networking, joint appearances Shared events, explicit articulation of values, narratives, redefinition
Physical capital	Land, facilities, infrastructure	Formally transferable / less transfer-sensitive	Formal inheritance, investment planning, maintenance
Financial capital	Own equity, resources, financing	Formally transferable / less transfer-sensitive	Liquidity management, risk management, profit reinvestment

Source: authors' own elaboration based on empirical reinterpretation

a) Dynamic (resources requiring conscious reproduction)

Resource elements classified in the table as dynamic and reproduction-dependent share the common characteristic that their value is closely tied to their enactment in everyday practice — through individuals, relationships, and informal routines — and therefore cannot retain the same level of functionality through formal transfer alone.

From a continuity perspective, these resources remain functional only if successors integrate it in the everyday routines and decision-making situations in which such knowledge, trust, identity, or renewal capacity is generated.

Within human capital, tacit professional knowledge, routines related to quality standards, and decision-making patterns appeared as practice-based elements that are learned through practice and are therefore inherently fragile. Their value can be preserved only if successors do not merely receive information but actively participate in practice. In the wineries studied, transmission typically took the form of joint work, mentoring, and gradual involvement; professional socialization was embedded in everyday work routines. **One interviewee described this mode of learning as follows:** *"I made the wine in my own vineyard, or we made it together — and this was perhaps the most important moment."* (W4)

Knowledge related to harvest timing, tasting decisions, and cellar practices was in several cases explicitly not formalized. Rather than being codified in manuals, it was transmitted through recurring situations, shared interpretations, and decision contexts. For continuity, the decisive factor was therefore not declarative knowledge transfer, but whether successors were exposed early and frequently enough to situations in which they had to apply the same decision logics.

The dynamic character of external social capital — regional professional ties, commercial networks, collaborations, and reputation — stemmed from the fact that their maintenance requires active presence. Without the visibility of successors, relational resources tended to erode over time. In the cases examined, founders' relational capital appeared as a key condition for market access and stability. **Another winemaker described the logic of maintaining relationships in the following way:** *"I have always believed that long-term viability is built through shared thinking and joint decision-making."* (W4)

Transmission could be observed only where successors were gradually introduced into the professional milieu through events, organizational memberships, and regional exposure, and where the handover of relationships was handled consciously and transparently. In these cases, reproduction did not consist of transferring a name, but of rebuilding trust-based relationships around the successor as a person.

Culture, identity, and traditions emerged in the empirical material as internal integrative resources that support intra-family cooperation, the legitimacy of decisions, and a shared understanding of quality. Their dynamic nature is derived from the fact that persistence was not a matter of declaration, but was tied to shared events, recurring narratives, and the explicit articulation of values. Harvest-related traditions often carried strong identity-forming functions; where traditions operated as lived practices, cohesion and commitment appeared stronger. By contrast, where traditions were not experientially accessible to successors, identity reproduction did not occur automatically but required conscious redefinition. From a continuity perspective, dynamic functioning was evident where culture did not appear as a “preserved” element, but as a shared meaning that was repeatedly reinforced. **One interviewee reflected this identity formation as follows:** *“I grew into this from childhood — it was not a conscious process; it simply evolved this way.” (W5)*

The above resource elements — especially relational capital and culture/identity — primarily strengthened the cohesive and coordinating dimensions of continuity. At the same time, a distinct pattern emerged across the cases: firms did not respond to change in an ad hoc manner, but through recurring decision routines, and were able to rearrange elements of their operations when necessary. In line with dynamic capabilities theory, we interpret this pattern as renewal-oriented routines. These consist of decision-making patterns that enable the recognition and interpretation of change, the formulation of responses, and the conscious reconfiguration of resources and organizational routines. **This logic of joint decision-making was explicitly articulated in one of the wineries as follows:** *“Our decisions work when we all stand behind them — and if they fail, they still are shared decisions.” (W9)*

In the present analysis, renewal capabilities are treated as a distinct, reproduction-dependent subdimension within human capital, as their persistence is typically realized through experiential learning, joint problem-solving, and shared decision-making rather than through formal transfer. In the cases studied, renewal did not manifest as the abandonment of tradition, but as the updating of quality and market interpretations. In several wineries, established traditional practices were combined with modern technological solutions. Where founders and successors participated jointly in innovation-related decisions, reconfiguration appeared as a gradual transition rather than a sharp rupture; the shared decision space also tended to reduce tensions arising from shifts in roles and responsibilities. Thus, the dynamic

character is captured not primarily in innovative outcomes themselves, but in the firm's capacity for conscious, context-sensitive reconfiguration of routines and resource combinations.

b) Formally transferable (less transfer-sensitive) resources

In the cases examined, physical and financial resources typically persisted through formal transfer, yet on their own they did not explain differences in continuity. Elements of physical capital — vineyards, cellar facilities, machinery, and infrastructure — were generally inherited within formal legal frameworks. From a continuity perspective, these resources provide the operational base and production capacity of the firm, but they do not determine long-term continuity.

Financial capital, including equity, external funds, and financing opportunities, appeared as a precondition for development and stable operation. However, across the cases, financial resources alone did not constitute a sufficient explanatory factor for variations in continuity. Their impact became analytically meaningful only when considered in conjunction with managerial and renewal capabilities: the quality of resource allocation, investment decisions, and risk management was closely linked to ordinary and renewal-oriented routines.

Across the cases analysed, human and social capital resources predominantly exhibited a dynamic character, requiring conscious reproduction, while physical and financial resources were largely relatively stable, except where their value depended on renewal-oriented routines. This distinction highlights that continuity in family-owned wineries is closely tied not only to ownership and formal transfer, but to successors' sustained participation in routines, decision-making, and relational practices.

Finally, building on the preceding analytical steps, we identify dynamic familiness as those family-specific intangible resource elements and routines whose functionality, in the cases studied, could not be sustained through formal transfer alone, but required conscious reproduction through transmission, maintenance, and renewal. These include tacit knowledge and decision-making processes, trust-based and regionally embedded relational networks and reputation, culture, identity, and

traditions, as well as capabilities associated with renewal and reconfiguration routines.

5 Conclusion

The main finding of this study is, that in the family-owned wineries examined, continuity depends less on the formal transfer of physical or financial capital than on family-specific intangible resource elements. Tacit knowledge and decision-making routines (human capital), trust-based and regionally embedded relational networks (social capital), culture, identity, and traditions, as well as capabilities linked to renewal and reconfiguration routines — need to be effectively transmitted and sustained over time. Case-based patterns indicate that physical and financial resources constitute necessary conditions for operation, but do not in themselves explain divergent continuity outcomes. In several instances, family-specific intangible elements remained functional only through conscious reproduction involving transmission, maintenance, and renewal.

The theoretical contribution of the study lies in the empirical grounding of the concept of dynamic familiness. Building on the familiness literature (Habbershon & Williams, 1999), we argue that the role of the resource and capability bundle emerging from the interaction between family and business in ensuring continuity is best understood through its temporal functioning. What matters is not merely whether a resource exists, but whether it can be transmitted, sustained, and reconfigured by the successor generation in a context-sensitive manner. In this perspective, the study links the VRIN logic of the RBV (Barney, 1991) with the temporal dimension emphasized by dynamic capabilities theory and explains continuity in terms of the ability of resources to remain functionally viable across generations.

From a practical perspective, ensuring continuity requires not only the identification of key resources, but the deliberate development of the transferability, adaptability, and reconfigurability of family-specific intangible resources. Within this framework, the dynamic functioning of familiness can be interpreted as a learnable and developable bundle of capabilities, whose sustainability over time determines whether family resources effectively contribute to the long-term continuity of the firm.

These findings are interpretive in nature and context-bound to Hungarian family-owned wineries; however, the proposed distinction offers a transferable analytical lens for examining resource continuity in other family business contexts.

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MANAGERIAL INTENTIONALITY: LINKING EARNINGS QUALITY AND SUSTAINABILITY

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While earnings quality and sustainability performance have been extensively researched as independent domains, their synchronized analysis as an indicator of managerial intentionality remains an open question. This study operationalizes earnings quality through earnings persistence and examines its synchronized presence with ESG (Environmental, Social, and Governance) quality and the temporal stability of ESG performance. Focusing on the period between 2011 and 2019 – a window free from major global economic shocks – these dimensions are analyzed using a filtered panel dataset of 460 listed companies. Results reveal a moderate positive correlation between earnings persistence and overall ESG scores ($r = 0.10$), as well as ESG persistence ($r = 0.11$), demonstrating the concurrent presence of financial and non-financial stability within the sample. A management-oriented interpretation of these findings suggests that the convergence of persistence patterns serves as an empirical indicator of conscious strategic coordination. An empirical framework is provided for measuring corporate strategic coherence through the synchronized stability of financial and sustainability outcomes.

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1 Introduction

In modern corporate evaluation, the integration of sustainability (ESG) criteria is no longer merely an ethical choice but a fundamental element of long-term risk management and value creation. The core idea of this study is that the synchronicity between sustainability performance and financial earnings quality – specifically their temporal stability – serves as an empirical indicator of conscious managerial intentionality and coherent corporate strategy. The purpose of this research is to explore whether companies can manage financial and non-financial stability in parallel and in harmony, or whether sustainability commitments merely serve to mask financial uncertainties.

Investigation of this topic is made particularly timely by the uncertainty surrounding sustainability ratings and the proliferation of "greenwashing". While previous researchers have devoted significant attention to the relationship between ESG levels and profitability, findings are often contradictory: while proponents of the ethical hypothesis have confirmed a positive co-movement between sustainability and earnings quality, followers of the opportunistic or "decoupling" theory suggest that aggressive ESG communication often appears as a shield to disguise weak financial fundamentals. This research contributes to this discourse by analyzing not only static indicators but also the degree of stability – namely, the relationship between earnings persistence and ESG persistence. This approach allows for an empirical distinction between strategic decoupling and genuine managerial intentionality.

The subject of the investigation is verified using a panel dataset of 460 listed companies, focusing on a stability window between 2011 and 2019 that is free from major global economic shocks. The methodology is based on first-order autoregressive (AR1) models, which enable the temporal stability of financial and sustainability outcomes to be quantified individually for each company. Correlation analysis of the two persistence dimensions combined with pillar-level examinations ensures the testing of hypotheses and the exact measurement of the degree of strategic synchronization.

2 Literature review

The evaluation of corporate earnings quality has been at the forefront of accounting research for decades. A fundamental consensus in the literature is that earnings quality is not captured by a single metric but rather by a series of indicators. Within this framework, conservative accounting practices play a critical role; as Velte (2017) suggests, ethical and well-governed firms tend to engage in more conservative and transparent accounting, which minimizes discretionary interventions and enhances the reliability of reports. Such practices ensure that the reported figures represent the actual economic performance rather than managerial manipulation.

Among the various proxies for earnings quality, earnings persistence is regarded as one of the most important and significant indicators. According to Barth et al. (2023), persistence expresses the extent to which current period earnings are sustainable and serve as a reliable basis for predicting future performance. High persistence reduces investor uncertainty by containing fewer transitory or "noisy" elements (Hou et al., 2020). Conversely, a lack of persistence is often a signal of earnings management; Dechow et al. (2010) point out that managers often utilize discretionary accruals to smooth profits or meet specific targets, thereby distorting the informational content of financial reports. Empirical studies by Eliwa et al. (2021) have confirmed that companies with transparent and persistent earnings face significantly lower costs of capital, as the market rewards predictability with a "quality premium".

The importance of sustainability performance in corporate evaluation has grown exponentially, as it is increasingly viewed as an indicator of long-term risk and future resilience. Serafeim (2020) highlights that the market distinguishes between "symbolic" and "substantive" commitment, where the latter is characterized by its alignment with financial goals. Consistent sustainability development is not merely a reporting obligation but indicates the maturity of internal corporate processes (Christensen et al., 2021) and acts as "long-term insurance," stabilizing operations even in the event of market shocks (Attig et al., 2016; Liang and Renneboog, 2017).

Sustainability is primarily quantified through ESG (Environmental, Social, Governance) ratings yet debates regarding the reliability of these metrics persist. Berg et al. (2022) describe "aggregate confusion," where different rating agencies

assign drastically different evaluations due to varying methodologies. Due to this uncertainty, research attention has shifted from static scores toward ESG persistence. Zheng et al. (2022) argue that the temporal stability of sustainability metrics reveals far more about a company's strategic orientation than a one-time value. Frequent and unjustified fluctuations in ESG scores may be signs of "greenwashing" or a lack of strategic focus (Dorfleitner et al., 2020).

The relationship between ESG performance and earnings quality is a central debate. The ethical hypothesis suggests that leading ESG firms produce more reliable reports and exhibit higher earnings persistence (Velte, 2017; Jordaan et al., 2018; Kim et al., 2012). Rezaee and Tuo (2019) argue that sustainability disclosures and financial transparency are mutually reinforcing processes. Conversely, "Decoupling" Theory suggests that management may use ESG results as a "shield": when financial performance is unsustainable, managers may use aggressive ESG communication to divert investor attention (Tashman et al., 2019; Torelli et al., 2020). This strategic decoupling occurs when rhetoric diverges from actual performance (Hawn and Ioannou, 2016).

The integration of these dimensions is fundamentally rooted in managerial intentionality. Schiehl and Kolahgar (2021) explain that the coordination of financial and non-financial metrics requires effective management, while Henri & Journeault (2010) emphasize that coordinated management is evident when profitability and sustainability KPIs are explicitly linked. These patterns are also driven by institutional investor expectations; as Dyck et al. (2019) and Grewal et al. (2019) show, the market punishes companies when ESG commitments lack stable financial foundations. Ultimately, ESG persistence leads to more stable cash flows (Albuquerque et al., 2019), but only the consistent improvement of material ESG factors brings genuine market value growth (Khan et al., 2016). A divergence in these persistence patterns undermines trust in managerial competence (Billio et al., 2021).

3 Hypotheses

Based on ethical theory, it is assumed that companies performing well in ESG engage in more conservative and transparent accounting practices.

- **H₁:** The level of ESG performance is positively associated with the degree of earnings persistence.

Strong sustainability performance reflects a commitment to transparency, which marginalizes discretionary earnings management, making profits more sustainable.

Furthermore, it is assumed that the temporal stability of sustainability and financial performance is the result of conscious strategic planning.

- **H₂:** The temporal stability of ESG performance (ESG persistence) is positively correlated with earnings persistence.

If management can produce stable outcomes in both dimensions, it indicates that sustainability goals have been integrated into operational and financial decision-making processes.

4 Methodology

The research focuses on a panel database covering the period between 2011 and 2019 to avoid structural breaks caused by the post-2008 consolidation and the 2020 pandemic (Barth et al., 2023; Ding et al., 2021). Examining this "stability window" allows for a bias-free analysis of the long-term strategic relationship between managerial intentionality and ESG persistence.

Data were sourced from the LSEG / Refinitiv Eikon database. The base sample consisted of 8,918 listed companies with ESG ratings in 2019; the financial sector was removed due to its specific accounting regulations. Earnings quality is measured by the temporal stability of results using a first-order autoregressive AR(1) model (1). Persistence coefficients (β) were determined individually for each company with Newey-West standard errors to correct for autocorrelation and heteroskedasticity:

$$\frac{NI_{i,t}}{TA_{i,t-1}} = \alpha + \beta * \frac{NI_{i,t-1}}{TA_{i,t-2}} + \varepsilon_{t,i} \dots \dots \dots (1)$$

where $\frac{NI_{i,t}}{TA_{i,t-1}}$ represents the earnings of firm i in period t scaled by lagged total assets; denotes $\frac{NI_{i,t-1}}{TA_{i,t-2}}$ the lagged scaled earnings; α is the intercept term; β represents the

persistence coefficient, which quantifies the sustainability of current earnings for future periods; and $\varepsilon_{t,i}$ is the error term.

To ensure reliable firm-level estimations, the sample was restricted to companies with at least 6 years of continuous data within the stability window ($T_{\min}=6$). The final analysis sample includes 460 firms where the firm-level autoregressive models yielded statistically significant earnings persistence and ESG persistence coefficients at the 5% level.

5 Results

The direction and strength of relationships between variables were quantified using Pearson correlation coefficients. This method allows for the measurement of the synchronization between earnings persistence and ESG metrics.

The correlation between earnings persistence (β) and the 2019 overall ESG score is 0.10, supporting H_1 . Statistically, this indicates a weak but positive and significant relationship, which is consistent with the findings of Velte (2017), who demonstrated that companies with superior ESG performance tend to exhibit higher earnings persistence. Results suggest that higher sustainability performance generally coincides with more sustainable profitability. Pillar-level breakdowns show highly homogeneous values: earnings persistence correlates at 0.10 with the Environmental (E) pillar, 0.09 with the Social (S) pillar, and 0.10 with the Governance (G) pillar. This uniform, albeit moderate, intensity suggests that the integration of sustainability considerations moves holistically alongside earnings quality. A notable finding is the -0.11 correlation with the LSEG Controversies Score, indicating that sustainability scandals and ethical breaches correlate with lower earnings quality.

The relationship between the β of earnings persistence and the β of ESG persistence was examined to address H_2 . The correlation between these metrics is 0.11, reflecting a positive but weak relationship. Based on the current results, H_2 is supported. This empirical result confirms the existence of strategic coordination between financial and sustainability stability management, though such synchronization remains nascent for a significant portion of companies.

Table 1: Summary of Correlation Results (Pearson r)

Variable pair (with earnings persistence)	Correlation coeff.	Hypothesis	Outcome
ESG Score (2019)	0.10	H ₁	Supported
Environmental (E) Pillar	0.10	-	Positive relationship
Social (S) Pillar	0.09	-	Positive relationship
Governance (G) Pillar	0.10	-	Positive relationship
LSEG Controversies Score	-0.11	-	Negative relationship
ESG Persistence	0.11	H ₂	Supported

Source: author's own calculation based on LSEG / Refinitiv Eikon data (2011–2019)

The empirical results provide statistical support for the core propositions of the study regarding the synchronization of financial and sustainability metrics:

- **Support for H₁:** A moderate positive correlation ($r = 0.10$) was found between earnings persistence and the overall ESG score. This indicates that firms with higher sustainability performance generally exhibit more sustainable profitability, consistent with the ethical hypothesis that suggests responsible management views stability holistically.
- **Pillar-Level Homogeneity:** The correlations across the individual Environmental (0.10), Social (0.09), and Governance (0.10) pillars are remarkably uniform. This suggests that the integration of sustainability considerations into the financial framework is a holistic process rather than being driven by a single dimension.
- **Impact of Controversies:** The negative correlation with the LSEG Controversies Score ($r = -0.11$) highlights that ethical breaches and sustainability scandals are significantly associated with lower earnings quality. This suggests that corporate scandals often characterize organizations with less stable financial fundamentals.
- **Support for H₂:** The positive correlation ($r = 0.11$) between earnings persistence and ESG persistence confirms that the temporal stability of these two dimensions is interconnected. While the relationship is relatively weak, it provides empirical evidence of strategic coordination, indicating that for a portion of the sample, stability in both financial and sustainability outcomes is a result of conscious managerial planning.

6 Conclusions

The relationship between the temporal consistency of earnings quality and sustainability performance was examined, operationalizing earnings quality through earnings persistence. Focusing on the crisis-free stability window of 2011–2019, the analysis highlights a concurrent movement between high-level sustainability performance and the temporal stability of financial results. This relationship confirms that responsible operation and profitability stability are inseparable, parallel corporate characteristics. The individual dimensions of sustainability – environmental, social, and governance – appear balanced alongside financial stability, reflecting a holistic integration of sustainability aspects within firms.

Conversely, the emergence of sustainability risks and ethical incidents correlates with a weakening of earnings quality. This negative logical connection suggests that corporate scandals and uncertain financial fundamentals often characterize less stable organizations. The central conclusion of the study pertains to the internal alignment of financial and sustainability stability metrics. The positive relationship between the persistence of these two dimensions supports the existence of strategic coordination, indicating that maintaining stability in both areas is the result of conscious managerial planning and control. However, the intensity of this relationship also reveals that such synchronization is often nascent or partial in corporate practice. The convergence of persistence patterns may thus be one of the most important empirical indicators of strategic management maturity and coherent decision-making.

Beyond the theoretical contributions, these findings offer significant practical implications for several stakeholders. For corporate managers and executives, the results underscore that sustainability should not be managed as a siloed function but as a strategic pillar integrated with financial planning. The synchronization of financial and non-financial persistence serves as a benchmark for managerial intentionality and strategic management maturity, signaling to leadership when a 'decoupling' or 'shielding' risk exists. For investors, particularly institutional owners, the results provide a novel screening tool; rather than relying on static ESG scores, they can evaluate the temporal stability of these metrics alongside earnings quality to identify firms with substantive commitments and stable financial foundations. Finally, for regulators and auditors, the convergence or divergence of persistence

patterns offers an empirical indicator to detect potential greenwashing or strategic decoupling in corporate reporting.

Future research could develop these findings by employing more complex statistical models to identify causal relationships and company-specific fixed effects. Additionally, sectoral breakdowns are warranted, as the financial materiality of ESG factors varies across industries. Finally, it would be compelling to extend the analysis to include the ownership share of institutional investors, as they drive more sustainable operations and facilitate closer strategic alignment between financial and ESG performance through enhanced monitoring. Ultimately, this study provides a framework for measuring long-term alignment, highlighting that genuine managerial intentionality is found in the synchronized stability of financial and sustainability outcomes.

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Gábor Horváth is an Assistant Lecturer at the University of Pécs, Faculty of Business and Economics, and a PhD student at the University of Pécs, Doctoral School of Business Administration. A qualified chartered accountant and specialist in company valuation and fintech management, he possesses extensive professional experience in public and corporate finance. Since 2014, he has been active in higher education and professional training, focusing on accounting, reporting, and applied informatics. His research interests include the financial valuation of intangible assets (primarily data), non-financial disclosure methodologies, and corporate sustainability compliance.

IMPLEMENTACIJA EVROPSKEGA NAČRTA ZA BOJ PROTI RAKU Z VIDIKA SLOVENSКИH PACIENTOV

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Skladno z deveto vodilno pobudo Evropskega načrta za boj proti raku (angl. Europe's Beating Cancer Plan – EBCP), ki je namenjena zmanjševanju neenakosti v Evropski uniji, je potekal projekt OriON Joint Action (JA). Ker je EBCP namenjen pacientom z rakom, je še posebno zanimiv njihov pogled na izvajanje EBCP. Na Nacionalnem inštitutu za javno zdravje smo s tem namenom organizirali delavnico s predstavniki šestih slovenskih združenj pacientov. Namen je bil pridobiti vpogled v izvajanje EBCP v Sloveniji in v koristi EBCP za paciente. Razprava se je osredotočila na izvajanje EBCP ter priložnosti in izzive na nacionalni ravni. Predstavniki pacientov so bili mnenja, da bi se moralo okrepiti informiranje o EBCP, nameniti večji poudarek celostni oskrbi, odpravi stigme paliativne oskrbe ter krepitvi duševnega zdravja pacientov in njihovih skrbnikov. Namen prispevka je predstaviti pogled predstavnikov organizacij pacientov z rakom na EBCP, njegovo implementacijo v slovenskem prostoru, koristi, pomanjkljivosti ter možnosti za izboljšave.

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IMPLEMENTATION OF EUROPE'S BEATING CANCER PLAN FROM THE PERSPECTIVE OF SLOVENIAN PATIENTS

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In accordance with the Flagship No9 of Europe's Beating Cancer Plan (EBCP), which aims to reduce inequalities in the EU, the OriON Joint Action (JA) was implemented. Since EBCP is intended for cancer patients, their perspective on its implementation is of particular interest. For this purpose, we organized a workshop at the National Institute of Public Health with representatives of 6 Slovenian patient organizations. The workshop aimed to gain insight into the implementation of the EBCP and its benefits for patients. The discussion focused on advantages, opportunities and challenges at the national level. Patient representatives highlighted the need for improved information about the EBCP, greater emphasis on comprehensive care, eliminating the stigma surrounding palliative care, and strengthening the mental health of patients and their caregivers. This paper presents the perspectives of patient organizations on EBCP in Slovenia, its implementation, benefits, shortcomings and opportunities for improvement.



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1 Uvod

Evropski načrt za boj proti raku (angl. Europe's Beating Cancer Plan – EBCP), ki ga je Evropska komisija (EK) sprejela leta 2021, predstavlja krovni dokument na področju načrtovanja obvladovanja raka v Evropski uniji (EU). Obvladovanje rakavih bolezni namreč še vedno predstavlja velik izziv na področju zdravstva v Evropski uniji (EU). Izhodišče Evropskega načrta za boj proti raku so raziskave, inovacije in nove tehnologije, kar predstavlja nov pristop v EU k preprečevanju raka, zdravljenju in oskrbi na področju raka. Temelj načrta predstavljajo štirje tako imenovani stebri (angl. pillars), ki so v bistvu štiri najpomembnejša področja obvladovanja raka: preventiva in zgodnje odkrivanje raka, diagnostika z zdravljenjem ter kakovost življenja bolnikov z rakom, vključno z osebami, ki so bolezen prebolele, oz. s preživelimi. Načrt ima tudi tako imenovane presečne (angl. cross cutting) teme, kamor so uvrščene tudi inovacije, raziskave, področje zmanjševanja neenakosti in personalizirana medicina (Jelenc, Albreht in Hribar, 2021; European Commission, 2021).

Tematska področja Evropskega načrta za boj proti raku vključujejo 10 vodilnih pobud (angl. flagship initiatives), na uresničevanje katerih so vezani projekti, s katerimi EK udejanja svojo vizijo. EK je za izvedbo Evropskega načrta za boj proti raku in vse nanj vezane projekte namenila štiri milijarde evrov (Jelenc, Albreht in Hribar, 2021; European Commission, 2021). Vsebina omenjenih projektov je sicer zastavljena širše, saj so vezani tudi na področje izobraževanja, socialne politike in enakosti, zaposlovanja, okolja, podnebja, kmetijstva, trženja, energije, prometa, obdavčenja in kohezijske politike (European Commission, 2021).

Deveta vodilna pobuda Evropskega načrta za boj proti raku je namenjena zmanjševanju neenakosti v EU. Nanjo je bil vezan dvoletni (2024–2025) projekt OriON Joint Action (JA), v katerem je sodelovalo 23 partnerjev iz 17 držav (Belgija, Ciper, Grčija, Hrvaška, Irska, Italija, Litva, Madžarska, Malta, Nizozemska, Norveška, Poljska, Romunija, Slovaška, Španija, Švedska in Slovenija). OriON JA je imel tri splošne cilje (spremljanje sprejemanja in implementacije Evropskega načrta za boj proti raku v državah članicah EU, priprava pilotnega okvirja za spremljanje in vrednotenje Evropskega načrta za boj proti raku, povečanje učinka znanja, ustvarjenega z Evropskim načrtom za boj proti raku) ter dva specifična cilja (podpora spremljanju in analizi izvajanja Evropskega načrta za boj proti raku ter

priprava analize na področju nacionalnih programov za obvladovanje raka s posebnim poudarkom na neenakostih) (European Commission, 2023). Delo znotraj JA je organizirano v petih delovnih sklopih ali paketih (angl. Work Packages – WP), treh horizontalnih oz. obveznih (WP 1 – Koordinacija, WP 2 – Diseminacija, WP 3 – Evalvacija) in dveh vsebinskih delovnih paketih (WP 4 – Trajnost in izvajanje – podpora spremljanju in analizi izvajanja Evropskega načrta za boj proti raku ter WP 5 – Analiza razvoja nacionalnih programov za obvladovanje raka).

Primarna ciljna skupina OriON JA so oblikovalci politik iz držav članic EU in njihovi predstavniki, sekundarno ciljno skupino pa predstavljajo organizacije EU, strokovnjaki, zagovorniki in predstavniki pacientov ter pacienti iz cele Evrope (European Commission, 2023).

Nacionalni inštitut za javno zdravje (NIJZ) je koordiniral celotni projekt OriON JA v sklopu dela prvega delovnega paketa. Poleg tega je NIJZ koordiniral še peti delovni paket, namenjen utiranju poti za izboljšanje kakovosti nacionalnih programov za obvladovanje raka v EU, s posebnim poudarkom na neenakostih na področju raka na podlagi analize razvoja nacionalnih programov za obvladovanje raka v EU (Jelenc, 2024).

Četrty delovni sklop projekta, ki ga je sicer vodil inštitut Sciensano iz Belgije, je bil namenjen sledenju implementacije Evropskega načrta za boj proti raku. Ker je načrt namenjen pacientom z rakom, je namreč še posebno zanimiv njihov pogled na njegovo izvajanje.

Namen prispevka je predstaviti pogled predstavnikov organizacij pacientov z rakom v Sloveniji na Evropski načrt za boj proti raku, poznavanje načrta, njegovo implementacijo v našem prostoru, koristi, ki jih prinaša, pa tudi pomanjkljivosti ter možnosti za izboljšave.

2 Metodologija

Z namenom pridobitve vpogleda v izvajanje EBCP v Sloveniji in zlasti v korist EBCP za paciente smo izvedli delavnico s predstavniki združenj pacientov v Sloveniji. Pripravili smo predstavitev EBCP in projekta OriON JA ter izhodišča za diskusijo v obliki vprašanj in tem, kot so prednosti izvajanja EBCP, priložnosti in

izzivi na nacionalni ravni. Naš cilj je bil zagotoviti udeležbo čim večjega števila predstavnikov organizacij pacientov. Zato smo poiskali kontakte združenj pacientov ter pripravili in poslali vabila na delavnico z razlago in namenom delavnice.

3 Rezultati

Na NIJZ smo 9. aprila 2025 izvedli delavnico s predstavniki šestih slovenskih združenj pacientov, ki so se odzvali našemu povabilu. Na delavnici so sodelovali predstavniki naslednjih združenj: Europa Donna Slovenija, Združenje bolnikov z limfomom in levkemijo Slovenije, Združenje bolnikov s krvnimi boleznimi Slovenije, Združenje bolnikov z rakom Slovenije, Zavod Zlati trak – otroci z rakom in EuropaColon Slovenija. Razprava se je osredotočila na prednosti izvajanja EBCP, preostale izzive in priložnosti na nacionalni ravni.

Predstavljamo mnenja pacientov glede glavnih točk razprave:

- Zaznane priložnosti EBCP, zagovorništvo in izvajanje

Udeleženci so poudarili, da vidijo v EBCP veliko prednost in predlagali, da Slovenija sprejme podoben pristop glede Državnega programa za obvladovanje raka (DPOR). Čeprav predstavlja slovenski DPOR trden okvir, je njegovo izvajanje po njihovem pomanjkljivo. Združenja pacientov menijo, da je DPOR ključno orodje zagovorništva, zavezujoča dejstva k takim dokumentom pa so bistvena za podporo njihovem delu (npr. za integrirano in multidisciplinarno oskrbo). V praksi po njihovem mnenju mnogi vidiki, kot je integrirana oskrba, ne delujejo učinkovito, vendar EBCP daje organizacijam pacientov dodaten vzvod poleg slovenskega DPOR.

- Vloga evropskih mrež in praktičnih pristopov

Evropske mreže, kot je Digestive Cancers Europe (DiCE), so zelo aktivne ter ponujajo pobude in pomoč (npr. pobuda ENTERO). Praktično izmenjevanje izkušenj in sodelovanje deležnikov sta ključna. Dogodki, na katerih sodelujejo vsi deležniki, spodbujajo pozitivno medsektorsko sodelovanje.

- Financiranje združenj pacientov in ovire pri nacionalnih razpisih za financiranje

Pomemben izziv je pomanjkanje stabilnega financiranja nevladnih organizacij, ki delujejo na področju raka. Te organizacije pogosto delujejo brez stalnega osebja in se močno zanašajo na prostovoljce, kar omejuje njihove zmogljivosti. Pozivajo k namenskim in doslednim shemam financiranja dela, povezanega z rakom, ki bodo ločene od splošnih pobud javnega zdravja. Poudarili so, da združenja pacientov ne morejo učinkovito delovati brez financiranja. Udeleženci so delili primere nacionalnih razpisov, pri katerih so združenja pacientov izgubila točke ali bila izključena zaradi tehničnih podrobnosti (npr. lokacija organizacije), kljub temu da DPOR poudarja pomen njihove vloge. To neskladje jasno kaže na vrzel med strateškimi cilji in praktično izvedbo. Javni diskurz v Sloveniji je vse bolj negativen do financiranja nevladnih organizacij (npr. trditve o »preveč nevladnih organizacijah«). To otežuje izvajanje ukrepov DPOR. Vladni organi ne nadzorujejo in ne zagotavljajo poštene in racionalne dodelitve sredstev. Najpomembnejša prednostna naloga je zagotavljanje stabilnega, ciljno usmerjenega financiranja za organizacije pacientov, saj predstavljajo ključni most med pacienti in strokovno skupnostjo.

- Vključenost institucij javnega zdravja

Udeleženci so priznali prizadevanja institucij, kot je Nacionalni inštitut za javno zdravje (NIJZ), za vključitev nevladnih organizacij in pozdravili ustanovitev namenske enote za nevladne organizacije leta 2023. Zgodnja natančna opredelitev vrste sodelovanja je po njihovem bistvenega pomena za uspeh.

- Težave z definicijami v slovenskem DPOR

Slovenija uporablja nedosledne definicije v primerjavi z mednarodnimi standardi. Mladostnike in mlade odrasle (angl. adolescents and young adults – AYA) opredeljuje na primer starostno različno (25–32 let) v primerjavi z mednarodno sprejetimi definicijami (15–39 let). Te nedoslednosti zahtevajo utemeljitev in uskladitev s priporočili EBCP.

- Vloga EBCP pri oblikovanju nacionalnih strategij

Udeleženci so poudarili, da bi moral EBCP predstavljati temelj za oblikovanje in revizijo slovenskega DPOR. Vključevanje nevladnih organizacij je treba izrecno opredeliti, prav tako njihove vloge in odgovornosti. Vrednost EBCP je v njegovi praktični uporabi, ne le v njegovem obstoju. Izpostavljeni so bili uspešni primeri, kot je nacionalni program presejanja in zgodnjega odkrivanja kolorektalnega raka SVIT. Kljub temu je potrebno boljše izvajanje in prepoznavnost ukrepov EBCP.

- Sistemski in strukturni izzivi

Šibko sodelovanje in komunikacija med deležniki še vedno obstajata. To so sistemska vprašanja, ki zahtevajo usklajena prizadevanja in boljše mehanizme za povezovanje in sodelovanje.

V nadaljevanju delavnice smo predstavnike združenj pacientov z rakom vprašali, kako EBCP koristi pacientom. Podali so naslednje odgovore:

- z zagotavljanjem, da se EBCP izvaja v praksi – ne le v pisni obliki;
- z omogočanjem boljše strukturiranih in hitrejših razpisov za zbiranje predlogov z zagotovljenim financiranjem;
- z namensko finančno shemo, posebej namenjeno pobudam, povezanim z rakom, ločeno od drugih kroničnih bolezni;
- z večjim poudarkom na celostni oskrbi;
- z dajanjem prednosti duševnemu zdravju bolnikov z rakom in njihovih družin;
- z zmanjševanjem stigme v zvezi s paliativno oskrbo in zagotavljanjem pravočasnega dostopa do nje;
- z uporabo EBCP kot okvira za nacionalne programe za boj proti raku, kot je slovenski DPOR, ter z omogočanjem rednih posodobitev in izboljšav;
- z okrepljeno preventivo, zbiranjem podatkov, s projekti, ki temeljijo na dokazih, in z vključevanjem glasov bolnikov;
- z ozaveščanjem – mnogi bolniki še vedno ne poznajo EBCP, čeprav ga združenja bolnikov dobro poznajo;
- s primeri dobrih praks, kot je presejalni program SVIT;

- s pospešitvijo diagnostike – npr. rak prebavi bi moral biti diagnosticiran v šestih tednih;
- s spodbujanjem sodelovanja med deležniki (vključno z zdravstvenimi delavci, bolniki in industrijo);
- z zagotavljanjem enake, varne in visokokakovostne oskrbe v vseh regijah;
- s podporo organizacijam pacientov, ki povezujejo paciente in ponudnike zdravstvenih storitev.

4 Diskusija

Glede na podatke Onkološkega inštituta oz. Registra raka, ki kažejo, da v Sloveniji za rakom zboli vsako leto več kot 15.000 ljudi, okoli 6500 pa jih umre, je razvidno, da je rak tudi pri nas velik javnozdravstveni problem (Škrbec, 2021) in da bo ob neustreznem ukrepanju z vidika staranja populacije lahko ostal takšen tudi v prihodnje. V Sloveniji je namreč pri moški populaciji rak prvi vzrok smrti, pri ženski pa drugi. V naši državi živi okrog 110.000 ljudi, ki jim je bila diagnoza rak postavljena vsaj enkrat v življenju. Najpogostejši raki so pri nas rak dojk, prostate, debelega črevesa in danke, pljučni rak in kožni rak. Poznamo sicer okrog 200 vrst rakavih bolezni (Škrbec, 2021).

Prav zaradi zavedanja vsega navedenega se Slovenija kljub svoji geografski majhnosti že vrsto let trudi aktivno sodelovati pri različnih evropskih projektih s področja raka. Poleg zadnjega projekta OriON JA (2024–2025) je Slovenija oz. NIJZ koordiniral zahtevne projekte s področja obvladovanja raka, kot so European Partnership for the Action Against Cancer – EPAAC JA (2011–2014), Joint Action on Cancer Control – CanCon JA (2014–2017), Innovative Partnership for Action Against Cancer – iPAAC JA (2018–2021) in European Network of Comprehensive Cancer Centres – CraNE JA (2023–2024) (Commission of the EC, 2009; Jelenc, idr., 2011; Jelenc, idr., 2018; Jelenc in Albrecht, 2020; Jelenc, idr., 2023; Consortium CraNE, 2024). Rezultati omenjenih projektov so številni in nedvomno prispevajo k uspešnejšemu obvladovanju raka. Projekt skupnega ukrepanja s področja obvladovanja raka OriON je bil usmerjen v zmanjševanje neenakosti na področju raka, ki še vedno predstavljajo problem v EU (Jelenc, 2024; Jelenc, idr., 2024; Peiró Pérez, idr. 2017).

Vodena razprava s predstavniki pacientov se je v okviru delavnice, organizirane v sklopu četrtega delovnega paketa projekta OriON JA, osredotočila na njihov vidik prednosti izvajanja EBCP ter različne izzive in priložnosti na nacionalni ravni. Predstavniki pacientov so bili mnenja, da informiranje o EBCP v Sloveniji ni zadostno ter da bi se moralo okrepiti informiranje o načrtu in njegovih vsebinah. Na podlagi tega odgovora bi se morali NIJZ ter predstavniki Onkološkega inštituta in Ministrstva za zdravje dogovoriti, kako z informacijami doseči paciente in ne samo njihove predstavnike v združenjih. Načrt bi po njihovem moral predstavljati nekakšen okvir slovenskemu DPOR, moral bi biti živ dokument, ki bi se redno posodabljal.

Zagotovitev stalnega financiranja dela organizacij pacientov je bilo izpostavljeno kot eno od prednostnih področij. Večji poudarek bi morali nameniti celostni oskrbi, odpravi stigme paliativne oskrbe ter krepitvi duševnega zdravja pacientov in njihovih skrbnikov. Razprava s predstavniki organizacij pacientov je nenazadnje pokazala, da EBCP za boj proti raku predstavlja pomemben strateški okvir, vendar njegova dejanska vrednost nastopi šele ob učinkovitem prenosu v nacionalne politike in prakse. Glas pacientov je pri tem ključni korektiv, saj razkriva razkorak med strateškimi dokumenti in vsakdanjo izkušnjo bolnikov. Ugotovitve delavnice potrjujejo potrebo po sistematičnem in trajnostnem vključevanju organizacij pacientov v procese oblikovanja, izvajanja in spremljanja nacionalnih programov za obvladovanje raka.

5 Zaključek

Izsledki delavnice s predstavniki organizacij pacientov, ki delujejo na področju raka v Sloveniji, so pokazali, da je informiranje o EBCP v slovenskem prostoru nezadostno in da obstaja glede implementacije EBCP še veliko možnosti za izboljšave. Izsledki delavnice so jasno pokazali, da predstavniki združenj pacientov sicer v izvajanju EBCP v Sloveniji vidijo številne prednosti, vendar te koristi pogosto ne dosežejo pacientov zaradi pomanjkljive informiranosti. Na ravni pristojnih institucij se bo treba dogovoriti o usklajenem in ciljno usmerjenem obveščanju pacientov z rakom ter sistematično upoštevati njihova priporočila za izboljšave. Prispevek poudarja, da je uspešnost EBCP v veliki meri odvisna od njegove prepoznavnosti in učinkovite operativne implementacije, kar predstavlja ključni pogoj za zmanjševanje neenakosti na področju obvladovanja raka.

Opomba

Ta prispevek izhaja iz skupnega ukrepa OriON JA (angl. OriON Joint Action), ki je prejel sredstva Evropske unije prek Evropske izvajalske agencije za zdravje in digitalno tehnologijo (angl. European Health and Digital Executive Agency – HaDEA) v okviru programa EU za zdravje (angl. EU4Health) 2021–2027.

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UNPRECEDENTED REVISION OF THE EU BUDGET: DRIVERS AND INNOVATIONS OF THE MID-TERM REVISION OF THE 2021–2027 MULTIANNUAL FINANCIAL FRAMEWORK AND THE CROATIAN PERSPECTIVE

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In the turbulent global circumstances brought by the COVID-19, as well as by the energy crisis and the war in Ukraine, the European Commission considers the transition to a new economic model of responding to emerging economic, political, and environmental challenges. Alongside the European Recovery and Resilience Facility, the EU Multiannual Financial Framework for the period 2021–2027 (MFF), is currently in force, for which the Commission proposed a mid-term revision. The aim of this paper is to analyse the reasons behind this unprecedented revision, with particular emphasis on Croatia as one of the largest net beneficiaries of EU funds. The findings show that insufficient absorption of Cohesion Policy funds did not play a decisive role in triggering the revision. Instead, inflationary pressures, the war in Ukraine, and the exhaustion of existing budgetary flexibility are main drivers.

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1 Introduction

Since 2020, the EU has been confronted with a series of unpredictable circumstances, while the Multiannual Financial Framework (MFF) for 2021–2027, in combination with the NextGenerationEU instrument (NGEU), has enabled a rapid and effective response to the COVID-19 pandemic and its economic and social consequences. NGEU was designed to strengthen the EU on its path to recovery and to accelerate the transition process. Common borrowing and limited risk-sharing became defining features of the NGEU, marking a historic first for the Union. As noted in the Recovery Watch (2023) report, NGEU has not transformed EU budgetary planning or the foundations of the Union, given that it has limited scope and duration, does not address the legacy public debts of Member States, and has not established permanent joint investment capacities. This instrument does not lead to the federalisation of the EU, just as the Reform Treaty (Treaty of Lisbon) of 2007 did not do so. The EU is now facing a new and serious challenge in the form of Russia's invasion of Ukraine and its repercussions, such as the energy crisis. The EU responded within the constraints of its own budget, drawing on its limited structural flexibility. Yet, owing to the multi-layered consequences of these crises, EU budgetary resources have become insufficient, prompting the European Commission (EC) to introduce a budgetary revision. At the same time, the EU's MFF for the 2021–2027 period is in force, with a budget of EUR 1.074 trillion at 2018 prices. In the 1980s, when the first MFF was introduced, a growing disparity between available and required budgetary resources led to tensions among EU institutions. The combined resources of the 2021–2027 MFF and NGEU, together exceeding EUR 1.8 trillion, have provided Member States with substantial funding. However, NGEU must be fully absorbed by 2026, while resources under the MFF must be implemented by the end of 2029 in accordance with the $n+2$ rule. The allocation of EU funds, aimed primarily at less developed Member States, has raised concerns regarding absorption capacities and the feasibility of achieving objectives within the prescribed timeframes. Considering the state of the Union and significant geopolitical factors, the EC has, for the first time in its history, conducted a revision of the EU budget. In its Communication on the mid-term revision of the 2021–2027 MFF (European Commission, 2023), EC assesses the performance of the MFF to date, including whether the EU budget can continue providing common solutions to shared challenges, support Ukraine, and address the consequences of the energy

crisis. This unprecedented revision strengthened the EU budget with an additional EUR 64.6 billion to finance priority areas.

2 Methodology

This paper applies a qualitative analytical approach based on the systematic examination of secondary sources, EU legislative documents, strategic frameworks, and publicly available statistical datasets, primarily using Eurostat data which were examined to identify the formal rationale, objectives, and financial implications of the MFF revision. The research doesn't involve primary data collection; instead, it relies on synthesising existing evidence and interpreting trends within the EU's budgetary and cohesion policy framework. The methodological design follows three complementary components: document analysis, comparative analysis, and case study analysis, enabling a structured assessment of the mid-term revision of the 2021–2027 MFF, with a specific focus on Croatia. The study is conceptualised as a qualitative desk research, aimed at identifying the economic, geopolitical, and institutional factors that led to the first-ever mid-term revision of the EU budget. The research builds on the hypothesis that the revision was driven, among other factors, by the insufficient absorption of MFF funds at the EU level and in Member States such as Croatia. Based on document analysis, a comparative analysis was conducted between the 2014–2020 and 2021–2027 MFF absorption dynamics at the EU level overall, and Croatia's absorption performance relative to the EU average and comparable Member States to test the absorption dynamics and administrative capacities. The case study of Croatia is analysed as a representative case of a major net beneficiary with structural absorption challenges which enables a deeper understanding of national-level implementation bottlenecks, governance issues, and the interaction between MFF and NGEU funding streams. However, this paper has several research limitations. Firstly, it relies exclusively on secondary data, which may reflect reporting delays or methodological differences across EU datasets. Secondly, the mid-term revision is a recent policy development, meaning that long-term effects cannot yet be empirically evaluated, and require *post festum* in-depth analysis of all budgetary components to enable the complete overview on dynamics and factors that influence its' full implementation. Thirdly, the analysis of absorption capacities is constrained by the availability of harmonised data, and subject to frequent updates. Despite these limitations, the methodological approach provides a robust foundation for assessing the drivers and implications of the MFF revision.

3 Results of Analysis of the 2021–2027 MFF Revision

Led by example of 2008-2010 financial crisis, Mauro (2025) claim that economic crises have been the cause of structural and budget reforms. In a period of multiple overlapping crises, the EU operated within a paradox in which shared challenges demanded coordinated responses, yet the decisive actions were ultimately taken by national governments. According to Fabbrini (2025) the construction of a crisis within the EU is shaped by three key factors: the distribution of competences laid down in the TEU and TFEU, the nature of the shock itself, and the political leadership's willingness to frame a given event as a crisis. The major crises of the past decade, from the financial crisis, through the pandemic, to the energy and security crises, erupted in policy domains where Member States retain primary authority, which significantly influenced both the scope and the dynamics of the Union's response. Authors (Fabbrini, 2025; Cipriani, Buti, Grossi & Mauro in Mauro, 2025) agree that recent world events and the public sector reform movement have underscored the need to reshape the EU budget and strengthen its focus on areas where the EU can deliver genuine added value. Therefore, this chapter will analyse the variables that could potentially underpin the unprecedented 2021–2027 MFF revision, such as macroeconomic and political drivers, the structure of revision novelties, and the absorption dynamics of Cohesion Policy under two consecutive MFFs at both EU and national level, using Croatia as a case study, in order to assess whether the revision may indeed be rooted, among other factors, in the insufficient absorption of funds at EU and Member State level, as initially hypothesised.

3.1 Macroeconomic and Geopolitical Drivers of the MFF Revision Inflation.

Following the COVID-19 pandemic, from 2022 onwards, the EU and other major economies experienced a sharp rise in inflation, the most significant in more than forty years, further intensified by Russia's invasion of Ukraine. According to Eurostat (2025), over the past decade inflation in the EU began at a low level of 0.1% in 2015, after which the average annual inflation rate gradually increased. At EU level, inflation stood at 0.2% in 2016, 1.7% in 2017, and 1.9% in 2018. Influenced by COVID-19-related measures, inflation fell substantially to 0.7% in 2020, but subsequently surged to 2.9% in 2021, and in the following year reached an historic peak of 9.2%. The rate fell again in 2023, though it remained above the 2021

level at 6.4%. In 2024, the annual inflation rate declined once more, to 2.6%. According to Eurostat's Harmonised Index of Consumer Prices (HICP) (ibid.), in 2024 consumer prices increased most sharply in Romania (5.8%), Belgium (4.3%) and Croatia (4.0%), while the lowest average annual inflation rates were recorded in Lithuania (0.9%), Finland (1.0%) and Italy (1.1%). Compared with major global competitors, in 2022 the EU recorded a significantly higher inflation rate 9.2%, than the United States (8%). Inflation remained relatively stable in Japan (2.5%) and China (2%). Although inflation fell in all observed economies in 2023, the EU's rate of 6.4% remained higher than that of the United States (4.1%) and Japan (3.3%).

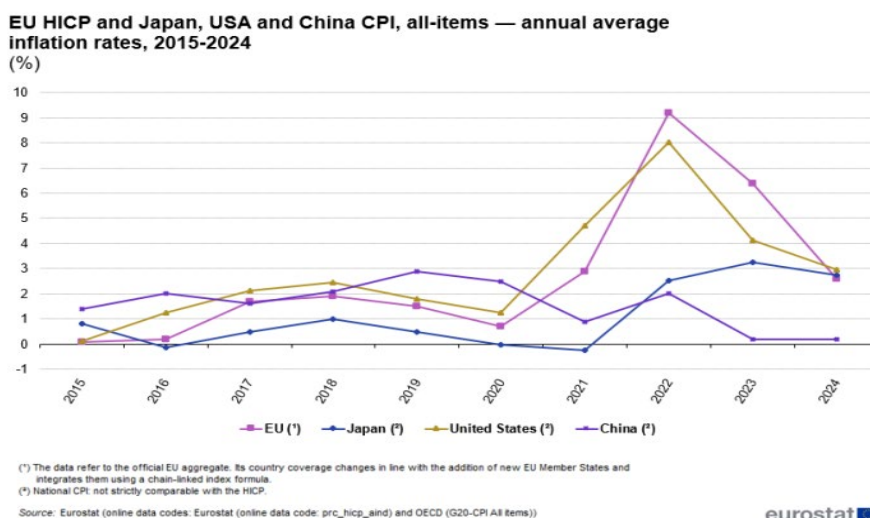


Figure 1: Representation of changes in the average annual inflation rate, 2015–2024

Source: Eurostat, 2025

As part of efforts to curb inflation, central banks tightened monetary policy. Interest rates on international capital markets rose more rapidly and yields on ten-year EU bonds increased from near zero to over 3%, with consequences for the EU budget as well. For special instruments, programmes or national schemes, EC had pre-allocated 90% of the EU budget and the NGEU. To date, 75% equivalent to EUR 5.5 billion of the initially unallocated margins under the 2021–2027 ceiling have been used to adjust and respond to unexpected crises. According to the European Central Bank, EU Member States submitted requests amounting to EUR 650 billion from the NGEU during 2024, and a total of EUR 206.4 billion in grants and EUR

111.7 billion in loans has so far been disbursed at EU level. According to Bańkowski et al. (2024), despite the substantial increase in funds made available to Member States through NGEU, part of this increase was offset by the unexpected inflationary shock that followed its launch.

War in Ukraine. Since the outbreak of the war in Ukraine in 2022, Europe's security has come into question, alongside the emergence of broader global geopolitical instability. By amending the budget, as explained later, the EU has enabled the potential to allocate funds to support Ukraine (Mauro, 2025).

Energy crisis. Energy prices reached record levels in 2022, largely due to Russia's invasion of Ukraine. The energy crisis peaked in August 2022, with significant repercussions for both households and the economy. The European Commission launched REPowerEU, a plan to strengthen the EU's energy autonomy and promote clean energy. According to the *2024 State of the Energy Union Report* (European Commission, 2024), during the first half of 2024 gas imports fell from 45% of total EU gas imports in 2021 to just 18% (from 150.2 to 25.4 billion m³), while annual imports in 2023 were 72% lower than in 2021. Norway became the largest supplier of pipeline gas to the EU, accounting for 34% of imports in the first half of 2024, while the United States was the largest supplier of LNG over the same period, accounting for 18%. These factors have resulted in the full utilisation of all available resources, limiting the EU's ability to respond to urgent crises, to support Europe's long-term competitiveness in critical sectors, and to preserve and strengthen the European social model. Additionally, the Union's capacity to react to challenges expected over the next four years has been weakened, given the unstable geopolitical and economic context. All these reasons undoubtedly contributed to the first budgetary revision in the history of the EU.

3.2 Innovations of MFFs' Unprecedented Revision

Considering the above circumstances, the EC's Communication (2023) proposed further steps to secure essential financial resources for the EU's shared priorities and needs. The focus was placed on those key areas where adjustment is unavoidable if the EU is to meet its common objectives in the current global environment. This marks the first occasion on which a mid-term review of the MFF has resulted in a net increase in expenditure ceilings. Delasnerie (2025), through an analysis of

Council Regulation (EU, Euratom) 2024/765 of 29 February 2024 amending Regulation (EU, Euratom) 2020/2093 laying down the MFF for the period 2021–2027, summarised the amendments introduced through the revision.

A key innovation is the **Ukraine Facility**, designed to support recovery, reconstruction, modernisation and Ukraine's progress towards EU membership. With a value of EUR 50 billion, the facility seeks to consolidate bilateral EU support and provide financial assistance. To strengthen competitiveness in critical technologies, the EU has established the **Strategic Technologies for Europe Platform (STEP)**. New and emerging technologies (digital and deep tech, clean technologies and biotechnology) will be financed through Cohesion Policy funds, the InvestEU programme, Horizon Europe, the EU Defence Fund, the Innovation Fund and NGEU. Under STEP, an additional EUR 1.5 billion will be allocated to the European Defence Fund to enhance defence-investment capacities. To support Member States in addressing urgent **migration and border-management** challenges, the EU budget will be increased by EUR 2 billion. In the context of exceptional geopolitical tensions, EUR 7.6 billion will be directed towards the **EU's neighbourhood** and global partnerships. Another important innovation introduced by the revision is a **cascade mechanism** to meet the EU's obligations related to interest payments under NGEU which opens the possibility of mobilising a new extraordinary instrument in cases where interest payments cannot be financed within the existing EU budget. The revision also increased the EU's financial resources for **emergencies** by EUR 1.5 billion, addressing natural disasters and humanitarian crises within and beyond the EU, which will be deployed through two separate instruments: EUR 1.016 billion annually for the European Union Solidarity Reserve, and EUR 508 million annually for the Emergency Aid Reserve, enabling rapid responses to urgent situations in the EU and worldwide. The **Flexibility Instrument** will be increased by EUR 2 billion to finance measures that cannot be covered by other budgetary sources. The revision further includes the **Reform and Growth Facility for the Western Balkans**, a new financial instrument providing EUR 6 billion. Finally, to alleviate pressure on national budgets, EUR 10.6 billion will be reallocated from existing EU financial resources to support the priorities identified in the mid-term revision.

3.3 Cohesion Policy Absorption Dynamics as a Factor of Revision

The management of the EU budget is carried out through three principal models, each characterised by a specific structure and distribution of responsibilities. Under **direct management**, the EC allocates funds and oversees their use directly, relying on its own departments and executive agencies. **Indirect management** is entrusted to other bodies, such as international organisations, third countries, decentralised agencies, and joint undertakings, which then assume responsibility for implementing selected programmes. The most prevalent model is **shared management**, in which the EC cooperates with the Member States. In this framework, national paying agencies, managing authorities and audit bodies are responsible for the implementation and control of expenditure, particularly within Cohesion Policy and the Common Agricultural Policy. Regardless of the management method, EC remains ultimately accountable for the EU budget. Member States play a key role, as they administer around three-quarters of the budget under the shared management principle. This means that Member States distribute funds to beneficiaries, while EC conducts audits and on-the-spot checks to monitor award procedures and verify compliance (EU, 2021). According to the allocation of Cohesion Policy funds for the 2021–2027 period, Poland is the largest beneficiary, with a total budget of EUR 91,566,644,847 followed by Italy (approx. EUR 74 billion), Spain (EUR 51.5 billion), Romania and Germany, each with allocations exceeding EUR 30 billion, predominantly through the ERDF and the CF. Croatia is positioned in the upper half of the scale, with a total allocation exceeding EUR 10,236,199,849. Luxembourg, Malta and the Netherlands are among the Member States with the lowest allocations.

From 2015, the beginning of the absorption period for the 2014–2020 MFF, until 2018, a total of EUR 174,329,632,335 had been disbursed from the EU budget, representing 24.8% of planned funding. In the corresponding period of the current 2021–2027 MFF, EUR 84,664,339,407 has been disbursed, which is 51% less than in the 2015–2018 period. Although this analysis highlights reduced EU fund absorption over time, data show that from 2015 to 2018, 24.8% of EU funds had been paid out, while from 2022 to 2025 only 11.2% was disbursed, representing almost a 55% decrease in payments. EC data therefore indicate that the pace of EU budget payments for Cohesion Policy up to 2025 is **twice as slow** as during the previous MFF. Despite the EU trend, 12 Member States still receive

higher-than-average EU payments of 11.2%: Poland, Romania, Cyprus, Lithuania, Greece, Estonia, Netherlands, Sweden, Finland, Denmark, Czechia and Luxembourg.

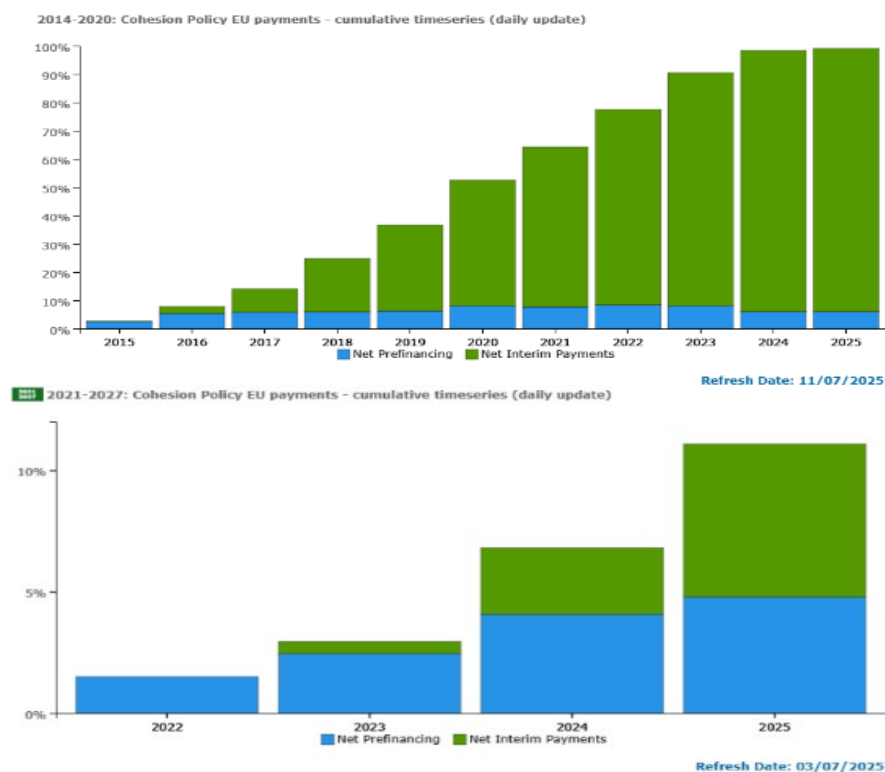


Figure 2: Payment dynamics under the 2014–2020 MFF and the 2021–2027 MFF

Source: European Commission, 2025 — https://cohesiondata.ec.europa.eu/cohesion_overview/14-20/#eu-payments (accessed 11 July 2025).

3.4 Case study of Croatia and EU Fund Absorption - A Syndrome or a Symptom of the Revision?

Since becoming a full member of the EU in 2013, Croatia has had access to several sources of funding from the EU budget. First, given its date of accession, under the 2007–2013 MFF, Croatia was allocated EUR 449.4 million, which could be absorbed until 2016. This period was characterised by the establishment of the EU funds management system and the vertical absorption capacities; therefore, it's not

considered relevant for this analysis. Under the 2014–2020 MFF, Croatia was allocated EUR 10.7 billion from the EU budget, with funds eligible for use until the end of 2023, in line with the $n+3$ rule. In the framework of NGEU, under the 2021–2026 National Recovery and Resilience Plan (NRRP), for Croatia EUR 9.9 billion is available, including EUR 6.3 billion in grants and EUR 3.6 billion in loans.

Within the current 2021–2027 MFF, Croatia has been allocated slightly more than EUR 14 billion, of which EUR 10,236,199,849 is designated for Cohesion Policy. The remainder relates to the European Maritime, Fisheries and Aquaculture Fund (EMFAF), the Asylum, Migration and Integration Fund (AMIF), the Internal Security Fund (ISF), the Instrument for Financial Support for Border Management and Visa Policy (BMVI), the European Agricultural Fund for Rural Development (EAFRD), the European Agricultural Guarantee Fund (EAGF), and STEP — the Strategic Technologies for Europe Platform (added as part of the budget revision). According to EC data, between 2022 and 2025 Croatia received 67% less funding (EUR 2,511,334,211) compared to the 2015–2018 period. The total share of paid-outs in 2025 amounted to 5.9%, significantly lower than the 17.2% recorded in 2018. The data on EU funds absorption follow the overall EU trend for the same period; however, Croatia's absorption rate remains nearly half the EU average, apart from 2022, when the difference between Croatia's absorption and the EU average narrowed to just 7%. The data clearly point to significant challenges in the use of Cohesion Policy funds during the current MFF: Croatia is implementing projects more slowly, absorbing less from EU funds, and lagging compared with the previous period. Croatia remains second to last (26th) among all Member States regarding disbursed EU funds, ahead only of Spain, whose absorption rate by July 2025 stands at 3.9%. On the other side, according to the *EC Recovery and Resilience Scoreboard*, Croatia has, through its five submitted NGEU payment requests, absorbed EUR 3.69 billion in grants and EUR 795.9 million in loans under 263 investments and 173 reforms. Data for Cohesion Policy show that comparable Member States, including Czechia (20.4%), Romania (15.2%), Poland (12%), Hungary (10.5%), and Slovenia (8.1%), all have higher absorption rates than Croatia. Croatian professional associations argue that EU-fund absorption requires a new governance model with activities evenly distributed across the entire financial cycle. The Croatian Employers' Association proposes an integrated, multi-annual call publication plan to improve absorption planning at all territorial levels, while expert organisations emphasise that reducing administrative burdens through simplified procedures,

evaluation and reporting, and strict adherence to indicative call schedules would substantially strengthen national absorption capacities.

4 Discussion

The findings enable a critical reflection on the initial hypothesis that insufficient absorption of Cohesion Policy funds, both at EU level and in Croatia, was among the drivers of the MFF 2024 mid-term revision. Although the analysis confirms that absorption has been significantly slower in the current period, while the pace of EU budget payments for Cohesion Policy up to 2025 is twice as slow as during the previous MFF, the evidence shows that this factor did not play a decisive role for revision. Instead, it was primarily shaped by exogenous shocks, including inflation, the war in Ukraine, and the energy crisis, which resulted in the full utilisation of all available resources, limiting the EU's ability to respond to urgent crises. The analysis demonstrates that absorption challenges, although relevant for long-term policy effectiveness, were overshadowed by the immediate need to reinforce the EU budget's crisis-response capacity. The introduction of new instruments such as the Ukraine Facility and STEP confirms that the revision was forward-looking, aimed at geopolitical stability, technological competitiveness, and energy security rather than at correcting implementation shortcomings within Member States. A key insight emerging from the results is the interaction between the MFF and the NGEU. The coexistence of these two major funding streams has created parallel implementation pressures on national administrations. NGEU's strict deadline by the end of 2026, has redirected administrative capacity away from Cohesion Policy, contributing indirectly to slower absorption. However, this interaction did not influence the EC's decision to revise the MFF; rather, it shaped the implementation environment in which Member States operate. From a governance perspective, the findings highlight the structural limitations of the EU's budgetary framework. The rapid exhaustion of flexibility instruments, combined with rising interest payments on NGEU borrowing, exposed the rigidity of the existing MFF architecture. The 2024 revision thus represents not only a response to crises but also an implicit acknowledgment that the EU's fiscal framework requires greater adaptability to external shocks. For Croatia and comparable Member States, several lessons emerge. First, reliance on EU funds as a primary development driver requires stronger administrative and strategic planning capacities, particularly in periods when multiple funding streams overlap. Second, the Croatian case illustrates how delayed absorption can weaken the developmental impact of available resources, even if it does not directly influence

EU-level budgetary decisions. Finally, the findings suggest that future reforms of EU budget governance should consider mechanisms that better align national implementation capacities with the increasing complexity of EU instruments.

5 Conclusion

This paper has opened several important questions, highlighted underexplored dimensions of EU budgetary governance, and brought forward a set of observations that merit further analytical attention. Firstly, the scarcity of scientific literature represents a significant research limitation, leaving the topic largely unexplored, lacking an established analytical framework, reducing opportunities for theoretical triangulation. Although the initial hypothesis assumed that the EU budget revision was driven, among others, by insufficient absorption from the 2021–2027 MFF (both at EU level and within Member States such as Croatia), the analysis shows that absorption levels themselves didn't play a significant role in the 2024 revision. The findings clearly indicate that the revision was primarily a response to turbulent and unpredictable geopolitical events, which prompted EC to seek additional resources to enable more flexible prerogative action and rapid intervention. Although the analysis doesn't demonstrate a direct causal link between lower EU fund absorption and the budgetary revision, the findings open a broader debate on the complementarity of financing sources, design of a more flexible and resilient fiscal architecture capable of responding to increasingly frequent and complex crises, strengthening administrative capacities, improving multi-annual planning, and simplifying procedures to ensure that available resources translate into tangible developmental outcomes. This raises an important question for future research: to what extent do different funding instruments influence one another and affect the overall success of MFF absorption, and can the budgetary revision become a permanent instrument that (re)sets performance indicators, strengthens the dynamics of funds absorption, and evaluates the achieved policy outcomes?

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FROM PRECEDENT TO PARADIGM: SUSTAINABILITY AND TOURISM COMPETITIVENESS UNDER THE NEXTGENERATIONEU

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The NextGenerationEU (NGEU) instrument was launched in 2021 as the European Union's unprecedented response to turbulent global crises, including the COVID-19 pandemic and economic downturns. Its purpose is to bring about a new economic model centered on sustainable development and higher competitiveness. Despite its ambitious scope, the EU's economic growth continues to lag, necessitating substantial annual investments. This paper will provide comparative analysis of the implementation effectiveness and real-world impact of NGEU in fostering sustainable development, green transition, and investments in tourism across member states focusing on net recipient countries, Croatia and Slovenia. It addresses how NGEU is absorbed, translated into outcomes, and identifies challenges in achieving its goals especially in tourism sector. This paper conducts a large-scale quantitative analysis of secondary sources, comparing planned and realized investments, focusing on green and digital transitions, and examining absorption rates dynamics within EU member states.

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1 Introduction

The severe economic downturn caused by the pandemic profoundly changed the macroeconomic image of the EU. According to Eurostat (2025), negative GDP rates in member states in 2020 ranged up to 7.4% in France, 8.2% in Portugal, 8.3% in Croatia, 8.9% in Italy, 9.2% in Greece, and 10.9% in Spain – all of them highly dependent on tourism. Authors (Crescenzi, Di Cataldo, Giua in Crescenzi, Giua and Sonzogno, 2021) point out that the EU has often been criticized in the past for its inability to act in the common interest of member states, as well as for the lack of timely responses to their problems that would be commensurate with their size and urgency. The existence of European added value is increasingly questioned, fuelled by the rise of nationalist movements and Euroscepticism and growing dissatisfaction in neglected regions (Rodríguez-Pose, 2018). Therefore, at the economic level the European Recovery and Resilience Plan – NextGenerationEU (NGEU) was issued by the European Commission (EC), as a part of a joint response to the crisis caused by the COVID-19 pandemic. According to Pfeiffer, Varga, and in 't Veld (2021), in addition to national stabilization measures, EU policy responded with an unprecedented macroeconomic package combining reforms and public investments. Based on the EU Green Deal (European Commission, 2019) and the "Shaping Europe's Digital Future" strategy (European Commission, 2020), investments within the NGEU must be aligned with the EU's priorities which are in the field of green and digital transition. These two fundamental areas are recognized as crucial for Europe's future prosperity and resilience, given their potential to stimulate economic growth and create new jobs. Financed by joint borrowing, the instrument is worth up to 750 billion euros at 2018 price levels, representing 5.4% of the EU's 2019 GDP, of which 390 billion euros will be allocated as grants and the remainder as loans. This instrument should ensure rapid recovery and implementation of structural reforms in the period from 2021 to 2026, and with evenly distributed funds from 2021 to 2024, the authors (Unsworth, Andres, Cecchinato, Mealy, Taylor, and Valero, 2020) estimate that the level of real GDP in the EU-27 will be about 1.5% higher than without NGEU. To enable NGEU funding, Member States had to submit National Recovery and Resilience Plans (NRRP) whose measures contribute to six EU-level objectives, including cohesion, resilience, crisis mitigation, and the green and digital transitions.

The primary objective of this paper is to analyse the results of the implementation of NGEU in the areas of green transition, and investment in tourism competitiveness as strategic determinants for the recovery of the EU. Through quantitative analysis of secondary sources, the paper synthesizes and builds upon insights from relevant scientific studies that have used various methodological approaches and seeks to present the main tendencies of future development of the EU. The paper focuses on financial support for sustainable development and tourism competitiveness policies, analysing the implementation of the Recovery and Resilience Facility and its effects in EU member states especially Croatia and Slovenia.

2 Theoretical framework

The research by Almazán-Gómez et al. (2025) shows that, despite not being conceived as a cohesion instrument, NGEU's initial allocation had a pro-cohesion effect by directing more funds to countries with lower GDP per capita and deeper pandemic-related economic losses, thereby benefiting less developed regions. According to Christie et al. in Almazán-Gómez et al. (2025), the NGEU proved to be extremely innovative in two key aspects. First, the instrument established a new EU industrial policy paradigm centred on digitalisation and the green economy, and second, introduced joint public borrowing that reshaped the Union's financial architecture, and, beyond a Keynesian counter-cyclical tool, holds potential to shape a new model of EU industrial policy. Allemand et al. (2023) note that NGEU has not reshaped EU budgetary planning or its institutional foundations. It is a limited, temporary instrument that neither addresses past debts nor creates permanent common investment capacities. Instead, it provides only exceptional, one-off financial support rather than sustained operational funding. During NGEU negotiations, however, some actors pushed to cut funding for genuine European public goods, such as education and healthcare, reducing investment in critical sectors while encouraging the proliferation of 27 national priorities, thereby increasing the risk of politicising allocations. Finally, Allemand et al. (2023) argue that a key criticism of NGEU and the EU more broadly stems from a democratic legitimacy gap, as many citizens remain unaware of EU achievements and policy impacts, leading to a persistent information deficit. Research by Ciornei (2025) finds that the politicization of NGEU reduces perceptions of EU reliability, especially in

Italy, while its investments increase EU support in transition regions, but decrease it in more developed ones. On the other hand, Almazán-Gómez et al. (2025) identify a paradox: although wealthier regions, capture larger direct and indirect NGEU gains, positive net effects are more visible and more strongly supported in Eastern European regions (Bulgaria, Romania, Croatia, Slovenia, Poland, Baltic States) due to substantial funding and their relatively brief recession. The authors (*ibid.*) conclude that the negative effects of the crises in 2020 in most regions outweighed the positive effects of NGEU, which failed to fully compensate for the economic downturn and thus refuted public opinion surveys. Comparing data from several Eurobarometer surveys, authors (Rivas-de-Roca and García-Gordillo, 2022), that NGEU and vaccine management boosted trust in EU institutions by six percentage points, twice the increase seen for national authorities, while optimism about the EU's future rose from 58% in 2019 to 66% in 2021, accompanied by declining pessimism. Thus, the legitimacy deficit generally stems from the principle of separation of powers, while the implementation of the NGEU itself enjoys a permissive consensus, as the formulation of its measures and implementation depends on the capacities of national authorities.

3 Analysis of NGEU implementation in Member States

To assess the impact of NGEU, this chapter will analyse secondary data on planned and realized investments, particularly in the context of investments in green transition measures and tourism competitiveness.

3.1 NGEU expenditures overview

According to Eurostat and the EC, the largest beneficiary under the NGEU is Italy, which was allocated 194.38 billion euros. Spain ranks second in terms of allocation, with a total of 163.01 billion euros, also with a large share of loans. For Poland, an amount of 59.82 billion euros was allocated, while Greece, with a total of 35.95 billion euros, is among the member states with the largest amounts for beneficiaries, and is also the member state with the largest share of NGEU in its national GDP (19.79% share of NGEU in GDP), followed by Croatia (17.24% share in GDP) and Spain (13.51% share in GDP). These are also the member states with the highest dependence on tourism, as one of the most affected sectors, and consequently, the

most vulnerable countries regarding the consequences of the pandemic (Kotarski, 2022; Almazán-Gómez et al., 2025). The EC required that NRRPs allocate at least 37% of investments to the green transition and 20% to digitalisation, while its assessment shows that, overall, NGEU spending is expected to reach 42% for climate objectives and 26% for digital transformation.

According to EC data on the shares of funds from NRRPs, significant variability among member states regarding the orientation of funds has been noted. The largest contributions to climate action are recorded by Luxembourg with 80.05%, Denmark (69.02%), Malta (68.76%), Hungary (66.90%), and Estonia (59.45%), thereby not only exceeding the minimum requirement of 37% but also surpassing the EU average in the green transition. On the other hand, the lowest shares of funds directed towards climate goals were recorded in Greece (38.06%), Lithuania (37.90%), Croatia (38.56%), Spain (39.87%), and Italy (39.76%). When it comes to digital transformation, the highest shares were recorded in Germany (46.30%), Luxembourg (37.52%), Austria (35.72%), Ireland (34.19%), and Denmark (28.89%). The lowest contribution to digital goals was recorded by Croatia (20.22%), Bulgaria (20.60%), Poland (20.65%), Slovakia (21.02%), and Sweden (21.29%). EC data also indicate a very different dynamic of NGEU absorption until August 2025. Of the total of 24 member states that submitted requests for payment under NGEU, only six (Italy, Belgium, France, Malta, Lithuania, and Luxembourg) exceed the EU average in total fund expenditure, while Ireland, the Netherlands, and Sweden have not submitted any payment requests.

The latest EC data point to the same trend as in the study by Kreel and Kaiser (2024), which found that due to many unrealized payments, with some countries significantly deviating from the absorption of allocated loan and grant amounts, spillover effects could be very limited. However, in the research authors Almazán-Gómez et al. (2025) elaborated two scenarios that show a clear positive effect. Although the results of individual scenarios reflect regional heterogeneity, the authors highlighted a pronounced pattern of distribution by country, indicating that the territorialization mechanism applied ultimately has positive territorial effects in terms of added value and employment, showing high consistency, with the effects on added value being somewhat more pronounced. All cited analyses consistently indicate that the NGEU generates highly favourable long-term economic effects (Creel & Kaiser, 2024; Hinterlang et al., 2023; Boscá et al., 2021; Fernández-Cerezo

et al., 2023; Malliaropulos et al., 2021; Picek, 2020; Bańkowski et al., 2021; Barbero et al., 2022; Pfeiffer et al., 2023; Canova & Pappa, 2021; Durand & Espinoza, 2021; Almazán-Gómez et al., 2025).

3.2 NGEU investments in green transition and competitiveness

To monitor the implementation of green transition and competitiveness measures based on EC data for the period up to August 2025, allocated funds and their realization by predefined expenditure categories has been compared. Due to a changed research methodology¹, the EC monitors the contribution of NRRPs' to each of the six pillars of the Facility. Disbursements are based on the fulfilment of targets and milestones, each with equal value within a member state's plan, and each measure receives two thematic tags (pillars). Therefore, these data do not refer to the concrete realization of projects, but to the execution of measures.

Clean transport and infrastructure (27.2%), energy efficiency (25.8%), and clean energy and networks (22.6%) together account for 75.6% of total eligible funds. The results of overall payments to member states by intervention show that energy efficiency and transport, which relate to the decarbonization of mobility, buildings, and energy systems, have a significantly higher share in actual disbursements than planned. However, investments in clean energy and networks, which include renewable sources such as solar, wind, and hydropower, and the modernization of electricity grids, record the largest decline (-13.7%). Investments in research and innovation have a significant share of 7.8% of the planned funds for technological development and scientific support for the green transition, while the realization of funds at the EU level is 6.7%. The 8.1% allocated to water and waste management underscores the circular economy's importance, yet absorption remains slow, with only 48% of planned funds realised. According to the Report on the Future of European Competitiveness (Draghi, 2024), the lack of progress in clean-technology investments is notable, given that over one-fifth of global clean and sustainable technologies originate in the EU. Although Europe held strong innovation potential, with most clean-tech firms in early development and a smaller share already scaling or mature, patenting of low-carbon innovations has slowed since 2020, threatening the EU's early-stage advantage.

¹ In accordance with Article 29(3) of the Recovery and Resilience Facility (RRF) Regulation

Measures under the “Smart, Sustainable and Inclusive Growth” pillar that reinforce entrepreneurship and competitiveness include initiatives to drive industrialization, enhance the business environment, foster research and innovation, and support SMEs. These are directly related to overall competitiveness. The largest share of funds within NRRPs is directed towards strengthening competitiveness (25%) and supporting SMEs’ (21%), which indicates a strategic orientation towards increasing productivity, innovativeness, and resilience of the business sector. Investments in the renovation and construction of buildings within this pillar account for (18%) and primarily relate to the green transition and energy efficiency. Significant funds are also allocated to research, development, and innovation (11%). In parallel, the business environment and entrepreneurship account for 9%, and (re)industrialization account for 5% of total disbursements. Smaller shares in payments relate to business infrastructure (5%), the cultural sector (3%), regulatory changes (2%), support for large enterprises (1%), and transnational cooperation (1%). The data show that disbursements are heavily concentrated in a few large economies, most notably Spain, which recorded by far the highest utilization rate, while several smaller or wealthier member states drew only minimal amounts or allocated a comparatively small share to competitiveness investments. This distribution highlights substantial disparities in absorption and provides only a preliminary foundation for deeper qualitative assessment.

3.3 NGEU investments in tourism competitiveness

Although tourism has not been specified as separate sector or pillar, in their qualitative analysis of NRRPs, authors (Mileva and Lyutova, 2023) state that they reveal a coherent set of strategic orientations that collectively redefine the role of tourism in post-pandemic recovery. Despite varying depth and specificity across national plans, common trends emerge in tourism-related measures. Across several Member States, particularly Spain, Greece, Croatia, Cyprus, Romania, Portugal, and Slovenia, tourism is positioned as a strategic policy domain. These countries articulate dedicated, analytically grounded investment components for tourism. A key element of the NRRPs is the modernisation of tourism governance, with major tourism economies prioritising reforms to boost competitiveness and support sustainable, digital, and green business models. In Spain, Croatia, Romania, and Slovenia, new sustainable tourism strategies are directly embedded within the reform

components. Digital transformation emerges as a universal priority across all NRRPs, regardless of whether tourism is explicitly targeted. Even in countries without tourism-specific investments, the sector stands to benefit from horizontal digitalisation programs. Examples include Ireland's Digital Transformation of Enterprises, Lithuania's Financial Instruments for Digital Innovation, and similar initiatives in Latvia, Estonia, Belgium, Austria, Denmark, Sweden, Germany, Poland, and Bulgaria. Human capital development by reskilling, upskilling, and workforce transformation appear in every NRRP, with some countries establishing tourism-specific training infrastructures. Malta plans a Center of Excellence in Vocational Education in Tourism; Greece introduces comprehensive training programs for workers and unemployed; Croatia invests in strengthening the system for sustainable and resilient tourism through workforce retraining; and Portugal deploys a wide array of knowledge centres.

Another prominent trend is the diversification of tourism products and the development of new market niches. Established destinations seek to reduce dependence on seasonal or mass tourism by promoting alternative forms such as winter, spa, wine, gastronomy, diving, rural, cultural, cycling, and health tourism. This diversification is often accompanied by investments in tourism infrastructure such as ski resorts, ports, hotels, and visitor centres, aimed at enhancing the quality and resilience of the tourism offer.

Finally, many NRRPs introduce innovative financing mechanisms to support tourism enterprises. Spain reforms its State Financial Fund for Tourism Competitiveness; Italy establishes new competitiveness funds; and Portugal develops a sophisticated suite of financial instruments, including tourism bonds and debt-refinancing schemes. All these elements illustrate a profound reconfiguration of tourism policy within the EU's recovery framework with broader economic, social, and territorial impact.

4 Analysis of NGEU implementation in tourism: Croatia and Slovenia

Croatia and Slovenia occupy a prominent position among the EU Member States that treat tourism as a strategic priority within their NRRPs. Both countries align their plans with key European strategic frameworks, including the Transition Pathway for Tourism and the European Agenda for Tourism 2030, emphasising

digital and green transitions, sectoral modernisation, and the strengthening of institutional and governance capacities.

According to EC data, **Croatia's** NRRP articulates a structurally coherent framework for the transformation of its tourism sector. The measures and sub-measures contained within the component "*Developing sustainable, innovative and resilient tourism*" reveal a multidimensional intervention logic grounded in the principles of the green and digital transitions, territorial rebalancing, and human-capital development. The total allocation dedicated to tourism-specific investments amounts to **€284.7 million**, channelled exclusively through grants both for private and public segments of the tourism ecosystem.

A central pillar of the Croatian approach is the strengthening of entrepreneurial competitiveness through three interlinked sub-measures targeting large enterprises, SMEs, and digital transformation. These interventions prioritise the adoption of energy-efficient technologies, renewable energy sources, circular-economy practices, and advanced digital solutions. The explicit use of the national Tourism Development Index as an allocation criterion underscores a territorially sensitive distribution mechanism designed to prioritise less developed tourist areas and stimulate employment in local communities.

Complementing enterprise-focused interventions, Croatia emphasizes the *regional diversification and specialisation* of its tourism offer. Two sub-measures: one general and one specifically oriented toward energy efficiency, support the development, adaptation, and upgrading of public tourism infrastructure. These investments aim to enhance the quality and attractiveness of destinations, extend the tourism season, promoting high-value tourism, and mitigate pressures associated with over-tourism in the most saturated coastal regions.

Digital transformation is positioned as a key structural priority, with investments aimed at modernising Croatia's tourism governance through the expansion of the e-tourism system, enhancement of Croatian Sustainable Tourism Development Observatory- CROSTO, and creation of an European Tourism Indicators System - ETIS aligned destination monitoring platform, thereby strengthening analytical capacities and enabling evidence-based management. Finally, Croatia's NRRP set human capital as a key determinant of sectoral resilience. The measure "*Strengthening*

system capacity for resilient and sustainable tourism” introduces education and training programmes designed to equip workers, students, unemployed, and public-sector with digital, green, and managerial competencies.

Slovenia’s NRRP articulates a strategically integrated and sustainability-oriented vision for the transformation of its tourism sector, as a lever for cultural revitalisation, environmental stewardship, and long-term competitiveness. The measures under the component *“Restructuring of Slovenian tourism and investment in infrastructure in the field of tourism and cultural heritage”* reflect Slovenia’s long-standing commitment to high-value, low-impact tourism development. The total allocation dedicated to tourism-specific investments amounts to **€90 million**, channelled exclusively through grants. A central pillar of Slovenia’s approach is the sustainable restoration and revitalisation of cultural heritage and public cultural infrastructure, supported through a €42 million investment. This measure aims to modernise, restore, and repurpose cultural heritage assets owned by the state or municipalities, with the explicit expectation to generate multiplier effects for tourism development. The integration of ICT-based tools for interpretation, promotion, and visitor engagement, further positions cultural heritage as a technologically enhanced component. This measure reflects Slovenia’s recognition that cultural heritage, when sustainably managed, constitutes a critical source of competitive advantage in the global tourism market. Over €40 million across two sub-measures are dedicated to the sustainable development of tourist accommodation, with a particular emphasis on energy-efficient buildings, supporting the refurbishment, extension, or construction of accommodation facilities that meet high energy-efficiency standards, thereby reducing the environmental footprint. Measures also incorporate mandatory training in service quality, digital competences, and managerial skills, as well as requirements for marketing research and economic analysis. A further €10 million is dedicated to the sustainable development of public and shared tourism infrastructure and natural attractions, reflecting Slovenia’s commitment to destination-level sustainability. This measure supports the refurbishment and establishment of public tourism facilities designed to complement and elevate the overall quality of the tourism offer. By targeting shared infrastructure and natural attractions, Slovenia aims to strengthen the resilience and competitiveness of its destinations, particularly those that rely on nature-based tourism.

Croatia and Slovenia articulate two closely aligned yet distinct strategic approaches to tourism within their NRRPs. Croatia adopts a broad, multi-layered transformation model centred on enterprise competitiveness, regional diversification, digital governance, and human-capital development, supported by a substantially larger financial envelope. Its measures explicitly target both private and public tourism infrastructure, with strong emphasis on reducing overtourism and elevating destination quality across less developed regions. Slovenia pursues a more focused investment strategy, concentrating on the sustainable revitalisation of cultural heritage, energy-efficient accommodation, and the enhancement of public and shared tourism infrastructure. While Croatia's approach is expansive and system-wide, Slovenia's is more selective and heritage-driven, yet both converge on the shared objective of building a high-value, sustainable, and resilient tourism ecosystem aligned with EU strategic priorities.

5 Conclusion

The analysis of implementation of European Recovery and Resilience Facility, launched in response to the drastic economic consequences of the crisis until 2022, showed that, despite its unprecedented scale and alignment with EU sustainability and digital priorities, the instrument primarily accelerates existing strategic trajectories rather than reshaping the Union's economic governance. Significant disparities in absorption, investment focus, and administrative capacity across Member States limit its transformative reach, while delays in clean-energy and circular-economy measures further reduce its structural impact. Tourism, not being identified as separate pillar, has a significant role in European recovery. The comparative cases of Croatia and Slovenia demonstrate that NGEU can meaningfully modernise tourism governance and strengthen resilience: Croatia through a broad, system-wide model emphasising enterprise competitiveness, regional diversification, and digital governance, and Slovenia through a more targeted approach centred on cultural-heritage revitalisation, energy-efficient accommodation, and shared infrastructure. These experiences confirm that outcomes depend largely on national administrative and institutional capacities.

Overall, the findings affirm that NGEU undoubtedly represents a historic step forward in European financial mechanisms, and, although innovative in its use of joint borrowing, it has not produced a Copernican shift in EU economic policy. As

a temporary and exceptional instrument, it supports recovery and structural adjustment but does not establish lasting common fiscal capacities or fundamentally alter the architecture of EU economic governance. In this context, NGEU was highlighted as a positive example in the context of issuing common safe instruments, but the systematic issuance of such instruments would require strengthening a set of fiscal rules, deeper integration in the field of fiscal policy, and decisions on new own EU resources. Precisely for this reason, modifications are necessary for the future application of this model.

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METODOLOGIJA MERJENJA VPLIVA UVAJANJA MODELOV KROŽNEGA GOSPODARSTVA

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Prispevek predstavlja metodologijo merjenja vpliva (učinkov) uvajanja (angleško: »Impact«) in uporabe modelov krožnega gospodarstva (angleško: »Circular Economy Business Models« s kratico »CEBM«) v poslovno okolje in njeno uporabo v pilotnih primerih projekta DECIDE (Kern, 2025). Predstavljen je dvajset-dimenzijski okvir kazalnikov (angleško: »Circular Economy 20-Dimension Framework«), s katerim lahko merimo okoljske, ekonomske in socialne učinke na osnovi primerjave stanj sistema v treh časovnih presekih; dejansko stanje pred začetkom projekta (AS-IS), ciljno stanje pred začetkom projekta (WISH-TO) in doseženo stanje po zaključku projekta (TO-BE). Zbiranje podatkov za pilotne projekte je potekalo s pomočjo standardizirane Excel predloge, ki omogoča sočasno zajemanje numeričnih vrednosti in komentarjev. Analiza združuje kvantitativne postopke (normalizacijo enot, opisno statistiko, parne primerjave stanj ter kvalitativno sintezo. Rezultat prispevka je enovit pregled vplivov, ki omogoča primerjavo pilotnih projektov, identifikacijo dobrih praks in podporo odločanju deležnikov.

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METHODOLOGY FOR MEASURING THE IMPACT OF IMPLEMENTING CEBM

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The paper presents a methodology for measuring the impact of the introduction and use of Circular Economy Business Models with the abbreviation "CEBM" in the business environment and its use in pilot cases of the DECIDE project (Kern, 2025). A Circular Economy 20-Dimension Framework is presented, with which we can measure environmental, economic and social effects based on a comparison of the states of the system in three time sections; the actual state before the start of the project (AS-IS), the target state before the start of the project (WISH-TO) and the achieved state after the end of the project (TO-BE). Data collection for the pilot projects was carried out using a standardized Excel template, which allows simultaneous capture of numerical values and comments. The analysis combines quantitative procedures (unit normalization, descriptive statistics, pairwise comparisons of states, and qualitative synthesis. The result of the paper is a unified overview of impacts that enables comparison of pilot projects, identification of good practices, and support for stakeholder decision-making.



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1 Uvod

V projektu DECIDE je bilo v okviru aktivnosti: Prenos najboljših praks poslovnih modelov krožnega gospodarstva na izbrane transnacionalne in medsektorske potenciale (angleško: »Transfer of Best Practice Circular Economy Business Models to Identified Transnational and Intersectoral Potentials«) pripravljeno gradivo in rezultati delovnega paketa: WP 1.4.2 Poročilo o napredku vpliva pilotnih projektov (angleško: »Pilot Impact Progress Reports«). Namen priprave gradiva je bil pregled in ovrednotenje najboljših praks krožnega gospodarstva, razvitih in preizkušenih v pilotnih projektih, ter prenos načel krožnega gospodarstva v druga okolja.

Osrednji izziv pri prenosu krožnih poslovnih modelov v druga poslovna okolja je predvidevanje in merljivost njihovega vpliva (učinkov). Deležniki kot so: upravljavci, management, investitorji, javne institucije in drugi, namreč potrebujejo utemeljene ocene zmanjšanja okoljskih vplivov, ustvarjene ekonomske vrednosti in socialnih učinkov, že pred odločitvijo o prenovi sistemov in procesov v njih. Rezultati obravnavanega delovnega paketa projekta Decide zato predstavljajo strukturiran način opredelitve ključnih procesnih kazalnikov (KPI-jev) in merjenja sprememb njihovih vrednosti, ki nastanejo zaradi implementacije izbranega modela krožnega gospodarstva (CEBM) (Lüdeke-Freund, 2019), (Bocken, 2016).

Metodološko se delo opira na uveljavljene večdimenzionalne pristope in evropske okvire spremljanja krožnega gospodarstva (Elkington, 1998), (ISO, 2006) (UNEP, 2020), (EU, 2021), (EU, 2023), (Ellen MacArthur Foundation, 2015), vendar so ta operacionalizirna na raven pilotnih poslovnih sistemov z enotnim dvajset-dimenzijskim okvirom kazalnikov in z integracijo kvantitativnih ter kvalitativnih analiz.

2 Metodologija

2.1 Dvajset dimenzijski okvir kazalnikov krožnega gospodarstva

Dvajset-dimenzijski okvir kazalnikov krožnega gospodarstva (angleško: »Circular Economy 20-Dimension Framework«) je bil izbran za določitev ključnih procesnih kazalnikov in strukturo poročanja, ker bil v projektu DECIDE ta uporabljen že pri predstavitvi primerov dobrih praks s tega področja v podonavski regiji (DigiTrans Project, 2020), (CIRCE2020 Project, 2021), (RENEW Danube Project, 2022). Okvir

združuje dvajset dimenzij in pripadajoče kazalnike. Ti pokrivajo tri glavne vidike (ekološkega, ekonomskega in socialnega) ter dodatne vidike (npr. tveganja in skalabilnost), s čimer okvir zagotavlja spremljanje vplivov vpeljave modelov in primerjavo med sektorji in državami.

Tabela 1: Dimenzije dvajset dimenzijskega okvira s pripadajočimi kazalniki

Dimenzija	Namen dimenzije	Kazalnik (KPI)
1–4 Splošne informacije	kontekst (sektor, geografski doseg, deležniki)	opisni podatki
5 Zmanjšanje (Reduction)	zmanjšanje porabe materialov /energije/vode in odpadkov	% zmanjšane materiala
6 Ponovna uporaba (Reuse)	podaljševanje življenjske dobe brez večje predelave	% ponovno uporabljenega materiala
7 Recikliranje (Recycling)	reintegracija materialov v proizvodne tokove	% recikliranega materiala
8 Obnova (Remanufacturing)	obnova izdelkov/delov v »kot novo« stanje	% remanufactured
9 Verige/vrednostne mreže	sodelovanje in povezovanje deležnikov	število partnerjev
10 Vpliv verige/vrednostne mreže	spremembe v tokovih in poslovnih vlogah	št. procesov/modelov
11 Zmanjšanje emisij CO ₂	zmanjšanje toplogrednih plinov	emisije CO ₂
12 Varčevanje surovin	zmanjšanje rabe primarnih virov	prihranek materiala
13 Učinkovitost	izboljšanje procesne učinkovitosti	pretočni čas, strošek procesa
14 Trajni proizvodi	zasnova dolgotrajnih produktov	% trajnih produktov
15 Nova delovna mesta	socialni učinki krožnih praks	št. novih delovnih mest
16 Inovativnost	novost tehnologij/procesov/modelov	investicije v zelene tehnologije/produkte
17 Povezano delo	povezave z drugimi iniciativami	št. sorodnih projektov
18 Cilji trajnostnega razvoja	povezava s SDG/ESG	seznam/označbe SDG
19 Izzivi in tveganja	ovire in negotovosti implementacije	seznam okoljskih/finančnih/operativnih tveganj
20 Skalabilnost	možnost razširitve/replikacije	možnosti širitve

2.2 Modeliranje treh stanj: AS-IS, WISH-TO in TO-BE

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Slika 1: Primer dvajset dimenzijske tabele za vnos vrednosti kvantitativnih kazalnikov

Vir: Zajem zaslona.

Your Expert Opinion	
Impact	Comment
Environmental	
Economic	
Social	
Other	

Slika 2: Primer tabele za vnos ekspertnih mnenj projektnih partnerjev

Vir: Zajem zaslona.

Merjenje vplivov temelji na primerjavi modelov treh stanj sistema. Stanje AS-IS predstavlja izhodiščno stanje pred uvedbo krožnih sprememb. Stanje WISH-TO predstavlja cilj, ki ga želijo deležniki doseči, in je pomemben zaradi vloge v pred-investicijskem odločanju. Če so pričakovani učinki (WISH-TO) skladni s pričakovanji deležnikov, ima projekt uvajanja krožnih modelov večjo verjetnost potrditve. Stanje TO-BE predstavlja doseženo stanje po implementaciji krožnega modela. Pri tem je treba poudariti, da je mogoče stanje po implementaciji tudi v naprej izračunati s pomočjo modeliranja in simulacije.

Metodologija predvideva, da mora projektni tim po implementaciji dokazati doseganje ali preseganje ciljev, sicer se sproži dodatna analiza vzrokov in korektivnih ukrepov

2.3 Organizacija priprave in testiranja metodologije izračuna vpliva

Delovni paket projekta DECIDE, v okviru katerega se je oblikovala in testirala metodologija (WP 1.4.2) je bil izveden v petih fazah in znotraj štirih obdobjih projekta:

(1) zasnova metodologije	(obdobje Q3 in Q4 v letu 2024),
(2) zbiranje podatkov	(obdobje Q1 in Q2 v letu 2025),
(3) spremljanje napredka	(obdobje Q1 in Q2 b letu 2025),
(4) analiza vplivov	(obdobje Q3 in Q4 v letu 2025) in
(5) poročanje	(obdobje Q4 v letu 2025).

2.4 Zasnova metodologije ocenjevanja vplivov

V drugem in tretjem obdobju projekta DCIDE je bila ključna zgodnja priprava in preverjanje metodologije, da bi ugotovili morebitna odstopanja in jih odpraviti še pred zbiranjem testnih podatkov pilotnih projektov. Za to je bil vzpostavljen formaliziran proces zbiranja podatkov v platformi MS Teams. Izvedene so bile periodične kontrole vnesenih podatkov posameznih pilotnih projektov. Organizirana je bila tudi skupna delavnica za projektne partnerje ter več individualnih srečanj za tiste projektne partnerje, ki so potrebovali dodatno podporo.

2.5 Zbiranje podatkov

Za poročanje o vplivih vpeljave metodologije v posameznih pilotnih projektih je bila pripravljena Excel predloga, ki je standardizirala vnos podatkov in omogočila kasnejšo enotno analizo. Predloga je vključevala več zavihkov. V prvem zavihku so bile podane informacije za projektne partnerje o načinu in posebnostih vnosa podatkov. V drugem zavihku je bila tabela za vnos numeričnih podatkov, v tretjem zavihku pa so projektni partnerji lahko vpisali ekspertna mnenja, torej ne-numerične informacije. Projektni partnerji so morali vnesti vrednosti posameznih dimenzij, obvezna pojasnila (»Comments«) in ekspertno oceno vplivov po dimenzijah. Predloga je bila najprej testirana s strani izbranih projektnih partnerjev. Na podlagi komentarjev in priporočil je bila revidirana tako, da je jasneje ločevala med indikatorji okoljskega, ekonomskega in socialnega vidika ter omogočila bolj strukturirano ekspertno presojo.

Zaradi izrazite sektorske raznolikosti pilotov je metodologija dopuščala, da partnerji po lastni presoji, a z ustrezno utemeljitvijo in komentarjem uvedejo dodatne kazalnike. To omogoča razširitev uporabe metode v poljubna poslovna okolja. Je pa ta pristop hkrati povečal potrebo po harmonizaciji merskih enot in metapodatkov, da je bilo mogoče izdelati primerjalno analizo pilotnih projektov.

2.6 Analiza podatkov in validacija metodologije

Analiza podatkov in validacija metodologije sta bili izvedeni v dveh medsebojno povezanih delih:

- **V kvantitativnem delu** so bili uporabljeni podatki iz prvega zavihka Excel tabele (zavihek »20-D«). Merske enote so bile najprej normalizirane (npr.: odstotki med 0 in 100, masa v kg, čas v urah, itd.). Izdelana je bila opisna statistika ter parne primerjave AS-IS in TO-BE podatkov posameznih dimenzij s parnim t-testom ali Wilcoxonovim preizkusom predznakov, odvisno od porazdelitve razlik. Nekatere dimenzije so bile obravnavane kot »kvantitativni vplivi«, čeprav zanje pogosto ni bilo vpisane izhodiščne (AS-IS) vrednosti. Zato so bile interpretirane le kot binarna stanja.
- **V kvalitativnem delu** so bili sintetizirani komentarji pri kazalnikih (»Comments«) in ekspertne ocene (zavihek »Expert Opinion«). Tematska

analiza je bila izvedena po večstopenjskem postopku, prilagojenem po Braun in Clarke (Braun, 2006), in je bila podprta z leksikalno analizo TF-IDF po Saltonu in Buckleyju (Salton, 1988). Ključni namen kvalitativnega sklopa je bil:

- pojasniti posebnosti numeričnih podatkov,
- nadomestiti numerične podatke tam, kjer jih ni bilo mogoče pridobiti in
- identificirati kontekstualne dejavnike, relevantne za prenos dobrih praks.

Za doseganje primerljivosti med posameznimi pilotnimi projekti je bila uvedena normalizacija merskih enot in minimalni nabor metapodatkov (obseg, časovno obdobje, meje sistema). Ker so podatki praviloma izvirali iz poslovnih okolij in so bili označeni kot občutljivi.

3 Rezultati

3.1 Obseg pilotov in njihova vsebinska raznolikost

V prvih fazah projekta DECIDE je bilo izbranih 27 pilotnih projektov. Za nekatere se je izkazalo, da ne bo mogoče pridobiti vseh potrebnih podatkov. Nekateri od predlaganih pilotnih projektov v času projekta še niso bili zreli za realizacijo. V končni fazi je bilo zato za dokončno analizo izbranih osem pilotnih projektov. Trije so bili izbrani že ob začetku projekta in so ostali v izboru. Ti pilotni projekti so bili razvrščeni po državah, po področjih krožnega gospodarstva in po vsebini:

- Hrvaška, področje tekstila, naziv: »Vključevanje v delo prek ravnanja s tekstilnimi odpadki«;
- Slovenija, področje embalaže, naziv: »Papirne vrečke iz paradižnikovih stebel«;
- Madžarska, področje embalaže, naziv: »Embalaža: PLA filamenti kot zamenjava tradicionalnih materialov«.

Na usmerjevalnem odboru projekta DECIDE (Kern, 2025), v začetku četrte faze projekta, je bilo dogovorjenih še pet dodatnih pilotnih projektov, za katere je bilo odločeno, da se bo za njih meril vpliv vpeljave modelov krožnega gospodarstva. Tudi ti pilotni projekti so bili razvrščeni po državah, po področjih krožnega gospodarstva in po vsebini:

- Nemčija, področje pametnih mest, naziv: »Pametno mesto: energija iz biomase«;
- Moldavija, področje baterij, naziv: »Gospodinjska reciklaža baterij«;
- BiH, področje embalaže, naziv: »Embalaza: proizvodi iz recikliranih/biološko razgradljivih materialov«;
- Avstrija, področje tekstila, naziv: »Tekstil: zastave iz starih tekstilij«;
- Romunija, področje prehrane, naziv: »Hrana: dehidrirano sadje/zelenjava iz ostankov«.

Za vse izbrane pilotne projekte so bile v teku četrte faze projekta zbrani podatki in s strani projektnih partnerjev vneseni v končne verzije Excel tabel, kar je omogočilo enotno obdelavo in pripravo skupnega zaključnega poročila. Z analizo podatkov smo ugotovili pogloblitve značilnosti, ki so podane v nadaljevanju.

3.2 Nepopolnost podatkov in posledice za analizo

Čeprav so bile tabele za zbiranje podatkov enake za vse pilotne projekte, je bila stopnja popolnosti podatkov pomembno različna. Za šest projektov so bili zbrani popolni podatki. Za en primer smo se morali zadovoljiti z delnimi numeričnimi podatki, dopolnjenimi s kvalitativno razlago. Za en primer, pa smo ugotovili, da numerični podatki ne omogočajo ustrezne kvantitativne obdelave in smo lahko izdelali le kvalitativno presojo. Razlogi za pomanjkanje kvantitativnih podatkov so bili predvsem:

- občutljivost podatkov, ki so jih posredovala podjetja, ki so bila vključena v posamezen pilotni projekt in jih niso želela v celoti razkriti, ker so jih obravnavala kot zaupne;

- nedostopnost podatkov o doseganju ciljnega stanja (podatki o TO-BE stanju) v okviru obdobja projektnega projekta, ker projekt še ni bil dokončan oziroma ciljno stanje še ni bilo modelirano v celoti;
- primeri, kjer merjenje izhodiščnega (AS-IS) stanja ni bilo izvedljivo in so bili na voljo le podatki o ciljnem stanju (TO-BE). To so bili pilotni projekti, ki so se začeli že pred začetkom projekta DECIDE in projektni partnerji tedaj niso zbrali podatkov, naknadno pa teh podatkov ni bilo več mogoče pridobiti.

3.3 Splošne (agregirane) kvantitativne ugotovitve

Agregirani kvantitativni rezultati kažejo izboljšave TO-BE vrednosti glede na AS-IS vrednosti pri večini kazalnikov, pri čemer so najizrazitejše izboljšave v okoljskih in ekonomskih dimenzijah. Posebej izstopajo primeri, povezani z energijsko učinkovitostjo, izrabo biomase ter ponovno uporabo in recikliranjem materialov. Socialni kazalniki so nasprotno izkazovali zgolj zmerne spremembe, kar povezujemo z ohlapno opredeljenimi kvantitativnimi kazalniki socialnih vplivov uvedbe modelov krožnega gospodarstva in posledično večjo odvisnostjo od kvalitativnih kazalnikov.

Pričakovano stanje (WISH-TO vrednosti kazalnikov) je bilo prav tako mogoče ugotoviti v večini pilotnih projektov, vendar praviloma le za nekatere izbrane kazalnike. V večini doseženo stanje (TO-BE vrednosti kazalnikov) približalo pričakovanemu stanju (WISH-TO vrednostim kazalnikov). V ostalih primerih, kjer so bila razhajanja večja, smo ugotovili, da so bile vrednosti kazalnikov pričakovanega stanja opredeljena dokaj ohlapno.

3.4 Splošne ugotovitve o doseganju okoljskih ciljev

V analizi doseganja okoljskih ciljev(»Sustainability Goals«) je bilo ugotovljeno, da so bili v večini pilotnih projektov, kot pričakovani (WISH-TO), navedeni cilji:

- odgovorna potrošnja in proizvodnja,
- dostojno delo in gospodarska rast,
- industrija/inovacije/infrastruktura,
- trajnostna mesta in skupnosti ter podnebni ukrepi.

Kot dejansko doseženi cilji (TO-BE vrednosti so bile enake ali boljše od WISH-TO vrednosti) so bili ti cilji potrjeni v štirih pilotih.

3.5 Splošne (agregirane) kvalitativne ugotovitve

Kvalitativna analiza je pokazala med-organizacijsko sodelovanje kot ključen mehanizem krožnosti. Gre za povezovanje podjetij, podpornih institucij in javnih deležnikov. Na okoljskem področju so izstopala področja energetske prenove, povečevanja učinkovitosti rabe virov in zmanjševanja količine odpadkov. Na ekonomskem področju je poudarjena dobičkonosnost, izvedljivost, pripravljenost odločevalcev na investicije in skalabilnost. Na socialnem področju so se kot pomembna področja izkazala nadgradnja kompetenc, interna komunikacija in podpora skupnosti.

3.6 Primerjalna analiza pilotov

Primerjalna analiza med pilotnimi projekti kaže skupno usmerjenost v krožna načela, vendar z različno stopnjo metodološke zrelosti. Okoljski učinki so konsistentni, ekonomski učinki variabilni, socialni učinki pa pogosto le opisni. Ključna omejitev je nepopolno poročanje zaradi česar niso podane vse vrednosti kazalnikov in uporaba nestandardnih merskih enot, kar zmanjšuje neposredno primerljivost in otežuje agregacijo rezultatov po področjih ali državah. Kljub temu kvantitativne ugotovitve kažejo, da so uporabljene metode in orodja ustrezne za organizacijsko učenje, inoviranje in povečanje stopnje sodelovanja deležnikov v na novo oblikovanih verigah krožnega gospodarstva.

4 Diskusija

Ugotovimo lahko, da ima razvita in uporabljena metodologija dve pomembni lastnosti:

- Dvajset dimenzijski okvir omogoča uravnoteženo obravnavo vplivov: poleg okoljskih vplivov (materiali, odpadki, emisije) sistematično vključuje ekonomske vidike (učinkovitost, stroški, partnerstva) in socialne vplive (na primer: zaposlovanje), kar je ključno za odločanje o prenovi procesov v realnih organizacijah.

- Koncept preseka treh stanj (AS-IS, WISH-TO, TO-BE) metodologijo približa odločevalcem, saj omogoča, da se pred odločitvijo o implementaciji oblikuje projekcija pričakovanih učinkov, po implementaciji pa verifikacija doseganja dejanskih rezultatov.

Ob tem pa opazamo tudi nekatere omejitve, značilne za metodologije, ki so razvite v raziskovalno-razvojnih okoljih in jih želimo prenesti v poslovna okolja. Omejitve je mogoče z razvojem metodologije odpraviti, zato so predlagane usmeritve in predlogi izboljšav:

- **Nepopolni podatki in zaupnost:** manjkajoče AS-IS in/ali TO-BE vrednosti zmanjšujejo možnosti izračuna učinkov. Predlagana se vzpostavitev formalno-pravnega okvira za pridobivanje in uporabo občutljivih podatkov in dodatno usposabljanje projektnih ekip za modeliranje izhodiščnega stanja.
- **Kakovost podatkov:** začetne verzije podatkov so pogosto vsebovale napake, neustrezne merske enote in pomanjkljive metapodatke. Priporoča se zamenjava Excel predlog z aplikacijo, ki bi omogočala preverjanje pravilnosti vnosa podatkov in zaznavo nekonsistentnih podatkov.
- **Povezovanje kvantitativne in kvalitativne metode:** praviloma so projektni partnerji za svoje pilotne projekte poročali bodisi numerične podatke bodisi opisne informacije, ne pa obojega. Za boljšo interpretacijo je smiselno, da se pri ključnih indikatorjih vedno zahteva tudi utemeljitveno pojasnilo (mehanizem spremembe, meje merjenja, viri podatkov, idr.).
- **Socialni indikatorji:** socialni vplivi uvajanja modelov krožnega gospodarstva so bili praviloma le opisni, ne pa numerični. Priporoča se revizija nabora merljivih socialnih indikatorjev (npr.: število novo zaposlenih na področjih ekologij »Green jobs«, pridobljene kompetence zaposlenih, idr.).
- **Dolgoročno spremljanje vpliva:** zaradi časovne omejitve projekta ni bila izvedena post-mortem evalvacija pilotnih projektov. Predlagan je mehanizem zbiranja podatkov o doseženih vrednostih indikatorjev po določenem obdobju ali v več časovnih presekih po implementaciji krožnih modelov. To mora vključevati tudi posebno predlogo za primerjavo WISH-TO in TO-BE vrednosti v teh časovnih presekih.

Pomemben rezultat, ki presega zahteve projekta DECIDE, je izdelan postopek zbiranja vrednosti kazalnikov in ob tem organizacijsko učenje deležnikov. To saj zagotavlja ponovljivost merjenja in izračuna vplivov tudi po zaključku projekta. Standardiziran postopek, podprt z MS Teams platformo omogoča iterativno izboljševanje predlog, izvedbo delavnic in individualno metodološko podporo. To je pomembno za širitev uporabe metodologije in orodij v druge sektorje in v druge regije.

5 Zaključki

Prispevek obravnava rezultate delovnega paketa WP.1.4.2 raziskovalnega projekta DECIDE in predstavlja metodologijo merjenja vpliva uvajanja krožnih poslovnih modelov (CEBM) ter povzema ključne rezultate uporabe v osmih pilotnih projektih. Metodologija temelji na dvajset dimenzijskem okviru kazalnikov in na primerjavi treh stanj (AS-IS, WISH-TO, TO-BE), podatkovno pa je metodologija podprta z Excel predlogo in MS Teams platformo, kar omogoča enostavno vpisovanje vrednosti kazalnikov. Analiza združuje kvantitativni pristop (normalizacija enot, opisna statistika, parne primerjave) in kvalitativno analizo, pri čemer sta oba pristopa združena s skupno interpretacijo rezultatov.

Rezultati potrjujejo sektorsko neodvisnost metodologije in njeno uporabnost za podporo pri odločanju o implementaciji projektov uvajanja krožnih modelov. Pomembna je ugotovitev, da so okoljski učinki najizrazitejši in najbolj konsistentni, ekonomski učinki večinoma pozitivni, socialni učinki pa v prihodnosti zahtevajo boljšo operacionalizacijo.

Za nadgradnjo metodologije in širšo uporabnost metodologije so ključne usmeritve:

- uvedba formalnih podlag za zaščito občutljivih podatkov,
- izboljšanje kakovosti podatkov z uvedbo aplikacije,
- dosledno povezovanje kvantitativnih meritev in pridobivanja opisnih informacij ter
- uvedba mehanizma dolgoročnega spremljanja učinkov (post-mortem) po implementaciji modelov krožnega gospodarstva v prakso.

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SIMULACIJA PROIZVODNEGA PROCESA Z UPORABO ODPR TOKODNEGA PROGRAMA BLENDER KOT ORODJE ZA USPOSABLJANJE V INDUSTRIJI

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Prispevek obravnava uporabo 3D-simulacij kot sodobnega pristopa k usposabljanju zaposlenih v industriji. Namen raziskave je bil prikazati, kako je mogoče z uporabo odprtokodnega programa Blender razviti realistično simulacijo proizvodnega procesa, ki izboljša razumevanje delovnih postopkov, poveča varnost pri delu in zmanjša stroške izobraževanja. Teoretični del obravnava značilnosti odprtokodne programske opreme, razvoj in zmogljivosti programa Blender ter vlogo 3D-simulacij v industrijskem izobraževanju. V empiričnem delu je predstavljena izdelava 3D-animacije sestave električne polnilnice ter analiza njene uporabnosti v primerjavi s klasično tehnično dokumentacijo. Ugotovitve kažejo, da 3D-simulacije omogočajo boljše razumevanje delovnih nalog, večjo ponovljivost učnih postopkov in zmanjšanje napak. Prispevek potrjuje, da odprtokodna orodja predstavljajo učinkovito podporo sodobnemu industrijskemu usposabljanju.

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SIMULATION OF A MANUFACTURING PROCESS AS A TOOL FOR INDUSTRIAL TRAINING USING THE OPEN-SOURCE SOFTWARE BLENDER

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The paper addresses the use of 3D simulations as a modern instructional approach in industrial employee training. The aim of the research was to demonstrate how a realistic simulation of a manufacturing process can be developed using the open-source software Blender, improving the understanding of work procedures, increasing workplace safety, and contributing to reduced training costs. The theoretical part of the paper discusses the characteristics of open-source software, the development and capabilities of Blender software, and the role of 3D simulations in industrial education. The empirical part presents the creation of a 3D animation of an electric charging station assembly and an analysis of its usability compared to traditional technical documentation. The findings indicate that 3D simulations enable better understanding of work tasks, greater learning repeatability, and a reduction in errors. The paper confirms that open-source tools provide effective support for modern industrial training.



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1 Uvod

Učinkovito usposabljanje zaposlenih je eden ključnih dejavnikov uspešnega delovanja sodobnih industrijskih organizacij (Serrano et al., 2016; Radianti et al., 2020). Zaradi nenehnega tehnološkega razvoja, avtomatizacije in večje kompleksnosti proizvodnih procesov se zahteve po znanju in usposobljenosti zaposlenih nenehno povečujejo, kar od organizacij zahteva uvajanje novih, prilagodljivih oblik izobraževanja (Chiang & Qin, 2018). Neustrezno usposobljeni delavci lahko povzročijo napake v proizvodnji, zastoje delovnih procesov ter povečano tveganje za poškodbe, kar neposredno vpliva na stroške in konkurenčnost podjetja (Borsci et al., 2015).

V industrijski praksi se še vedno uporabljajo tradicionalni pristopi k usposabljanju, kot so mentorstvo na delovnem mestu, pisna navodila in priročniki. Čeprav ti pristopi omogočajo neposreden stik z realnim delovnim okoljem, imajo tudi pomembne omejitve, zlasti pri prenosu kompleksnih znanj in standardizaciji učnega procesa (Sampaio & Henriques, 2010). Usposabljanje v proizvodnji je lahko povezano z varnostnimi tveganji, kakovost prenosa znanja pa je pogosto odvisna od izkušenj posameznega mentorja (Borsci et al., 2015). Pisna dokumentacija praviloma ne omogoča zadostne prostorske predstave, kar otežuje razumevanje zapletenih postopkov sestave in delovanja naprav (Vergara et al., 2015).

Razvoj digitalnih tehnologij omogoča uvajanje sodobnejših učnih metod, med katerimi imajo 3D-simulacije in virtualna resničnost pomembno vlogo (Freina & Ott, 2015). S pomočjo vizualnih in dinamičnih prikazov je mogoče proizvodne procese predstaviti jasno in pregledno, še preden zaposleni stopijo v dejansko delovno okolje. To prispeva k boljšemu razumevanju postopkov in hitrejšemu učenju (Mujber et al., 2004; Radianti et al., 2020). Takšen pristop zmanjšuje možnost napak, povečuje varnost ter omogoča učenje v lastnem tempu, saj lahko uporabniki postopke večkrat ponovijo brez tveganja za poškodbe ali materialno škodo (Makransky et al., 2019).

Poleg tega 3D-simulacije omogočajo večjo dostopnost učnih vsebin, saj so digitalni materiali lahko na voljo ne glede na čas in lokacijo bodisi v intranetu ali na medmrežju (Radianti et al., 2020). To je posebej pomembno v podjetjih z več izmenami ali razpršenimi proizvodnimi enotami, kjer je klasično usposabljanje

pogosto organizacijsko zahtevno (Vergara et al., 2015). Digitalne učne vsebine je mogoče tudi hitreje posodabljeni v primeru sprememb proizvodnih postopkov ali tehnologije, kar dolgoročno prispeva k večji učinkovitosti in aktualnosti izobraževanja zaposlenih (Chiang & Qin, 2018).

Namen prispevka je predstaviti uporabo odprtokodnega programa Blender za simulacijo proizvodnega procesa kot podporo industrijskemu usposabljanju. Prispevek temelji na raziskovalnem delu, v okviru katerega je bila razvita 3D-animacija sestave električne polnilnice ter analizirana njena uporabnost v primerjavi s klasično tehnično dokumentacijo, kar sovпада z ugotovitvami raziskav o pozitivnem vplivu 3D in virtualnih simulacij na razumevanje tehničnih postopkov (Sampaio & Henriques, 2010; Radianti et al., 2020).

2 Teoretično ozadje

Odprtokodna programska oprema temelji na javno dostopni izvorni kodi, ki uporabnikom omogoča pregledovanje, prilagajanje in razširjanje funkcionalnosti v skladu z licenčnimi pogoji. Ta način dela spodbuja inovativnost in znižuje stroške uporabe (Feller & Fitzgerald, 2002). Nasprotno pa je za lastniško programsko opremo značilno, da je izvorna koda nedostopna, uporaba programske opreme pa omejena z licenčnimi pogoji proizvajalca (Fitzgerald, 2006). V tem primeru uporabniki praviloma nimajo možnosti prilagoditve in nadzora nad razvojem programske rešitve.

V industrijskem okolju se odprtokodne rešitve vse pogostejše uporabljajo kot alternativa lastniški programski opremi, saj omogočajo večjo prilagodljivost, neodvisnost od posameznega ponudnika ter lažjo integracijo v obstoječe informacijske in proizvodne sisteme (Dedrick & West, 2004). To je posebej pomembno pri razvoju učnih in simulacijskih orodij, kjer se zahteve pogosto spreminjajo in je potrebna hitra prilagoditev vsebin specifičnim proizvodnim procesom.

Pomembna prednost odprtokodnih rešitev je tudi njihova stroškovna dostopnost, saj praviloma ne zahtevajo plačevanja licenčnih stroškov, hkrati pa zmanjšujejo odvisnost uporabnikov od posameznega ponudnika programske opreme (Raymond, 2001; Fitzgerald, 2006).

Program Blender predstavlja enega najvidnejših primerov odprtokodnih programov za ustvarjanje 3D-vsebin, saj omogoča celovit proces izdelave 3D-modelov, animacij in simulacij, vključno z modeliranjem, animiranjem, renderiranjem ter osnovno postprodukcijo (Blender Foundation, 2025). Zaradi odprtokodne narave je v stalnem razvoju, njegova funkcionalnost pa se izboljšuje s prispevki globalne skupnosti razvijalcev in uporabnikov, kar povečuje njegovo prilagodljivost in razširljivost v različnih aplikacijskih okoljih (Feller & Fitzgerald, 2002).

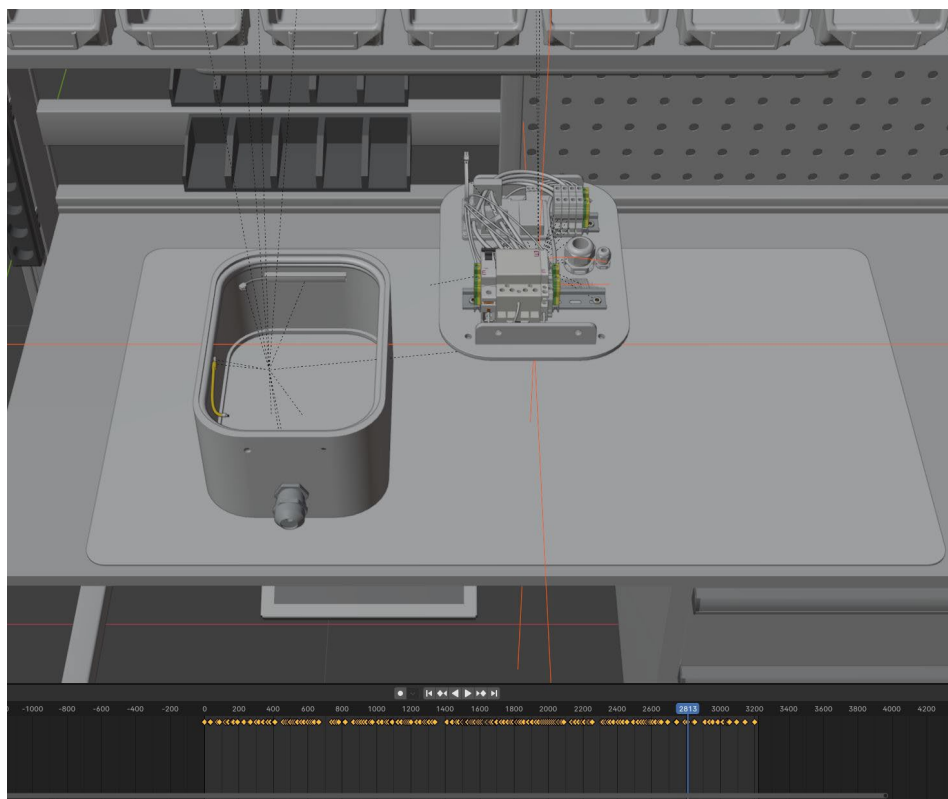
Dodatno prednost predstavlja možnost uporabe programskega jezika Python, ki omogoča avtomatizacijo postopkov, razvoj lastnih skript in prilagajanje orodij specifičnim potrebam uporabnikov (Blender Foundation, 2025). Takšna prilagodljivost omogoča uporabo programa Blender tudi za razvoj specializiranih simulacijskih rešitev, prilagojenih konkretnim proizvodnim procesom.

2.1 3D-simulacije v industrijskem usposabljanju

3D-simulacije predstavljajo sodoben učni pristop, ki omogoča vizualno in dinamično predstavitev delovnih postopkov ter proizvodnih procesov. V primerjavi s statičnimi slikami ali zgolj besedilnimi navodili animirani prikazi omogočajo boljše razumevanje zaporedja korakov, gibanja komponent in medsebojnih povezav elementov sistema (Mujber et al., 2004; Zhang et al., 2014).

Pomemben vidik uporabe 3D-simulacij je tudi njihov kognitivni učinek na proces učenja. Vizualno podprte in interaktivne vsebine omogočajo lažje procesiranje informacij ter prispevajo k boljšemu dolgoročnemu pomnjenju in razumevanju učnih vsebin (Makransky et al., 2019). Učenje v simuliranem okolju zaposlenim omogoča, da se z delovnimi postopki seznanijo brez časovnih omejitev in možnosti napak v realnem proizvodnem okolju. To zmanjšuje stres ter spodbuja aktivno in samostojno učenje (Radianti et al., 2020).

Poleg tega 3D-simulacije omogočajo varno učenje, saj zaposleni niso neposredno izpostavljeni nevarnim strojem, električnim komponentam ali drugim potencialno tveganim dejavnikom. Takšen pristop (Slika 1) je še posebej primeren za uvajanje novih zaposlenih ter za ponavljanje zahtevnejših in redkeje izvajanih delovnih postopkov (Sampaio & Henriques, 2010).



Slika 1: Prikaz 3D-simulacije procesa.

Vir: Lasten

3 Metodologija

Raziskava je temeljila na kombinaciji teoretičnega pregleda in praktične študije primera. Najprej je bil opravljen pregled literature s področja industrijskega usposabljanja, digitalnega učenja in 3D-simulacij. Na tej osnovi je bil razvit praktični del, v katerem je bila v programu Blender izdelana 3D-simulacija proizvodnega procesa.

Praktični del je vključeval pripravo in uvoz 3D-modelov, modeliranje manjkajočih komponent, postavitev elementov v tridimenzionalni prostor, animacijo montažnih korakov ter končno renderiranje animacije. Poseben poudarek je bil namenjen preglednosti prikaza in realističnemu zaporedju delovnih postopkov. V empiričnem

delu so udeleženci primerjali učenje s pomočjo 3D-animacije in klasične tehnične dokumentacije. Zbrane so bile ocene razumljivosti, uporabnosti in zaznane učinkovitosti obeh pristopov.

4 Simulacija proizvodnega procesa

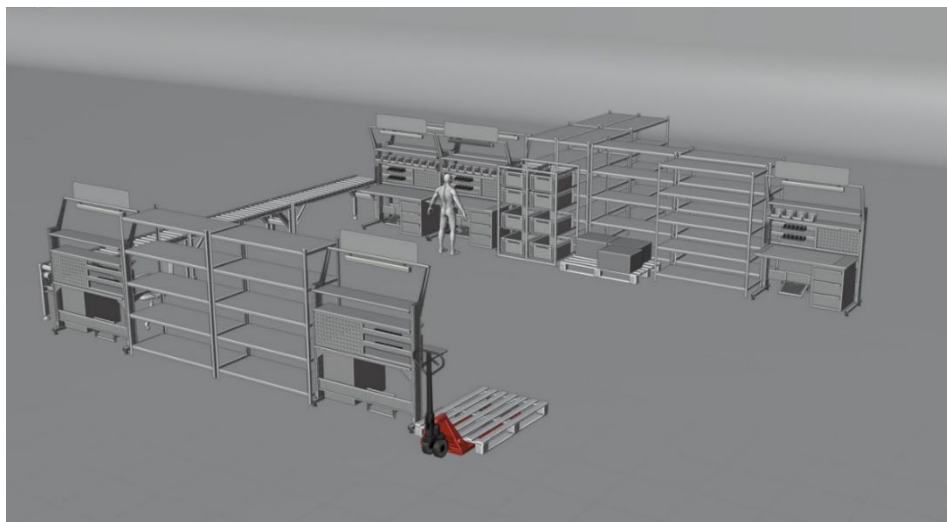
Simulacija proizvodnega procesa temelji na realnem primeru sestave domače električne polnilnice. Izbrani proces je večstopenjski in dobro ponazarja zaporedje montažnih korakov, zato je primeren za prikaz prednosti uporabe 3D-simulacije pri industrijskem usposabljanju (Slika 2).

Pri izdelavi simulacije smo v programu Blender uporabili kombinacijo obstoječih 3D-modelov in lastno izdelanih komponent. Pripravljeni so bili osnovni elementi, kot so ohišje polnilnice, elektronski sklopi, kabli in pritrdilni deli. V primerih, kjer ustrezni modeli niso bili na voljo, smo jih izdelali sami, pri čemer smo upoštevali dejanske mere in razporeditev komponent, da bi se čim bolj približali realnemu izdelku (Slika 3).



Slika 2: 3D-model polnilnice.

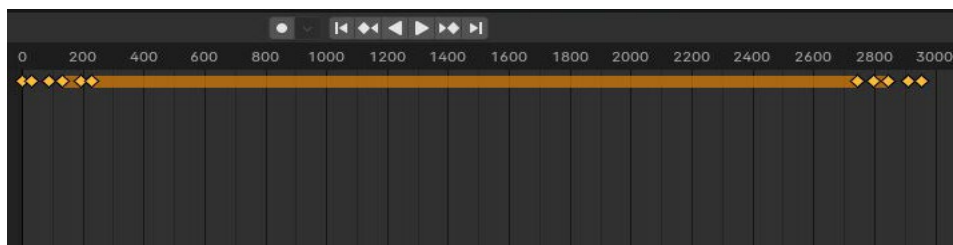
Vir: Lasten



Slika 3: Postavljeno 3D-okolje.

Vir: Lasten

Po pripravi modelov smo jih postavili v skupno delovno okolje in uredili njihov medsebojni položaj. Sledila je izdelava animacije, ki je bila izvedena s pomočjo ključnih točk (Slika 4), s katerimi smo določili začetni in končni položaj posameznih komponent, medtem ko je program samodejno izračunal vmesne premike. Na ta način je bil postopoma prikazan celoten potek sestave, od nameščanja posameznih delov do končnega zapiranja ohišja.



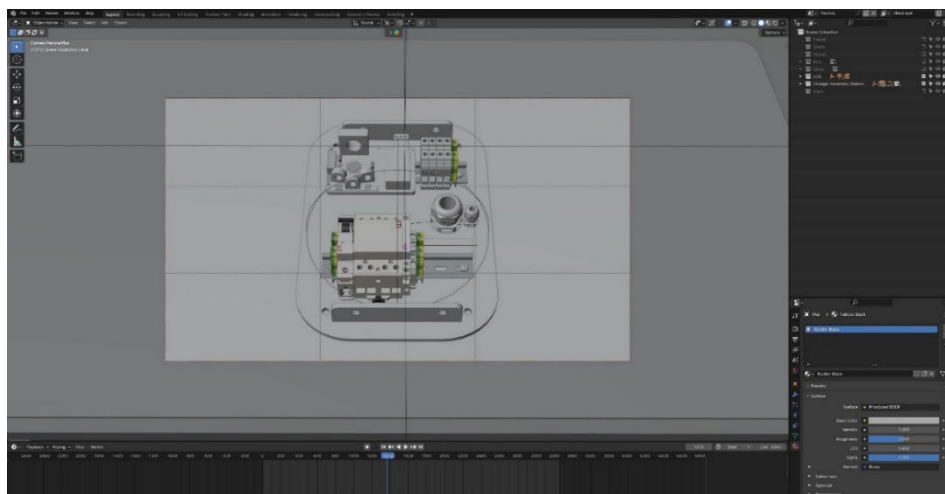
Slika 4: Prikaz točk animacije enega od elementov v časovnici.

Vir: Lasten

Poseben poudarek je bil namenjen jasnemu zaporedju korakov, saj je bil cilj simulacije, da gledalec razume potek postopka in povezavo med posameznimi elementi brez dodatnih razlag. Animacija je bila zato zasnovana pregledno in v

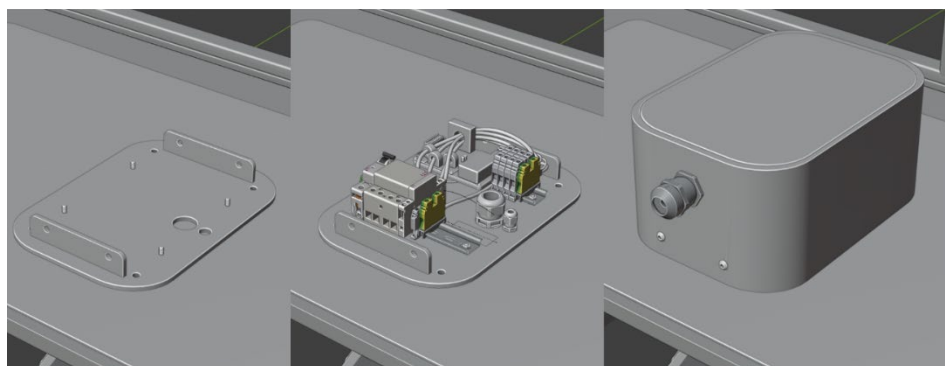
zmernem tempu, kar omogoča lažje spremljanje postopka tudi manj izkušenim uporabnikom.

Za boljšo preglednost in boljšo uporabniško izkušnjo je bila vključena tudi animacija kamere. Ta je bila nastavljena tako, da sledi ključnim fazam sestave in se osredotoča na pomembne detajle, kot so nameščanje komponent in njihova pritrditev. S tem je gledalcu omogočen jasen pogled na postopek brez potrebe po ročnem spreminjanju pogleda, kar dodatno prispeva k razumljivosti prikaza (Slika 5).



Slika 5: Pogled na animacijo skozi kamero.

Vir: Lasten

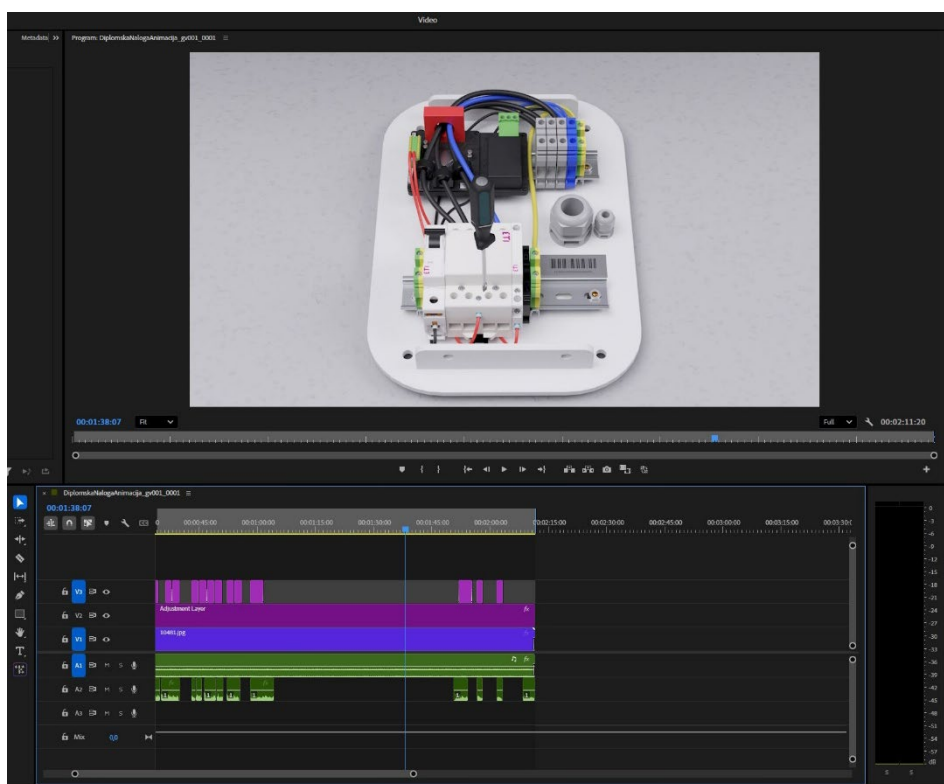


Slika 6: Faze poteka animacije sestavljanja ohišja in elektronskih komponent.

Vir: Lasten

Simulacija je bila zasnovana modularno, kar omogoča uporabo posameznih delov animacije za različne namene, kot so osnovno usposabljanje novih zaposlenih, ponavljanje posameznih postopkov ali osvežitev znanja (Slika 6).

Po končani animaciji je sledila še postprodukcija, v okviru katere smo animacijo dodatno uredili in prilagodili za uporabo v učne namene. Posamezni kadri so bili časovno usklajeni, dodani so bili osnovni napisi in poudarki, ki gledalca usmerjajo na pomembne korake postopka. S tem je animacija postala bolj pregledna in primerna za samostojno učenje brez dodatnih razlag (Slika 7).

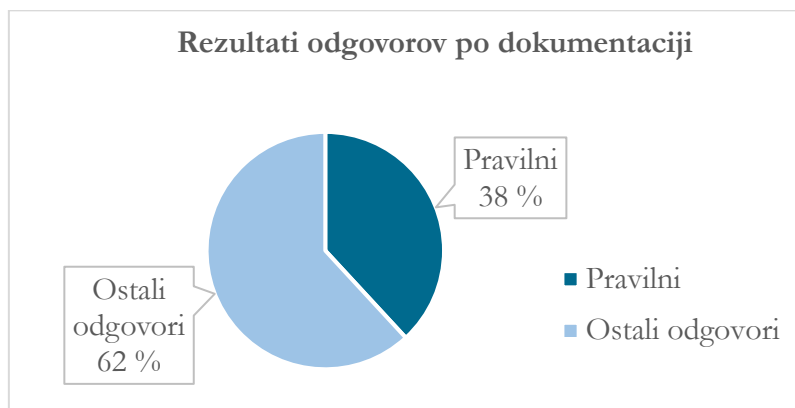


Slika 7: Zaslonski posnetek v programu Adobe Premiere Pro.

Vir: Lasten

5 Rezultati in analiza

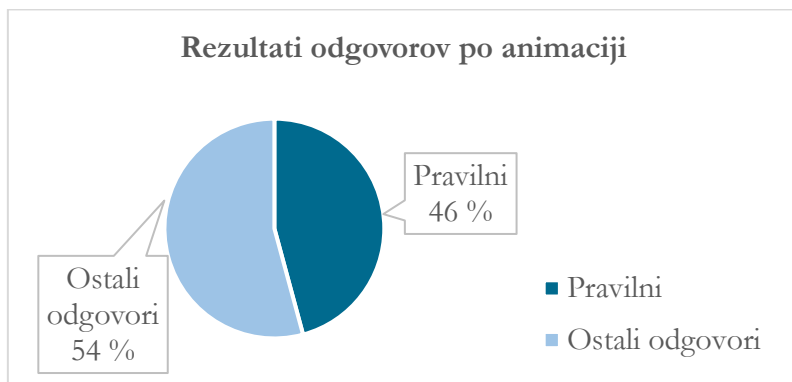
Rezultati raziskave kažejo, da v primerjavi s klasično tehnično dokumentacijo uporaba 3D-simulacij izboljša razumevanje delovnih postopkov. Raziskava je bila izvedena v obliki ankete, v kateri so udeleženci najprej prebrali pisna navodila, nato pa si ogledali 3D-animacijo istega postopka. Po obeh fazah so reševali enak vprašalnik, kar je omogočilo neposredno primerjavo obeh učnih metod. V raziskavo je bilo vključenih 53 anketirancev (57 % moških, 41 % žensk), 2 % se jih ni opredelilo. Po ogledu 3D-animacije so udeleženci praviloma dosegli boljše rezultate pri vprašanjih, povezanih z zaporedjem korakov in pravilno montažo posameznih delov. Vizualni prikaz jim je pomagal lažje slediti postopku in si ustvariti boljšo predstavo o tem, kako se deli med seboj povezujejo (Slika 8 in 9).



Slika 8: Rezultati odgovorov po dokumentaciji.

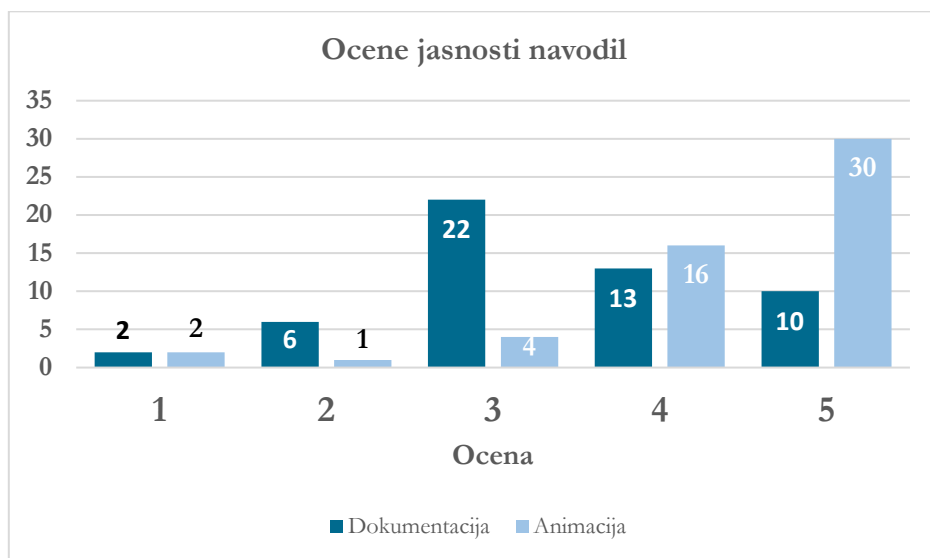
Vir: Lasten

Udeleženci so v anketi poudarili, da se jim je zdela 3D-animacija bolj pregledna in razumljiva kot pisna navodila. Večina jih je izpostavila, da so z animacijo hitreje razumeli celoten potek dela in se pri tem počutili bolj samozavestne. Pomembna prednost je bila možnost večkratnega ogleda postopka, kar pri klasični dokumentaciji ni tako učinkovito. Kljub pozitivnim odzivom so udeleženci opozorili na nekatere omejitve, predvsem na časovno zahtevnost izdelave 3D-animacij in potrebo po ustrezni računalniški opremi.



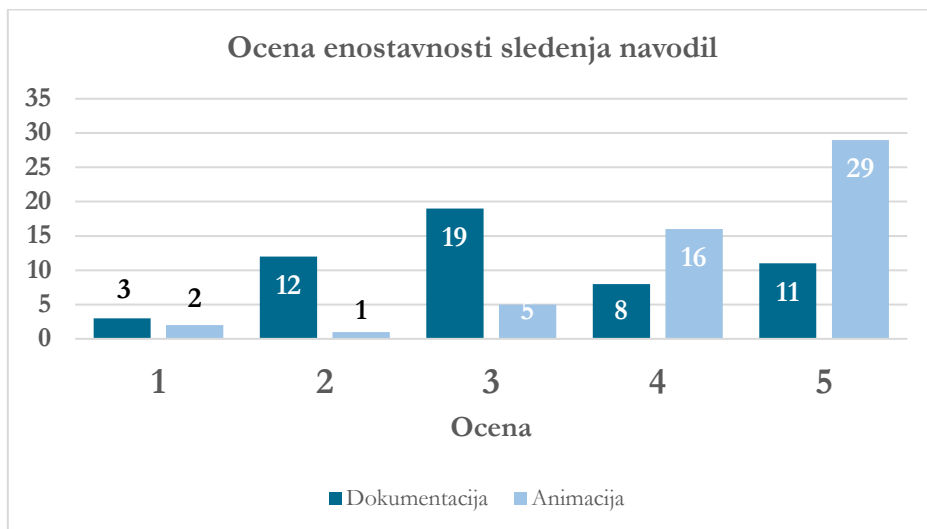
Slika 9: Rezultati odgovorov po dokumentaciji.

Vir: Lasten



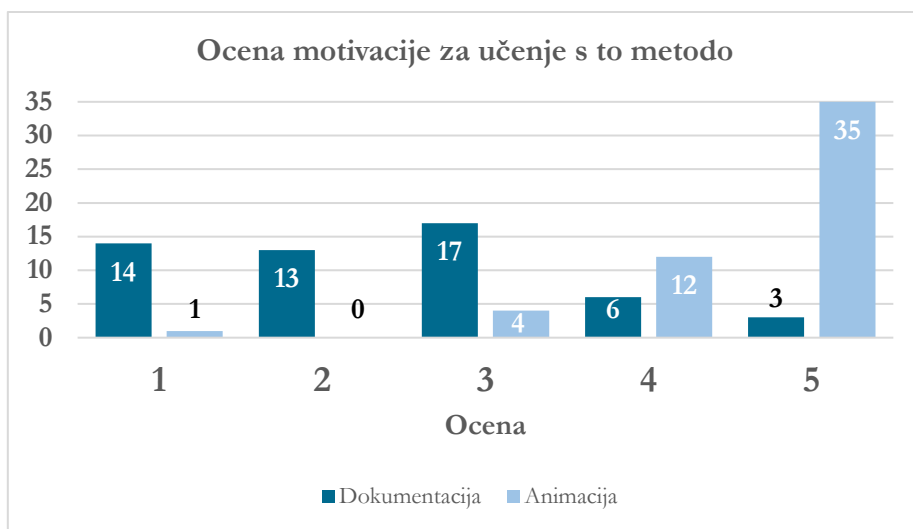
Slika 10: Ocena jasnosti navodil.

Vir: Lasten



Slika 11: Ocena enostavnosti sledenja.

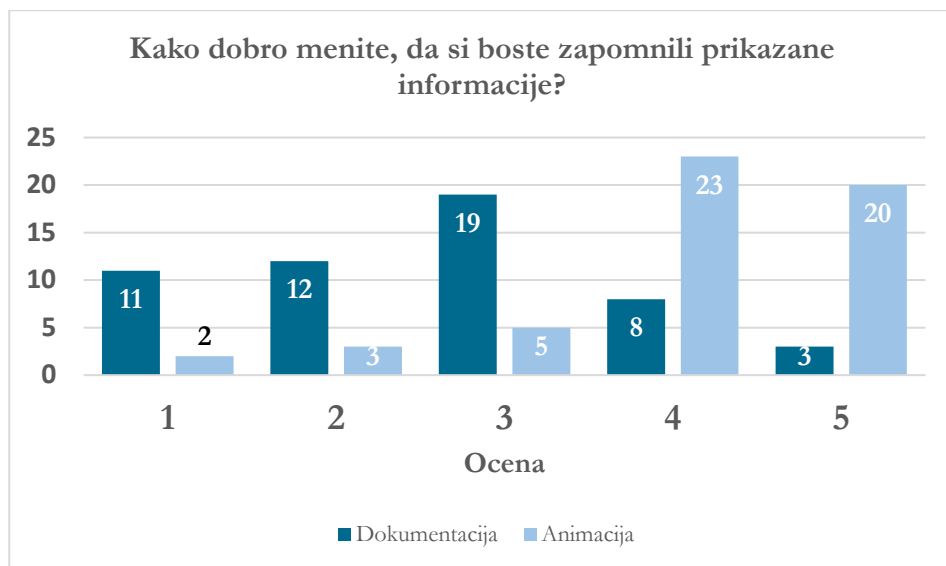
Vir: Lasten



Slika 12: Ocena motivacije za učenje s to metodo.

Vir: Lasten

Kljub temu večina meni, da prednosti, kot so boljše razumevanje, večja varnost pri učenju in enotnost navodil, te pomanjkljivosti odtehtajo (Slika 10, 11, 12 ter 13).



Slika 13: Kako dobro menite, da si boste zapomnili prikazane informacije?

Vir: Lasten

Na podlagi rezultatov raziskave lahko zaključimo, da odprtokodni program Blender omogoča izdelavo kakovostnih učnih animacij brez dodatnih licenčnih stroškov. Za primerjavo vzemimo zelo drago in kompleksno 3D-simuliranje letenja za pilote in 3D-simuliranje operacij za kirurge. Zakaj sodobna 3D-simulacija ne bi pomagala tudi pri usposabljanju drugih poklicev? 3D-simulacije se izkazujejo kot uporaben in sodoben učni pripomoček, ki lahko učinkovito dopolni ali delno nadomesti klasično tehnično dokumentacijo pri industrijskem usposabljanju. Vseeno pa ostaja nekaj, česar 3D-simulacija še ne more nadomestiti – občutka na koži, v zapestju, potrebne moči za izvedbo operacije, posebnega giba za pritrditev ter občutka za postopno dodajanje moči, torej elementov, ki zahtevajo praktično delo.

Čprav so rezultati preverjanja znanja po animaciji v povprečju boljši le za približno 8 %, je treba upoštevati še prednosti, kot so večja motivacija, boljše razumevanje prostorskih odnosov, večja varnost pri učenju ter enotnost podanih navodil. Ti

dejavniki kažejo, da je vložek v pripravo 3D-gradiv smiseln predvsem pri kompleksnejših postopkih in dolgoročni uporabi v industrijskem usposabljanju.

Pri interpretaciji rezultatov je treba upoštevati tudi omejitve raziskave, zlasti relativno majhen vzorec udeležencev in enkratni preizkus znanja. Rezultati zato predvsem nakazujejo trende in potencial uporabe 3D-simulacij v industrijskem usposabljanju.

6 Zaključek

Prispevek potrjuje, da odprtokodni program Blender predstavlja učinkovito orodje za simulacijo proizvodnih procesov in industrijsko usposabljanje zaposlenih. Uporaba 3D-simulacij omogoča varno, ponovljivo in stroškovno učinkovito učenje ter predstavlja kakovostno dopolnitev tradicionalnih metod usposabljanja, kot so pisna navodila in priročniki.

Rezultati izvedene ankete so pokazali, da so udeleženci po ogledu 3D-animacije dosegli občutno boljše rezultate pri preverjanju znanja. Pri vprašanjih o zaporedju montažnih korakov se je delež pravilnih odgovorov povečal za približno 8 % v primerjavi z učenjem iz klasične dokumentacije. Poleg tega so udeleženci 3D-simulacijo v povprečju ocenili kot jasnejšo, enostavnejšo za sledenje in bolj motivacijsko, kar potrjuje njen pozitiven vpliv na učni proces.

Večina sodelujočih je poudarila tudi večjo samozavest pri razumevanju postopkov ter boljše zapomnitev prikazanih informacij. To kaže, da vizualni in dinamični prikaz postopkov pomembno prispeva k boljšemu prenosu znanja in zmanjšanju možnosti napak pri dejanskem delu.

Na podlagi ugotovitev je mogoče sklepati, da ima uporaba 3D-simulacij velik potencial tudi v prihodnje, zlasti v povezavi z drugimi digitalnimi tehnologijami, kot so sistemi za upravljanje učenja (LMS), navidezna in razširjena resničnost ter interaktivni učni moduli. Takšne rešitve lahko podjetjem omogočijo še bolj prilagodljivo, standardizirano in učinkovito usposabljanje zaposlenih ter dolgoročno prispevajo k večji varnosti in kakovosti delovnih procesov.

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KOMUNICIRANJE V DOLGOŽIVI DRUŽBI

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V družbi, ki jo živimo, je hitrost tehnoloških, družbenih, kulturnih, ekonomskih, naravnih sprememb vsako leto hitrejša in spodbuja različne možnosti ter potrebe po prilagoditvah. Raznolikost generacij nedvomno bogati družbo, po drugi strani pa predpostavlja izzive, ki so na področju komuniciranja še posebej zaznani. Glede na demografske spremembe in staranje prebivalstva v celotni družbi se predpostavlja, da hiter tehnološki razvoj na nekaterih področjih zapostavlja starejšo generacijo, pri čemer se z različnimi pristopi vse generacije spodbuja k usvajanju komunikacijskih sredstev, ki jih omogoča tehnologija. Mladi so po drugi strani skorajda rojeni s tehnologijo, ki omogoča tako posredno kot neposredno komuniciranje, zato ni pretirano reči, da strategija komuniciranja v dolgoživi družbi zaradi raznolikosti generacij zahteva vse večjo sinergijo med generacijami.

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COMMUNICATION IN A LONGEVITY SOCIETY

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In the society we live in, the pace of technological, social, cultural, economic, and natural change is accelerating every year, promoting various opportunities and the need for adaptation. The diversity of generations undoubtedly enriches society, but on the other hand, it poses challenges that are particularly noticeable in the field of communication. Given demographic changes and the aging of the population, it is assumed that rapid technological development is leaving the older generation behind, with numerous approaches attempting to encourage all generations to embrace the means of communication offered by technology. Young people, on the other hand, are practically born with technology that enables both indirect and direct communication, so it goes without saying that a communication strategy in a long-lived society requires ever greater synergy between generations, given the diversity of generations.



University of Maribor Press

1 Uvod v prispevek

Družbene vezi, prosocialnost, duhovnost, optimizem in delo – vedno več dokazov kaže, da lahko teh pet dejavnikov pomembno vpliva na izboljšanje blaginje ljudi in skupnosti (Cambieri, 2024). Med družbene vezi nedvomno uvrščamo principe komuniciranja, ki jih v prispevku naslavljamo kot pomembne vezi med različnimi generacijami in v družbi nasploh.

Raznolikost generacij je ena največjih prednosti današnjega delovnega okolja. A brez usklajene komunikacije lahko postane tudi breme. Prihodnost dela ni odvisna le od tega, kar rečemo, ampak tudi od naše sposobnosti razumeti, kako to razumejo drugi (Lancioni, 2025).

Raziskovalci se strinjajo, da lahko socialne vezi pomagajo ljudem živeti dlje in bolj zdravo. Socialna osamljenost je na primer povezana z višjim tveganjem za bolezni, vključno s srčnimi boleznimi, možgansko kapjo, anksioznostjo, depresijo in demenco. Dokazano je tudi, da osamljenost in socialna izolacija povečata tveganje za prezgodnjo smrt za 26 % oziroma 29 % (Cambieri, 2024).

Tudi Aristotel je v svoji knjigi *Politika* trdil, da so ljudje po naravi družbena bitja in da posameznik, ki živi zunaj družbe, ni „samozadosten“ (Aristotel, 1905/335–323). Številna literatura iz različnih disciplin (npr. sociološke perspektive socialne integracije, psihološke konceptualizacije socialne podpore) dokumentira socialne vezi kot dosledni napovednik boljšega zdravja, vključno z daljšo življenjsko dobo (Berkman et al., 2000; Cohen, 2004; Holt-Lunstad et al., 2010).

Glede na izpostavitve družbenosti in povezljivosti s komuniciranjem in komunikacijo lahko rečemo, da je to vsekakor ena pomembnejših vezi med ljudmi.

2 Dolgoživa družba

Dolgoživa družba predstavlja novo stopnjo za človeštvo in zahteva, da se globoko zakoreninjene predstave o starosti in staranju postavijo pod vprašaj, če želi družba kar najbolje izkoristiti dodatni čas, ki ga prinaša dolgoživost (Scott, 2021).

V preteklosti je naraščajoči delež starejših ljudi pomenil staranje družbe, kar je vodilo k razvoju srebrne ekonomije, osredotočene na gospodarske priložnosti, ki izhajajo iz posebnih potreb starajočega se prebivalstva. Vendar ta perspektiva, zasidrana v tradicionalnem tristopenjskem modelu življenja (izobraževanje, delo, upokožitev), omejuje naš pogled, saj starejše ljudi zreducira na njihovo kupno moč in se ozko osredotoča na vprašanja, povezana s koncem življenja, kot so pokojnine, oskrba in zdravstveno varstvo (Šuica, 2024).

Staranje je kot demografska dimenzija nekaj, kar nedvomno potegne za seboj že v povzetku omenjene spremembe. Je pa ključen vidik v perspektivah, ki jih kljub vsemu ponuja »tradicionalno komuniciranje« in seveda sodobni koncepti komunikacije.

Gospodarstvo dolgoživosti se pojavlja kot transformativni koncept. Priznava ne le staranje, ampak tudi pomemben premik v dolžini življenja, kar nas sili, da izkoristimo prožnost in zmožnosti starosti. To novo gospodarstvo ne zadeva le daljšega življenja: gre za zagotavljanje, da so ta podaljšana leta zdrava, produktivna in izpolnjujoča. Presega osredotočenost na starejše starostne skupine in izkorišča dolgoživost v vseh starostnih skupinah, pri čemer priznava dragocene socialne in gospodarske prispevke starejših posameznikov, ki presegajo njihove zdravstvene potrebe (Šuica, 2024).

Prožnosti in zmožnosti lahko nedvomno izpostavimo kot pomembne koncepte v povezovanju med dolgoživostjo in komuniciranjem, pri čemer se seveda naslonimo na principe, ki jih ponuja tako neposredna kot posredna komunikacija.

3 Komuniciranje v dolgoživi družbi

Peine in Neven (2019) sta trdila, da je disciplinska ločnica med študijami znanosti in tehnologije (STS) ter gerontologijo akademikom preprečila, da bi ustrezno obravnavali odnos med tehnologijo in družbo.

Tehnološko posredovana komunikacija se nanaša na metode medosebne komunikacije, ki jih nadzirajo in omogočajo tehnološka orodja in aplikacije. Tehnološko posredovana komunikacija vključuje starejše (telefon) in novejši (besedilna sporočila, e-pošta, videoklici) oblike tehnologije. Čeprav je tehnološko

posredovana komunikacija vključena v širši pojem informacijsko-komunikacijske tehnologije (IKT), razlikujemo med uporabo tehnologij za informacije in storitve ter komunikacijo z drugimi (Lubben et al., 2006).

V zadnjem desetletju je širok vpliv digitalizacije in medsebojno povezanih omrežij pripeljal do znatnega povečanja uporabe tehnologije. Sodobna medijska tehnologija ponuja raznoliko paleto naprav, kanalov in platform za družbeno mreženje, ki spodbujajo nemoteno interakcijo in komunikacijo med uporabniki (Choudhary et al., 2024).

Med številnimi dejavniki, ki vplivajo na uporabo tehnologije in vključenost, se starost kaže kot pomembna spremenljivka. Generacijske značilnosti, ki opredeljujejo posameznike, rojene v istem obdobju, imajo skupne ideje, cilje, vrednote in vedenjske vzorce, kar prispeva k izraziti generacijski identiteti (Lyons in Kuron, 2014).

Dejstvo je, da od tradicionalnih medijev, ki so – tako kot sodobni – omogočali neposredno ali posredno komuniciranje, še danes marsikaj obstaja, pri čemer večji delež uporabe še vedno pripada starejšim generacijam. Družba gre naprej, zato je posameznik tudi pri vsakodnevnih opravilih, če želi storitve opravljati hitreje, postavljen v okolje sodobnih medijev, pri čemer se v družbi velik poudarek namenja usposabljanju predvsem tistih, ki se s sodobnimi mediji niso srečevali že od rojstva. Uporaba obeh stebrov, tako tradicionalnega kot sodobnega, predstavlja ključen pripomoček pri komunikaciji tako na osebni, družbeni kot na organizacijski ravni.

4 Komuniciranje, generacije in raznolikost na delovnem mestu

Na današnjem večgeneracijskem delovnem mestu komunikacija ni samo v tem, kar rečemo, ampak tudi v tem, kako, kdaj in zakaj to rečemo. Od generacije »baby boomers« do generacije Z ima vsaka generacija svoje preference, pričakovanja in nepisana pravila za profesionalno komunikacijo. Čeprav izhajajo iz razvijajočih se tehnologij in kulturnih norm, te razlike pogosto vodijo do trenj, nesporazumov in zamujenih priložnosti za sodelovanje (Lancioni, 2025).

Komunikacija na delovnem mestu je ključna povezava za prenos informacij in sodelovanje znotraj organizacije, njena učinkovitost pa neposredno vpliva na operativno učinkovitost organizacije, kakovost odločanja ter zadovoljstvo in uspešnost zaposlenih (De Dreu in Weingart, 2003). Vendar pa so generacijske razlike prinesle številne izzive za komunikacijo na delovnem mestu (Wang, 2025).

Razlike med generacijami v povezavi s komuniciranjem in delovnim okoljem se v literaturi povezujejo z (Lancioni, 2025):

»Boomerji« so odrasli v času formalnosti in hierarhije. Osebna srečanja, strukturirana obvestila in telefonski klici so že dolgo njihovi najljubši načini komuniciranja. Mnogi cenijo neposrednost, profesionalnost in lojalnost v komunikaciji.

Generacija X, ki jo pogosto opisujejo kot neodvisno in skeptično, ceni učinkovitost in jasnost. Premosti analogno in digitalno spretnost, saj se je prilagodila prehodu s papirja na elektronsko pošto. Njeni predstavniki dajejo prednost neposredni komunikaciji, ki ne zahteva veliko vzdrževanja – mislijo na »samo dejstva«.

Milenijci, ki so tehnološko podkovani in usmerjeni v sodelovanje, dajejo prednost hitri digitalni komunikaciji, kot so sporočila »Slack«, skupinska sporočila in video klepeti. Cenijo preglednost, povratne informacije in integracijo poklicnega ter zasebnega življenja, v njihovi komunikaciji pa pogosto prevladuje čustvena inteligenca.

Prvi pravi digitalni domorodci, generacija Z, so večši kratkih vsebin, vizualne komunikacije (GIF-i, emoji) in asinhronih platform. Pomembni sta pristnost in hitrost. So manj formalni, bolj prilagodljivi in pogosto bolj udobni pri večopravnosti na več platformah hkrati.

Razumevanje vrednot in komunikacijskih preferenc vsake generacije je ključnega pomena za oblikovanje povezanih, spoštljivih in učinkovitih timov. »Boomerji« cenijo lojalnost in priznanje; Generacija X išče avtonomijo in jasnost; Milenijci želijo prožnost, podporo in ravnovesje; Generacija Z hrepeni po pristnosti, smislu in človeških odnosih. Prilagajanje stilov vodenja tem potrebam zagotavlja sodelovanje, zavzetost in skupni uspeh med generacijami (Medina, 2025).

Na področju komunikacije na delovnem mestu so zaposleni različnih generacij kot plesalci z različnimi slogi, ki kažejo povsem različne komunikacijske držje. Tradicionalna generacija in generacija »baby boomers« sta močno pod vplivom tradicionalne kulture na delovnem mestu. Pogosto dajejo prednost formalnemu in strogemu slogu komunikacije. V smislu jezikovnega izražanja pripisujejo velik pomen standardizaciji in logiki jezika. Vsaka uporabljena beseda je skrbno premišljena, da bi informacije posredovali natančno in brez napak. Na sestankih se popolnoma osredotočijo na zapisovanje vsebine sestanka, strogo sledijo vnaprej določenemu dnevnemu redu za napredovanje razprave, vsaka povezava pa upošteva ustaljena pravila in postopke, kar kaže na visoko stopnjo discipline in profesionalnosti (Wang, 2025).

Na delovnem mestu prihodnosti, ko se generacijska struktura nenehno spreminja, morajo organizacije nenehno paziti na vpliv generacijskih razlik na komunikacijo ter nenehno prilagajati in izboljševati strategije upravljanja, da se prilagodijo razvoju časa in potrebam zaposlenih (Wang, 2025).

5 Zaključek

Če si želimo ustvarjati pozicijo razumevanja raznolikosti generacij, pri čemer je pomemben element staranje prebivalstva, ne moremo mimo včasih »čarobne paličice«, ki v komuniciranju prepozna ključne družbene vezi. Ob tem je treba izpostaviti, da so značilnosti različnih generacij tiste, ki omogočajo ustvarjanje mostu in sinergije, ob čemer se dopušča razumevanje širših in ožjih principov razlik, ki so v družbi nedvomno prisotne. Biti samo na stališču, da se zaradi različnih pristopov do komunikacije v različnih starostnih skupinah ustvarja vrzel, je neustrezno. Dejstvo je, da je raznolikost v vseh dimenzijah družbe nekaj, kar nas bogati, in da je na slehernem posamezniku, skupinah ter organizacijah, da komunikacija predstavlja vez in ne razdvaja.

Dolgoživost kot taka je v družbi področje, ki naj nas bogati, komunikacijsko-socialne vezi pa naj z razvojem tehnologije omogočajo več, tudi na področju usposabljanja za uporabo tehnologije ter osnovnega medsebojnega razumevanja. Organizacijsko gledano je namreč komunikacija nekaj, kar predstavlja poslušanje, pomembno pa je, da ne ostane samo na tej ravni, temveč da gre tudi za slišanje in razumevanje. Morda je v določenih starostnih skupinah razumevanje večje, v drugih pa je večje

tehnološko znanje, in še bi lahko naštevali. Prispevek bi tako strnili z dejstvom, da je most med raznolikostmi možnost, da skupaj rastemo in se v osnovi čim bolje razumemo.

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IZ LABORATORIJA V DIGITALNO REALNOST: SISTEMATIČNI PREGLED LITERATURE O UPORABI NEVROMARKETINGA PRI RAZUMEVANJU POTROŠNIKOVE IZKUŠNJE V DIGITALNIH OKOLJIH

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V prispevku sistematično so podane in kritično ovrednotine raziskave s področja nevromarketinga, ki med letoma 2020 in 2025 obravnavajo potrošnikovo izkušnjo v digitalnih okoljih. Na podlagi sistematičnega kvalitativnega pregleda literature so analizirane študije, ki uporabljajo EEG, sledenje očem, galvanski odziv kože in analizo obrazne mimike v kontekstu spletnih mest, e-trgovin, digitalnega oglaševanja in virtualne resničnosti. Konceptualni okvir temelji na triadi pozornost-čustva-odločitev, ki pojasnjujejo povezave med vizualno pozornostjo, emocionalno angažiranostjo in odločitvenimi procesi v digitalni uporabniški izkušnji. Rezultati kažejo na premik od laboratorijskih meritev k raziskavam v realnih digitalnih okoljih ter na rast pomena večmodalnih, z umetno inteligenco podprtih pristopov k personalizaciji marketinških vsebin. V zaključku so opredeljeni ključni metodološki in etični izzivi ter predlagane smernice za nadaljnje raziskovanje in praktično uporabo nevromarketinga v digitalnem trženju.

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FROM THE LABORATORY TO DIGITAL REALITY: A SYSTEMATIC REVIEW OF NEUROMARKETING APPLICATIONS IN UNDERSTANDING CONSUMER EXPERIENCE IN DIGITAL ENVIRONMENTS

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In this article, systematic review is presented and critically evaluated neuromarketing research published between 2020 and 2025 that examines consumer experience in digital environments. Building on a systematic qualitative literature review, the studies employing EEG, eye-tracking, galvanic skin response, and facial expression analysis in the context of websites, e-commerce, digital advertising, and virtual reality are analysed. Conceptual framework grounded in the triad attention-emotion-decision to explain how visual attention, emotional engagement, and decision-making processes jointly shape digital user experience is explored. Findings indicate a clear shift from laboratory-based experiments toward studies conducted in ecologically valid digital settings, alongside a growing importance of multimodal, AI-supported approaches to content personalization. In conclusion, key methodological and ethical challenges are identified and directions for future research and practical application of neuromarketing in digital marketing are outlined.



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1 Uvod

Nevromarketing je interdisciplinarno raziskovalno področje, ki z uporabo metod nevroznanosti in biometrije preučuje nevronske, fiziološke in vedenjske odzive potrošnikov na trženjske dražljaje v različnih okoljih (Fortunato et al., 2014; Robaina-Calderín & Martín-Santana, 2021). S povečevanjem digitalnih stičnih točk v trženju izdelkov in storitev ter relativnim upadom fizičnih stikov med prodajalcem in kupcem se raziskave vse bolj usmerjajo v razumevanje nevronske, čustvene in vedenjske odzive potrošnikov v digitalnih okoljih. Razvoj elektroencefalografije (EEG), sledenja očem (angl. eye-tracking), galvanskega odziva kože - GSR (angl. galvanic skin response) in analize obrazne mimike omogoča podrobnejše vpogled v to, kako uporabniki doživljajo digitalne vsebine in z njimi povezane oglaševalske dražljaje (Alsharif et al., 2023a). Nevromarketing se pri tem uveljavlja kot most med potrošniško nevroznanostjo in trženjem, saj združuje znanja nevroznanosti, psihologije in ekonomije z namenom razumevanja pretežno nezavednih procesov odločanja (Fortunato et al., 2014; Robaina-Calderín & Martín-Santana, 2021). Celovit pregled nevromarketinških študij oglaševanja kaže, da so za razumevanje učinkov oglasov ključni notranji in zunanji čustveni procesi, endogena in eksogena pozornost, spomin, nagrajevanje, motivacijski odnos ter percepcija (Alsharif et al., 2023b).

Digitalni marketing postaja osrednji kanal tržnega komuniciranja, uporabnik pa pogosto deluje za zaslonom anonimno in v kratkih, razdrobljenih interakcijah (Chygryn et al., 2024; Sri Ram Kailash et al., 2024). V takšnem okolju tradicionalne metode (ankete, fokusne skupine) ne zadoščajo več za razumevanje, kaj pritegne pozornost, sproži čustveni odziv in vodi v odločitev o nakupu, medtem ko nevromarketinška orodja omogočajo objektivno merjenje teh procesov v realnem času. Članek ponuja sistematični in kritični pregled literature o uporabi nevromarketinga pri razumevanju potrošnikove izkušnje v digitalnih okoljih v obdobju 2020-2025.

Osrednja raziskovalna vprašanja so: (1) kako obravnavane študije definirajo in merijo digitalno potrošniško izkušnjo; (2) katere metode in kombinacije metod (EEG, sledenje očen, GSR, obrazna mimika) se uporabljajo ter kakšne prednosti in omejitve imajo; (3) katere so ključne vrzeli, izzivi in etična vprašanja pri prenosu nevromarketinga iz laboratorija v realna digitalna okolja. Raziskavo razumemo kot

prispevek k razvoju povezav med nevroznanostjo in digitalnim marketingom, pri čemer nevromarketing obravnavamo kot orodje za razumevanje potrošnikove pozornosti, emocij in odločitev v kompleksnem digitalnem ekosistemu.

2 Pregled literature

2.1 Obstoječe študije o nevromarketingu v digitalnih okoljih

Pregled literature potrjuje, da je nevromarketing v zadnjem desetletju prešel iz eksperimentalne faze k bolj sistematičnim in aplikativnim pristopom. Združuje nevroznanstvene metode in marketinške cilje z namenom odkrivanja nezavednih dejavnikov in vzorcev vedenja potrošnikov (Fortunato et al., 2014; Robaina-Calderín & Martín-Santana, 2021). Avtorji poudarjajo kombinacijo tradicionalnih in nevrofizioloških meritev za natančnejše merjenje donosnosti (ROI) marketinških aktivnosti (Robaina-Calderín & Martín-Santana, 2021), pri čemer digitalna okolja ustvarjajo »hitro spreminjajoče se, interaktivno in informacijsko bogato« oglasovalsko okolje (Chygryn et al., 2024; Sri Ram Kailash et al., 2024), v katero se vključujejo tudi gamifikacijski pristopi (Behl et al., 2023).

Sodobne študije pogosto uporabljajo kombinacijo EEG, sledenja očem (eye-tracking), GSR in analize obrazne mimike; integrirani pristopi omogočajo boljše razumevanje podzavestnih procesov pri zaznavi mobilnih oglasov (Mancini et al., 2022) in dosegajo večjo pojasnjevalno moč kot posamezne metode (Alsharif et al., 2023a). Nedavni pregled študij o EEG ugotavlja, da je EEG najpogostejše uporabljeno nevroslikovno orodje v nevromarketingu, pri čemer se večina del osredotoča na učinke promocijskih kampanj in značilnosti izdelkov na vedenje potrošnikov (Panteli et al., 2024). Skupno lahko povzamemo, da se nevromarketing uveljavlja kot most med nevroznanostjo in trženjem (Fortunato et al., 2014; Jukić, 2023), digitalna okolja predstavljajo naravno in rastočo aplikativno polje (Chygryn et al., 2024; Sri Ram Kailash et al., 2024), kombinacija več metod pa sistematično izboljšuje razumevanje potrošnikove izkušnje (Mancini et al., 2022; Alsharif et al., 2023a).

2.2 Vrzel v preteklih raziskavah

Kljub napredku pregled literature razkriva več pomembnih vrzeli. Študije pretežno temeljijo na relativno majhnih vzorcih, kar omejuje statistično moč in zunanjo veljavnost rezultatov (Robaina-Calderín & Martín-Santana, 2021). Velik del raziskav poteka v nadzorovanih laboratorijskih pogojih, ki ne odražajo kompleksnosti realnih digitalnih okolij, kjer vedenje potrošnikov sooblikujejo kontekst, naprava, okolje in algoritmično filtriranje vsebin (Adhanom et al., 2023). Poleg tega so definicije nevromarketinga in njegovega razlikovanja od potrošniške nevroznanosti še vedno neenotne (Fortunato et al., 2014; Šekerci, 2024). In končno, dosedanje raziskave izpostavljajo potrebo po jasnejši regulaciji zbiranja in uporabe biometričnih podatkov v digitalnem oglaševanju (Rawnaque et al., 2020) ter po večji pozornosti do vprašanj zasebnosti in zavestne privolitve pri eksperimentih (Beyari et al., 2024).

3 Konceptualni okvir

Na podlagi pregleda literature je smiselno oblikovati konceptualni okvir, v katerem digitalno uporabniško izkušnjo razumemo skozi **triado pozornost-čustva-odločitev**. Pozornost se z vidika nevromarketinga meri z očesnim sledenjem: meritve poti pogleda, trajanja zadrževanja in ponovitev pogledov razkrivajo, kateri elementi digitalnega vmesnika delujejo kot vizualna sidra uporabniške izkušnje (Gheorghe et al., 2023; González-Mena et al., 2022). Ob tem je smiselno poudariti, da je sledenje očem (eye-tracking) »najmanj invazivna« nevromarketinška metoda (Gheorghe et al., 2023), kar je pomembno tako glede praktičnosti uporabe v digitalnih okoljih kot tudi z vidika raziskovalne etike.

Čustva in emocionalno angažiranost zajemata metodi galvanskega odziva kože (GSR), ki meri intenzivnost vzburjenosti na podane dražljaje, ter obrazne mimike, ki meri valenco odzivov. Kombinacija očesnega sledenja, GSR in obrazne mimike omogoča ločevanje med vsebinami, ki pritegnejo pogled, in tistimi, ki sprožijo čustveni odziv, relevanten za spomin in odločanje (Mancini et al., 2022). Bolj poglobljene odločitvene procese pa predstavljajo EEG-vzorci v frontalnih možganskih režnjih, kjer se aktivnost povezuje z motivacijo za pristop ali umik (Georgiadis et al., 2022).

Triada pozornost-čustva-odločitev povezuje tri tipe informacij: **vizualno** (sledenje očem, eye-tracking), **emocionalno** (GSR, obrazna mimika) in **odločitveno kognitivno** (EEG). Omenjeno ogrodje je možno razširiti na celotno nakupno pot, ki jo v tej raziskavi uporabljava kot osnovo za interpretacijo pregledane literature in za razmislek o izboljšanju digitalnih uporabniških izkušenj (Oliveira et al., 2022).

4 Metodologija

4.1 Raziskovalni načrt

Uporabljen je sistematični kvalitativni pregled literature (SQLR), s katerim je sintetizirano obstoječe znanje o vlogi nevromarketinga pri razumevanju potrošnikove izkušnje. Raziskava se osredotoča na analizo načinov merjenja pozornosti, čustvenih ozdivov in odločanja v spletnih in drugih digitalnih okoljih s pomočjo nevromarketinških orodij. Sistematični pristop omogoča strukturiran pregled z jasno opredeljenimi koraki iskanja, izbora in razvrščanja virov ter s tem večjo ponovljivost ugotovitev.

Vključitveni kriteriji so bili: (1) recenzirani znanstveni članki in konferenčni prispevki, (2) objava v obdobju 2020-2025, (3) uporaba vsaj ene nevromarketinške oziroma nevrofiziološke metode, (4) neposredna povezanost z digitalnimi okolji (spletne strani, e-trgovine, mobilne aplikacije, digitalno oglaševanje, virtualna oziroma razširjena resničnost) in (5) dostop do celotnega besedila. Izključeni so nerecenzirani prispevki, podvojeni zapisi ter študije, ki so se ukvarjale izključno s tradicionalnim (offline) marketingom.

4.2 Zbiranje in selekcija podatkov

Osrednji vir za oblikovanje nabora člankov so bile podatkovne baze Web of Science Scopus, IEEE Xplore in Google Scholar. Uporabljene so bile iskalne kombinacije ključnih besed in fraz, kot so »neuromarketing«, »consumer neuroscience«, »eye-tracking«, »EEG«, »digital advertising«, »online consumer experience«, »user experience«, »virtual reality«, in sorodni termini.

Iz vseh baz so bili izvoženi zadetki, odstranjeni podvojeni zapisi in oblikovan enoten seznam referenc. Na ravni naslovov in povzetkov je bila preverjena domenska ustreznost glede na vključitvene kriterije. Prispevki, ki so izpolnjevali osnovne kriterije, so bili v naslednji fazi pregledani na ravni celotnega besedila. Sledila je dokončna odločitev o njihovi vključitvi v analizo. Končni vzorec obsega kombinacijo preglednih člankov ter empiričnih študij, usmerjenih v digitalna okolja.

4.3 Analiza podatkov

Za vsak izbrani prispevek je pripravljena preglednica z osnovnimi podatki (avtorji, leto objave, znanstvena revija ali konferenca, digitalni kontekst, uporabljene nevromarketinške metode ter ključne ugotovitve in omejitve). Klasifikacije je upoštevala definiranje digitalne potrošniške izkušnje, uporabljene metode, rezultate in etična vprašanja.

Rezultat je bil pet vsebinskih skupin, ki odražajo glavna raziskovalna področja: (1) od laboratorija do digitalne realnosti, (2) triada pozornost-čustva-odločitev, (3) od enostavnih do hibridnih modelov, (4) personalizacija in umetna inteligenca ter (5) sledenje očem (eye-tracking) prihodnosti. Tabela 1 prikazuje raziskovalna področja izbranih prispevkov.

Tabela 1: Področja izbranih prispevkov nevromarketinških raziskav

Področje	Članki
Od laboratorija do digitalne realnosti	Šekerci (2024); Sri Ram Kailash et al. (2024); González-Mena et al. (2022); Chygryn et al. (2024); Behl et al. (2023)
Triada pozornost-čustva-odločitev	Cleveland et al. (2022); Oliveira et al. (2022); Jukić (2023); Alsharif et al. (2023b); Panteli et al. (2024)
Od enostavnih do hibridnih modelov	Rawnaque et al. (2020); Georgiadis et al. (2022); Kalaganis et al. (2025); Mancini et al. (2022); Fortunato et al. (2014); Alsharif et al. (2023a); Robaina-Calderín & Martín-Santana (2021); Pérez et al. (2024); Xu et al. (2025)
Personalizacija in umetna inteligenca	Millagala & Gunasinghe (2024); Beyari et al. (2024); Alsharif et al. (2025)
Sledenje očem (Eye-tracking) prihodnosti	Gheorghe et al. (2023); Adhanom et al. (2023)

Ta klasifikacija omogoča neposredno povezavo med pregledom literature in konceptualnim okvirom triade pozornost-čustva-odločitev ter v nadaljevanju članka strukturirano razpravo o digitalni potrošniški izkušnji v različnih tipih digitalnega okolja.

5 Ugotovitve in razprava

5.1 Od laboratorija do digitalne realnosti: veljavnost v realnem okolju

Sporočilo pregledanih študij je, da zgolj natančnost meritev (npr. milisekundna časovna ločljivost EEG) ni več dovolj; odločilno je okolje, v katerem meritve nastanejo. V laboratoriju raziskovalci nadzorujejo motnje, a pogosto izgubijo kompleksnost realnih digitalnih interakcij, kjer uporabniki preklaplajo med vsebinami, uporabljajo različne naprave in delujejo v družbeno filtriranem informacijskem toku (Adhanom et al., 2023; Chygryn et al., 2024).

Naprednejše študije zato predlagajo prenos eksperimentalnih postopkov v realna digitalna okolja ali vsaj v simulacije, ki bolj verodostojno posnemajo realne pogoje (Adhanom et al., 2023; González-Mena et al., 2022). Hibridni pristopi, ki združujejo EEG in sledenje očem (eye-tracking), dosegajo občutno boljšo napovedno moč vedenja kot posamične metode (Kalaganis et al., 2025). Veljavnost v realnem okolju postaja tako temeljni pogoj, če želimo, da nevrosignali res pojasnijo vedenje potrošnikov.

Implikacija

Za digitalni marketing to pomeni, da naj testiranje oglasov in uporabniških vmesnikov poteka v dejanskem okolju uporabe, kjer kombinacija eye-trackinga in fizioloških meritev zajame spontano pozornost, afekt in odločitev uporabnika v realnem času. Tak pristop krepi povezavo med nevroznanstvenim raziskovanjem in resničnim vedenjem v digitalnem prostoru.

5.2 Triada pozornost-čustva-odločitev

Raziskave tudi potrjujejo medsebojno povezanost potrošnikove pozornosti, intenzivnosti emocionalnega odziva na dražljaje in odločitvenih vzorcev. Sledenje očem (eye-tracking) z veliko natančnostjo določa točke pogleda in zaporedja zadrževanja pogleda, ki strukturirajo vizualno iskanje pomena opazovanega predmeta (Adhanom et al., 2023; Gheorghe et al., 2023). GSR in mikroizrazi dopolnjujejo informacijo s čustvenim tonom odziva (Mancini et al., 2022; Chygryn et al., 2024), medtem ko EEG omogoča vpogled v motivacijo in naklonjenost izbiri.

Frontalna aktivacija leve hemisfere napoveduje pozitivno, pristopno vedenje, medtem ko aktivacija desne hemisfere kaže na umik (Georgiadis et al., 2022).

Nevrosemantični modeli povezujejo semantično skladnost vsebine s povečano verjetnostjo sodelovanja uporabnika (Cleveland et al., 2022). Tovrstna logika se razširi na celotno nakupno pot, pri čemer se nevromarketinške meritve razporedijo po fazah, od zavedanja prek vrednotenja do odločitve in lojalnosti (Oliveira et al., 2022).

Implikacija

Pri oblikovanju digitalne izkušnje je smiselno vključiti meritve poti pogleda in časovne povezanosti z emocionalnim odzivom, ker so sinhroni trenutki ključni pokazatelji učinkovitosti vsebine. Ko so pozornost, čustva in odločitev usklajeni, se verjetnost pozitivnega vedenjskega odziva bistveno poveča.

5.3 Od enostavnih do hibridnih modelov: več integracije izboljša zanesljivost

Pregled potrjuje premik k večmodalnim pristopom, pri katerih se kombinirajo EEG, sledenje očem (eye-tracking), GSR in analiza obrazne mimike, kar zmanjšuje verjetnost napačnih interpretacij in povečuje zanesljivost rezultatov (Mancini et al., 2022; Alsharif et al., 2023a). Združevanje več biosignalov (EEG, ET, EDA) in naprednih metod obdelave povečuje natančnost merjenja potrošnikovih odzivov, a odpira vprašanja usklajevanja virov in računske zahtevnosti analiz (Pérez et al., 2024). Kombinacija tradicionalnih podatkov (ankete, samoporočanje) in nevrofizioloških meritev pa omogoča natančnejše ocenjevanje učinkovitosti kampanj in ROI (Robaina-Calderín & Martín-Santana, 2021). Kombinacija EEG, GSR in sledenja očem (eye-tracking) razkriva razlike v odzivih na oblikovalske zasnove med produktnimi kategorijami in spoloma, ki bi jih klasične ankete spregledale (Xu et al., 2025).

Implikacija

V praksi je smiselno uveljaviti večmodalni protokol, ki kombinira sledenje očem (eye-tracking), GSR in EEG. Kadar EEG ni izvedljiv, že kombinacija sledenja očem (eye-trackinga) in GSR omogoča ločevanje med pozornostjo in čustvenim odzivom ter izboljšanje digitalnih vsebin na podlagi merljivih podatkov.

5.4 Personalizacija in umetna inteligenca

Novejša dela kažejo, da umetna inteligenca (AI) v nevromarketingu ni več le analitično orodje, temveč posrednik med zaznavo in prilagajanjem vsebine. Nevromarketing v digitalnem kontekstu deluje kot strateška osnova za personalizacijo, pripovedovanje zgodb in upravljanje blagovne znamke, ne le kot diagnostični instrument (Millagala & Gunasinghe, 2024). Integracija nevromarketinških metrik v platforme za podatkovno analizo omogoča natančnejše ciljanje in večjo angažiranost uporabnikov (Sri Ram Kailash et al., 2024), AI pa lahko v realnem času prepozna vzorce pozornosti in emocionalnih odzivov ter sproti optimizira digitalne vsebine (Beyari et al., 2024). Algoritmi strojnega in globokega učenja pa omogočajo analizo obsežnih neurofizioloških podatkov ter iz njih izluščijo vzorce pozornosti, emocij in spomina, ki jih klasične metode težko zajamejo (Alsharif et al., 2025).

Implikacija

Za trženje to pomeni možnost dinamične personalizacije, ki presega vedenjske metrike (kliki, čas na strani) in vključuje neuroindikatorje angažiranosti. Hkrati pa ta pristop odpira pomembna etična vprašanja glede zasebnosti, privolitve in transparentnosti obdelave podatkov (Rawnaque et al., 2020; Beyari et al., 2024).

5.5 Sledenje očem (eye-tracking) prihodnosti

Sledenje očem (eye-tracking) že presega tradicionalno vlogo merjenja pozornosti in se razvija v orodje za zajem emocionalnih in kognitivnih procesov. Z razvojem visokoločljivostnih IR-kamer in umetne inteligence je iz parametrov pogleda (širjenje zenice, stabilnost zadrževanja, frekvenca premikov) mogoče sklepati o emocionalni vznburjenosti in valenci (Gheorghe et al., 2023; Adhanom et al., 2023; Kalaganis et al., 2025).

Vzorci pogleda se vse pogostejše uporabljajo tudi kot indikator odločanja: zaporedja, trajanje in ponovitve pogledov razkrivajo dvom ali odločnost ter omogočajo napoved vedenjskih namenov (González-Mena et al., 2022; Georgiadis et al., 2022). Napredek algoritmov strojnega učenja obeta, da bo sledenje očem (eye-tracking)

postalo najmanj moteč napovedovalec emocionalnih in odločitvenih vzorcev v digitalnih okoljih.

Implikacija

Sledenje očem (eye-tracking) se razvija v integrirano metodo za razumevanje čustev in odločanja, ki ob minimalnem tehničnem posegu omogoča analizo resničnih digitalnih interakcij, od UX-testiranj spletnih mest do oglaševalskih kampanj in virtualne resničnosti (Adhanom et al., 2023; Chygryn et al., 2024).

6 Izzivi in omejitve raziskave

Metodološko pregled razkriva tri glavne sklope izzivov. Študije temeljijo na majhnih vzorcih, kar omejuje reprezentativnost in možnost posploševanja na različne skupine potrošnikov (Robaina-Calderín & Martín-Santana, 2021; Šekerci, 2024). Izrazita heterogenost metod in merilnih protokolov otežuje primerljivost rezultatov; kombinacije EEG, sledenej očem (eye-tracking), GSR in drugih meritev niso standardizirane, javno dostopne nevromarketinške podatkovne zbirke pa ostajajo omejene (Mancini et al., 2022; Alsharif et al., 2023a; Robaina-Calderín & Martín-Santana, 2021; Pérez et al., 2024). Veliko izzivov je tudi etičnih. Uporaba nevroznosti za trženje odpira vprašanja manipulativnih praks, zasebnosti in informirane privolitve, zlasti pri zbiranju, shranjevanju in obdelavi biometričnih podatkov v digitalnem oglaševanju in personalizaciji vsebin (Rawnaque et al., 2020; Beyari et al., 2024). Poleg tega obstajajo tveganja pristranskih algoritmov in netransparentnega odločanja in s tem povezane težnje k jasnim etičnim standardom in regulativnim okvirom (Alsharif et al., 2025).

Tudi ta raziskava ima omejitve: opira se na SQLR in sekundarne vire, brez primarnih meritev, ter je omejena na obdobje 2020-2025. Kljub temu sinteza različnih pregledov ponuja zanesljiv vpogled v razvoj in trenutna odprta vprašanja področja.

7 Povzetek ključnih ugotovitev

V tej raziskavi smo pokazali, da se nevromarketing kot interdisciplinarno področje premika iz laboratorijskih pogojev v realna digitalna okolja ter lahko prispeva k poglobljenemu razumevanju potrošnikove izkušnje na osnovi triade pozornost-

čustva-odločitev. Slednja predstavlja okvir za interpretacijo rezultatov sistematičnega pregleda.

Nevromarketing se vzpostavlja kot most med nevroznanostjo in trženjem, saj dopolnjuje tradicionalne metode z vpogledom v nezavedne procese odločanja; nevromarketinške tehnike omogočajo »vpogled v nezavedne dejavnike, ki vplivajo na izbiro potrošnikov« (Gheorghe et al., 2023), emocionalni odzivi pa sooblikujejo spomin in odnos do blagovne znamke (Robaina-Calderín & Martín-Santana, 2021).

Digitalna okolja postajajo ključno raziskovalno polje, saj se uporabniki srečujejo s kompleksnimi, dinamičnimi in personaliziranimi dražljaji (Adhanom et al., 2023; Mancini et al., 2022), kar poudarja potrebo po veljavnosti v realnem okolju (Adhanom et al., 2023, str. 1484). Triada pozornost-čustva-odločitev ponuja uporaben okvir za razumevanje digitalne izkušnje: sledenje očem (eye-tracking) meri vizualno pozornost, GSR in obrazna mimika intenzivnost in valenco čustev, EEG pa motivacijske in odločitvene vzorce (Georgiadis et al., 2022; Chygryn et al., 2024; Mancini et al., 2022).

Prehod k hibridnim, večmodalnim modelom (EEG, sledenje očem, GSR, obrazna mimika) izboljšuje zanesljivost in razlago rezultatov ter uvaja napredne pristope na osnovi strojnega učenja (Mancini et al., 2022; Alsharif et al., 2023a; Kalaganis et al., 2025). Umetna inteligenca postaja povezovalni element med nevromarketinškimi podatki in digitalnim trženjem, saj omogoča analizo biometričnih signalov v realnem času ter prilagajanje vsebin glede na vzorce pozornosti in čustvenega odziva (Beyari et al., 2024), pri čemer nevromarketing deluje kot strateška osnova za personalizacijo in pripovedovanje zgodb (Millagala & Gunasinghe, 2024).

Ugotovitve poudarjajo tudi etične, pravne in družbene izzive: »potrebna je večja regulacija pri zbiranju in uporabi biometričnih podatkov, zlasti v digitalnem oglaševanju« (Rawnaque et al., 2020), obenem pa obstajajo tveganja glede zasebnosti in manipulacije (Sri Ram Kailash et al., 2024).

Skupno pregledi in analizirane študije potrjujejo: (a) nevromarketing se uveljavlja kot most med nevroznanostjo in digitalnim trženjem, (b) digitalna okolja predstavljajo ključno aplikativno sfero, kjer triada pozornost-čustva-odločitev omogoča celovit vpogled v izkušnjo, ter (c) hibridni modeli in integracija z umetno inteligenco

prinašajo novo napovedno moč, hkrati pa odpirajo pomembna metodološka in etična vprašanja.

8 Prispevek raziskave k teoriji

Sistematični pregled je razpršene teoretične pristope povezal v enoten okvir, ki digitalno potrošniško izkušnjo razume skozi triado pozornost-emocionalna angažiranost-odločitveni procesi. Koncept nevromarketinga se tako premakne od splošnega pojmovanja »merjenja možganov« k jasnejši povezavi med specifičnimi nevro- in biometričnimi merami ter fazami digitalne interakcije, triada pa deluje kot konceptualni most med potrošniško nevroznanostjo, teorijami odločanja in raziskavami uporabniške izkušnje (UX).

Raziskava nevromarketinške metode umešča v kontekst celotne potrošniške poti v digitalnem okolju. Kazalce je smiselno razporediti po fazah od zavedanja do lojalnosti; v tej študiji sva pokazala, kako se lahko orodja (EEG, sledenje očem, GSR, obrazna mimika) konceptualno porazdelijo od prvega vizualnega stika, prek vrednotenja in čustvene obdelave, do odločitve in ponovnega vedenja. Prispevek k teoriji je tudi v kritičnem pogledu na raziskovalno okolje in etična vprašanja. Laboratorijske študije, čeprav metodološko natančne, pogosto ne zajamejo kompleksnosti realnih digitalnih okolij z večopravilnostjo in personalizacijo (Adhanom et al., 2023; Mancini et al., 2022), etična dimenzija pa postaja neločljiv del prihodnjega razvoja nevromarketinga (Rawnaque et al., 2020; Sri Ram Kailash et al., 2024).

9 Predlogi za nadaljnje raziskovanje

Na podlagi študij in ugotovljenih vrzeli je izpostavljenih več ključnih smernic. Potrebne so raziskave z večjimi in bolj raznolikimi vzorci. Trenutne študije se pogosto opirajo na majhne, homogeno sestavljene skupine, kar omejuje posploševanje ugotovitev (Robaina-Calderín & Martín-Santana, 2021). Smiselne so medkulturne študije, ki bi preverjale, ali triada pozornost-čustva-odločitev deluje podobno v različnih starostnih skupinah, kulturah in tipih digitalnih platform. Prihodnje raziskave bi morale razvijati in testirati standardizirane, hibridne protokole merjenja. Ob izraziti metodološki heterogenosti (Alsharif et al., 2023a) bi bilo

koristno oblikovati priporočene kombinacije orodij, jasne parametre ter standarde poročanja, kar bi povečalo primerljivost in ponovljivost študij.

Priporočljivi so terenski eksperimenti v realnih digitalnih okoljih, v dejanskih aplikacijah, spletnih trgovinah, družbenih omrežjih ali VR-okoljih, ne le v laboratoriju (Adhanom et al., 2023; Mancini et al., 2022). Razvoj umetne inteligence nakazuje na globljo integracijo nevromarketinških podatkov v adaptivne sisteme. Potrebujemo študije, ki bodo testirale, kako uporaba biometričnih kazalcev v realnem času v AI-sistemih vpliva na vedenje uporabnikov, njihovo zadovoljstvo, zaupanje in dolgoročni odnos do blagovne znamke (Beyari et al., 2024; Oliveira et al., 2022). Končno so pomembne etične in regulativne dimenzije nevromarketinga. Potrebne so interdisciplinarne študije, ki povezujejo pravne, etične, tehnološke in trženjske vidike uporabe biometričnih podatkov v digitalnem okolju (Rawnaque et al., 2020; Sri Ram Kailash et al., 2024), zlasti glede modelov informiranega soglasja, ponovne uporabe podatkov, pravičnosti, preprečevanja diskriminacije ter razlikovanja med legitimnim vplivanjem in manipulacijo.

Skupaj to potrjuje, da je nevromarketing v digitalnih okoljih dinamično razvojno področje, katerega prihodnost bo odvisna od povezovanja znanstvene natančnosti, tehnološke inovativnosti in etične odgovornosti.

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O avtorjih

Mag. Leon Korošec je direktor športne divizije in podpredsednik skupine Elan. Po izobrazbi je magister ekonomskih ved. V času lastniškega preoblikovanja je bil član uprave, po koncu postopka pa je prevzel vodenje športnega programa skupine. Kot direktor divizije pokriva vsa ključna poslovna področja, s posebnim poudarkom na marketingu kot strateški funkciji za krepitev prepoznavnosti blagovne znamke in notranje kulture podjetja. Aktivno se udeležuje strokovnih seminarjev in konferenc ter kot gostujoči predavatelj deli svoje znanje z novimi generacijami tržnikov. Poučuje strokovne vsebine in predstavlja poslovne poglede tudi v industrijskih medijih in dogodkih.

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POTENCIAL OBČANSKE ZNANOSTI ZA VKLJUČUJOČE ZDRAVSTVO IN DOLGOŽIVO DRUŽBO

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V svetu in Sloveniji se vse bolj uveljavljajo načela odprte znanosti, vključevanja skupnosti in občanske znanosti (ang. citizen science). Občanska znanost je v Sloveniji še ne do konca izkoriščen potencial uporabnega znanja za nadaljnji razvoj vključujočega zdravstva in dolgožive družbe. V članku je zato predstavljena kot sestavni del obetavnega koncepta odprte znanosti na področju zdravstva, saj laična javnost, od pacientov do drugih posameznikov, prostovoljcev in skupin, v sodelovanju z medicinsko znanostjo in strokovnjaki že zdaj pomembno sodeluje v različnih fazah izvajanja raziskav in storitev. V prispevku so predstavljeni primeri občanske znanosti z uporabo narativne metode raziskovanja s pripovedovanjem »mikro«
zgodb. Gre za zgodbe o dejanskih življenjskih situacijah, v katerih sodelovanje občanov raziskovalcev in pacientov dejansko prispeva k raziskavam ter profesionalizaciji v zdravstvu. Tako lahko dobra praksa občanske znanosti hkrati prispeva k dolgoživi družbi, vzajemnemu spodbujanju ustvarjalnosti in zaupanja med javnostjo ter zdravstvenimi ustanovami, krepi medgeneracijsko sodelovanje ter spodbuja vse pomembnejšo digitalno vključenost prebivalstva.

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THE POTENTIAL OF CITIZEN SCIENCE FOR AN INCLUSIVE, HEALTHY AND LONG-LIVING SOCIETY

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The principles of open science, community involvement and citizen science are increasingly adopted worldwide and in Slovenia. By involving the community and citizen or lay science, open science significantly contributes to improving the literacy of decision-makers on matters of common interest. In Slovenia, citizen science remains an untapped source of applied knowledge for the further development of inclusive healthcare and a long-lived society. Accordingly, this article presents citizen science as an integral part of the promising concept of open science in healthcare, as the lay public – including patients, individuals, volunteers, and groups – in cooperation with medical science and experts, is already significantly involved in various phases of research and service implementation. This paper presents examples of citizen science using the narrative research method of telling “micro” stories. These stories describe real-life situations in which the participation of citizen researchers and patients contributes to research and professionalisation in healthcare. Good practice in citizen science can simultaneously contribute to a long-lived society, promote creativity and trust between the public and healthcare institutions, strengthen intergenerational cooperation, and support the increasingly important digital inclusion of the population.



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1 Uvod

Zdravstvo se v zadnjem desetletju sooča z vedno večjimi izzivi, kot so staranje prebivalstva in porast kroničnih bolezni na eni strani ter digitalizacija in hitra rast podatkov, ki jih ustvarjajo raziskave in klinična praksa, na drugi strani. To narekuje potrebo po transparentnem, etičnem in vključujočem raziskovalnem pristopu. V tem kontekstu se kot ključna v svetu in v Sloveniji vse bolj uveljavljajo načela odprte znanosti, vključevanja skupnosti in občanske znanosti. Gre za razmeroma nov in obetaven koncept za demokratizacijo znanosti in povečanje skupnostnega potenciala znanja v sodobni družbi. To je proces dinamične krožnosti, ki v delujočo celoto družbe znanja povezuje bazično (akademsko) znanost in njeno primarno vlogo pri proizvodnji znanja (ang. *evidence-based*) z demokratizacijo in pretakanjem (kontekstualizacijo) znanja v družbeno prakso. Odprta znanost temelji na prostem dostopu do znanstvenih rezultatov, podatkov in metod, s čimer spodbuja sodelovanje, ponovljivost raziskav ter hitrejši prenos znanja v prakso. Občansko raziskovanje vključuje aktivno sodelovanje posameznikov, pacientov in skupnosti pri oblikovanju raziskovalnih vprašanj, zbiranju podatkov in interpretaciji ugotovitev. Združevanje teh dveh pristopov v zdravstvu ne povečuje le kakovosti raziskav, temveč tudi krepi zaupanje javnosti ter omogoča bolj pravične, vključujoče in inovativne rešitve za kompleksne zdravstvene izzive. V prispevku sta podrobneje osvetljena pojma odprta znanost in občanska znanost. Predstavljeni so primeri občanske znanosti z uporabo participativnega narativnega raziskovanja in »mikro« zgodb v zdravstvu ter njena dodana vrednost z izboljšavami, ki jih lahko prinese občanskim projektom in raziskavam v zdravstvu. Prispevek je nastal z namenom približati področje odprte znanosti in občanskega raziskovanja v zdravstvu. Zakonodajni okvir za delovanje odprte znanosti zaradi omejitve dolžine prispevka ni obravnavan.

2 Odprta znanost

Odprta znanost, katere del je tudi občanska znanost, temelji na transparentnosti, sodelovanju in deljenju rezultatov znanstvenih raziskav, vključno s publikacijami, podatki, fizičnimi vzorci in programsko opremo tako v raziskovalni skupnosti kot v splošni javnosti. Spodbuja sodelovanje v akademski skupnosti in dialog s širšo javnostjo ter je vključujoča in družbeno angažirana. Odprta znanost zajema vse znanstvene vede in področja ter vse tipe raziskav, od temeljnih do aplikativnih

projektov. Obsega različne vidike znanstvenoraziskovalnega dela, kot so odprti dostop do raziskovalnih rezultatov, odprta znanstvena komunikacija, odprte znanstvene infrastrukture, odprto sodelovanje vseh družbenih akterjev in odprto sodelovanje z drugimi sistemi znanja (UNESCO, 2021, str. 7).

Ena ključnih sprememb, ki jih prinaša odprta znanost, je prehod od tekmovalne k sodelovalno usmerjeni znanosti. Odprta znanost pripada človeštvu in prispeva k uresničevanju enakosti, nepristranosti ter pravičnosti za vse, ne glede na spol, ekonomski status, starost, stopnjo kariere, narodnost, jezik, oviranost ali druge okoliščine. Vključevati mora raznolikost znanja, praks, delovnih postopkov, jezikov, raziskovalnih rezultatov in tem. Prizadevati si mora za vključevanje širše javnosti, manjšin, lokalnih skupnosti in drugih zainteresiranih v raziskovanje, znanstvenoraziskovalno ter inovacijsko dejavnost. Odprta znanost ponuja priložnost in prednost pri reševanju sodobnih družbenih izzivov, kot so podnebne spremembe, trajnostni razvoj, omejevanje ogljičnega odtisa, iskanje novih virov energije in prehranska varnost, ki jih lahko naslovi le znanost z raziskovalnimi rezultati in inovacijami. S tega vidika je pomembno, da vrednote in načela odprte znanosti podpirajo tudi nosilci javnih politik, kot so Evropska komisija, vlade držav članic Evropske unije ter mednarodne organizacije (UNESCO, 2021, str. 19).

3 Občansko raziskovanje ali občanska znanost

Občansko raziskovanje ali občanska znanost (ang. citizen science) je inovativni pristop odprte znanosti, ki vključuje širok krog ljudi, ki sicer niso znanstveniki v strogem pomenu besede, vendar lahko s svojim praktičnim delom in izkušnjami veliko prispevajo k razumevanju in urejanju družbenih problemov in izzivov (Kečanovič, 2024). Občanski raziskovalci so lahko dijaki in študenti, člani različnih društev, predstavniki posameznih družbenih skupin (npr. skupine za tretje življenjsko obdobje ali lokalne skupnosti, kjer se raziskave izvajajo), ljubiteljski raziskovalci ter vsi drugi predstavniki zainteresirane javnosti, ki niso profesionalni raziskovalci (CitizenScience.si, 2025). Najpogostejše metode občanskega raziskovanja so raziskovalno delo na terenu, akcijsko raziskovanje in pripovedovanje zgodb oziroma etika narativa (Kečanovič, 2024). Občanski raziskovalci lahko sodelujejo v različnih fazah raziskave, na primer pri načrtovanju in oblikovanju raziskovalnega problema, pri zbiranju in ustvarjanju podatkov, pri analizi podatkov ter pri interpretaciji rezultatov.

Občanska znanost je vse bolj uveljavljena znanstvena in družbena praksa, ko znanstveniki in državljani sodelujejo pri ustvarjanju ter demokratizaciji novega znanja za znanost in družbo. Čeprav obstaja že stoletja in temelji na dolgoletnih raziskavah družbene udeležbe, vključevanja ter demokratizacije odločanja na lokalni in širši ravni, je bil izraz »citizen science« skovan v devetdesetih letih prejšnjega stoletja (Vohland et al., 2021; Mlinar, 2022). Koncept občanske znanosti je v zadnjih letih pridobil prepoznavnost kot priznan, promoviran in financiran pristop, ki spodbuja znanstveno pismenost in demokratizacijo znanosti. Promovira ga več mednarodnih organizacij in združenj, kot je Evropsko združenje za občansko znanost (ECSA), ki je vzpostavilo katalog občanske znanosti v Evropi (Adam & Gorišek, 2024). Z opolnomočenjem občanskih raziskovalcev za sodelovanje v projektih občanske znanosti, ki vključujejo usposabljanja z namenom povečanja individualne in kolektivne ozaveščenosti o njihovem potencialnem prispevku k znanstvenim raziskavam (Watson et al., 2020), se med občanskimi raziskovalci in znanstveniki gradi pošten odnos, ki temelji na zaupanju in lojalnosti (Rodriguez-Gomez et al., 2019).

Pomemben korak pri uveljavitvi občanske znanosti v slovenskem okolju je bil ustrezen prevod termina »citizen science«. Rešitev je ponudil akademik prof. dr. Zdravko Mlinar, ki je ustreznost termina »občanska znanost« utemeljil z argumentom, da »hkrati vključuje množstvo elementov drugih terminov in še posebej upošteva tako individualno kot kolektivno raven obravnavanja raziskovalne dejavnosti. Po Slovarju slovenskega knjižnega jezika književna raba besede *občan* pomeni *pripadnika* človeške skupnosti in tako daleč presega zamejitev na upravnopolitično razumevanje občine« (Mlinar, 2021, 36).

Trenutno še ni enotne oz. splošno sprejete definicije občanske znanosti, saj je pri tako širokem interdisciplinarnem prizadevanju, ki je postavljeno na presečišče številnih znanstvenih področij, težko doseči soglasje o skupni definiciji (Heigl et al., 2019). Evropsko združenje občanske znanosti je pripravilo 10 načel občanske znanosti, ki so osnova za dobre prakse v občanski znanosti in jih je potrdila organizacija Science Europe (European Citizen Science Association, 2015). Načela zajemajo zaveze med organizatorji projekta in udeleženci, odnos do odprte znanosti, ravnanje s podatki, objavljanje itn.

Strategije za vključevanje javnosti kot občanskih raziskovalcev v znanost pravzaprav niso nove; novost sodobne občanske znanosti je pogosto v obsegu vključevanja nestrokovnjakov. Vključenost uporabnikov in pacientov v zdravstveno varstvo ter druge javne storitve je s strani WHO priznana in potrjena že od sedemdesetih let prejšnjega stoletja, njen cilj pa je okrepiti demokratične pravice, javno odgovornost ter izboljšati zdravstvene storitve in medicinsko znanje (Larson, 2022). Wiggins in Wilbanks (2019) menita, da je le malo raziskovalnih področij za javnost tako pomembnih kot človeško zdravje, zato bi moralo biti dobro pozicionirano za vključevanje državljanov. Zdravstvene raziskave zajemajo širok nabor potencialnih raziskav, od katerih je veliko na novo dostopnih zaradi razvoja tehnologije, zlasti mobilne tehnologije. Tako so se priložnosti za prispevke občanskih raziskovalcev eksponentno povečale, od testiranja kakovosti zraka do sekvenciranja DNK (Ibid.).

Sodelovanje občanskih raziskovalcev v raziskavah s področja zdravja lahko vodi do širšega razumevanja lastnega zdravja in dobrega počutja ter pridobivanja znanja o zdravem načinu življenja (Ceccaroni et al., 2021). Podobno menita Adam in Gorišek (2024), ki poudarjata, da so raziskovalni pristopi v okviru odprte znanosti in občanske znanosti v mnogih primerih koristni tako za raziskovalce kot za kognitivno aktivne državljane, saj pomenijo obogatitev znanja in potencialno priložnost za družbeno inovacijo. Haywood (2013) je razvil seznam desetih koristi za občanske raziskovalce, ki vključujejo: izboljšanje znanstvenega znanja in pismenosti, boljše razumevanje znanstvenih metod, izboljšan dostop do znanstvenih informacij, povečanje znanstvenega mišljenja, izboljšanje interpretacijskih sposobnosti, zmanjšanje vrzeli med znanostjo in ljudmi, krepitev povezav med ljudmi in okoljem, opolnomočenje občanskih raziskovalcev, večjo gradnjo skupnosti, spreminjanje stališč, vplivanje na politiko ter pridobivanje dostopa do širših omrežij.

V prejšnjih raziskavah s področja zdravstvenega varstva je sodelovanje pacientov temeljilo na orodjih za pridobivanje povratnih informacij, kot so dnevniki in vprašalniki za zbiranje podatkov o izboljšavah storitev (Zhang et al., 2015). Digitalizacija je močno olajšala vključevanje pacientov pri soustvarjanju zdravstvenih podatkov in spodbujanju sodelovanja pri odločanju o zdravju (Ciasullo et al., 2020). Digitalizacija olajša komunikacijo z zdravstvenimi delavci ter z zmanjšanjem kognitivnih obremenitev, fizičnih in časovnih omejitev prispeva k opolnomočenju pacientov. V praksi obstaja veliko orodij e-zdravja, ki zagotavljajo dostop do celovite podpore in pomoči pacientom. Zagotavljanje funkcionalne pomoči ter socialne in

čustvene podpore lahko privede do aktivacije pacientov kot potrošnikov pri soustvarjanju vrednosti s povečanjem ozaveščenosti, varovanja zdravja in obvladovanja tveganj (Roepert et al., 2018). Poleg tega lahko digitalna orodja okrepijo upoštevanje terapevtskih medicinskih indikacij prek obvestil, kot so besedilna sporočila in priporočila, naslovljena na paciente (Biederman et al., 2019). S pridobivanjem povratnih informacij pacientov se vzpostavi neposreden komunikacijski kanal med pacienti in zdravniki za boljše razumevanje, kar pripomore h kakovosti storitev in soustvarjanju vrednosti storitve (Ciasullo et al., 2020).

Digitalna orodja lahko ustvarijo pozitivno okolje za vključevanje občanskih raziskovalcev v občansko znanost tudi prek igrifikacije (Cigarini et al., 2018) in izobraževalnega razvedrila (Laut et al., 2015). Tak primer je projekt Neureka, ki ga vodijo raziskovalci laboratorija Gillian na Global Health Institute Trinity College Dublin. Projekt združuje mobilno tehnologijo z občansko znanostjo, da pomaga ustvariti jasnejšo sliko o tem, kaj ohranja možgane zdrave. Aplikacija Neureka poziva prostovoljce k sodelovanju v nevroznanstvenih raziskavah doma z igranjem iger ter spremljanjem razporeditve in vedenja. V projekt je vključenih na tisoče ljudi, zato lahko tako imenovani »veliki podatki« pomagajo raziskovalcem odkriti nove načine za obvladovanje težav z duševnim zdravjem in spodbujanje odpornosti proti kognitivnemu upadu v poznem obdobju življenja (Neureka, 2025).

Podoben primer občanske znanosti v slovenskem prostoru je igra Besedomat, ki so jo razvili na Inštitutu za slovenski jezik Frana Ramovša ZRC SAZU in je namenjena bolnikom po kapi ali poškodbi glave. Besedomat poleg zabave zbira dragocene podatke za klinične logopede Nevrološke klinike UKC Ljubljana. Gre za interaktivno igro, v kateri igralci presojujejo, ali je prikazana beseda resnična ali izmišljena, pri čemer krepijo besedni zaklad in znanje jezika. Obenem je igra Besedomat del širše raziskave o **besedni razširjenosti**, ki preučuje, katere besede v slovenskem jeziku so najbolj razširjene med Slovenci. Raziskava pomaga logopedom izbrati ustrezno zahtevne besede pri obravnavi oseb z motnjami v jezikovnem procesiranju ter prispeva k boljšemu razumevanju jezika in njegove rabe (Pogorelčnik, 2025).

Avtorici Malterud in Elvbakken (2019) menita, da občansko raziskovanje ni pristop, ki bi ga lahko uporabili na vseh področjih raziskav v zdravstvu. Opravili sta sistematični pregled raziskav, v katerih so pacienti sodelovali kot občanski

raziskovalci, in ugotovili nekaj večjih izzivov pri strategijah sodelovanja in pri vključevanju pacientov v zdravstvene raziskave. Pri pregledu člankov in njihovi presoji glede na predpise, ki dovoljujejo in priporočajo model sodelovanja pri vključevanju pacientov na Norveškem, ugotavljata, da se daje prednost skupnim prizadevanjem na račun akademskih veščin, znanstvene kakovosti in znanja. Menita, da bodo za sodelovanje pacientov v medicinskih raziskavah morda potrebni drugi modeli sodelovanja, ki bodo dopolnili obstoječe znanje.

4 Participativno narativno raziskovanje

Različne oblike občanske znanosti uporabljajo obstoječe metodologije, kot so participativne akcijske raziskave, participativne raziskave v skupnosti in akcijska znanost (Wiggins in Wilbanks, 2019). Metoda participativnega narativnega raziskovanja se vse pogosteje uporablja za obravnavo kompleksnih večdeležniških izzivov na ravni organizacij, mrež in širših skupnosti. Omogoča poglobljeno razumevanje določene tematike skozi osebne zgodbe ljudi, ki subjektivno pričajo o izkušnjah pripovedovalcev v povezavi s proučevano temo na ravni izbranega družbenega sistema (Burns et al., 2022).

Na področju mentalnega zdravja je narativna metoda dolgo v uporabi; v psihiatrijo jo je uvedel že Jaspers. Narativna metoda kot raziskovalna metoda ima tudi vzgojni in včasih terapevtski vpliv (Ličen, 2013). Naratologija oziroma teorija pripovedi je področje literarne teorije. Kečanović (2025) meni, da je narativ pripovedna oblika predstavljene realnosti, ki omogoča vpogled v čustvene razsežnosti upodobljene zgodbe, ki jo s svojimi besedami in dejanji sooblikujejo njeni akterji, naratorji in poslušalci.

Participativno narativno raziskovanje je zasnovano tako, da v procesu zbiranja in interpretacije zgodb aktivno sodelujejo pripovedovalci, zbiratelji zgodb in drugi deležniki, povezani s proučevano tematiko. Uporablja se za različne namene, na primer za prepoznavanje potreb, merjenje družbenih učinkov, strateško načrtovanje in podobno ter tako dopolnjuje klasične kvantitativne in kvalitativne pristope. Narativno raziskovanje omogoča poglobljeno razumevanje določene tematike z različnih zornih kotov deležnikov. Večja kot sta raznolikost in številčnost zbranih zgodb, bogatejše in natančnejše je lahko razumevanje tematike na ravni celotnega opazovanega družbenega sistema (Burns et al., 2022).

Dodatna vrednost participativnega narativnega raziskovanja je, da opolnomoči tako pripovedovalca, ki ima priložnost prispevati svojo zgodbo, kot poslušalca, ki pridobi neposreden vpogled v izzive s terena. Kadar sta zbiranje in osmišljanje zgodb zasnovana participativno, je to za udeležence priložnost, da si na podlagi slišanih zgodb in lastnih izkušenj sami ustvarijo širšo sliko o razmerah v opazovanem družbenem sistemu ter poglobijo razumevanje realnosti. Participativna zasnova prispeva tudi k izgradnji zaupanja in zavedanja soodvisnosti med udeleženci ter krepi njihovo povezanost. Uporaba tega pristopa zato prispeva k opolnomočenju sodelujočih deležnikov za individualno in kolektivno akcijo na podlagi širšega razumevanja tematike, ki se oblikuje v procesu (Vidmar et al., 2024).

Prednost je tudi ta, da se ne osredotoča na pripovedovalčevo splošno mnenje o določeni temi, temveč na njegovo mikrozgodbo, torej pripoved o konkretnem dogodku ali izkušnji, ter na pripovedovalčevo lastno refleksijo te izkušnje, v katero zbiralci oziroma raziskovalci ne posegajo. Mikrozgodbe omogočajo poglobljen vpogled v izbrano tematiko, saj nastajajo v strukturiranem procesu kot odgovor na skrbno izbrano povabilno vprašanje (Escalas, 2004).

Metoda mikrozgodb omogoča sistematično analizo večplastnosti zbranih zgodb in pojavov, ki jih opisujejo, brez vnaprejšnjih predpostavk (Deprez & Guijt, 2020). S tem pristopom je mogoče v relativno kratkem času zbrati in analizirati veliko število zgodb. Praktične izkušnje kažejo, da za zajem nabora pogostih tematik zadostuje že približno 70 do 100 zgodb, specializirana digitalna orodja, kot je SenseMaker®, pa omogočajo sistematično zbiranje in analizo vzorcev tudi za več tisoč zgodb hkrati. Ta pristop se zato vse pogosteje uporablja tako v aplikativne kot tudi v raziskovalne namene, na primer za razumevanje potreb različnih deležnikov skozi pristop »od spodaj navzgor« (ang. bottom-up), za strateško načrtovanje, merjenje učinkov intervencij skozi daljše časovno obdobje ipd. (van der Merwe, 2019).

Primer uporabe mikrozgodb v slovenskem prostoru je raziskava Nacionalnega inštituta za javno zdravje (NIJZ), ki je potekala v okviru Nacionalnega programa duševnega zdravja, Programa Mira, v sklopu prednostnega področja Promocija duševnega zdravja in preventiva ter destigmatizacija duševnih motenj na delovnem mestu, oktobra 2021. Z uporabo metodologije mikrozgodb za raziskovanje potreb v javnozdravstvene namene so zbrali pričevanja ljudi o doživetih duševnih stiskah v različnih delovnih organizacijah v Sloveniji. Raziskava je potekala v drugem letu

epidemije covida-19, zato so nekatera pričevanja povezana z epidemijo, številni izzivi in priložnosti pa niso bili povezani z njo. Rezultati analize zgodb so pokazali pomembno vlogo sodelavcev in neposredno nadrejenih pri prepoznavanju in razreševanju duševne stiske posameznika. Poleg priporočil so sodelujoči v raziskavi podali konkretne predloge ukrepov. Predlagani ukrepi in rezultati so lahko v pomoč pri načrtovanju aktivnosti v delovnih organizacijah, v okviru zunanje strokovne podpore ter na ravni sistema oziroma države (Vidmar et al., 2024).

5 Sklepne misli

Občansko raziskovanje v zdravstvu prinaša številne prednosti, kot so vključevanje skupnosti ali posameznikov, ki so neposredno prizadeti zaradi bolezni ali zdravstvenih težav in imajo možnost aktivno sodelovati, kar povečuje relevantnost in uporabnost raziskav. Posamezniki lahko prispevajo podatke, zato so ti bogatejši, rezultati pa bolj raznoliki in realistični. Udeleženci v raziskavah dobijo občutek, da vplivajo na raziskave in razvoj rešitev. Sodelovanje v raziskavah povečuje zdravstveno pismenost in zavest o lastnem zdravju, kar vodi do opolnomočenja posameznikov ter zaupanja v znanost in zdravstvene ustanove. Vključevanje občanov v raziskave in odločanje na področju zdravstva je pomembno, saj se zdravstveni sistemi razvijajo v smeri pristopov, osredotočenih na pacienta, s poudarkom na vključevanju njihovih stališč. Naraščajoča vloga participativnih pristopov sovpada s trendom napredka metod strojnega učenja in umetne inteligence, kar spreminja način izvajanja medicinskih raziskav in klinične prakse. Uporaba mikrozgodb oziroma osebnih izkušenj se je izkazala kot odlično orodje za ozaveščanje in vključevanje občanov na področjih, kjer kvantitativni podatki ne povedo vsega.

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IDENTIFYING ENTREPRENEURIAL PATTERNS AMONG WOMEN: A CLUSTER ANALYSIS APPROACH

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Introduction – Female entrepreneurship has become an increasingly prominent topic in business research. Although women exhibit lower entrepreneurial activity across most countries, the underlying drivers remain poorly understood. The study examines determinants of women’s entrepreneurial engagement. **Methodology** – Using Global Entrepreneurship Monitor (GEM) data from Hungary between 2021 and 2024 (n=4,080 women), an exploratory principal component analysis (PCA) was first conducted using 14 variables measuring entrepreneurial attitudes and perceptions, followed by Python-based K-means clustering. **Results** – Three distinct clusters emerged: (1) entrepreneurially engaged women with high perceived readiness and strong opportunity recognition; (2) proactive aspirants with high fear of failure despite positive attitudes; and (3) disengaged non-entrepreneurs with low proactivity and higher risk aversion. The clusters show clear separation in PCA space and significant differences across all attitudinal dimensions. **Discussion** – Results reveal heterogeneity in women’s entrepreneurial attitudes. Entrepreneurship-related perceptions may change over time due to external factors, suggesting that targeted interventions can foster female entrepreneurial activity.

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1 Introduction

Women's participation in economic life is a topic of flourishing and growing interest in the social sciences. Research on women is driven by several factors. On the one hand, women's intensive participation in the economy has become an economic necessity, as sustainable growth and development are impossible without their active presence (Duflo, 2012). Research on women is also fueled by indices that reveal a significant gender gap (Behr & Xi, 2025). In addition to quantifiable reasons, soft factors also urge a deeper exploration of the topic, such as the recognition that old, traditionally established solutions do not always work. Proven differences in approach between the sexes may be the source of optimal solutions. Parallel to women's economic participation, female entrepreneurship has become an increasingly prominent topic in business research. Although empirical findings consistently show that women exhibit lower entrepreneurial activity across most countries, the underlying drivers of this gap remain poorly understood. This study contributes to the ongoing debate by examining the determinants of women's decisions to engage in entrepreneurial activity.

In our work, we seek to determine whether entrepreneurial attitudes, mindsets, and social perceptions are associated with entrepreneurship among adult women in Hungary. We also aim to identify differences between the characteristics of female entrepreneurs, women with entrepreneurial intentions, and non-entrepreneurs.

2 Literature review

The scholarly discourse surrounding women entrepreneurs emerged within the broader domain of entrepreneurship in the late 1970s, gaining significant momentum during the late 1990s and early 2000s. This period marked a pivotal shift as researchers began to challenge the prevailing assumption that entrepreneurial activity was gender-neutral, arguing instead that the distinct characteristics of female entrepreneurship warranted separate investigation (Yadav & Unni, 2016). This finding was confirmed by the 2025 GEM report which finds that women's entrepreneurial activity is lower than men's in most economies, regardless of the phase of entrepreneurship or a country's income level (GEM, 2025). Furthermore, women who intend to start a new business tend to realise it is less likely than men do. The case of Hungary aligns with this very international trend.

While the majority of foundational publications in this field originate from the United States and the United Kingdom (Deng et al., 2024), international studies have gradually expanded into six key thematic areas: the barriers to women's entrepreneurial activity; the role of human and social capital in business growth; culture and gender differences; family support and motherhood; the intersection of social entrepreneurship; and feminist perspectives (Cardella et al., 2020).

As the field has matured, research has increasingly focused on the embeddedness of female entrepreneurial activity, its environmental drivers, and its varied impacts across regions (Deng et al., 2020). A contextual nuance is required when examining Central and Eastern Europe (CEE). Rugina and Ahl (2023) suggest that because entrepreneurial activity was severely restricted during the socialist era, research in this region remains relatively young on the international stage. Despite this unique historical and economic trajectory, the normative assumptions of Western literature still permeate CEE studies. While women entrepreneurs in this region are recognized as vital contributors to economic growth and social problem-solving, research highlights a persistent need for skill development and support to increase their participation in entrepreneurship.

The decision to enter entrepreneurship is often mediated by psychological factors, most notably the fear of failure. In a cross-national study of 17 countries, Koellinger et al. (2013) found that women exhibit lower levels of entrepreneurial activity primarily due to this heightened anxiety, which acts as a critical barrier even when the necessary skills and resources are present. Furthermore, gender-specific dynamics influence how entrepreneurs access networks and their motivation; for instance, although human capital levels may be similar, significant differences exist between men and women in psychological drivers and social capital dimensions (Širec & Močnik, 2012).

Understanding these decision-making processes requires examining the "push" and "pull" factors that define the entrepreneurial continuum. Pull factors include positive motivations such as personal fulfillment, independence, and financial gain, while push factors include external constraints such as unemployment, job dissatisfaction, or family responsibilities (Uhlener & Thurik, 2007; Verheul et al., 2006). Lingappa and Rodrigues (2023) argue that these motivations are rarely mutually exclusive; rather, women's entrepreneurial entry typically emerges from a nuanced

combination of personal aspirations and external necessity. This complexity is further addressed by Human Capital Theory, which posits that education and experience are key predictors of success (Becker, 1994), and the expanded "5M" model. By adding "Motherhood" and the "Meso/Macro environment" to the traditional 3Ms (Market, Money, Management), Brush et al. (2009) provided a holistic framework that accounts for the family context and societal expectations that disproportionately shape female ventures.

These external and internal pressures are deeply intertwined with women's life-course trajectories. Role transitions, such as becoming a mother or taking on caregiving duties, often lead to nonlinear entrepreneurial paths (Jennings & McDougald, 2007). This persistent dilemma between professional and familial commitments can act as both a catalyst for seeking the flexibility of self-employment and a primary challenge in daily operations (Santos et al., 2018; Zhang & Zhou, 2021). Social cognitive career theory further explains these variations, suggesting that confidence levels and perceived barriers—such as the "glass ceiling," "glass cliff," or the "career labyrinth"—significantly dictate whether a woman pursues an entrepreneurial path (Carli, 2018; Glass & Cook, 2018; Mattis, 2004; Wilson et al., 2007).

Ultimately, the literature underscores that women entrepreneurs are not a homogeneous group (Sarri & Trihopoulou, 2005). Their decisions are influenced by a multifaceted array of attitudes, social perceptions, and life stages. Recognizing this diversity is vital for advancing the field, as it allows for a deeper understanding of the specific patterns and mindsets that characterize different segments of female entrepreneurs.

3 Methodology

Our study adopts a quantitative approach using Global Entrepreneurship Monitor (GEM) Adult Population Survey (APS) data from Hungary for the years 2021–2024. GEM is an international research consortium that collects harmonized entrepreneurship data using a standardized methodology, ensuring cross-country comparability and high data quality (Reynolds et al., 2005; GEM, 2023).

The APS is a representative survey of the active-age population, with at least 2,000 respondents per country per year. As the focus of this study is female entrepreneurship, only female respondents were included, yielding approximately 1,000 observations per year. To increase statistical power, the datasets were merged across years, resulting in a final sample of 4,080 Hungarian women. Since the analysis relies on attitudinal and perceptual variables that tend to change slowly over time, this pooling is expected to introduce minimal bias.

The analysis proceeded in two steps. First, exploratory principal component analysis (PCA) was used to identify latent dimensions of entrepreneurial attitudes and perceptions. Second, a Python-based clustering procedure was applied using 14 attitudinal variables and one dummy variable distinguishing non-entrepreneurs, nascent entrepreneurs, and current entrepreneurs. Cluster Optimization K-means clustering was employed to identify distinct groups within the female population based on their entrepreneurial attitudes and perceptions. The optimal number of clusters was determined using the elbow method, which examines the Within-Cluster Sum of Squares (WCSS) for cluster solutions ranging from $k=2$ to $k=9$. The elbow curve analysis indicated that $k=3$ provides the optimal balance between model complexity and explanatory power, as the rate of WCSS reduction substantially decreased beyond three clusters. Clusters were interpreted using descriptive statistics and visualized through PCA plots to characterize distinct attitudinal profiles.

The analysis incorporates 14 variables capturing multiple dimensions of entrepreneurial attitudes and perceptions (see Table 1). The respondents' actual entrepreneurial status (FEMENT) was categorized using two dichotomous variables, namely whether actively involved in a business (ANYBUSOW) and intends to start a new venture (FUTSUP), following the following pattern: (0) non-entrepreneurs with no entrepreneurial intentions, (1) individuals expecting to start a business within three years, and (2) current entrepreneurs.

All analyses were conducted using Python 3.x with the scikit-learn library for machine learning procedures, pandas for data manipulation, and matplotlib and seaborn for visualization.

Table 1: Variables concerning entrepreneurial attitudes, mindsets, and social perceptions are associated with entrepreneurship analyzed

Variable name	Question text
knowentR	Personal knowledge of entrepreneurs
opportL	Perceived business opportunities in the local area
suskillL	Self-assessed skills and knowledge for starting a business
fearfailL	Fear of failure prevents startup a new business venture
easystartL	Perceived ease of starting a business
oppism	Opportunism and proactive opportunity seeking
proact	Proactivity in pursuing entrepreneurial activities
creativ	Self-perceived creativity
vision	Decisions are part of a long-term career plan
equalincL	Perception of equal income opportunities
nbgoodcL	Perception that most people consider starting a business as a good career choice
nbstatusL	Perception that successful entrepreneurs have high social status
nbmediaL	Perception of positive media attention for entrepreneurs
nbsocentL	Perception that entrepreneurship is valued in society

Source: Data compiled by the author, based on GEM definitions

4 Results

4.1 Cluster Identification and Distribution

The K-means clustering method is popular for segmentation because it is computationally efficient and scalable for large datasets, and it helps extract interpretable clusters that inform interventions. Multi-attribute or PCA+K-means implementations have reported large reductions in within-cluster error and easier interpretation (Proksch et al, 2018; Gosztonyi and Csákné Filep, 2022; Rijati 2108, Srikar, 2025)

The K-means clustering algorithm identified three distinct clusters within the sample of 4,080 women: (cluster 0) Entrepreneurially engaged (n=1,422, 34.9%); (cluster 1) Proactive aspirants (n=1,788, 43.8%); (cluster 2) Disengaged non-entrepreneurs (n=870, 21.3%). The two-component PCA solution explained a substantial portion of variance in the standardized data. Visual inspection of the PCA scatter plot revealed clear separation between clusters, particularly between disengaged non-entrepreneurs (positioned predominantly in the left portion of the plot) and the two other clusters (positioned more centrally and to the right). While some overlap exists between non-entrepreneurs and proactive aspirants, they occupy distinct regions of

the PCA space, with entrepreneurially engaged individuals showing greater dispersion along both principal components.

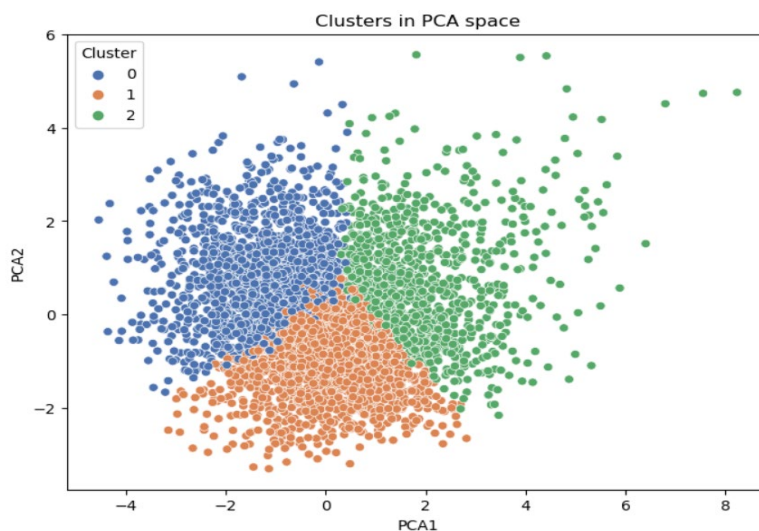


Figure 1: Clusters in PCA space

Source: Own elaboration

The elbow curve analysis confirmed that three clusters represent an optimal solution, with the WCSS decreasing from approximately 51.000 at $k=2$ to 47.600 at $k=3$, followed by diminishing returns for additional clusters.

4.2 Cluster Characteristics

Analysis of cluster means revealed distinct attitudinal profiles for each group (see Table 2).

Entrepreneurially engaged individuals are typically either entrepreneurs or have strong entrepreneurial intentions, as the average FEMENT score is rather high (0.58). Cluster members assess their own skills, experiences, and knowledge as sufficient for starting a new business, know at least one person who started a new business in the last 2 years, and consider starting a business to be easy. They show strong opportunity recognition and relatively low fear of failure. Furthermore, group members are considered creative by others, and their steps are part of a long-term

career plan. They have positive perceptions of entrepreneurs' social status and media attention.

Table 2: Cluster means

feature	Cluster 0	Cluster 1	Cluster 2	feature	Cluster 0	Cluster 1	Cluster 2
knowentR	1.39	0.46	0.5	creativ	3.29	2.31	1.39
opportL	2.65	1.91	0.72	vision	3.89	3.22	2.6
suskillL	3.52	1.57	1.72	equalincL	3.38	3.75	2.76
fearfailL	2.25	3.91	2.54	nbgoodcL	3.49	3.48	1.66
easystartL	3.32	2.1	1.2	nbstatusL	3.45	3.48	1.85
oppism	2.88	3.86	2.48	nbmediaL	3.63	3.41	2.05
proact	3.05	4.2	3.1	nbsocentL	2.58	2.27	0.86

Source: Own elaboration

The cluster of proactive aspirants has the lowest proportion of current entrepreneurs, with an average FEMENT score of 0.11, suggesting that cluster members are primarily non-entrepreneurs. However, they exhibit the highest proactivity and opportunism scores among all clusters. Paradoxically, this group shows the highest fear of failure and relatively low self-assessed skills, experiences, and knowledge in entrepreneurship. Their perceptions of entrepreneurs are rather positive, but they lack confidence in their own capabilities.

Disengaged non-entrepreneurs have, similarly, rather low but somehow higher entrepreneurial engagement (FEMENT=0.19) than aspirants, and are characterized by consistently low scores across most dimensions. Members exhibit minimal opportunity perception, low self-assessed skills, experiences, and knowledge, very low perceived ease of starting a new business, and do not consider their decisions part of a long-term career plan, while their peers do not consider them creative. Critically, this group demonstrates the most negative perceptions of entrepreneurship's social value, with particularly low scores for career desirability, social status, and societal appreciation.

These findings suggest that entrepreneurial attitudes cluster in ways that partially, but not perfectly, align with actual entrepreneurial behavior, indicating that the transition from non-entrepreneur to entrepreneur involves complex attitudinal shifts that may occur gradually over time.

5 Discussion & Conclusion

This study investigated the determinants influencing women's entrepreneurial activity in Hungary using GEM data from 2021-2024. Scholarly discourse emphasizes that the fear of failure acts as a critical barrier to women's entrepreneurial entry, even when the necessary skills are present (Koellinger et al., 2013). Our results confirm these findings: the proactive aspirants cluster exhibited the highest fear of failure, which explains why, despite their high proactivity, this group has the lowest proportion of actual entrepreneurs. Conversely, the members of the entrepreneurially engaged cluster possess high self-assessed skills, aligning with Human Capital Theory, which posits that education and experience are key predictors of success (Becker, 1994).

The "5M" model highlights that female entrepreneurial activity is disproportionately shaped by the family context and societal expectations - specifically "motherhood" and the "meso/macro environment" (Brush et al., 2009). In our study, the cluster of disengaged non-entrepreneurs showed the most negative social perceptions, reporting the lowest scores for entrepreneurs' social status and societal appreciation. This confirms that a lack of social recognition is a major deterrent, while the positive social perceptions in Cluster 0 correlate with actual entrepreneurial activity.

The literature distinguishes between "pull" factors, such as the desire for independence, and "push" factors, such as job dissatisfaction or unemployment (Uhlaner & Thurik, 2007; Verheul et al., 2006). Our findings indicate that opportunity recognition (*opportL*) is highest among current and intentional entrepreneurs. Members of Cluster 0 are clearly driven by "pull" factors, such as opportunism and vision, whereas the "aspirants" in Cluster 1 recognize opportunities but are often held back by a lack of confidence and high perceived risk.

Due to the unique historical trajectory of the Central and Eastern European (CEE) region, research highlights a persistent need for skill development and encouragement to bolster women's participation (Rugina & Ahl, 2023). Our cluster analysis of the Hungarian sample reinforces the 2025 GEM report's findings: women's entrepreneurial activity remains lower than men's. The extremely low "perceived ease of starting" observed in Cluster 2 suggests that environmental

barriers and the perceived difficulty of bureaucracy represent significant entry hurdles for Hungarian women.

The findings of this research offer policymakers vital insights. When designing policy interventions, it is essential to develop programs that support women's entrepreneurship by accounting for the complexity and interdependence of these identified factors. Providing financial resources alone is insufficient; programs must simultaneously address psychological barriers (such as confidence-building and failure management) and social and familial challenges (such as flexible childcare systems and mentoring).

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Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used Grammarly, ChatGPT 4.0, and Google Gemini as writing assistants to contextually supplement the existing text, improve readability and style, and provide translation services. After using these tools, the authors reviewed and edited the content as needed and took full responsibility for the publication's content. The authors certify that the use of these AI tools had no influence on the research results, data interpretation, or the final conclusions of the article.

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IDENTIFIKACIJA DEJAVNIKOV KRATKOROČNEGA USPEHA POSLOVNIH SISTEMOV

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V sodobnem poslovnem okolju je bistveno razumevanje, da dejavniki kratkoročnega uspeha predstavljajo temeljne gradnike dolgoročnega obstoja poslovnih sistemov. Kratkoročni uspeh poslovnega sistema se nanaša na njegovo sposobnost, da v omejenem časovnem obdobju zagotovi stabilno operativno delovanje, učinkovito rabo virov, visoko produktivnost ter pravočasno in kakovostno sprejemanje odločitev. Na doseganje teh rezultatov vplivajo različni dejavniki po svoji naravi, dinamiki in časovni razsežnosti. Namen prispevka je identificirati nabor dejavnikov, ki kratkoročno vplivajo na uspešnost poslovnih sistemov. Za doseg tega cilja je bil izveden pregled multidisciplinarne baze SCOPUS, ki omogoča širok vpogled v obravnavano tematiko. Prispevek predstavlja začetno točko za nadaljnje analitične in empirične raziskave teh dejavnikov ter njihove medsebojne povezanosti. Tako oblikovan nabor služi kot temelj za razvoj modela najpomembnejših dejavnikov kratkoročnega uspeha, katerega namen je zagotoviti uporabno metodološko podlago za različne poslovne sisteme.

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IDENTIFICATION OF THE FACTORS INFLUENCING SHORT-TERM SUCCESS OF BUSINESS SYSTEMS

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In the contemporary business environment, it is essential to understand that the factors of short-term success represent the basic building blocks of the long-term existence of business systems. Short-term success of a business system refers to its ability, within a limited period of time, to ensure stable operations, efficient use of resources, high productivity and timely, high-quality decision-making. The achievement of these results is influenced by different factors in terms of their nature, dynamics and time horizon. The purpose of this paper is to identify a set of factors that influence the short-term performance of business systems. To achieve this goal, a review of the multidisciplinary SCOPUS database was carried out, providing a broad insight into the topic. The paper represents a starting point for further analytical and empirical research of these factors and their relationships. The resulting set serves as a foundation for the development of a model of the most important short-term success factors, whose purpose is to provide a useful methodological basis for different business systems.



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1 Uvod

Kratkoročni uspeh poslovnih sistemov predstavlja pomemben raziskovalni izziv v sodobnem poslovnem okolju, kjer so poslovni sistemi izpostavljeni nenehnim pritiskom po doseganju takojšnjih rezultatov, učinkovitosti in stabilnosti. V pogojih povečane tržne negotovosti, pospešenega tehnološkega razvoja in omejenih virov postaja sposobnost poslovnih sistemov, da v kratkem časovnem okviru zagotavljajo zanesljivo operativno delovanje, ključni dejavnik njihove kratkoročne učinkovitosti. Kratkoročni uspeh se v tem kontekstu ne nanaša zgolj na finančne rezultate, temveč zajema tudi širši spekter operativnih in upravljavskih vidikov delovanja poslovnih sistemov kot so učinkovitost procesov, kakovost odločanja, razpoložljivost virov in koordinacija aktivnosti (Lu et al., 2018; Handoyo et al., 2023; Najjar in Qandeel, 2025). Pri tem ima pomembno vlogo tudi usklajevanje procesov, funkcij in organizacijskih aktivnosti, ki zmanjšuje tveganje neučinkovitosti ter podpira kratkoročno operativno uspešnost poslovnega sistema (Sarai, 2020; Tokarev et al., 2024; Kot et al., 2025; Malesu in Syrovátka, 2025; Tran, 2025).

Namen prispevka je sistematično identificirati dejavnike, ki vplivajo na kratkoročni uspeh poslovnih sistemov. V ta namen je bil izveden pregled multidisciplinarne znanstvene literature v bazi SCOPUS, ki omogoča celovit vpogled v obstoječe raziskave s področja managementa, organizacijskih ved in poslovnih sistemov. Prispevek predstavlja izhodišče za nadaljnje analitične in empirične raziskave dejavnikov kratkoročnega uspeha poslovnih sistemov ter njihove medsebojne povezanosti. Identificirani nabor dejavnikov hkrati predstavlja osnovo za razvoj konceptualnega modela najpomembnejših dejavnikov kratkoročnega uspeha, katerega namen je zagotoviti metodološko podlago za analizo in primerjavo poslovnih sistemov v različnih organizacijskih in okoljskih kontekstih.

V nadaljevanju prispevka je najprej predstavljen pregled teoretičnih izhodišč s področja kratkoročnega uspeha poslovnih sistemov. Temu sledijo opis uporabljene metodologije, predstavitev rezultatov identifikacije dejavnikov ter razprava o njihovem pomenu in implikacijah za nadaljnje raziskave in prakso.

2 Teoretična izhodišča

2.1 Kratkoročni uspeh poslovnih sistemov

Kratkoročni uspeh poslovnih sistemov se nanaša na njihovo sposobnost doseganja stabilnih, ponovljivih in merljivih operativnih rezultatov v omejenem časovnem obdobju. V ospredju so predvsem operativna učinkovitost, likvidnost ter kakovost izvajanja ključnih poslovnih procesov, pri čemer gre za doseganje zastavljenih operativnih in upravljaljskih ciljev v razmerah negotovosti, omejenih virov in kratkoročnih pritiskov iz poslovnega okolja. Kratkoročni uspeh tako odraža stopnjo učinkovitega delovanja poslovnega sistema v danem trenutku in se ne nanaša na njegove dolgoročne razvojne ali strateške usmeritve (Shenhar et al., 2001; Marginson et al., 2010; Chatzoudes et al., 2021; Mouzas in Bauer, 2022; Aguilera et al., 2023; Arno, 2025). V znanstveni literaturi o kratkoročnem uspehu je praviloma poudarek na trenutni učinkovitosti in merljivih izidih. Nanaša se na to, ali poslovni sistem v kratkem roku doseže načrtovane projektne, operativne, tržne ali finančne rezultate ter ali so s temi dosežki zadovoljni ključni deležniki (Wu et al., 2017; Cupertino et al., 2022; Aguilera et al., 2023; Korhonen et al., 2023).

V sodobnem poslovnem okolju, zaznamovanem s krajšimi produktnimi in tržnimi cikli ter pritiski po hitrih in preverljivih rezultatih, kratkoročni uspeh postaja pomembna dimenzija upravljanja ciljev. Poslovni sistemi morajo hkrati obvladovati kratkoročne ciljne dosežke, ter ustvarjati pogoje za učenje, razvoj in pripravo na prihodnje faze delovanja. Sočasna zahteva po takojšnjih rezultatih in hkratnem razvoju prihodnjih zmožnosti ustvarja napetost med operativno in razvojno logiko delovanja, kar utemeljuje obravnavo kratkoročnega uspeha kot samostojne, konceptualno jasno opredeljene analitične kategorije (Shenhar et al., 2001; Mouzas in Bauer, 2022).

2.2 Dejavniki kratkoročnega uspeha poslovnih sistemov

Dejavniki kratkoročnega uspeha poslovnih sistemov predstavljajo mehanizme, s katerimi poslovni sistemi dosegajo in izboljšujejo svojo kratkoročno uspešnost. Nanašajo se na elemente, ki neposredno vplivajo na doseganje operativnih ciljev, učinkovitost procesov ter sposobnost obvladovanja kratkoročnih pritiskov in sprememb v poslovnem okolju (Shenhar et al., 2001; Kleinknecht et al., 2020; Joseph

in Marnewick, 2021). Razumevanje dejavnikov kratkoročnega uspeha je v literaturi pogosto povezano s konceptom kritičnih dejavnikov uspeha (angl. Critical Success Factors - CSF), ki predstavljajo omejen nabor notranjih operativnih, vodstvenih in organizacijskih dejavnikov, katerih ustrezno obvladovanje omogoča doseganje pravočasnih, stroškovno učinkovitih in kakovostnih rezultatov (Pinto in Slevin, 1987; Gunduz in Almuajebh, 2020).

Znanstvena literatura poudarja, da imajo pri doseganju kratkoročnega uspeha osrednjo vlogo predvsem notranji dejavniki, saj jih lahko poslovni sistemi neposredno oblikujejo in nadzorujejo, medtem ko zunanji dejavniki delujejo kot kontekstualne omejitve, na katere se morajo poslovni sistemi odzivati (Kaplan, 2012; Hanggraeni et al., 2019; Engidaw, 2021). Na kratkoročni uspeh poslovnih sistemov zato vpliva dinamična kombinacija notranjih in zunanjih dejavnikov, pri čemer njihovo medsebojno delovanje določa zmožnost poslovnega sistema, da v kratkem časovnem okviru ohranja operativno stabilnost, funkcionalnost in učinkovitost (Hanggraeni et al., 2019; Engidaw, 2021; Joseph in Marnewick, 2021).

Notranji dejavniki kratkoročnega uspeha

Notranji dejavniki izhajajo iz organizacijskih, procesnih in upravljalških značilnosti poslovnega sistema in so neposredno pod nadzorom managementa (Trkman, 2010; Aydiner et al., 2019; Huy in Phuc, 2025). Empirične raziskave dosledno potrjujejo, da imajo notranje značilnosti poslovnega sistema, vključno s procesnim managementom, upravljanjem informacij, organizacijsko strukturo, človeškimi viri in tehnologijo, izrazit in neposreden vpliv na kratkoročno poslovno uspešnost, saj oblikujejo operativno učinkovitost, zanesljivost izvedbe in sposobnost obvladovanja kratkoročnih pritiskov (Prajogo et al., 2018; Trkman, 2010; Kremsar et al., 2025). Spremljanje in usklajevanje kratkoročnih ciljev dodatno podpira metodologija Balanced Scorecard, ki povezuje finančne in nefinančne kazalnike ter omogoča celovitejše upravljanje kratkoročnega uspeha v kompleksnem in nestabilnem poslovnem okolju (Kaplan, 2012; Mio et al., 2021; Yawson in Paros, 2023; Hajji et al., 2025).

Zunanji dejavniki kratkoročnega uspeha

Na kratkoročni uspeh poslovnih sistemov pomembno vplivajo tudi zunanji dejavniki, ki izvirajo iz širšega tržnega, gospodarskega in institucionalnega okolja. Raziskave kažejo, da se kratkoročna uspešnost poslovnih sistemov izrazito spreminja glede na tržne razmere, makroekonomske pogoje, konkurenčne pritiske in regulatorni okvir, pri čemer ti dejavniki delujejo kot zunanji kontekst in omejitve, znotraj katerih se oblikujejo kratkoročni poslovni rezultati (Gini in Agala, 2023; Tyoso et al., 2024). Zunanji dejavniki lahko v kratkem časovnem obdobju pomembno vplivajo na operativne rezultate, likvidnost in stabilnost poslovanja, ne glede na raven notranje učinkovitosti poslovnega sistema. Njihov vpliv se pogosto kaže v obliki nenadnih sprememb povpraševanja, stroškovnih pritiskov, motenj v dobavnih verigah ali regulatornih zahtev, ki zahtevajo hitro operativno prilagajanje (Restrepo-Morales et al., 2023). Zunanji dejavniki delujejo kot okvir in pogoji, znotraj katerih se kratkoročni uspeh uresničuje. Njihova prisotnost poudarja pomen notranje prilagodljivosti, operativne odzivnosti in učinkovitega obvladovanja tveganj pri zagotavljanju kratkoročne stabilnosti poslovnih sistemov v dinamičnem poslovnem okolju (Haarhaus in Liening, 2020; Jafari-Sadeghi et al., 2023).

3 Metodologija

Sistematični pregled razpoložljive znanstvene literature je bil izveden s pomočjo podatkovne zbirke SCOPUS. Pregled je bil usmerjen v identifikacijo dejavnikov, ki so v obstoječi znanstveni literaturi povezani s kratkoročnim uspehom poslovnih sistemov, zlasti z vidika operativne učinkovitosti, upravljanja virov in doseganja merljivih kratkoročnih rezultatov.

Literaturo smo iskali med znanstvenimi članki, objavljenimi do / vključno z decembrom 2025. Iskanje je bilo izvedeno v angleškem jeziku, saj ta omogoča dostop do najširšega nabora mednarodno primerljivih raziskav. Pri pregledu literature je bil uporabljen iskalni niz, ki je bil usmerjen v identifikacijo dejavnikov kratkoročnega uspeha in je vključeval naslednje ključne pojme:

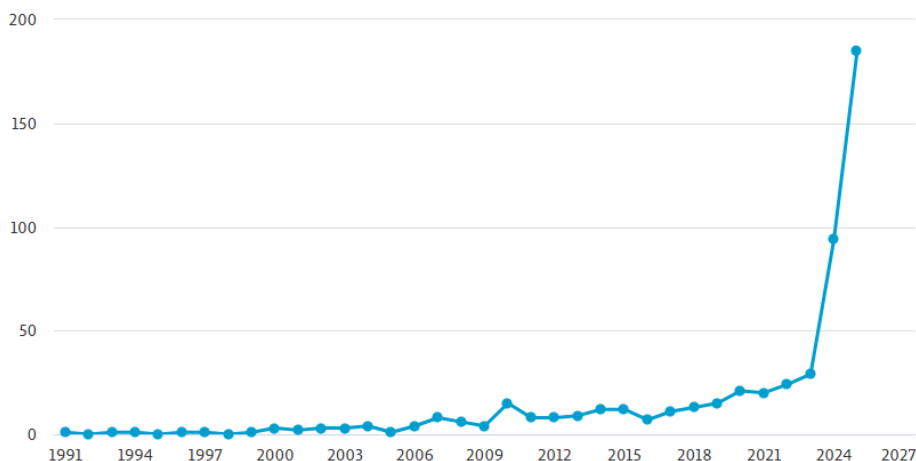
- "success factor" OR "success indicator" OR "critical factor" OR "critical indicator" OR "key factor" OR "key indicator"
- AND

- "organization" OR "company" OR "enterprise" OR "business"
- AND
- "short term success" OR "operational performance" OR "short term performance" OR "operational efficiency".

Na podlagi iskalnega niza je bilo identificiranih 527 virov. Nadaljnja analiza je vključevala pregled naslovov, povzetkov in ključnih besed, s ciljem izločanja ne relevantnih prispevkov ter identifikacije raziskav, ki eksplicitno obravnavajo dejavnike kratkoročnega uspeha poslovnih sistemov. Izluščeni viri so predstavljali osnovo za nadaljnjo vsebinsko analizo in sistematično identifikacijo dejavnikov kratkoročnega uspeha.

4 Rezultati raziskave

4.1 Bibliometrična analiza pridobljenih virov



Slika 1: Razporeditev virov po letih

Na začetku bibliometrične analize pridobljenih virov je prikazan graf razporeditve znanstvenih virov po letih objave. Iz grafa je razvidno, da se število raziskav, ki obravnavajo tematiko kratkoročnega uspeha poslovnih sistemov, v zadnjih petih letih izrazito povečuje. Naraščajoč trend objav kaže na vse večji raziskovalni interes

The network graph displays a complex web of connections between countries. The nodes are colored and sized, and the edges are colored lines connecting them. The graph shows a dense cluster of connections between countries like India, China, Malaysia, and the United States, with other countries like South Korea, Taiwan, and the Netherlands also showing significant connections.

Zemljevid vizualizacije omrežja prikazuje odnose med državami na podlagi soavtorstva in citiranosti znanstvenih virov s področja kratkoročnega uspeha poslovnih sistemov. Posamezno vozlišče predstavlja državo, pri čemer večja vozlišča označujejo večji obseg raziskovalne produkcije in večjo vpetost v mednarodno sodelovanje. V mreži izstopajo Združene države Amerike, Kitajska in Indija kot osrednja vozlišča z izrazitim raziskovalnim vplivom. Razporeditev vozlišč razkriva več regionalnih grozdov, med drugim azijsko-pacifiški in evropski raziskovalni

prostor, ki sta med seboj tesno povezana. Različne barve ponazarjajo skupine držav s podobnimi raziskovalnimi usmeritvami, gostota povezav pa potrjuje, da je raziskovanje kratkoročnega uspeha poslovnih sistemov izrazito mednarodno in interdisciplinarno področje.

4.2 Ključni dejavniki kratkoročnega uspeha poslovnih sistemov

Na podlagi sistematičnega pregleda znanstvene literature smo identificirali nabor ključnih notranjih in zunanjih dejavnikov, ki so v obstoječih raziskavah povezani s kratkoročnim uspehom poslovnih sistemov. Identificirani dejavniki vplivajo predvsem na sposobnost poslovnih sistemov, da dosegajo operativne cilje, ohranjajo učinkovitost procesov ter se pravočasno in ustrezno odzivajo na kratkoročne pritiske iz poslovnega okolja. Pomembno je poudariti, da identificirani notranji in zunanji dejavniki ne predstavljajo kazalnikov učinkovitosti in uspešnosti (angl. Key Performance Indicators), temveč mehanizme, ki oblikujejo kratkoročne poslovne rezultate.

Med notranje dejavnike kratkoročnega uspeha poslovnih sistemov spadajo:

- **Lastnosti podjetnika / vodje:** podjetniška in managerska kompetentnost, operativne veščine in strokovno znanje, podjetniška samo učinkovitost, notranja motivacija, sposobnost vodenja, izkušnje, formalna izobrazba ter osebne značilnosti vodje, ki neposredno vplivajo na kakovost, hitrost in doslednost odločanja (Radzi et al., 2017; Srimulyani et al., 2023; Nguyen et al., 2021; Caliendo et al., 2023; Khan et al., 2020; Mai et al., 2022; Grözinger et al., 2023).
- **Podjetniško vedenje in operativna organizacijska usmerjenost:** operativno podjetniško vedenje, pripravljenost na takojšnje prilagoditve, pragmatična organizacijska kultura ter kratkoročna usmerjenost v doseganje rezultatov, ki omogočajo hitro izkoriščanje priložnosti in operativno odzivanje na tržne spremembe (Omri et al., 2015; Kumar in Duraipandian, 2021; Srimulyani et al., 2023; Khedhaouria et al., 2020; Scaliza et al., 2022).
- **Človeški viri in HR prakse:** kakovost in razpoložljivost kadrov, učinkovita selekcija zaposlenih, usposobljenost za tekoče naloge, operativni razvoj zaposlenih, sistemi nagrajevanja, delovni odnosi in sodelovanje, ki neposredno vplivajo na produktivnost, zanesljivost izvedbe (Gursoy in

- Swanger, 2007; Makarenko et al., 2019; Aziz in Utami, 2021; Kumar in Duraipandian, 2021; Inthavong et al., 2023).
- **Management in upravljavski sistemi:** kratkoročno planiranje, operativno odločanje, uporaba računovodskih in nefinančnih informacij, upravljanje informacijskih tokov, sistemi notranje kontrole ter spremljanje in nadzor rezultatov, ki omogočajo sprotno usmerjanje poslovanja, alokacijo virov in hitro korektivno ukrepanje (Franco in Haase, 2010; Engidaw, 2021; Aziz in Utami, 2021; Monteiro et al., 2022; Cupertino et al., 2022; Laitinen in Kadak, 2019).
 - **Trženje, prodaja in odnosi s strankami:** marketinške sposobnosti, prodajna učinkovitost, usmerjenost v kupce, kakovost storitev ter operativni učinek ugleda blagovne znamke, ki vplivajo na hitro realizacijo prihodkov in stabilnost poslovanja (Gursoy in Swanger, 2007; Radzi et al., 2017; Gs, 2020; Malesu in Syrovátka, 2025).
 - **Tehnologija in informacijske rešitve:** uporaba informacijske tehnologije, raven digitalne podpore procesom, e-poslovanje ter sprejemanje novih tehnologij za operativne izboljšave, ki povečujejo učinkovitost, preglednost in hitrost izvajanja nalog ter podpirajo sprotno obvladovanje operativnih pritiskov (Gursoy in Swanger, 2007; Radzi et al., 2017; Srimulyani et al., 2023; Malesu in Syrovátka, 2025; Jo, 2025; Moeuf et al., 2019).
 - **Finančni in materialni viri:** razpoložljivost notranjih finančnih virov, upravljanje gotovine in likvidnosti, upravljanje stroškov ter razpoložljivost fizičnih sredstev, ki omogočajo nemoteno operativno izvajanje dejavnosti, kratkoročno finančno stabilnost in doseganje kratkoročnih ciljev (Radzi et al., 2017; Omri et al., 2015; Cupertino et al., 2022; Mai et al., 2022).
 - **Znanje in notranji pretok znanja:** operativno znanje podjetnika in zaposlenih, delitev znanja znotraj organizacije ter učinkovita uporaba obstoječega človeškega kapitala, ki neposredno podpirajo kakovost odločanja, koordinacijo aktivnosti in izvedbo (Gs, 2020; Radzi et al., 2017; Srimulyani et al., 2023; Inthavong et al., 2023).
 - **Delovno okolje in delovni pogoji:** fizično delovno okolje, razpoložljivost opreme in delovnih sredstev, ustrezni delovni pogoji ter dobro počutje zaposlenih, ki vplivajo na kratkoročno delovno učinkovitost in zanesljivost izvedbe (Radzi et al., 2017; Mai et al., 2022; Srimulyani et al., 2023).

- **Osebnna motivacija in podporni kontekst podjetnika / vodje:** notranja motivacija, osebno zadovoljstvo, psihološka stabilnost ter podpora družine in bližnjega okolja, ki vplivajo na delovno intenzivnost, vztrajnost in kakovost vodenja (Srimulyani et al., 2023; Grözinger et al., 2023; Caliendo et al., 2023; Kariv et al., 2025).

Pregled literature kaže, da je kratkoročni uspeh poslovnih sistemov v pretežni meri pogojen s kombinacijo notranjih dejavnikov, ki izhajajo iz lastnosti podjetnika oziroma vodstva, podjetniškega vedenja, razpoložljivosti človeških, finančnih in materialnih virov ter iz upravljavskih, tehnoloških in operativnih praks. Literatura pri tem dosledno razlikuje med notranjimi dejavniki kratkoročnega uspeha kot vzročnimi mehanizmi delovanja poslovnega sistema ter rezultati kratkoročnega uspeha kot merami doseženih izidov, pri čemer se kratkoročni uspeh presoja na podlagi trenutne finančne in operativne uspešnosti. Vse te notranje zmožnosti se integrirajo skozi obvladovanje poslovnih procesov, kjer stabilni, jasno opredeljeni in podatkovno podprti procesi omogočajo zniževanje stroškov, izboljšanje pretočnosti, spoštovanje rokov in hitro prilagajanje spremembam, kar se neposredno odraža v kratkoročnih operativnih in finančnih rezultatih poslovnega sistema (Engidaw, 2021; Srimulyani et al., 2023; Trkman, 2010; Kremsar et al., 2025).

Pregled literature jasno kaže, da na kratkoročni uspeh poslovnih sistemov pomembno vplivajo tudi zunanji dejavniki, ki izhajajo iz makroekonomskega, politično-institucionalnega, sociokulturnega, tehnološkega in tržnega okolja. Ti dejavniki so zunaj neposrednega nadzora poslovnega sistema, vendar lahko v zelo kratkem času bistveno izboljšajo ali poslabšajo poslovne rezultate, zlasti z vidika prodaje, stroškov, marž, likvidnosti in operativne stabilnosti. Za razliko od notranjih dejavnikov, zunanji dejavniki oblikujejo pogoje, v katerih se delovanje poslovnega sistema odvija. Njihov vpliv se zato odraža posredno, prek sprememb v povpraševanju, stroških in operativnih omejitvah, ki se nato izrazijo v kratkoročnih rezultatih in kazalnikih uspešnosti.

Med zunanje dejavnike kratkoročnega uspeha poslovnih sistemov spadajo:

- **Makroekonomski pogoji:** inflacija, obrestne mere, valutni tečaji, dostop do kreditov, cenovni šoki vhodnih virov ter splošna gospodarska stabilnost, ki neposredno vplivajo na stroške poslovanja, povpraševanje, likvidnost in

finančno tveganje (Ndiaye et al., 2018; Zhang in Lucey, 2022; Cakir et al., 2025).

- **Politično-regulativno in institucionalno okolje:** politična stabilnost, davčna politika, regulativne zahteve, trgovinska politika, administrativna bremena ter učinkovitost pravnega sistema, ki določajo stopnjo predvidljivosti poslovnega okolja in lahko v kratkem času povečajo ali zmanjšajo poslovna tveganja, stroške in operativno fleksibilnost (Adomako in Danso, 2014; Engidaw, 2021; Suder, 2025).
- **Sociokulturni in demografski kontekst:** dohodkovne ravni, demografske značilnosti, kulturni in verski vzorci ter družbene norme, ki oblikujejo potrošniške preference, vedenje kupcev, sprejemanje inovacij in razpoložljivost delovne sile ter se hitro odražajo v prodaji in tržni uspešnosti (Ndiaye et al., 2018; Zhao et al., 2025; Sumarlin in Sutisna, 2025).
- **Tehnološko okolje in infrastruktura:** dostopnost in stroški relevantnih tehnologij, kakovost informacijsko-komunikacijske infrastrukture ter stopnja digitalne pripravljenosti okolja, ki omogočajo digitalizacijo poslovanja, hitrejšo prilagoditev procesov in izboljšanje operativne učinkovitosti (Troise et al., 2022; Qalati et al., 2021; Billi in Bernardo, 2025).
- **Naravna in okoljska tveganja:** naravne nesreče, podnebni dogodki in okoljske regulacije, ki lahko nenadoma povzročijo motnje v dobavnih verigah, povečajo stroške in zahtevajo hitre operativne prilagoditve (Jia in Li, 2020; Hizarci-Payne et al., 2020; Wu in Tham, 2023).
- **Razmere na trgu in povpraševanje:** obseg povpraševanja in spremembe preferenc kupcev, ki neposredno vplivajo na prodajo, prihodke in potrebo po prilagajanju ponudbe ter s tem na kratkoročno tržno in finančno uspešnost (Prajogo, 2015; Engidaw, 2021; Cakir et al., 2025).
- **Konkurenčna intenzivnost in struktura panoge:** število in agresivnost konkurentov, cenovni pritiski, vstop novih ponudnikov ter prisotnost nadomestnih proizvodov, ki oblikujejo konkurenčne strategije podjetij, vplivajo na marže in zahtevajo hitro odzivanje (Handoyo et al., 2023; Cao et al., 2025).
- **Kupci in dobavitelji:** pogajalska moč kupcev, koncentracija ključnih kupcev, zanesljivost dobaviteljev, kakovost vhodnih materialov in pravočasnost dobav, ki vplivajo na stroške, kakovost, zanesljivost

poslovanja in kratkoročne operativne rezultate (Crescenzi in Gagliardi, 2018; Qalati et al., 2021).

- **Cene in razpoložljivost vhodnih virov:** surovine, energija, logistične storitve ter kakovost fizične in digitalne infrastrukture, ki lahko v kratkem času bistveno spremenijo stroškovno strukturo in sposobnost pravočasne izvedbe poslovnih procesov (Engidaw, 2021; Cakir et al., 2025).
- **Poslovna omrežja, sejmi in socialni kapital:** članstvo v grozdih, dostop do podpornih industrij, udeležba na sejmi ter institucionalni in družbeni pritiski, ki omogočajo hitrejši dostop do informacij, trgov in virov ter povečujejo odpornost in kratkoročno konkurenčnost podjetij (Pulka et al., 2021; Garrido-Moreno et al., 2024).
- **Varnostno okolje in geopolitična tveganja:** politična nestabilnost, kriminal, konflikti in nenadni sistemski šoki, ki lahko povzročijo prekinitev poslovanja, povečajo stroške in zmanjšajo zaupanje kupcev ter vlagateljev. (Jia in Li, 2020; Cakir et al., 2025).

Zunanji dejavniki praviloma delujejo kot kontekstualni okvir in omejitve, znotraj katerih se oblikujejo kratkoročni poslovni rezultati. Njihov vpliv se pogosto manifestira v obliki nenadnih sprememb povpraševanja, stroškovnih pritiskov, motenj v dobavnih verigah ali regulatornih zahtev, ki lahko izboljšajo ali poslabšajo uspešnost poslovnih sistemov, tudi kadar notranja učinkovitost ostaja nespremenjena. Raziskave dosledno kažejo, da je kratkoročni uspeh poslovnih sistemov v veliki meri pogojen z zunanjim makro in mikro okoljem, znotraj katerega delujejo notranje zmožnosti podjetij. Na tej podlagi kratkoročni uspeh poslovnih sistemov ni rezultat posameznega dejavnika, temveč rezultat ujemanja notranjih zmožnosti, vodstvenih odločitev in zunanjih razmer, ki se v raziskavah odraža skozi različne kazalnike učinkovitosti in uspešnosti (Hanggraeni et al., 2019; Joseph in Marnewick, 2021; Ahmad et al., 2023).

5 Diskusija in zaključek

Na podlagi sistematičnega pregleda znanstvene literature je mogoče zaključiti, da je kratkoročni uspeh poslovnih sistemov povezan predvsem s stabilnostjo operativnega delovanja, učinkovito rabo virov in sposobnostjo pravočasnega odzivanja na kratkoročne pritiske iz okolja ter vključuje procesno učinkovitost, kakovost odločanja, koordinacijo aktivnosti in uspešnost zaposlenih v kratkem

časovnem obdobju (Wu et al., 2017; Chatzoudes et al., 2021; Aguilera et al., 2023). V praksi se spremlja z omejenim naborom ključnih kazalnikov učinkovitosti in uspešnosti (KPI), ki zajemajo finančne rezultate, operativno učinkovitost, vedenje kupcev in uspešnost zaposlenih. Ti ne predstavljajo dejavnikov uspeha, temveč merijo delovanje notranjih mehanizmov poslovnega sistema, zato njihova jasna opredelitev in redno spremljanje omogočata pravočasno managersko ukrepanje (Garengo et al., 2005; Kaplan, 2012; Joseph in Marnewick, 2021).

Analiza identificiranih dejavnikov potrjuje, da kratkoročni uspeh poslovnih sistemov izhaja predvsem iz notranjih zmožnosti poslovnega sistema. Podjetniške in managerske kompetence, kakovost vodenja, procesna in operativna učinkovitost, inovacijske in prilagoditvene sposobnosti ter učinkovito upravljanje človeških in finančnih virov delujejo kot neposredni vzročni mehanizmi doseganja kratkoročnih rezultatov (Prajogo et al., 2018; Srimulyani et al., 2023; Restrepo-Morales et al., 2023). KPI-ji v tem kontekstu ne predstavljajo samostojnih ciljev, temveč kvantitativno operacionalizacijo delovanja teh notranjih mehanizmov (Kaplan, 2012; Domaskin in Sokolova, 2021).

Sočasno pregled literature potrjuje, da imajo zunanji dejavniki pomemben vpliv na kratkoročni uspeh poslovnih sistemov, vendar praviloma ne delujejo kot neposredni vzročni mehanizmi. Njihov vpliv se odraža posredno, prek sprememb v povpraševanju, stroških, tveganjih in razpoložljivosti virov, s čimer oblikujejo kontekst, v katerem se notranje zmožnosti poslovnega sistema bodisi okrepijo bodisi oslabijo (Engidaw, 2021). Razmerje med notranjimi in zunanjimi dejavniki je izrazito interaktivno, pri čemer močne notranje zmožnosti povečujejo sposobnost poslovnih sistemov, da se učinkovito odzivajo na zunanje pritiske in izkoriščajo priložnosti v dinamičnem okolju (Hanggraeni et al., 2019; Jafari-Sadeghi et al., 2023).

Prispevek s tem potrjuje, da kratkoročni uspeh poslovnih sistemov ni naključen rezultat, temveč posledica usklajenega delovanja notranjih dejavnikov, vodstvenih odločitev in zunanjih razmer, ki se v raziskavah odražajo skozi različne kazalnike uspešnosti (Shenhar et al., 2001; Wu et al., 2017; Hanggraeni et al., 2019). Identificirani nabor dejavnikov predstavlja ustrezno izhodišče za nadaljnjo empirično operacionalizacijo ter razvoj analitičnih modelov, ki omogočajo primerjavo kratkoročne uspešnosti poslovnih sistemov v različnih organizacijskih in okoljskih kontekstih).

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INTERGENERATIONAL BRIDGE: LINKING FAKE NEWS EVALUATION WITH ATTITUDE TOWARD SCIENCE

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Post-truth misinformation undermines trust in science; schools may foster “information resilience” by combining evaluative competence with awareness of societal harms. Data from a 2025 survey conducted as part of the oooScience! project were used to compare teachers’ and students’ responses (N = 1,071; teachers n = 246, upper-secondary students n = 825) on seven Likert-type statements measuring perceived misinformation-evaluation competence, perceived societal/democratic threat, and the perceived protective role of comprehensible science communication. Attitudes towards science were assessed using a 15-item semantic differential (lower scores indicate more positive attitudes). Teachers scored higher on a core fake-news composite (g = 0.86) and on a teaching/communication composite (g = 0.61). Overall attitudes towards science were moderately positive and did not differ significantly on the global index. However, teachers rated science’s societal utility more positively, whereas students rated status/visibility aspects more positively. Correlational and moderated regression analyses showed that FN_teaching predicted more favourable science attitudes among students, whereas associations among teachers were negligible. Results suggest an instructional “visibility gap”: making verification practices and comprehensible science communication more explicit may strengthen students’ information resilience and trust in science.

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1 Literature Review: Linking Fake News Evaluation with Attitudes Toward Science

Contemporary misinformation is embedded in a post-truth media ecology that challenges evidentiary norms and complicates judgements about what counts as credible knowledge (Marsh & Yang, 2017; Mason et al., 2018). In crises such as COVID-19, misinformation can escalate into an infodemic that shapes attitudes and erodes trust in science, institutions, and the media, suggesting that resilience requires multi-level responses (Scardigno et al., 2022; Mason et al., 2018). The science-society interface is further strained in “conflicting authority” settings, where evaluating sources depends on how audiences interpret authority claims and the affective drivers of belief (Lynch & Hunter, 2020). A persistent issue is that “fake news” is often conflated with misinformation (unintentional) and disinformation (intentional). Systematic reviews show that this ambiguity hampers the accumulation of knowledge, measurement validity, and targeted interventions because motives, production processes, and dissemination channels differ (Domenico et al., 2021).

Vulnerability is not merely ignorance. Political and identity alignment can override veracity, producing a pattern of concordance over truth, in which agreement predicts belief and sharing more than accuracy (Schwalbe et al., 2024). Sharing is influenced by belief reinforcement and framing; therefore, accurate evaluation does not necessarily guarantee the dissemination of truth (Piksa et al., 2023; Schwalbe et al., 2024). Cognitive reflection supports discernment, whereas network homogeneity and socio-technical dynamics—such as cognitive inertia and virality—affect exposure and the propagation of information (Facciani & Steenbuch-Traberg, 2024; Lima et al., 2024). Correlational evidence links cognitive failure and worldview to susceptibility, highlighting the need to incorporate psychological factors into literacy strategies (Lacap et al., 2025).

Susceptibility varies across the lifespan: older adults appear more prone to sharing fake news, highlighting the relevance of cognitive ageing to intergenerational resilience (Brasher & Schacter, 2020). Perceived stakes do not reliably protect audiences; no clear personal-relevance effect has been found for high-stakes misinformation (Ceccarini et al., 2023). These patterns support linking perceived evaluation capacity and threat awareness to attitudes towards science, because trust

and epistemic orientations reflect identity, networks, cognition, and discourse (Scardigno et al., 2022; Schwalbe et al., 2024; Facciani & Steenbuch-Traberg, 2024).

While responses based on literacy remain significant, their limitations are evident. Survey data indicate that information literacy is instrumental in identifying fake news, whereas other literacies are less reliably predictive (Jones-Jang et al., 2019). Incentives across platforms may still promote sensationalist or identity-affirming content; therefore, educational initiatives should be complemented by institutional and platform-aware strategies (Bulger & Davison, 2018; Mason et al., 2018). Additionally, instruction must encompass algorithmic and machine learning systems that influence exposure, thereby complicating the detection of manipulative or synthetic media (Valtonen et al., 2019). Policy efforts frame media literacy as a response to the phenomenon of truth decay, thereby reinforcing its importance in fostering institutional trust and resilience within democratic systems.

Design cues may increase deliberation (e.g., fake-news flags) but are unlikely to be sufficient without strategies that address identity-driven motivations (Moravec et al., 2019; Piksa et al., 2023; Schwalbe et al., 2024). Inoculation-style “prebunking” can build resistance by exposing audiences to manipulation techniques in advance and can weaken the links between exposure, belief, and sharing (van der Linden, 2019; Roşu et al., 2023).

Sustaining trust in science also requires communication that is comprehensible and socially meaningful, particularly where distrust is fuelled by post-truth narratives and institutional contestation (Scardigno et al., 2022; Lynch & Hunter, 2020). Researcher-school interactions and technology-enabled engagement (e.g., virtual lab tours) can support understanding of research and foster positive science orientations (Davies et al., 2012; Kiyuka et al., 2024). Teachers’ perspectives and explicit classroom routines are central, while non-formal stakeholders can extend critical thinking and media literacy beyond the classroom (Tkáčová et al., 2022; Delaney et al., 2022; Vrabec et al., 2023). Overall, school information resilience can be conceptualised as an intergenerational, organisational capacity that combines perceived evaluative competence, threat awareness, and clear science communication (Tkáčová et al., 2022; Vrabec et al., 2023; Lobnikar et al., 2025). The key gap is not whether fake news exists or whether literacy matters, but how perceived evaluative competence and threat awareness relate empirically to attitudes

towards science across teachers and upper-secondary students in one national context, informing school-level practices oriented towards explicit media- and science-literacy goals and comprehensible science communication (Bulger & Davison, 2018; Davies et al., 2012; Jones-Jang et al., 2019; Lobnikar et al., 2025).

Accordingly, this study examines how perceived capacity to evaluate fake news, perceived societal/democratic threat, and the perceived protective role of comprehensible science communication relate to attitudes towards science among Slovenian teachers and upper-secondary students, and whether these associations differ between the two groups.

2 Description of Methodology, Instrumentation, and Sample

The study draws on complementary survey datasets collected in Slovenia during the oooScience! activities, targeting upper-secondary students and teachers. Participation was voluntary, and respondents were guaranteed complete anonymity. Consent for data collection, processing, and storage was obtained from all participants. Data collection took place between June and December 2025.

In total, $N = 1,071$ respondents participated, comprising 246 teachers (23.0%) and 825 students (77.0%). Gender was reported by $n = 1,068$ participants: 51.5% female, 43.9% male, and 4.6% preferred not to answer. The teacher subsample was predominantly female (73.9% female; 22.0% male; 4.1% prefer not to say; valid $n = 245$), whereas the student subsample was more balanced (44.8% female; 50.4% male; 4.7% prefer not to say; valid $n = 823$). Age was reported by $n = 1,069$ participants and ranged from 13 to 69 years ($M = 23.96$, $SD = 15.11$). Teachers were aged 21–69 ($M = 50.15$, $SD = 10.05$; $n = 245$), and students were aged 13–22 ($M = 16.18$, $SD = 1.19$; $n = 824$). Analyses were conducted on valid responses; therefore, the effective sample size may vary across specific variables and models due to item nonresponse.

Data were collected using two parallel online questionnaires — one for upper-secondary students and one for teachers — designed to capture (a) respondents' overall image of science and (b) key components of information resilience in a school context, namely perceived competence to evaluate information, perceived

societal threat from misinformation, and the perceived role of clear scientific communication and teachers' educational practices in mitigating fake news.

Fake news/information evaluation was measured with seven Likert-type items (1 = strongly disagree, 5 = strongly agree) with an additional "don't know" option. The "don't know" responses were coded with user-defined missing codes and treated as missing in all analyses. The items captured (a) perceived ability to recognise distorted/false information and to distinguish credible from fake news, (b) perceived severity of fake news as a societal problem in Slovenia and as a threat to democracy, and (c) perceived usefulness of comprehensible communication of scientific results for differentiating verified facts from misinformation. Two items were role-adapted: teachers evaluated their own competence in clearly communicating scientific results and the extent to which they explicitly highlighted relevant teaching skills, whereas students evaluated their teachers on these two aspects. Internal consistency was acceptable to good (teachers: Cronbach's $\alpha = .748$; students: $\alpha = .818$). The latent structure was examined using exploratory factor analysis (Principal Axis Factoring; listwise deletion), indicating suitability for factor extraction (KMO = 0.884; Bartlett's test $\chi^2(21) = 3015.737$, $p < .001$) and supporting a single-factor solution (eigenvalue = 3.896; 48.36% explained variance; loadings $\lambda = .608-.750$). For group comparisons, and to avoid inappropriate pooling of role-adapted items into a single cross-group index, we computed two composite variables: *FN_core* as the mean of the five items common to both questionnaires requiring at least four valid responses (MEAN.4), and *FN_teaching* as the mean of the two role-adapted teaching/communication items requiring both responses (MEAN.2). Differences between teachers and students on these composites were tested using independent-samples t-tests with Welch's correction, complemented by bootstrap percentile 95% confidence intervals (1,000 resamples) and effect sizes (Hedges' g).

To assess science's overall image, we used 15 bipolar items (semantic differential, e.g., Beneficial to society vs. Not beneficial), with lower scores indicating a more positive view. The structure was examined using an exploratory factor analysis (EFA) with Principal Axis Factoring (PAF) and Oblimin rotation, with listwise deletion of missing data. Sampling adequacy was excellent (KMO = 0.934), Bartlett's test was significant ($\chi^2(105) = 6858.104$, $p < .001$), and communalities ranged from 0.382 to 0.683. EFA revealed three correlated factors: (1) societal relevance/utility, (2) status, visibility, benefits, and (3) integrity, autonomy, and public-good

orientation. Due to intercorrelations and dominance of the first factor, we treat the construct as mainly unidimensional with three facets. We use an overall index and facet scores where needed. Internal consistency was high: teachers (N=246) had Cronbach's $\alpha = .917$, students (N=825) $\alpha = .905$ (15 items). Both instruments collected demographics (gender, age).

3 Results and interpretation

Attitudes towards science in Slovenia were assessed using a 15-item semantic differential comprising bipolar adjective pairs (e.g., useful–not useful, trustworthy–not trustworthy). For interpretation, lower scores indicate a more positive evaluation (closer to the positive pole), whereas higher scores indicate a more negative evaluation. At the level of individual semantic-differential items, science in Slovenia was evaluated predominantly positively (the modal response category was “partly positive” across all items), although respondents expressed more ambivalence towards status-related and institutional aspects. The most positive evaluations concerned the usefulness of science to society (M = 1.98; 76.6% “very/partly positive”) and its contribution to Slovenia’s development (M = 1.97; 76.2% positive). Science was also widely seen as future-oriented (M = 2.06; 73.5% positive). Moderately positive ratings were observed for science being interesting (M = 2.31; 65.2% positive), useful in everyday life (M = 2.31; 66.3% positive), internationally recognised/influential (M = 2.33; 64.2% positive), objective/impartial (M = 2.36; 59.6% positive), and trustworthy (M = 2.26; 65.7% positive). The greatest reservations/neutrality emerged for items tapping influence, public communication, and institutional embeddedness: perceived influence on politics (M = 2.75; 45.6% positive; 31.7% neutral), independence from politics (M = 2.71; 46.5% positive; 31.0% neutral), and public promotion/communication of science (M = 2.65; 48.6% positive; 31.9% neutral). Ratings were similarly more ambivalent regarding science as a well-paid activity (M = 2.61; 49.3% positive; 31.7% neutral).

For the composite indicator of attitude towards science (mean across the 15 bipolar items; N = 1,048, listwise computation), the mean was M = 2.36 (SD = 0.65) with a median of 2.30. The interquartile range (P25 = 1.93; P75 = 2.80) indicates an overall moderately positive evaluation of science, with most responses clustering between “partly positive” and “neither positive nor negative”, and relatively few extreme negative evaluations. Consistent with the exploratory factor structure, facet-level

descriptive statistics indicate that positive evaluations were most pronounced for societal relevance/utility, whereas status/visibility-related aspects were rated more cautiously. (a) *Societal relevance and utility of science*: $M = 2.17$ ($SD = 0.72$; $N = 1,058$) — the most positive facet, reflecting perceptions of science as useful, development-oriented, future-oriented, and applicable to everyday life. (b) *Status, visibility, and instrumental benefits*: $M = 2.62$ ($SD = 0.81$; $N = 1,061$) — the least positive facet, consistent with higher neutrality or negativity for perceived political influence, public promotion/communication, and pay. (c) *Integrity, autonomy, and public-good orientation*: $M = 2.46$ ($SD = 0.76$; $N = 1,061$) — an intermediate evaluation, suggesting that science is seen as relatively trustworthy and objective, but with greater ambivalence about independence from politics and orientation towards the public good.

Because the three facet scores were conceptually related and empirically correlated, group differences between teachers and students were examined using a one-way multivariate analysis of variance (MANOVA) with respondent category (teachers vs. students) as the between-subjects factor and the three facet scores as dependent variables. Box's test indicated heterogeneity of covariance matrices across groups (Box's $M = 76.26$, $F = 12.65$, $p < .001$), so the multivariate effect was interpreted primarily using Pillai's trace, which is more robust under such conditions. The MANOVA revealed a significant multivariate effect of group (Pillai's Trace = .190, $F = 81.44$, $p < .001$, $\eta^2 = .190$), indicating that teachers and students differed in their overall profiles across the three facets.

Follow-up univariate tests revealed significant group differences for two facets. For *societal relevance/utility*, teachers reported more positive evaluations (lower scores) than students (teachers: $M = 1.94$, $SD = 0.77$, $n = 243$; students: $M = 2.24$, $SD = 0.69$, $n = 805$, $F = 33.52$, $p < .001$, $\eta^2 = .031$). For *status/visibility and instrumental benefits*, students reported more positive evaluations than teachers (teachers: $M = 2.95$, $SD = 0.77$, $n = 243$; students: $M = 2.51$, $SD = 0.79$, $n = 805$, $F = 58.57$, $p < .001$, $\eta^2 = .053$). The groups did not differ significantly on *integrity/autonomy/public-good orientation* (teachers: $M = 2.40$, $SD = 0.85$, $n = 243$; students: $M = 2.48$, $SD = 0.73$, $n = 805$, $F = 1.88$, $p = .170$, $\eta^2 = .002$). Notably, because the outcomes were derived from a semantic differential, lower values indicate more positive evaluations, and therefore, the direction of the mean differences should be interpreted accordingly.

To test whether the groups differed in the overall (predominantly unidimensional) attitude toward science index, we conducted an independent-samples t-test. Teachers ($M = 2.33$, $SD = 0.67$, $n = 243$) and students ($M = 2.37$, $SD = 0.64$, $n = 805$) did not differ significantly in the overall index. Using Welch's correction (given unequal group sizes), the difference was not significant ($t = -0.89$, $p = .375$). The effect size was negligible: Cohen's $d = -0.07$, Hedges' $g = -0.07$. The small, non-significant mean difference indicates that the two groups were broadly similar in their overall attitudes toward science. The findings show a strong similarity between teachers' and students' attitudes towards science, with no significant difference in the overall index. However, MANOVA indicates they differ in specific areas: teachers view science more favourably for societal relevance and utility, while students value its status, visibility, and benefits more. No significant differences exist in integrity, autonomy, and public-good facets, suggesting differences are in how each group prioritises different aspects of science.

We then examined the distributions and descriptive statistics for each item on the *Fake News/Information Assessment Scale*. In both subsamples, responses generally leaned towards agreement; however, teachers consistently reported higher mean scores than students across all items. Among teachers, the highest means were observed for perceiving fake news as a threat to democracy ($M = 4.48$, $SD = 0.79$, $N = 241$) and for the view that clear, comprehensible communication of scientific results would help distinguish verified facts from misinformation ($M = 4.28$, $SD = 0.80$, $N = 240$). Teachers also rated fake news as a salient societal problem in Slovenia ($M = 4.12$, $SD = 0.86$, $N = 240$). Self-assessed ability to recognise distorted or false information ($M = 3.80$, $SD = 0.77$, $N = 238$) and to distinguish credible from fake news ($M = 3.79$, $SD = 0.79$, $N = 242$) were somewhat lower but remained within the agreement range. For the role-adapted teaching/communication items¹, teachers reported moderately positive evaluations (a: $M = 3.56$, $SD = 0.87$, $N = 239$; b: $M = 3.96$, $SD = 0.83$, $N = 244$).

Among students, mean scores were lower and clustered around 3.5. Students rated their ability to distinguish credible from fake news as highest ($M = 3.53$, $SD = 0.96$, $N = 759$) and expressed similar levels of agreement that fake news is a problem in

¹ (a) "I believe I have sufficient knowledge and skills to communicate scientific findings clearly, which would help distinguish between fake news and verified facts." (b) "In my work with pupils/students, I explicitly draw their attention to the knowledge and skills that would help them distinguish between fake news and verified facts."

Slovenia ($M = 3.56$, $SD = 0.96$, $N = 715$) and a threat to democracy ($M = 3.53$, $SD = 1.01$, $N = 706$). Perceived usefulness of comprehensible scientific communication was comparable ($M = 3.51$, $SD = 0.97$, $N = 705$). The lowest mean was found for self-assessed ability to recognise distorted or false information ($M = 3.39$, $SD = 0.97$, $N = 731$). For the role-adapted items² where students evaluated their teachers, both means were lower than those reported by teachers (a: $M = 3.35$, $SD = 0.96$, $N = 720$; b: $M = 3.20$, $SD = 1.00$, $N = 721$), suggesting a less favourable perception of instructional support for developing skills to differentiate between verified facts and misinformation.

Next, we compared teachers and students using two composite measures. On *FN_core* (the mean of five substantively identical items), teachers scored higher ($M = 4.09$, $SD = 0.52$, $N = 241$) than students ($M = 3.51$, $SD = 0.72$, $N = 698$). Welch's independent-samples t-test indicated a statistically significant difference ($t = 13.42$, $p < .001$). The effect size was large (Hedges' $g = 0.86$). These results indicate that, relative to students, teachers reported higher perceived competence in recognising and distinguishing false information and simultaneously expressed stronger agreement that fake news constitutes a serious societal and democratic challenge, as well as stronger endorsement of clear scientific communication as a protective factor against misinformation. On *FN_teaching* (the mean of the two teaching/communication items), teachers again scored higher ($M = 3.76$, $SD = 0.71$, $N = 239$) than students ($M = 3.27$, $SD = 0.83$, $N = 688$). This difference was statistically significant ($t = 8.78$, $p < .001$). The effect size was medium (Hedges' $g = 0.61$).

Because *FN_teaching* relies on role-specific items- teachers assessing their practice and students evaluating teachers- this pattern reflects a perspective difference: teachers view their scientific communication and emphasis on relevant skills more positively than students do. Both item and composite analyses show consistent intergenerational differences. Teachers' higher *FN_core* scores suggest greater confidence in their evaluative abilities and a stronger framing of misinformation as a societal and democratic threat, possibly due to professional socialisation and exposure to public discourse. Conversely, students' lower scores indicate

² (a) "I believe my teachers have sufficient knowledge and skills to communicate scientific findings clearly, which helps us distinguish between fake news and verified facts." (b) "During lessons, my teachers explicitly highlight the knowledge and skills that would help us distinguish between fake news and verified facts."

ambivalence or situational confidence, with many agreeing but remaining uncertain about translating awareness into concrete evaluation skills. The pattern for *FN_teaching* reveals a potential “instructional alignment gap”: teachers think they communicate clearly and signal verification skills well, while students are more reserved. This gap may stem from teachers considering general clarity or examples sufficient, whereas students expect explicit, practice-oriented guidance, such as routines and criteria. To improve students’ informational resilience, teaching strategies must become more routine and visible in classrooms, emphasising concrete skills such as source verification and cue detection, rather than just stressing trustworthiness. The self- versus other-rating difference highlights perception gaps that can guide better communication and teaching methods.

We conducted correlational analyses between fake-news composites and attitudes towards science, using Pearson correlations for teachers and students with pairwise deletion. Both groups showed moderate positive associations: higher scores on the core fake-news dimension were associated with higher scores on the teaching/communication dimension (teachers: $r = .548$, $p < .001$, $N = 236$; students: $r = .433$, $p < .001$, $N = 633$).

In the teachers’ subsample, neither the core fake-news composite (*FN_core*) nor the teaching/communication composite (*FN_teaching*) showed a significant link with the attitude-towards-science index ($r = .033$, $p = .612$, $N = 238$ for *FN_core*; $r = -.016$, $p = .807$, $N = 236$ for *FN_teaching*). The same pattern was observed across three attitude factors, with correlations with *FN_core* and *FN_teaching* being small and non-significant. Overall, teachers’ attitudes towards science seem largely independent of their self-reported evaluations of fake news and teaching practices. In the *students’ subsample*, *FN_core* again showed no meaningful association with the overall attitude-towards-science index ($r = .052$, $p = .176$, $N = 682$) and was essentially unrelated to the “social relevance/benefit” dimension ($r = -.032$, $p = .402$, $N = 689$). However, *FN_core* showed small positive correlations with two dimensions: status/visibility/instrumental benefits ($r = .113$, $p = .003$, $N = 692$) and integrity/autonomy/public good ($r = .098$, $p = .010$, $N = 692$). Given the scoring direction (higher values indicate more negative attitudes), these small positive associations indicate that higher *FN_core* scores were linked to slightly more negative views of science on these two dimensions, although the effect sizes were modest.

By contrast, the teaching/communication composite (*FN_teaching*) showed a consistent pattern of negative associations with students' attitudes towards science: overall attitude index ($r = -.191$, $p < .001$, $N = 675$), social relevance/benefit ($r = -.194$, $p < .001$, $N = 680$), status/visibility/instrumental benefits ($r = -.140$, $p < .001$, $N = 684$), and integrity/autonomy/public good ($r = -.145$, $p < .001$, $N = 683$). Interpreted in light of the scoring direction, these results suggest that students who more positively evaluated teachers' clear communication of scientific results and the explicit emphasis on relevant skills for distinguishing misinformation from verified facts tended to express more favourable attitudes towards science (lower attitude scores). The pattern is specific to students and the teaching/communication dimension, implying that perceived classroom communication and explicit skill-signalling may be more closely linked to students' science attitudes than their general self-perceived competence in evaluating fake news.

To examine whether the association between perceived fake news, related teaching practices and attitudes towards science differs between teachers and students, we conducted a moderated linear regression with attitudes towards science as the dependent variable (higher scores indicate more negative attitudes). Group membership was dummy-coded (0 = teachers, 1 = students). The predictor *FN_teaching* was mean-centred and entered together with group in the first step, followed by the interaction term (*FN_teaching* $\times$ *group*) in the second step to test moderation and quantify the incremental variance explained by the interaction. The main-effects model was statistically significant ($R^2 = .023$, $F = 10.684$, $p < .001$), with higher *FN_teaching* scores associated with less negative (i.e., more favourable) attitudes towards science ($B = -0.119$, 95% CI $[-0.170, -0.067]$, $p < .001$), whereas the group main effect was not significant. Adding the interaction term produced a small but statistically significant improvement in model fit ($\Delta R^2 = .004$, $F\text{-change} = 3.957$, $p = .047$), and the interaction coefficient was negative ($B = -0.130$, 95% CI $[-0.258, -0.002]$, $p = .047$), indicating that the relationship between *FN_teaching* and attitudes towards science was stronger among students than among teachers. Interpreted substantively, this pattern suggests that students who more positively evaluate teachers' clear communication of scientific results and explicit emphasis on skills for distinguishing misinformation from verified facts tend to report more favourable attitudes towards science. In contrast, the same association is negligible in teachers' self-reports.

4 Discussion

Addressing the study's aim, teachers reported higher perceived fake-news evaluation and a greater perceived societal/democratic threat than students, yet overall attitudes towards science were similarly moderately positive. The key link emerged for students: more positive ratings of teachers' clear science communication and explicit verification-related teaching predicted more favourable science attitudes, whereas associations for teachers were negligible.

In line with post-truth/truth-decay accounts, the results suggest that school-level information resilience hinges on making epistemic standards visible and actionable, especially under 'conflicting authority' (Huguet et al., 2019; Mason et al., 2018; Lynch & Hunter, 2020). Beyond general media-literacy messaging, classrooms should institutionalise routine, explicit verification practices and transparent source criteria, paired with clear communication of scientific results (Bulger & Davison, 2018; Davies et al., 2012). Brief inoculation/prebunking activities may complement these routines by foregrounding standard manipulation techniques (van der Linden, 2019).

Because the findings are based on cross-sectional self-reports and role-adapted items, future studies should include behavioural measures and longitudinal/experimental designs to test causal effects on discernment and science attitudes (Jones-Jang et al., 2019).

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BARRIERS IN THE IMPLEMENTATION OF FAMILY AND COMMUNITY NURSE MODEL USING CONSOLIDATE FRAMEWORK FOR IMPLEMENTATION RESEARCH: FINDINGS FROM A QUALITATIVE STUDY

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The growing burden of chronic conditions requires integrated models of care across hospital and community settings. The Family and Community Nurse (FCN) role has been introduced in Italy to support continuity of care and prevention, yet its implementation remains uneven. This study aimed to explore barriers influencing the implementation of FCN model from nurses' perspectives and to identify implementation strategies using the CFIR–ERIC approach. A descriptive qualitative study was conducted in a North-East Italian region. Fourteen FCNs participated in semi-structured interviews. Data were analysed using deductive content analysis and mapped to the five CFIR domains. Barriers were identified across innovation, inner and outer settings, individuals and process, including organisational misalignment, limited resources, insufficient role recognition, low community awareness and difficulty in adopting preventive practices. CFIR–ERIC matching supported the identification of context-sensitive strategies to guide future implementation.

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1 Introduction

Chronic diseases represent a growing global burden for healthcare systems, requiring increasing efforts in prevention, health education, early diagnosis, and timely treatment (World Health Organization, 2023). More than half of adults over 65 live with at least two chronic conditions, a situation associated with higher risks of hospital readmissions, loss of autonomy, reduced quality of life, and rising healthcare costs (Endalamaw et al., 2024). People with chronic conditions frequently experience fragmented care, limited holistic support, and insufficient guidance from healthcare providers. This fragmentation challenges continuity, access to care, and sustained therapeutic relationships (Endalamaw et al., 2024). World Health Organization (WHO) has emphasized the need for people-centred integrated care models that promote proactive management, continuity, and coordination across care settings (World Health Organization, 2018). Strengthening primary health care and shifting from hospital-centred to integrated hospital–community models have been identified as key strategies for chronic disease management (Azzellino et al., 2025). Nurses play a central role, particularly through the Family and Community Nurse (FCN) model, which focuses on prevention, health promotion, and continuity of care at the community level (Gasperini et al., 2023). In countries such as Italy and Spain, the FCN role requires specialized postgraduate training and has been formally recognized within national health system reforms. However, in Italy the implementation of the FCN model remains fragmented, and few studies have explored FCNs' experiences during this process. Existing literature suggests that successful implementation depends not only on regulatory frameworks, but also on cultural, organizational, and professional factors, including interprofessional collaboration, recognition of roles, and responsiveness to local needs (Torrens et al., 2020).

1.1 Framework of implementation science

Implementation science offers a range of theories and frameworks that help to identify the barriers and facilitators and strategies to improve the implementation.

The Consolidated Framework for Implementation Research (CFIR) was used in the current study. This framework provided a shared taxonomy of 48 constructs related to implementation across five domains (Damschroder et al., 2022). The domains

include innovation (in this case, implementation of family and community model), the inner setting (the healthcare settings), the outer setting (the context in which the healthcare setting resides), individual characteristics (healthcare staff), and the processes used for implementing the intervention or process (Damschroder et al., 2022). The CFIR could help to identify the barriers, facilitators and strategies to improve the implementation and could be used in healthcare research. The Expert Recommendations for Implementing Change (ERIC) (Powell et al., 2015) is a refined compilation of implementation strategy terms and definitions, systematically gathered from a wide range of stakeholders with expertise in implementation science and clinical practice. The CFIR-ERIC Matching Tool (Waltz et al., 2019) was developed based on expert consensus and was utilised to help guide choice of theoretically informed matching strategies to address CFIR barriers. It provides a prioritised list of strategies to consider based on researchers' knowledge of potential CFIR barriers.

1.2 Aim

The aim of the study was to explore barriers influencing the implementation of the FCN model in Italy from nurses' perspectives, mapped across the CFIR domains and to develop strategies based on the ERIC-CFIR tool.

2 Methods

2.1 Study Design

A descriptive qualitative study was conducted in June and July 2025 and reported according to the Consolidated criteria for Reporting Qualitative research (COREQ) (Tong et al., 2007).

2.2 Setting and Participants

The study was conducted in the North-East Region of Italy, regional context encompassing three healthcare authorities, serving more than 1 million of citizens in 2023 (ISTAT, 2025). The FCN model had been introduced according with policy directive (Ministero della Salute, 2022). A purposeful sample (Patton, 2014) of nurses were involved. The eligible criteria were nurses who (i) were active nurses at time of

the study and (ii) gave the written consent to participate in the study. Fourteen nurses were contacted and all of them accepted to participated in the study. The purposeful sampling was ended when data saturation was reached, as judged by researchers (see authors) as when dominant themes were perceived to be complete, and no others emerged from the interviews (Morse, 1995). Saturation was monitored throughout the analysis and confirmed through team discussion.

2.3 Data collection

Interviews were conducted between June and July 2025. An audio-recorded open-ended interview was performed exploring the barriers and facilitators the implementation process. The interview guide included: (a) demographic/professional data and factors hindering or promoting such implementation. Topics included the perceived current degree of implementation, barriers and facilitators. Interviews were conducted by a researcher (GM). Another female researcher (AP), who had an advance expertise in qualitative research, supervised the process. No relationship with participants was established before the development of the study. Participants were informed only about the working position of the researchers and the aims of the study. The interviews were conducted via Zoom or Teams platforms with only the researcher and the participant present and lasted from 30 minutes to 60 minutes, were audio-recorded with consent, and transcribed verbatim. No interview was repeated.

2.4 Data analysis

The professional data was summarised with descriptive statistics (means, standard deviations (SD), frequencies and percentages). A content analysis framework (Elo & Kyngäs, 2008) was used, a systematic approach allowing a detailed description of the phenomenon to be obtained and based upon three phases: preparation, organization and reporting. The researcher (GM), who performed the interviews, transcribed the interviews verbatim. Subsequently, the researcher (GM) read the text individually to gain a general understanding of the data and underlined the units of analysis as sentences or words with meaning with a deductive approach by coding data with predefined categories based on the CFIRs' domains. Another researcher reviewed and validated the analysis (AP). The codes were then abstracted into subthemes and themes by formulating a general description of their contents. The themes were

aligned with the domains of CFIR. Consensus discussions were held to resolve disagreements, develop a shared understanding and to refine the subthemes and themes. Finally, CFIR-ERIC Matching Tool was used to create matching strategies to address prioritised barriers and amplify prioritised facilitators.

3 Results

3.1 Demographics of Participants

Fourteen nurses were involved in the study. They were mostly female (12/14) with a mean age of 51.1 (SD 8.3). Most of them had a nursing diploma (10/14) and four nurses had completed a postgraduate education course. Overall, they had a mean experience in community setting of 15.9 (SD 7.2).

3.2 Barriers of implementation

The analysis identified barriers affecting the implementation of the FCN model. Findings are presented in Table 1 according to the CFIR domains and illustrate how organizational, professional, and contextual factors interact in shaping the implementation process.

Table 1: Barriers Themes

CFIR domain (Costructs)	Barriers Themes
Innovation (Adaptability)	Experiencing differences between FCN model and organizational principles
Outer Setting (Patient needs & Resources, Cosmopolitanism)	Coping with increasing care demands and complexity of citizens
	Interacting with a poorly informed community
Inner Setting (Culture, Compatibility, Available Resources)	Undermining model sustainability through structural and organizational shortages
	Facing internal resistance and poor recognition of nursing work
Individuals (Knowledge & Beliefs about the Intervention)	Navigating limited readiness for the FCN role
Process (Engaging -Innovation Recipients)	Failing to implement preventive and proactive approaches

Legend: FCN, family and community nurse.

Seven themes were identified across five domains of CFIR. Within the Innovation domain, the theme “Experiencing differences between FCN model and organizational principles” reflects nurses’ perceptions that the FCN model is not fully integrated into the strategic goals of their organizations. This misalignment was often reinforced by staff rotation practices, which weakened continuity and diluted the specific identity of the FCN role. Two themes were identified within the Outer Setting domain. The theme “Coping with increasing care demands and complexity of citizens” reflects the growing workload associated with earlier hospital discharges and the challenges of responding to culturally and socially diverse populations. The theme “Interacting with a poorly informed community” points to limited awareness of the FCN model among citizens, often accompanied by passive attitudes that hinder proactive engagement. In the Inner Setting domain, two main themes emerged. The theme “Undermining model sustainability through structural and organizational shortages” captures persistent difficulties related to limited staffing, excessive administrative workload, inadequate skill mix, and the lack of suitable facilities. These conditions constrained nurses’ capacity to focus on community-oriented and preventive activities. The second theme, “Facing internal cultural resistance and poor recognition of nursing work”, describes how organizational cultures that prioritize task-based and highly visible activities tend to marginalize relational, coordination, and preventive components of the FCN role, contributing to feelings of low professional recognition. In the Individuals domain, the theme “Navigating limited readiness for the FCN role” highlights gaps in professional preparation. Participants reported insufficient education in community and inter-service collaboration and the recruitment of newly graduated nurses with limited clinical experience, which reduced confidence in managing complex home-based care. Finally, within the Process domain, the theme “Failing to implement preventive and proactive approaches” describes the difficulty in translating the preventive orientation of the FCN model into everyday practice, with activities remaining largely reactive.

3.3 ERIC Strategy mapping

Barriers were mapped to the ERIC tool to identify strategies, that were selected based on the level of agreement regarding their efficacy in addressing barriers. Based on the CFIR–ERIC matching, nine implementation strategies were identified as

those with the highest level of expert consensus to address the main barriers that emerged in this study, as shown in Table 2.

Table 2: Summary of barrier constructs mapped to ERIC strategies

CFIR construct	ERIC strategy (most strongly recommended)	% of agreement
Adaptability	Promote adaptability	76
Patient needs & Resources	Conduct local needs assessment	57
Cosmopolitanism	Built a coalition	62
Culture	Identify and prepare champions	52
Compatibility	Conduct local consensus discussion	41
Available Resources	Access new funding	78
Knowledge & Beliefs about the Intervention	Conduct educational meetings	56
Engaging - Innovation Recipients	Involve patients and family members	59
	Prepare patients to be active participants	55

Legend: CFIR, Consolidate Framework for Implementation Research; ERIC, Expert Recommendations for Implementing Change

Regarding the Adaptability construct, the strategy “Promote adaptability” (76%) was identified as a key action to counteract the perceived differences between FCN principles and organisational goals. This strategy supports a flexible implementation of the FCN model, allowing services to tailor interventions to local contexts and community needs. Within the Outer Setting domain, the strategies “Conduct local needs assessment” (57%) and “Build a coalition” (62%) were prioritised to address the increasing socio-cultural complexity of citizens and the low level of community awareness of the FCN role. Assessment of local needs enables organisations to align services with community priorities, while coalition building with community stakeholders, such as social services and third-sector organisations, strengthens territorial networks and promotes citizen engagement. In the Inner Setting domain, professional shortages were mainly targeted through the strategies “Access new funding” (78%), “Identify and prepare champions” (52%) and “Conduct local consensus discussions” (41%). Securing additional funding is essential to ensure the sustainability of the FCN model, whereas the identification of local champions and the promotion of structured consensus processes are crucial to foster organisational change and improve recognition of the FCN role. Finally, within the Individuals and Process domains, the strategies “Conduct educational meetings” (56%), “Involve patients and family members” (59%) and “Prepare

patients to be active participants” (55%) aim to enhance professional readiness and to shift everyday practice from a reactive to a preventive and proactive orientation, strengthening the active involvement of patients and caregivers in the care pathway.

4 Discussion

Our findings offer insights and learning experiences for other countries in the planning and refining stages of the implementation of a nursing model. The findings indicate that the introduction of the FCN role requires not only organisational change but also cultural and professional realignment. Furthermore, the study utilised the CFIR-ERIC matching tool to develop tailored implementation strategies, addressing barriers to improve FCN model implementation. The integrated use of the CFIR and ERIC frameworks made it possible not only to describe these barriers, but also to translate them into concrete operational strategies.

Within the Innovation domain, participants reported differences between FCN principles and organisational priorities. Similar difficulties in integrating community-oriented nursing models into hospital-centred health systems have been reported internationally (McCauley et al., 2021). Consistent with CFIR assumptions, adaptability emerged as a key construct supporting implementation (Damschroder et al., 2022). Barriers related to the Inner Setting included limited resources, administrative burden and insufficient recognition of nursing competencies. These findings are consistent with evidence indicating that organisational culture and lack of structural support hinder the development of advanced and community-based nursing roles (Torrens et al., 2020). The identification and preparation of local champions appear relevant for addressing these challenges, as leadership engagement has been associated with improved implementation processes (Ojemeni et al., 2019). In the Individuals domain, limited readiness for the FCN role and perceived gaps in professional preparation were reported. Previous studies have shown that insufficient training is associated with reduced self-efficacy and fragmented implementation of community care models (Johnson et al., 2022). Regarding the Outer Setting, participants highlighted increasing socio-cultural complexity and low public awareness of the FCN role. Similar findings have been described in studies on primary care access and community engagement, which emphasise the relevance of user involvement (Adeosun et al., 2018). In the Process domain, difficulties in adopting preventive and proactive approaches

reflect observations from other European settings, where established task-oriented routines limit innovation in community care (Caponnetto et al., 2024). The combined use of CFIR and ERIC supported the translation of qualitative findings into a set of context-sensitive implementation strategies. The recent update of the CFIR framework (Damschroder et al., 2022) and methodological refinements of the CFIR–ERIC Matching Tool provide further support for this approach. The prioritised strategies identified in this study, promoting adaptability, accessing new funding, preparing champions, and involving patients and family members, are consistent with established models for chronic care delivery and address the main barriers identified in the Italian context.

4.1 Limitations

This study has several limitations. Data were collected only from nurses; the perspectives of other stakeholders were not included and may provide a more comprehensive understanding of the implementation process. Furthermore, although the CFIR–ERIC Matching Tool supported the identification of implementation strategies, this process was based on expert consensus rather than empirical testing within the study, and effectiveness of the proposed strategies remains to be evaluated in future implementation research.

5 Conclusion

The study analyses the barriers affecting the implementation of FCN model in an Italian regional context, using the CFIR framework and CFIR-ERIC matching to guide the identification of implementation strategies. Barriers were identified across the five CFIR domains, particularly concerning limited organisational support, insufficient recognition of the FCN role, and challenges in adopting preventive and proactive approaches in daily care. The integration of CFIR and ERIC enabled the translation of qualitative findings into strategies tailored to the context. The strategies mainly concern the promotion of adaptability, the allocation of specific fundings, the preparation of local champions and the active involvement of patients, families and community. These strategies could assist policymakers and nurses' managers in planning and refining the implementation of FCN model.

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IDENTIFYING EDUCATION AND TRAINING NEEDS: A COMPARATIVE CASE STUDY OF PROVIDER AND USER PERSPECTIVES

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We address the issue of identifying education and training needs from two key perspectives: education and training providers and program users. Misalignment between users' perceived needs and the educational offer may reduce the effectiveness of education and training programs and limit the transfer of acquired knowledge into practice. Our purpose is to examine how different stakeholders identify and define education and training needs and to what extent their expectations and priorities align. We explore similarities and differences in the understanding of competency gaps, learning goals, and expected outcomes of education and training through comparative perspective. Our findings contribute to a better understanding of the importance of aligning provider and user perspectives and emphasize the need for more inclusive, responsive, and flexible approaches to the design of education and training programs. We also offer practical insights for improving the quality and relevance of education and training practices in contemporary organizational contexts.

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1 Introduction

In today's digital age and changing workplace skills, identifying and fulfilling the needs of education and training is a key activity for an organization and educational institution to perform. Due to the fast pace of technological change and changing skills requirement in the workplace, both organizations and training institutions have to be very sensitive in identifying the competencies gap and meeting the stakeholder's needs for learning (Rumanti et al., 2025). Recently, there has been an emphasis on the importance of digital literacy from an individual and organizational level, therefore requiring an analysis framework that incorporates the stakeholder's voice in the process of identifying the needs (Hairunisya et al., 2025; Shatila et al., 2025).

Skills training is required for a wider range of competences that ensure the employability of employees and the ability of an organisation to survive and adapt in a changing environment. In particular, digital literacy was found to facilitate the effective use of digital tools by employees, the sharing and exchange of digital information and participation in a knowledge-based, value-creation process (Rumanti et al., 2025; Shatila et al., 2025). These competences are not only defined by the organisation but also shaped by the interactions of the providers and users of education and training. Providers' ability to read the needs of users and adapt their offers is a critical capability in a professional learning ecology.

Even though the criticality of the needs identification process in professional education is recognized, evidence exists of a mismatch between organizational demands and training supplies (Hairunisya et al., 2025). A mismatch may diminish the impact of educational and training programs, result in low learner motivation and produce limited generalizability of skills to the job. To overcome this mismatch, there is a need to comparatively examine the views of the two actors involved in the education and training process, namely the parties who request education and training (organizational users) and those who supply education and training (providers).

This article examines this interplay on the basis of two qualitative case studies: one of a HR department manager in a software company of medium size and one of a manager in a public further education institute. The article examines the way in

which both interviewees recognize, negotiate and achieve both sets of interests to illustrate the related processes of interest recognition, negotiation and achievement and to contribute to the debate on demand-orientation of stakeholder-orientation of professional learning in the more and more complex professional worlds.

2 Literature Review

The need for needs assessment was identified as an essential part of HRD and training to identify the gap between the actual and expected knowledge, skills and attitudes. It also needs to be aligned with the organisational objective and performance (Shatila et al., 2025) and can be conducted at different levels (organisational, task and individual) to make sure the training is relevant. Without conducting needs assessment, training may not be utilised, and employees may not gain the skills they need (Hairunisya et al., 2025). The needs of training providers and consumers need to be aligned, as the needs will be different based on the objective, outcome and work experience.

The requirement of training is dynamic rather than static due to the changing nature of work. The digitalisation of work results in job insecurity and the need for continuous reskilling (Shah and Mola, 2026). The skill gap, which refers to the difference between the skills demanded and supplied, hinders innovation and competitiveness (Braun et al., 2025). The existing competence framework might not be comprehensive, particularly in the context of Industry 5.0 (Carminati et al., 2025). The digital competence required will also be influenced by organisational performance and stakeholder involvement (Rumanti et al., 2025; Shatila et al., 2025).

The needs identification based on evidence is limited due to the unavailability of needs assessment instruments, resulting in general expressions of needs which need to be further defined by the suppliers (Rashida and Bariham, 2025). In the absence of a transfer mechanism such as coaching, limited feedback will be available from the training for future needs assessment (Ambu-Saidi et al., 2024). A skill-first approach which considers both internal and external signals can help in keeping the needs up to date (Collings and McMackin, 2025; Caterino et al., 2025).

Misalignment between provider and user can occur due to the poor connection between education and industry, resulting in skill mismatch (Kayyali, 2025; Braun et al., 2025). Resource and cooperation will influence what needs can be communicated and offered. The existence of structured evaluation criteria and the involvement of stakeholders can help in translating the general needs into a curriculum (Akhtar et al., 2024; Caterino et al., 2025).

Digital literacy is one of the emerging needs due to the impact of digitalisation on job requirement and wellbeing (Shah and Mola, 2026) and is influenced by the organisational system and HRD practices (Rumanti et al., 2025; Hairunisyah and Narmaditya, 2025). The requirement for hard, soft and transversal skills needs to be considered together for the current work environment (Carminati et al., 2025; Akhtar et al., 2024). Continuous professional development considers the needs to be changing as the job and technology change and feasibility becomes a challenge for participation and effectiveness (Rashida and Bariham, 2025; Asmare, 2025).

Transfer of learning which refers to the extent to which learning is being applied at work is considered an essential aspect of training effectiveness and is influenced by time, opportunity and support (O'Neill, 2025; Blume et al., 2017; Ambu-Saidi et al., 2024). The bidirectional transfer which considers integrating on-the-job and off-the-job experiences can enhance the effectiveness (Wahl and Hybertsen, 2025).

3 Research

The purpose of the research was to find out how the corporate client and the education institution understand and perceive the educational and training needs of the former. Using the theory discussed in the above chapters the research was of a qualitative, comparative nature including opinions of a corporate HR manager in the company MIL Sistemika d.o.o. and a director of Davčno izobraževalni inštitut (DIZI).

This study aims to investigate, on the one hand, the mechanisms and principles that lead to identifying education and training needs and, on the other hand, the extent to which the education and training needs as perceived by the organizational customers match with what is being offered and prioritized by a professional education and training supplier. By involving key stakeholders on the demand and

supply sides of education and training, this study sheds further light on how learning needs are perceived, interpreted and implemented in professional settings.

Our research questions are:

- *RQ1: How do organizational representatives (users) and education providers differ in the way they identify education and training needs?*
- *RQ2: To what extent are the education and training needs expressed by users (employees/ organizations) aligned with the offerings of a professional training provider?*
- *RQ3: What methods or tools are used by training providers and organizations to gather and interpret needs related to education and training?*
- *RQ4: What are the key barriers and drivers influencing the effective matching of education and training programs to users' needs?*
- *RQ5: How do stakeholders' expectations about the outcomes of education and training differ between users and providers?*
- *RQ6: What role does continuous professional development play in organizational strategy and training provider program design?*

For the purpose of this paper, we conducted semi-structured interviews with two stakeholders: Nina Minov (MIL Sistemika d.o.o. HRM manager) and Petra Zidar (DIZI senior representative). Questions referred to practices, tools, and strategies for identifying needs, but also on barriers and enablers for ensuring a balance between supply and demand. The paper is structured according to the research questions and in the following sections, we thematically analyse the responses of the stakeholders by looking at the points of agreement and disagreement.

Based on the analysis, this chapter provides the basis from which it will become possible to explain how organizations and educational institutions could be better engaged with each other in order to develop education and training programs that are relevant and adaptive to changing occupational needs.

4 Discussion and Implications

These six research questions, developed during our literature review, guided our research and form the foundation of this chapter. We now address these questions in light of the empirical data collected through interviews with a key representative from each stakeholder group: the Head of Human Resources at MIL Sistemika d.o.o. (Nina Minov) and a senior staff member at Davčno izobraževalni inštitut (DIZI) (Petra Zidar). We discuss the specific activities of each stakeholder in terms of perceived and expressed education and training needs, we examine the match between supply and demand, and finally, we consider the potential consequences of these relations for the system of professional learning.

The first research question we posed was to determine what the similarities and differences in the perceived educational and training needs of organizational representatives (users) and the professional educational provider and the criteria and processes are that the organizational HR leaders of MIL Sistemika and DIZI employed to recognize the need for learning. The organizational representatives of the case study organization, MIL Sistemika, determine the educational and training needs of its members through a strategic, internal, business planning process that is achieved through annual business planning, performance and development interviews, and the identification of competency gaps. Needs are determined as a result of the organizational and personal requirements of the employee and are linked to the business needs of the organization (e.g., technological growth, project requirements). The professional educational provider, DIZI, determines the educational and training needs of its members through an environmental scanning process that is achieved by consulting with members and other stakeholders as well as monitoring legislative, professional, and industry developments. According to Petra Zidar, updates in tax legislation, changes in professional standards, and sector developments determine what is taught at DIZI, and input from course participants, member companies, and other professional associations and networks helps to determine what the changing needs of their members are. Therefore, we can conclude that the organizational process is more internally focused and the provider process is more externally focused.

The second research question is: to what extent do the education and training needs of the user (employees/organizations) correspond to the offer of a provider of professional education and training, or, in other words, to what extent do the demand side (organizational development needs) and the supply side (design of the training content) match? There is a partial match between the needs of the user and the offer of the provider. Both sides value the same kind of competence: MIL Sistemika relies on digital and technical skills which are connected to the organization's purpose, whereas DIZI offers content related to professional and legal needs. The match occurs at the point where organizational needs and professional needs overlap, such as areas that require knowledge of regulations and basic professional skills.

Nevertheless, a mismatch occurs with respect to specialisation and breadth. The majority of the skills demanded by MIL Sistemika are either technical and company-specific (i.e. software applications and digital documents) or fall out of the realm of the standard professional training supply provided by DIZI, which is focused on taxation, accounting and industry standards. In this respect, we witness the lack of a collective interface to translate the demand into the supply of the hybrid skills that combine the digital and professional components.

The third question was about the tools or instruments applied by the training provider or in the organization to collect and analyse training needs. In MIL Sistemika the main instruments are the annual performance and development interview, strategic HR planning, and managers. By using these instruments, the leader and the employee can together identify knowledge and skill gaps, prioritize the development needs, and suggest specific training solutions. In DIZI the main instruments are the continuous process of stakeholder involvement (participation sheets, final course evaluation, and involvement of professional institutions). Petra Zidar added that DIZI also follows changes in legislation and professional standards. Therefore, the interpretation of needs is done both through the learners' needs and through the needs imposed by changes in legislation and expected changes in professional situations.

The fourth research question focused on the most significant obstacles and enablers that support a successful alignment of training offers and user demands. Enablers identified are the integration of structured communication and feedback

mechanisms (performance interviews in MIL Sistemika and the evaluation of participants in DIZI to collect feedback and information about the learning requirements) and the alignment with a broader strategy and external standards (the higher the training is aligned with strategic or legal targets, the more probable it is that it will be aligned with the user demands). The most significant obstacles are temporal and content-related discrepancies between the business plan (planning horizon of the yearly business plan) and the offer development process (offering development in DIZI and MIL Sistemika is done on a continuous basis without specific planning cycles), as well as a lack of comprehensive or hybrid competences (digitalisation and professional competences) in the training offers.

The fifth question addressed the perceived outcomes of education and training of both users and providers. Organizational user (MIL Sistemika) outcomes are perceived to be performance improvement, utility for immediate application and utility for achievement of organizational objectives. This could be manifest as: employees being able to perform new technical work, use computer technologies or contribute to organizational development. Provider (DIZI) outcomes are perceived to be professional expertise, legal and sectoral standards. Petra Zidar explained that DIZI perceives outcomes as, how well the student knows and understands that what they have learned will fulfil professional and legal requirements. Both user and provider perceive outcomes to be relevant and applicable; however, the organizational outcomes are more specific to the performance of the user organization, and the provider outcomes are more general to the profession across various user organizations.

The last research question addressed the strategic importance of CPD within the organizational strategy and in training provider program planning and how it influences the strategic importance of lifelong learning and the needs assessment process of both interviewees. CPD is of great strategic importance to both stakeholders. MIL Sistemika's approach to CPD is to include it in the yearly plan and in the individual development plan of the employees, which demonstrates that the continuous improvement of professional knowledge and skills is of vital importance to the business success of the organization. For DIZI, CPD is the core business of the institute, and this is why the institute aims at constantly adapting its programs to the changing circumstances in the profession, particularly in the cases where the profession is influenced by legislative changes. DIZI maintains a long-

term relationship with its clients through its CPD programs, which have to be renewed with each new legislative and professional developments. Both perspectives demonstrate the fact that CPD is of vital importance for the long-term strategy of the organization, however, the strategies are different: one is focused on business strategy and the other on professional developments within the profession.

Our study is based on two qualitative interviews representing one user and one provider. While our study provides us with specific stakeholder's perspectives, it limits the generalisability of our findings.

5 Conclusion

Through a comparative case study approach, we found that in practice, both the organisational stakeholders and providers are well aware of the significance of needs identification and alignment. Although the two stakeholders have different goals and time cycles, the common interests of relevance, engagement and responsiveness offer a good base for collaboration. Collaboration and improvements are possible on the flexibility of curriculum, synchronisation of time cycles and the integration of competence requirements. The collaboration of the two stakeholders is necessary to improve the learning effectiveness of professional education and training in an ever-changing context.

Therefore, our findings have significant implications for both practice and policy in professional education and workforce development. Organizations and providers should, for instance, set up more formal channels for co-defining needs. Joint advisory panels, co-design workshops, and shared competency frameworks could improve alignment and ensure that training portfolios reflect both organizational priorities and broader professional standards.

Providers should consider more flexible curriculum structures that support modular learning and competency customization. This would allow organizations to combine foundational regulatory knowledge with specialized digital or technical skills tailored to their context.

Continuous feedback mechanisms, such as post-training evaluations, user surveys, and engagement analytics, should be systematically integrated into both organizational learning ecosystems and provider program development. These loops will enhance responsiveness and relevance over time.

And of course, to avoid the mismatch between organizational planning cycles and provider curriculum schedules, both parties could explore real-time needs sensing methods, such as pulse surveys or digital analytics, to detect emerging skill gaps ahead of formal planning cycles.

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INFLUENCING DRIVER BEHAVIOUR THROUGH DIGITAL WARNING SYSTEMS: AN INDUSTRY CASE STUDY OF INTERMATIC D.O.O.

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Digital warning systems are increasingly used to improve traffic safety by influencing driver behaviour in urban environments. This paper examines how radar-based speed displays and warning systems contribute to raising driver awareness and promoting safer driving practices. Using an industry case study of Intermatic d.o.o., the research is based on a qualitative, semi-structured interview with the company's director, complemented by insights from student-led project activities conducted in cooperation with the company. The study explores managerial perspectives on the design, deployment, and perceived behavioural effects of digital warning systems, as well as key challenges related to implementation, data interpretation, and stakeholder cooperation. The findings highlight the role of interactive feedback, contextual placement, and data-supported decision-making in shaping driver responses. The paper contributes to the literature on smart mobility and traffic safety by offering practice-oriented insights into how digital warning technologies can support sustainable urban mobility and safer road environments.

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1 Introduction

Driver behaviour management to enhance road safety is a current and ongoing key issue in the development of smart cities. Speed is currently among the top contributors to accidents and the severity of injury that can occur, especially in areas where urban traffic is mixed (da Silva et al., 2025). To mitigate this, smart cities are employing digital warning displays like radar speed feedback displays and variable message signs to manage the actions of drivers.

The literature highlighted the efficacy of speed feedback systems to lower average speeds and enhance awareness among drivers prone to speeding (Neupane, 2025). Variable message signs were also found to be effective in enhancing drivers' situational awareness and responsiveness to traffic control in the uncertain driving environment (Yang et al., 2024). These technologies are being backed up by intelligent traffic monitoring and control systems that facilitate real time data collection and dynamic control of traffic (Thabit et al., 2024).

On the other hand, although there is an abundance of literature on the quantitative effectiveness of digital warning systems, literature that discusses the managerial and organizational aspects of their implementation is scarce. A systematic review highlighted that the real-world operational context, stakeholder engagement, and implementation approaches are key factors in the successful implementation of intelligent transportation systems for road safety (Kontaxi et al., 2025). To fill this knowledge gap, this paper describes a case study analysis in a private sector company, Intermatic d.o.o., that produces, implements and maintains digital warning systems to manage driver behaviour and improve urban mobility.

2 Literature Review

2.1 Digital Warning Systems and Traffic Safety

Radar speed signs and variable message signs are valuable tools that are widely employed within the framework of intelligent transportation systems and road safety management. These signs present real-time speed, traffic and safety information to drivers to improve their behaviour (Thabit et al., 2024). Such signs are more critical in urban networks where the density of the vehicular traffic is higher and the

probability of mixed traffic flow with other vulnerable road users and various types of road infrastructure is greater.

It has been widely acknowledged in the literature that vehicle speed is a key factor in the frequency and severity of road crashes. Da Silva et al. (2025) demonstrated that small reductions in the mean speed may result in significant enhancements in the traffic safety indicators, and, hence, the need for speed management measures on urban streets.

A few studies emphasized that the perceptual and design aspects of digital warnings are crucial to their effectiveness. For example, the legibility of variable message signs in foggy weather is contingent upon their visual design, with optimal text colour and spacing facilitating quicker information processing and lowering the driver's mental burden (Huo et al., 2024). Inadequately designed signs may even increase the likelihood of accidents.

Likewise, in variable message signs, graph-based visual symbols have demonstrated their superior visibility compared to text-based visual information and overcome the language barrier problem. As a result, these design strategies facilitate drivers' recognition and understanding of traffic and weather advisories (e.g., rain, fog, wind, and snow) (Chen et al., 2013).

2.2 Influence of Speed Feedback on Driver Behaviour

Another common form of digital warning is speed feedback signs. There is research proving their effectiveness in reducing speeds in most cases (Neupane, 2025). The mechanism by which this effect is achieved is the self-awareness and feedback, which leads to self-control.

In addition to speed reduction, speed feedback signs are also found to influence other kinds of behavioural shifts, such as increased adherence to traffic laws and higher levels of caution when driving in areas like school zones and neighbourhood streets (Neupane, 2025).

The positive impact of speed feedback was further shown in a field study on roundabout approaches, where the application of dynamic warning signs resulted in lower entry speeds of the vehicles. The largest effect of the speed sign was observed when it was positioned around 150 m in front of the roundabout, which proves the need for an optimal positioning of the sign (Cavka et al., 2025).

However, Ratchaneepun et al. (2026) argue that the effects of warning systems on driver's behaviour may differ and that these effects should not be taken for granted. They show that the results of enhanced recognition of hazards do not lead to enhanced speed adjustment and therefore, each individual aspect of driving behaviour should be dealt with separately.

2.3 Variable Message Signs and Situational Awareness

Besides the functionalities of digital warning signs, variable message signs (VMS) can disseminate more tailored and dynamic information to drivers. A recent study by Yang et al. (2024) shows that the VMS can effectively promote the situation awareness of drivers, especially at places where the road geometry is complicated (e.g. freeway off-ramps and urban intersections). With a better situation awareness, drivers can make wiser decisions and decrease the probability of engaging in a dangerous maneuver.

Overall, the results highlight the need for clear, concise messages, appropriate locations, and relevant contexts in order to make use of the full potential of digital warning systems – it is not technology alone that matters but its targeted use.

Likewise, Chen et al. (2013) state that employing graphical symbols on variable message signs (VMS) has the benefit of providing a visual communication strategy that can be detected at a longer distance and is not limited by linguistic barriers. That is, the use of symbols on the VMS helps shorten the reading time and increase the recognition reliability of traffic and weather messages.

More recent studies suggest an evolution toward personal and contextual warning which aims at not only providing knowledge but also at influencing driver's on-line behaviours. The graphic control at the approach of a red light gives drivers sequential and self-explaining feedback on the appropriate moment and pressure of

the foot on the brake, and thereby facilitates more moderate deceleration (He et al., 2024).

They provide focused decision support by presenting only relevant information in the context of a particular traffic situation. Furthermore, combining driver-related information with environmental data reduces false alarms and facilitates more efficient cooperative warnings for other road users such as pedestrians (Stocker et al., 2025).

2.4 Data-Driven Traffic Management and Real-World Contexts

Due to the availability of traffic monitoring sensors, a vast amount of data can be generated for infrastructure planning and traffic management purposes. Thabit et al. (2024) suggest that a monitoring and management integrated system can facilitate real-time intervention and performance assessment, which further binds the data with the policy.

On the other hand, it is important to mention that according to a systematic literature review of Kontaxi et al. (2025) the organisational, managerial and contextual factors play an important role in the actual impact of digital traffic safety interventions. Limited research was found on stakeholder involvement, maintenance, and connectivity with urban mobility planning.

Machine learning techniques are now a key feature of modern data-driven traffic safety research. This is because they are capable of handling big and complex data and have shown superior ability in predicting traffic accidents in comparison with conventional statistical methods, as they can capture non-linear relationship and patterns of the data (Chai et al., 2024).

Empirical applications demonstrate that machine learning methods applied in the spatial context are able to find high-risk locations with high accuracy and that there is potential to derive proposals for safe route planning that are not only optimized by distance but also by traffic risk (Berhanu et al., 2024).

Data-driven approaches are based on data coming from devices used by drivers in their daily activities. For instance, the analysis of the data from smartphone sensors allows recognizing different driving styles and types, and classifying drivers into risk profiles, offering new possibilities for risk assessment and support to automation (Valente et al., 2024).

These results are also supported by practice in the insurance industry, as the use of telematics has already led to a decrease in the number of claim events. A case study of the DRAJV application in Slovenia has shown that observing and giving feedback to the driving behaviour of the users can significantly affect their behaviour in traffic and have a positive effect on road safety (Kop et al., 2022).

While there has been significant progress in this area, there has been relatively little focus on how organizations make sense of such insights, enact them, and integrate them into design and deployment choices.

2.5 Research Gap

Various studies have quantitatively shown that digital warnings (e.g. speed feedback display, variable message sign) can influence driver behaviour (e.g. Neupane, 2025; Yang et al., 2024), and the use of monitoring technologies for data-driven traffic management and infrastructure planning is expanding (Thabit et al., 2024). Yet, systematic reviews state that organizational, managerial, and contextual factors, which are less prevalent in the literature, have a significant impact on the actual impact of these digital warnings (e.g. Kontaxi et al., 2025).

In addition, the evidence base suggests that the behavioural impacts of digital warning systems are contingent upon specific conditions and cannot be readily extended to other traffic settings or behaviour areas (Ratchaneepun et al., 2026; Cavka et al., 2025). Although system design and data processing studies offer important knowledge about the systems (Huo et al., 2024; Chen et al., 2013; Chai et al., 2024; Berhanu et al., 2024; Valente et al., 2024), they are less concerned with how organizational decision-making processes contribute to the design, data interpretation, and system application. The knowledge gap is particularly evident from the standpoint of the companies that offer and implement traffic safety services.

In particular, there is a scarcity of qualitative studies that have examined the perspectives of the developers and providers of digital warning systems regarding their contributions to traffic safety, the factors and considerations involved in the decision making and management, and the cooperation with researchers and policy makers. As a result, little is known about the actual issues, potential, and decision-making mechanisms with respect to the application and effectiveness of digital warning technologies in the real traffic environments, especially in urban areas.

3 Research

This paper addresses the research gap by applying an industry-focused qualitative case study design, investigating the case of Intermatic d.o.o., a private company that supplies digital traffic safety services. The addition of a managerial perspective from the top management level of the company is intended to enrich the existing body of behavioural and technical research with practice-oriented knowledge relevant to the fields of smart mobility and sustainable urban development.

We use a qualitative case study approach. The data for the study were collected through a semi-structured, in-depth interview comprised of twenty questions with the director of the company Intermatic d.o.o., Mr. Sašo Živković. Such a method allows for an in-depth understanding of the managers' views on the design, implementation and perceived behavioural impact of the digital warning messages as well as of the organizational and contextual variables that moderate the effectiveness of the messages.

The semi-structured interview is then analysed by thematic analysis to find out the themes associated with driver behaviour influence, data usage, difficulties of application and working with other external parties (e.g. academia and cities).

Based on the identified research gap and study objectives, the following research questions are proposed:

- RQ1: How does Intermatic d.o.o. conceptualize the role of digital warning systems in influencing driver behaviour and improving traffic safety?
- RQ2: What managerial and organizational factors influence the design and implementation of digital warning systems in urban traffic environments?

- RQ3: How are data collected through digital warning systems used to support traffic safety interventions and infrastructure improvement proposals?
- RQ4: What challenges and opportunities does Intermatic d.o.o. identify in deploying digital warning systems in cooperation with public authorities and academic partners?
- RQ5: How can industry-academia collaboration contribute to the effectiveness and innovation of digital traffic safety solutions?

4 Discussion and implications

By conducting this research, we contributed to the existing traffic safety literature by discussing digital warning system usage and its impact on driver behaviour from an industry, managerial point of view. Based on the qualitative case study of Intermatic d.o.o. and the in-depth interview with the company's director, the argument is organised around the five research questions.

The results reveal that Intermatic d.o.o. views digital warning systems (RQ1, according to answers to interview questions: 2-6) as tools to encourage safe driving rather than a tool for punishment. Digital warning systems are an integral part of the company's strategic orientation and are perceived as real-time feedback systems that increase drivers' awareness and encourage them to voluntarily reduce speed. This perspective is consistent with previous studies that identified self-regulation and awareness as dominant behavioural mechanisms underlying speed feedback displays (Neupane, 2025).

The interview results revealed that the drivers are more likely to respond to immediate and direct feedback, and especially to speed feedback displays. The context-dependent nature of behavioural responses was also identified, with more pronounced effects in sensitive areas (school zones and residential streets). This is in line with the literature that warns that the effects of warning systems may depend on location and traffic environment and cannot be generalised (Cavka et al., 2025; Ratchaneepun et al., 2026). Thus, the industry perspective also points to the need for a context-dependent deployment strategy as highlighted by the literature.

On the organizational level (RQ2, based on answers to interview questions: 1, 3, 7, 8, 13 and 14), the success of digital alerting systems is dependent not only on the technological solution, but also on the organizational competences and the implementation process. Intermatic d.o.o. points out project management, team integration, legislation and information towards the public as key factors for success. This answers to the part of the organizational dimension that was determined as still lacking (Kontaxi et al., 2025).

Practical implementation difficulties such as site restrictions, environmental impact, power supply, maintenance needs, and cost constraints highlight the difficulty of applying theoretically optimal solutions in the real world. The choice of the company to prefer the modular, proven, and commonly used solutions indicates a trade-off between technology and practicality. This result contributes to the literature by emphasizing the importance of managerial decision in the actual effectiveness of the ITS solutions.

The responses to the interview show that digital warning signs are primarily valued for their ability to collect data (RQ3, derived from interview questions 10-12). Specifically, Intermatic d.o.o. utilizes the collected data related to speed, traffic volume, and time of the day for a before-after analysis, analysis of the effectiveness of countermeasures, and evidence-based decision making, which is in line with research that emphasizes the importance of data-driven traffic management and infrastructure planning (Thabit et al., 2024).

The data, however, are not the goal in and of themselves, but are used as a means to justify a suite of other infrastructure changes, including enhanced signage and lighting, reconstructed crosswalks and permanent traffic calming infrastructure. This implementation of data responds to a literature where a lot of attention is paid to data analytics, but less to the translation of data meaning to operational and planning practices.

These findings stress the importance of collaboration (RQ4, answered by questions: 9, 15 and 20) and policy adherence in the implementation of digital alertness systems, since the existing legislations, data protection and municipality's support define the design and location of the system. Such boundaries are certainly a limitation, but may become a source of legitimacy, acceptability and sustainability.

This case study highlights the key lesson that stakeholder engagement from the outset is crucial, that behavioural changes may be overestimated and that monitoring and maintenance should be on going. This paper adds to the literature by highlighting that governance and institutional factors are as critical as the technical issues for the implementation of ITS for traffic safety.

Our results show that the collaboration between industry and academia (RQ5, through interview questions: 16-18) is a win-win model for innovation and knowledge sharing. Firstly, the company believes that the collaboration with academia (including student projects) brings data analysis, new ideas and challenging ideas to conventional wisdom. The students are especially expected to find out the blind spots and provide customer-focused or creative solutions.

Success in collaboration requires well defined goals, mutual advantages, availability of real data or pilot sites and free communication. All these are conducive to the goals of applied learning programs and the argument of universities as a partner to solve real world problems and hence expand the scope of discussion on sustainable university-industry relations.

In terms of practical implications, our study offers recommendations for policymakers, urban planners, and traffic safety professionals, indicating that a digital warning system should be embedded in the context of mobility policies, with a strong focus on prevention and evidence-based policies and collaborative partnerships between industry, academia, and community.

From a theoretical perspective, the study adds to the literature on traffic safety and intelligent transport systems from an organizational and management angle. By focusing on the industrial point of view, our study complements previous behavioural and technical studies and answers directly to the recent appeal for more qualitative, context-dependent research on traffic safety measures.

5 Conclusion

This paper investigated the use of digital warning systems as driver behaviour management tools based on industry case study of Intermatic d.o.o. and provided one of the first insights into the managerial and organizational dimensions of the use

of this technology that the relevant literature lacked. Our results indicate that digital warning systems are mainly conceived of as preventive, non-punitive, driver awareness and self-management aids rather than enforcement tools, and that their actual impact heavily depends on the contextual factors such as design, location and contextual embeddedness of the system in the local traffic setting.

The research emphasizes that implementation-related factors such as the existence of competencies within the organization, the cooperation between stakeholders, and the compliance with the legislation are important factors for the success of the projects. Another important aspect is the data that the digital alert systems generate, as they serve as an important tool for decision making for investment and infrastructure improvement on a justified basis and also for long-term planning for traffic safety. The interaction between industry and academia also contributes to innovation, as it gathers the knowledge of the people in the field together with the analytical and research-based approach.

In summary, our paper provides additional empirically grounded practical knowledge that adds to the current behavioural and technological science and can help with mainstreaming digital warning tools into smart mobility and sustainable urban planning contexts.

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PRIMER RAZVOJA KRITIČNEGA ODNOSA DO UMETNE INTELIGENCE PRI DIJAKIH

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Umetna inteligenca (UI) postaja del sodobnega izobraževalnega procesa, zato je poleg funkcionalne uporabe nujno razvijati tudi razumevanje njenih prednosti, omejitev ter tveganj. V okviru predmeta za spoznavanje strojne opreme računalnika je bila oblikovana projektna naloga, ki spodbuja odgovorno in reflektirano uporabo UI. Dijaki so delovali v manjših skupinah, pri čemer je vsaka skupina prejela svojo tematiko s področja računalniške strojne opreme. Na podlagi pripravljenih didaktičnih smernic so morali informacije najprej pridobiti s pomočjo UI, nato pa jih preveriti v različnih verodostojnih virih ter na koncu predstaviti razredu. Tak pristop je prispeval k razvoju več ključnih kompetenc: digitalne pismenosti, sodelovalnega učenja, samostojnega raziskovanja, razumevanja tehniških vsebin in predvsem kritične presoje informacij, ki izvirajo iz umetne inteligence.

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FOSTERING CRITICAL THINKING ABOUT ARTIFICIAL INTELLIGENCE IN SECONDARY EDUCATION

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Artificial intelligence (AI) is increasingly becoming an integral part of modern education. Beyond its functional use, it is essential to develop students' understanding of AI's advantages, limitations, and potential risks. In a computer hardware course, a project-based assignment was designed to promote responsible and reflective use of AI. Students worked in small groups, each assigned a specific topic within the domain of computer hardware. Following predefined didactic guidelines, students first gathered information using AI, then verified it through various reliable sources, and finally presented their findings to the class. This approach fostered the development of key competencies, including digital literacy, collaborative learning, independent research skills, understanding of technical content, and, most importantly, the critical evaluation of AI-generated information.



University of Maribor Press

1 Uvod

Umetna inteligenca (UI) v zadnjih letih vse bolj zaznamuje izobraževalni prostor in postopoma postaja del vsakdanjih učnih praks. Dijakom omogoča hiter dostop do informacij, podporo pri razlagi učnih vsebin ter pomoč pri oblikovanju odgovorov, kar lahko pomembno prispeva k učinkovitosti učenja (Holmes, Bialik & Fadel, 2019). Zaradi svoje dostopnosti, intuitivne uporabe in navidezne zanesljivosti pa UI hkrati odpira nova pedagoška vprašanja, povezana z razvojem kritičnega mišljenja, digitalne pismenosti in odgovorne rabe digitalnih orodij (OECD, 2021).

Čeprav so odgovori umetne inteligence pogosto tekoče in prepričljivo oblikovani, niso nujno vsebinsko pravilni ali resnični. UI deluje na podlagi statističnih vzorcev in verjetnostnih modelov, kar pomeni, da lahko generira tudi napačne ali zavajajoče informacije (Luckin et al., 2016). Prav samozavestna oblika odgovorov lahko pri mladostnikih vodi v nekritično sprejemanje ponujenih vsebin, še posebej v okoliščinah, ko preverjanje podatkov zahteva dodaten čas in miselni napor.

V sodobnem izobraževanju zato ni več dovolj, da učni proces spodbuja zgolj funkcionalno uporabo umetne inteligence. Evropske in mednarodne smernice poudarjajo potrebo po sistematičnem razvijanju kritičnega odnosa do UI, razumevanju njenih omejitev ter odgovorni rabi digitalnih informacij (European Commission, 2022; UNESCO, 2023). Šola ima pri tem ključno vlogo, saj lahko z ustrezno zasnovanimi učnimi dejavnostmi dijakom omogoči varno, vodeno in reflektirano uporabo teh tehnologij.

Prispevek predstavlja primer učne prakse, namenjene razvoju kritičnega odnosa do umetne inteligence pri dijakih. Skozi projektno nalogo, umeščeno v pouk s področja računalniške strojne opreme, je bila UI uporabljena kot izhodiščni vir informacij, ki so jih dijaki nato sistematično preverjali, vrednotili, kritično presojali in javno predstavljali. Pri oblikovanju projektne naloge smo uporabili Feynmanovo tehniko učenja (Feynman, Leighton & Sands, 1964), ki spodbuja razumevanje vsebin preko poenostavljene razlage in refleksije, kar krepi kritični odnos dijakov do informacij, pridobljenih z umetno inteligenco.

2 Teoretična izhodišča

2.1 Umetna inteligenca v izobraževanju

Umetna inteligenca (UI) v zadnjih letih vse izraziteje vstopa v izobraževalni prostor in spreminja načine poučevanja, učenja ter dostopa do znanja. Njena uporaba v izobraževanju zajema širok spekter dejavnosti, od personaliziranih učnih okolij in prilagojenih povratnih informacij do podpore pri razlagi učnih vsebin in reševanju nalog (Luckin idr., 2016; Holmes, Bialik in Fadel, 2019). Zaradi svoje dostopnosti in preproste uporabe UI postaja orodje, ki ga dijaki pogosto uporabljajo tudi samoiniciativno, zunaj formalnega učnega procesa.

Raziskave poudarjajo, da ima UI potencial izboljšati učinkovitost učenja, povečati motivacijo ter omogočiti bolj individualiziran pristop k pouku (Holmes idr., 2019). Vendar pa njeno delovanje temelji na statistični obdelavi velikih količin podatkov in ne na razumevanju vsebine v človeškem smislu. Posledično lahko UI generira odgovore, ki so jezikovno dovršeni in prepričljivi, vendar vsebinsko napačni, nepopolni ali zavajajoči (Luckin idr., 2016). Prav ta lastnost predstavlja poseben izziv v izobraževalnem kontekstu, kjer se znanje pogosto dojema kot nekaj objektivnega in zanesljivega.

Evropska komisija in OECD opozarjata, da nekritična raba umetne inteligence v izobraževanju lahko vodi v zmanjšano samostojnost učečih se ter v preveliko zanašanje na tehnologijo kot avtoritativni vir znanja (OECD, 2021; European Commission, 2022). Zato se v sodobnih pedagoških razpravah vse bolj poudarja potreba po premišljeni integraciji UI, ki temelji na jasnih didaktičnih ciljih in razvoju kritičnega odnosa do tehnologije, ne zgolj na njeni funkcionalni uporabi.

2.2 Kritično mišljenje in kognitivna lenost pri mladostnikih

Kritično mišljenje je ena temeljnih kompetenc sodobnega izobraževanja in vključuje sposobnost analize, vrednotenja, interpretacije ter utemeljevanja informacij (Facione, 1990). V digitalnem okolju se ta kompetenca razširja tudi na zmožnost presojanja verodostojnosti virov, preverjanja dejstev ter refleksije o načinu nastajanja in posredovanja informacij. Razvoj kritičnega mišljenja pri mladostnikih je še

posebej pomemben, saj se v tem obdobju oblikujejo trajne učne strategije in odnos do znanja.

Digitalne tehnologije, vključno z umetno inteligenco, lahko kritično mišljenje bodisi spodbujajo bodisi zavirajo. Carr (2010) opozarja, da stalna izpostavljenost hitro dostopnim informacijam in takojšnjim odgovorom zmanjšuje pripravljenost posameznikov za poglobljeno razmišljanje in daljšo kognitivno osredotočenost. Ta pojav, pogosto opisan kot kognitivna lenost, se kaže v težnji po izbiri najlažje in najhitreje poti do odgovora, brez preverjanja ali poglobljene obdelave informacij.

Uporaba umetne inteligence lahko ta pojav še okrepi, saj UI ponuja takojšnje in navidezno celostne odgovore, ki zmanjšujejo potrebo po lastnem razmišljanju in dvomu. Pri dijakih se to lahko izraža v nekritičnem sprejemanju podatkov, pomanjkljivem preverjanju virov ali nepreverjanju virov ter nezmožnosti prepoznati očitne napake ali nelogičnosti v besedilu. Facione (1990) poudarja, da kritično mišljenje ni spontana veščina, temveč zahteva sistematično razvijanje skozi usmerjene učne dejavnosti, ki spodbujajo vpraševanje, argumentacijo in refleksijo.

V tem kontekstu ima učitelj ključno vlogo, saj mora z ustreznimi didaktičnimi pristopi ustvarjati učna okolja, v katerih so dvom, preverjanje in razprava zaželeni in pričakovani. Umetna inteligenca lahko pri tem služi kot didaktično sredstvo za razkrivanje lastnih omejitev tehnologije, kar dijakom omogoča razvoj globljega razumevanja razmerja med tehnologijo in znanjem.

2.3 Digitalna pismenost in odgovorna raba umetne inteligence

Digitalna pismenost v sodobnem izobraževanju ne pomeni zgolj tehnične zmožnosti uporabe digitalnih orodij, temveč vključuje tudi kritično razumevanje digitalnih vsebin, etične razsežnosti rabe tehnologije ter zavedanje o njenih družbenih in izobraževalnih posledicah (OECD, 2021). V povezavi z umetno inteligenco digitalna pismenost pomeni razumevanje osnovnih principov njenega delovanja, zavedanje o možnostih napak ter sposobnost odgovorne in reflektirane uporabe.

Evropska komisija (2022) posebej poudarja, da morajo izobraževalne institucije dijake sistematično usposabljanje za kritično vrednotenje rezultatov, ki jih ponuja UI, ter za razumevanje, da ti rezultati niso nujno objektivni ali brez pristranskosti.

Odgovorna raba umetne inteligence v izobraževanju tako vključuje sposobnost razlikovanja med informacijami, ki so preverjene in utemeljene, ter tistimi, ki zahtevajo dodatno preverjanje ali kritično distanco.

Raziskave kažejo, da so projektno in raziskovalno usmerjene učne oblike posebej učinkovite pri razvoju digitalne pismenosti in kritične presoje (Holmes idr., 2019). Takšni pristopi dijakom omogočajo aktivno vlogo v učnem procesu ter jih spodbujajo k primerjanju virov, utemeljevanju sklepov in refleksiji o lastnem učenju. V tem okviru lahko umetna inteligenca postane orodje, ki spodbuja višje kognitivne procese, kot so analiza, sinteza in evalvacija, skladno z višjimi ravni Bloomove taksonomije.

Ključno pa je, da je uporaba umetne inteligence v pouku jasno strukturirana in didaktično vodena. Le tako lahko UI prispeva k razvoju odgovornega in kritičnega odnosa do digitalnih informacij ter podpira temeljni cilj izobraževanja – oblikovanje samostojnih, reflektiranih in kritično mislečih posameznikov.

3 Namen in cilji prispevka

Namen prispevka je predstaviti in analizirati primer učne prakse, v okviru katere je bila umetna inteligenca načrtno vključena v projektno učno nalogo kot izhodiščni vir informacij, ob hkratnem sistematičnem razvijanju kritičnega odnosa dijakov do UI-generiranih vsebin. Prispevek izhaja iz predpostavke, da lahko umetna inteligenca pomembno prispeva k učenju procesu, vendar le ob sočasnem razvoju digitalne pismenosti, kritičnega mišljenja in zavedanja o njenih omejitvah (OECD, 2021).

Cilji prispevka so:

- predstaviti didaktično zasnovano večfazno projektno nalogo s področja računalniške strojne opreme, v kateri je umetna inteligenca uporabljena kot začetni vir informacij,
- spodbuditi dijake k preverjanju, primerjanju in kritični presoji vsebin, pridobljenih z umetno inteligenco, v različnih verodostojnih virih,
- razvijati zavedanje o omejitvah, nezanesljivosti in možnih napakah umetne inteligence ter o pomenu odgovorne rabe digitalnih orodij (Luckin et al., 2016),

- krepi digitalno pismenost, sodelovalno učenje in samostojno raziskovanje
- skozi razdelitev vlog in odgovornosti znotraj skupin,
- spodbujati poglobljeno razumevanje tehniških vsebin z uporabo ponovne razlage in refleksije, skladno z načeli Feynmanove tehnike učenja,
- ovrednotiti učne učinke opisanega pristopa v konkretnem učnem okolju na
- podlagi opazovanj, izdelkov dijakov in preverjanja znanja.

Prispevek je usmerjen v kvalitativno analizo didaktičnega pristopa in ne v statistično posploševanje rezultatov, temveč v osvetlitev pedagoškega potenciala umetne inteligence pri razvijanju kritične presoje in odgovornega ravnanja z informacijami.

4 Metodologija

4.1 Učni kontekst in udeleženci

Primer učne prakse je bil izveden v okviru pouka predmeta s področja računalniške strojne opreme v srednješolskem izobraževanju. V dejavnosti je sodelovalo šest razredov dijakov drugih letnikov računalniške smeri srednjega strokovnega izobraževanja (SSI), ki so že imeli osnovno znanje o delovanju računalniških komponent ter predhodne izkušnje z uporabo digitalnih orodij, vključno z umetno inteligenco. Projektna naloga je bila izvedena v rednem učnem procesu in prilagojena časovnim ter vsebinskim omejitvam učnega načrta.

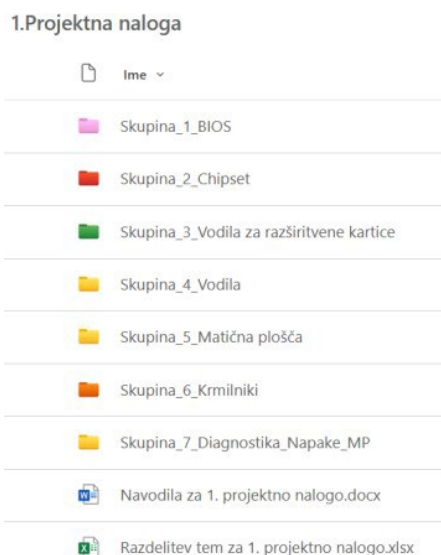
Dijaki so bili razdeljeni v manjše skupine po štiri ali tri osebe, kar je omogočalo sodelovalno učenje, izmenjavo mnenj ter skupno reševanje problemskih nalog. Skupinsko delo je hkrati ustvarjalo pogoje za razpravo o zanesljivosti informacij ter za oblikovanje utemeljenih sklepov na podlagi različnih virov.

4.2 Opis projektne naloge

Projektna naloga je bila zasnovana kot raziskovalno usmerjena dejavnost, pri kateri je umetna inteligenca predstavljala izhodiščni vir informacij. Vsaka skupina je prejela svojo tematiko s področja računalniške strojne opreme, pri čemer so bile tematike izbrane tako, da so omogočale preverjanje dejanskih tehničnih podatkov in primerjavo več virov. Čez celotno šolsko leto je izvedenih več projektnih nalog, za

ilustracijo je kot primer navedena tema o matični plošči računalnika. Vsaka skupina je dobila svojo temo in vsak iz skupine je dobil svojo podtemo in s tem tudi svojo odgovornost. Podteme so obsegale največ dve strani besedila iz učbenika, teme pa so bile določene z naključnim žrebanjem prek spletnega programa Wheel of Names (<https://wheelofnames.com/sl/>).

Prva faza – zbiranje gradiva: Dijaki so s pomočjo umetne inteligence pridobili osnovne informacije o dodeljeni podtemi. Nato so podatke sistematično preverili v verodostojnih virih, kot so učbenik Vzdrževanje informacijske strojne opreme (Šet, 2021), tehnična dokumentacija proizvajalcev in zanesljive spletne strani. Dodatno so poiskali kratek videoposnetek, ki je ponazarjal temo. Rezultat te faze je bil neurejen dokument v wordu, shranjen v aplikacijo MS Teams, ki je vseboval preverjene podatke, povezave do videov, vsaj štiri slike in štiri vprašanja v obliki kviza. Za izvedbo faze so imeli dijaki dve šolski uri.



Slika 1: Pregled razdeljenih tem po skupinah

Vir: Lasten

Druga faza – obdelava in predstavnost: Po zaključeni fazi zbiranja podatkov so dijaki v skupinah na kratko predstavili svojo podtemo ostalim članom skupine. Med predstavitvami so bila vprašanja sošolcev izrecno dovoljena in spodbujena, saj so

omogočala prepoznavanje in zapolnjevanje vrzeli v razumevanju obravnavane vsebine. Tak pristop temelji na Feynmanovi tehniki učenja, ki poudarja, da je za poglobljeno razumevanje treba snov poenostaviti, jo znati razložiti drugim ter se odzivati na vprašanja, ki razkrijejo nepopolno razumevanje (Feynman, Leighton & Sands, 1964; Feynman, 1997).

Na podlagi te skupinske razprave so dijaki pridobljene podatke nadalje predelali in jih pripravili v štirih različnih predstavitenih oblikah: urejen wordov dokument po določeni predlogi, PowerPoint predstavitev z dodanimi slikami, videi in animacijami, spletno stran s predstavitvami vseh podtem, avtorjev in kviza ter kviz v orodju

Kahoot in H5P. Naloge znotraj skupine so bile razdeljene tako, da je vsak dijak prevzel odgovornost za eno vrsto predstavitve, vodilni član skupine pa je skrbel za usklajenost gradiv, pregleden videz map v okolju MS Teams in pravočasno oddajo vseh prispevkov.

Tretja faza – predstavitev: Vsak dijak je predstavil svojo podtemo iz PowerPoint predstavitev pred razredom, medtem ko so ostali beležili ključne informacije. O morebitnih napačnih podatkih smo razpravljali in na koncu zapisali pravilno vsebino, s čimer se je povečala pozornost in angažiranost. Po predstavitvah so si ogledali spletno stran in odigrali kviz, kar je dodatno utrdilo znanje. Predstavitve so potekale več šolskih ur, zaključile pa so se s formalnim testom, ki je preverjal obvladovanje celotne snovi.

Četrta faza – zagovori: Po testu so dijaki zagovarjali svoje področje iz predstavitev. Vsaka naloga je bila ocenjena po vnaprej določenem kriteriju, pri čemer je zagovor prispeval k oceni posameznika.

4.3 Didaktične smernice in način uporabe umetne inteligence

Uporaba umetne inteligence je bila vnaprej jasno didaktično usmerjena. Dijakom so bile podane smernice, ki so poudarjale, da UI ni končni avtoritativni vir znanja, temveč orodje za začetno zbiranje informacij. Poseben poudarek je bil namenjen prepoznavanju morebitnih netočnosti, nedoslednosti ali poenostavitev v odgovorih UI ter preverjanju teh podatkov v neodvisnih virih.

Učitelj je v procesu nastopal kot mentor in usmerjevalec, ki je dijake spodbujal k refleksiji o zanesljivosti pridobljenih informacij ter k utemeljevanju svojih zaključkov. Dijaki so morali v svojih predstavitvah jasno ločiti med informacijami, pridobljenimi z uporabo umetne inteligence, in tistimi, ki so jih potrdili z dodatnimi viri. Na ta način je bila umetna inteligenca vključena v učni proces kot sredstvo za razvoj kritične presoje, ne pa kot nadomestilo za samostojno razmišljanje in preverjanje znanja.

5 Rezultati

Analiza dela dijakov je pokazala, da so v začetni fazi projektne naloge pogosto nekritično sprejemali informacije, pridobljene z uporabo umetne inteligence, pri čemer so zaupali predvsem prepričljivosti in jezikovni dovršenosti odgovorov. V več primerih so se pojavili vsebinsko netočni, nepopolni ali pretirano poenostavljeni podatki, ki jih dijaki sprva niso prepoznali kot problematične. Pri delu se je pokazala tudi težnja k poenostavljanju učnih nalog, saj so nekateri dijaki prevzeli zgolj UI-generirane vsebine brez sistematičnega preverjanja v dodatnih virih. Takšen pristop se je odrazil v nižji kakovosti predstavitev in kasneje tudi pri zagovorih, kar je posledično vodilo v nižje ocene zaradi neupoštevanja predhodno podanih navodil in večkratnih opozoril.

Ostali so z nadaljnjim preverjanjem virov postopoma razvijali večjo pozornost do natančnosti informacij ter večjo pripravljenost na dvom. Posebej izrazita je bila sprememba v načinu razmišljanja pri predstavitvah, kjer so dijaki začeli jasno razlikovati med informacijami, pridobljenimi z UI, in tistimi, ki so bile preverjene v dodatnih virih. Razlike pri upoštevanju ali neupoštevanju navodil za preverjanje verodostojnosti so bile pri izdelkih in predstavitvah zelo očitne.

6 Razprava

Ugotovitve potrjujejo ugotovitve drugih raziskav, da umetna inteligenca lahko spodbuja površinsko učenje, če je uporabljena nekritično (Carr, 2010), hkrati pa predstavlja pomembno priložnost za razvoj kritičnega mišljenja, kadar je vključena v jasno strukturiran učni proces (Holmes et al., 2019).

Projektna naloga je dijakom omogočila neposredno izkušnjo z omejitvami umetne inteligence, kar je prispevalo k razvoju reflektiranega odnosa do tehnologije. Takšen pristop je skladen s priporočili OECD (2021) in UNESCO (2023), ki poudarjajo pomen kritične in odgovorne rabe UI v izobraževanju.

Na podlagi pridobljenih izkušenj so bili rezultati v naslednji projektni nalogi opazno izboljšani.

7 Zaključek

Prispevek predstavlja primer dobre prakse vključevanja umetne inteligence v pouk, pri katerem UI ni zgolj orodje za pridobivanje informacij, temveč sredstvo za razvoj kritičnega mišljenja in digitalne pismenosti. Rezultati kažejo, da lahko dijaki ob ustreznem didaktičnem vodenju razvijejo zavedanje o omejitvah umetne inteligence ter odgovoren odnos do digitalnih virov.

Umetna inteligenca ima v izobraževanju velik potencial, vendar le, če je uporabljena premišljeno, reflektirano in v podporo temeljnim ciljem izobraževanja.

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EMAIL AS A COMMUNICATION CHANNEL IN HIGHER EDUCATION: RELEVANCE AND FREQUENCY IN THE HEI SELECTION PROCESS

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Email remains one of the most commonly used communication tools across various contexts, including higher education. This study examines the importance of email as a communication channel from the perspective of prospective students during their higher education institution (HEI) selection process, and compares it with other HEI-owned communication media. A survey was conducted among 181 Croatian students, and descriptive statistical analysis was applied to evaluate the frequency of use and perceived relevance of eight HEI communication channels. The findings show that email is among the least frequently used and least relevant channels, ranking significantly below HEI websites. This suggests that email functions primarily as a tool for direct contact rather than for information gathering. The study contributes to understanding the specific role of email relative to other HEI-owned channels and highlights the need for institutions to adapt their communication strategies to reflect how students actually seek and engage with information during the selection process.

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1 Introduction

Technology is like a "fast horse"—accelerating changes in behaviors and daily habits. As Henry Ford famously stated when building his car for the masses, "If I had asked people what they wanted, they would have said faster horses." Instead of giving customers what they thought they needed, he provided a simpler, more effective solution to their problem—a car. The automobile reshaped the way people live, and no one considers returning to less practical solutions like "faster horses." The same applies to digital technologies. People no longer use carrier pigeons to communicate; today, people rely on smartphones—one of the many gifts of scientific progress to humanity. Instead of slow methods of sending and receiving messages, people use SMS, email, and the Internet, enabling access to information almost instantly, precisely when it is needed.

Digital communication technologies, devices, and media have enabled the rapid growth of digital information consumption (Shukla and Pande, 2023), and have inevitably become an intrinsic part of humanity (Dwivedi et al., 2021). Large portions of the world's population have become users of such technologies, thanks to the availability of affordable smartphones and tablets (Shukla and Pande, 2023), to the extent that these digital channels have become a fundamental means of communication (Goic, Rojas and Saavedra, 2016). As predicted, by 2021, more than half of the global population—and over 80% in developed countries—were expected to be users of email as a form of digital media (Chaparro-Peláez, Hernández-García and Lorente-Páramo, 2022). As consumers, most users spend a significant amount of time online, with one of the primary purposes being to access various types of information, especially during the buying decision process (Faruk, Rahman and Hasan, 2021). It is evident that digitalization has reshaped the way information is conveyed and perceived by users (Rajkumar et al., 2022), and how it is used.

As society evolves due to technological advancements, so do businesses. Companies adapt to consumer needs, habits, and behaviors—not the other way around. The development of digital technologies is continuously and inevitably advancing (Goic et al., 2016), and accordingly, consumer habits are shifting as more time is spent on online activities and social media engagement (Tiago and Veríssimo, 2014). As consumers become increasingly active in digital environments, marketers must

adjust their strategies to align with these behaviors (Tiago and Veríssimo, 2014). This shift calls for the creation of new, interactive, targeted, and measurable approaches to reach consumers through emerging digital media (Fierro, Cardona Arbelaez and Gavilanez, 2017), prompting businesses to rely heavily on digital marketing to promote and sell their products and services (Faruk et al., 2021).

Why focus on email? According to Kusumawati (2018), the majority of students prefer online channels to retrieve information and communicate with HEI staff, as opposed to offline media. Recognizing these behavioral patterns in prospective students, HEIs face the challenge of finding new ways to communicate with them—highlighting that higher education institutions are not immune to the shifting communication habits of their target audiences (Martin, 2015). Hanna, Swain, and Smith (2016) state that email is the most widespread and frequently used communication tool—not only among the general public but also among marketers. However, it remains one of the least researched digital tools within the context of higher education (Shukla, Mistri and Japee, 2025), which is the focus of this paper.

The goal of this research is to determine the extent to which email functions as a relevant and effective communication channel for prospective students in gathering information and influencing their higher education institution selection process, compared to other communication channels owned by HEIs.

2 Literature review

In today's age, technological innovation in the digital sphere has significantly shaped consumer behavior, influencing how they interact with sellers and make purchase decisions, thanks to the adoption of handheld devices (Dwivedi et al., 2021). The inevitable reality of adopting digital technologies has compelled firms to use these technologies through the internet to connect with their customers, giving rise to digital marketing (Shukla et al., 2025). Digital marketing provides new avenues to reach, inform, and engage with customers (Faruk et al., 2021) through digital channels such as email, social media, websites, and online advertising (Antczak, 2024), engaging with consumers anytime and anywhere (Sherief, 2024). Another significant advantage of digital marketing is the ability to personalize communication according to the specific needs of target audiences (Purcărea, 2023). Additionally, digital marketing allows firms to reach global audiences through targeted advertising;

it is cost-effective, flexible, and facilitates engagement with customers (Shukla et al., 2025). Acknowledging its benefits, marketers are investing significant resources in digital marketing (Faruk et al., 2021) in order to remain competitive in the market. The relevance of digital marketing today makes it essential to consider it as a fundamental and unavoidable part of marketing (Faruk et al., 2021).

Higher education is no exception. The approach to promotion has shifted from printed brochures to social media and the web to attract prospective students' attention (Kusumawati, 2018). The reason for this shift is that prospective students today primarily rely on the internet to gather information about HEIs (Al-Qazzaz, 2024). Digital marketing facilitates students' access to comprehensive information about institutions and study programs (Shukla et al., 2025). Its interactivity and two-way communication allow easier and more effective access and engagement with prospective students (Purcărea, 2023).

Kusumawati (2018) identified that the preferred digital media for students when selecting an HEI are social media and university websites, and that mobile phones are the most frequently used devices for accessing information relevant to their choice. Other relevant sources of information include HEI websites, HEI planning and ranking sites, online reviews, college emails (Harahap et al., 2017), and internet searches (Purcărea, 2023; Shukla et al., 2025). Moogan (2020) agrees that the majority of prospective students are influenced by the information on websites, as HEI websites represent primary sources of information due to their perceived credibility as well as the thoroughness of the information presented (Al-Qazzaz, 2024), serving as central information hubs (Shukla et al., 2025). Social media is used both for information dissemination and for direct student engagement (Martin, 2015), and has been found to be the most effective means of communication for students (Moogan, 2020). Therefore, HEIs are increasingly relying on the most popular social networks not only for communication but also for promotional purposes (Camilleri, 2019). To communicate directly with prospective students, HEIs use direct marketing, and one of the tools is email (Koku, 2022). One way to achieve personalized communication is through targeted emails tailored to students' interests (Purcărea, 2023). Email marketing nurtures leads and provides updates through personalized content, interactive experiences, and real-time interactions (Shukla et al., 2025). Additionally, emails are one of the best ways to contact potential students (Moogan, 2011), as they are significantly influenced by personal email

correspondence with the HEI, which allows for speedy replies and interactive dialogue (Moogan, 2020).

But what is email? Email can be defined as a communication tool that enables the exchange of messages and information between two entities—for example, between individuals and organizations (Ginn, 2024). It is flexible and allows for the instant exchange of information over the internet globally (Pagliaro, 2019). For that reason, it is very popular and widely used across various industries (Dawkins, 2019; Derks and Bakker, 2010).

Email is popular for multiple reasons: it is an inexpensive way of sending messages, requires less preparation and execution time, enables faster responses, and provides the opportunity for interactive communication with customers (Zhang, Kumar and Cosguner, 2017).

It can be used to disseminate different categories of information, such as commercial and non-commercial messages (Hudak, Kianičková and Madleňák, 2017)—in other words, messages related to financial incentives (e.g., promotions) and those that are informational or relationship-focused (Thomas, Chen and Iacobucci, 2022). Email can be considered one of the most recent and reliable tools in e-commerce (Sabbagh, 2021) and is also the most commonly used form of direct marketing (Hudak et al., 2017). As a marketing tool, it remains one of the most effective methods for online promotion (Jeshurun, 2018), with the potential to retain existing customers and attract new ones (Nuseir et al., 2023).

Email is not only widely used, but it also has the potential to maximize user experience (Nuseir et al., 2023), particularly through its ability to deliver personalized messages (Goic et al., 2016). However, as previously noted, research on the effectiveness of email in influencing student decision-making is limited (Chauhan, 2022).

The research presented in this paper focuses on comparing the relevance and influence of communication channels owned by HEIs in students' decision-making, with particular emphasis on email. Table 1 provides a list of HEI-owned communication channels that will be examined for the purposes of this study.

Table 1: List of HEI-owned Communication Channels

HEI's website	Presentation in high schools
Open days	Posters and flyers in high schools
HEI's email	HEI's social media
HEI's phone	Google search

Source: Adapted from Marjanović, B. and Košara, D. (2025), "Assessing the Impact of Paid Media on Student Enrollment Decisions in Croatian Higher Education: A Comparative Analysis of Media Types", in Conference on Organizational Science Development: Human Being, Artificial Intelligence, and Organization, pp. 569–582.

The eight communication channels presented in Table 1 represent the primary tools owned and used by HEIs to communicate with their target audiences. Google Search is a unique case, as it cannot be strictly categorized as paid or earned media. It is included under owned media because it primarily serves as a gateway to content owned by HEIs, such as their websites or social media pages. However, it also provides access to paid content (e.g., sponsored links) and earned content (e.g., review sites or independent informational sources). Notably, four of the eight channels are online and internet-based, highlighting the growing significance of digital media in today's communication landscape.

3 Methodology

The study was conducted on a sample of 181 students from five higher education institutions located in Istria County and the city of Rijeka. The participants represented 12 different academic programs and came from 17 Croatian counties, along with three international students. The research examined the influence of eight HEI-owned communication channels, with particular emphasis on email, by evaluating their frequency of use, perceived relevance, and aggregated impact across the student population.

To measure the significance of these channels in the decision-making process, a Likert scale ranging from 0 to 5 was applied, where 0 indicated "not significant" and 5 indicated "extremely significant." Although the study was structured according to the stages of the decision-making process, the results from all phases were averaged and presented as a single value for the sake of simplicity.

A survey was used as the data collection tool, descriptive statistics were applied for data analysis, and Microsoft Excel was used to process the data and generate graphical representations of the findings.

4 Analysis

The analysis presents key calculations for HEI-owned media, including mean values, frequency of usage, and impact scores, which are relevant for drawing conclusions about the significance of media in formulating promotional strategies for HEIs. This is particularly important with an emphasis on email as a digital medium.

Table 2: Key Metrics of HEI-owned Media in the Decision-making Process

	Presentation in high schools	Posters and flyers in high schools	HEI's website	Open days	HEI's phone	Google search	HEI's social media	HEI's email
Mean	0,74	0,56	2,97	0,74	0,48	2,52	1,44	0,77
Count	45	38	132	43	29	115	73	43
Count (%)	24%	20%	72%	23%	16%	63%	40%	24%
Impact	0,18	0,11	2,15	0,17	0,08	1,58	0,57	0,18

Source: Own

Table 2 provides a summary of the significance and frequency of use of HEI-owned media. The HEI website is consistently rated as the most relevant, used, and influential source of information for prospective students when choosing a HEI. This is likely due to the comprehensive and centralized nature of the information it offers, making it a convenient one-stop source for key details about both the institution and its study programs. As the internet has become an integral part of daily life, online searches are often the first step people take when seeking information—since almost everything can now be found online.

Why do presentations in high schools, flyers, posters, and open days rank so low in importance and use? One possible explanation is that prospective students often already have a clear idea of what they want to study, and most of the information they need is readily accessible online.

Email appears to be the least relevant and used digital communication channel among students. This may be because email doesn't typically offer pre-packaged or easily accessible content; instead, prospective students must formulate specific queries to obtain the information they're looking for—usually only after they've exhausted other mass communication channels.

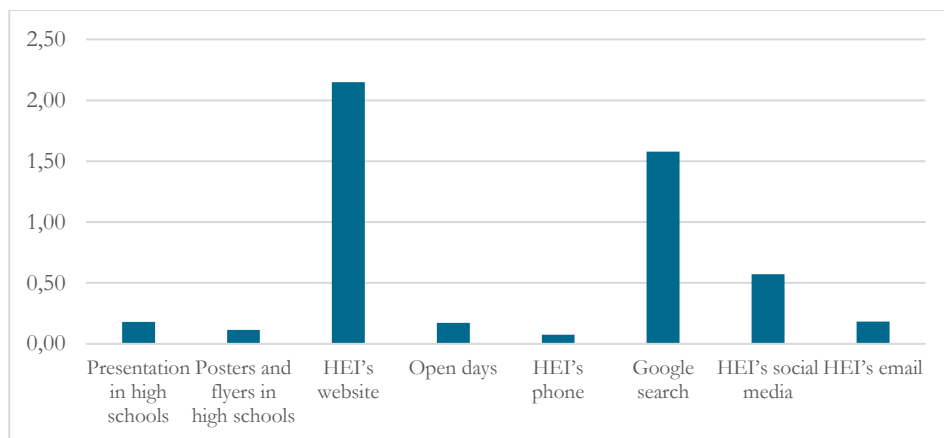


Chart 1: Graphical Representation of the Impact Score of HEI-owned Media in the Decision-making Process

Source: Own

Table 2 and Chart 1 present the impact scores of HEI-owned media. The impact score was calculated by multiplying the frequency of media use by the mean value. The mean value alone does not provide a complete picture of the relevance of a medium across the entire sample, as two media can have the same mean value while one is evaluated by only a few respondents and the other by the majority of the sample. This indicates that not all media have the same impact on the population of respondents, even when their mean values are identical.

Therefore, this score serves as a relevant indicator of which channels most effectively reach and influence the overall population of prospective students. It helps prioritize communication channels not only based on their perceived significance but also on their actual reach and influence on student decision-making. This approach provides a more comprehensive understanding of the real impact of each communication medium in the decision-making process.

The media impact highlights how the HEI website, internet search, and HEI social media stand out in terms of their relative impact across the entire sample. This indicates both their high relevance and frequent use compared to other channels. Other media, on the other hand, have a relatively low influence on students' choices.

Email, as the least impactful digital medium, shows a relatively low influence, comparable to other traditional media. This suggests that prospective students still prefer non-personal, easily accessible forms of communication over more direct or formal channels such as email.

These results provide a clear direction for shaping communication strategies, emphasizing the need to prioritize digital and indirect communication channels, which align with the growing preference for such media.

5 Discussion and conclusion

Despite being a relevant communication tool in general, email is underused in the context of HEI choice. The following discussion will shed light on this issue.

Importance of HEI-owned media in marketing communication: Prospective students are an online generation; they primarily rely on information that is available online (Al-Qazzaz, 2024). HEI websites, social networks, and internet searches dominate in terms of influence (Kusumawati, 2018). However, this analysis showed that email is not considered a highly influential communication channel. Even media such as presentations in high schools, which were once considered highly influential (Cai et al., 2015), now seem to pale in comparison to online media. The ability to access information on demand and the widespread use of online platforms (Shukla and Pande, 2023) likely contribute to the growing trend of students turning to digital resources first, while traditional media are viewed as secondary. Prospective students appear to regard online sources as not only more influential but also more relevant and trustworthy. This highlights the shift from more institution-controlled communication to more student-driven, easily accessible sources of information. It is also possible that online media are perceived as more authentic and reliable. This may not just be a matter of preference but a reflection of the evolving landscape in how prospective students engage with information.

Prospective students' preferences in communication: Prospective students clearly prefer online media, with the majority using these channels to gather information (Kusumawati, 2018). It seems that relatively few prospective students attend open days, school presentations, or take home flyers distributed during such events. Not many contact the HEI by phone for additional information, and even email—although it enables

direct contact with HEI staff—is not widely used. This may be because, although email connects prospective students to HEI staff, it still avoids real-time or face-to-face interaction. All of the most highly rated media are impersonal, involving no direct or live contact with HEI staff. Email also does not provide immediate access to information, as it requires a certain effort to initiate communication. Immediate access to information is what is primarily sought and preferred. This likely reflects a defining trait of the digital age: a preference for convenient, self-directed, and low-pressure information sources.

Email medium characteristics and usage. The analysis revealed that email is the least relevant and least utilized digital communication channel among students. This could suggest that email serves a different purpose compared to websites, internet searches, or school presentations. Each communication channel has a specific function, providing different types of information. For example, websites are tailored to provide large volumes of information continuously (Sicilia and Ruiz, 2010), whereas email is more suitable for direct inquiries and specific requests (Antczak, 2024; Koku, 2022). Information transmitted through email is not as visible or readily accessible as the information available on a website, which is constantly present and accessible. Email, like telephone communication, may primarily be used for direct interaction (Ginn, 2024) during the decision-making process rather than for promotional purposes, as seen with school presentations, open days, or flyers. Websites, on the other hand, are likely used to gather detailed technical information about study programs and other relevant details about the HEI.

It can be concluded that although prospective students prefer digital media, email remains an underused medium. While email is a valuable tool for personalized communication, its role in influencing prospective students' decisions is secondary to more immediate and accessible digital resources, such as websites and internet searches.

5.1 Scientific and practical implications

Scientific implications: The study highlights the significant role and impact of digital media in communication between HEIs and prospective students in today's digital age, particularly in relation the decision-making process in choosing an HEI. It also reveals the underutilization of email as a communication channel and its limited influence on prospective students.

Practical implications: The outcomes of this analysis can assist HEIs in shaping strategies that focus on more impactful media, such as HEI websites, internet presence, and social media. It also emphasizes the need to rethink the use of email, reassess its purpose, and enhance its effectiveness in line with prospective students' communication preferences. HEIs should evaluate the role of email, either as a marketing tool or an information-sharing channel, and adapt its usage based on prospective students' preferences for communication.

5.2 Limitations and suggestions for future research

Limitations: The sample size of 181 participants, with the research localized to the areas of Istria and Rijeka, limits the generalizability of the findings. Additionally, the number of institutions and study programs included in the study was limited. The research did not delve into the specifics of email usage—whether it was used as a marketing tool, a communication medium, or both.

Suggestions for future research: Future studies should explore how email is used, specifically whether it serves as a marketing tool or a communication medium, and investigate its impact on decision-making in accordance with its usage. Additionally, it would be valuable to explore why email is underused and identify strategies to increase the effectiveness of email as a communication channel.

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USTVARJANJE ZNANJA ZA TRAJNOSTNI RAZVOJ VISOKOŠOLSKIH USTANOV

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Izobraževanje za trajnostni razvoj predstavlja enega izmed globalnih ciljev iz Agende Združenih narodov do leta 2030 ter vsebuje pridobivanje novih znanj in veščin. Management znanja pomeni ustvarjanje, pridobivanje, deljenje, hranjenje in uporabo znanja. V slovenskem visokošolskem prostoru ne obstaja teoretična ali empirična raziskava, v kateri bi avtorji celovito povezovali institucionalno transformacijo, ustvarjanje znanja in trajnostne prakse. Namen našega prispevka bo predstaviti ugotovitve iz pregleda dosedanjih 35 raziskav o treh navedenih konceptualnih dimenzijah, ki so prisotne v globalnem visokošolskem prostoru. Pregled smo opravili v javno dostopnih bazah podatkov s pomočjo metodologije PRIZMA. Izidi iz naše raziskave bodo imeli teoretične in praktične implikacije za managersko znanost ter stroko in bodo spodbujali snovanje nacionalne raziskovalne ter izobraževalne politike in strategije.

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CREATING KNOWLEDGE FOR THE SUSTAINABLE DEVELOPMENT OF HIGHER EDUCATION INSTITUTIONS

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The Education for sustainable development is one of the global goals of the United Nations Agenda for 2030 and involves the acquisition of new knowledge and skills. Knowledge management means creating, acquiring, sharing, storing, and using knowledge. In Slovenian higher education, there is no theoretical or empirical research in which authors comprehensively link institutional transformation, knowledge creation, and sustainable practices. The purpose of our contribution is to present the findings from a review of 35 studies on the three conceptual dimensions mentioned above, which are present in the global higher education sector. We conducted the review in publicly accessible databases using the PRIZMA methodology. The results of our research will have theoretical and practical implications for management science and practice and will encourage the development of national research and education policies and strategies.



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1 Uvod

Izobraževanje za trajnostni razvoj (Education for Sustainable Development – ESD) predstavlja konceptualni in normativni okvir, s pomočjo katerega se poudarja vloga izobraževanja pri soočanju s kompleksnimi gospodarskimi, družbenimi in okoljskimi izzivi v sodobnem svetu. ESD presega tradicionalno razumevanje izobraževanja kot prenosa znanja in se osredinja na razvoj kompetenc, vrednot in sposobnosti kritičnega razmišljanja, ki posameznikom omogočajo aktivno sodelovanje pri oblikovanju trajnostne prihodnosti (UNESCO 2017, 7). ESD je tesno povezan s cilji trajnostnega razvoja (Sustainable Development Goals – SDGs), ki jih je leta 2015 sprejela Organizacija združenih narodov kot globalni razvojni okvir do leta 2030. Znotraj tega okvira ima izobraževanje posebno vlogo, saj je hkrati samostojen cilj (SDG 4) in prečni dejavnik, ki podpira uresničevanje vseh ostalih ciljev trajnostnega razvoja. Visokošolske institucije so prepoznane kot ključni akterji pri razvoju znanja, raziskovanja in inovacij, ki prispevajo k uresničevanju SDGs na lokalni, nacionalni, regionalni in globalni ravni (UN 2015).

ESD v visokošolskem prostoru vključuje tako vsebinske kot procesne razsežnosti. Na vsebinski ravni se nanaša na vključevanje trajnostnih vsebin v študijske programe, raziskovalne projekte in institucionalne strategije. Na procesni ravni pa poudarja participativne, reflektivne in interdisciplinarne pristope k učenju in poučevanju, ki spodbujajo aktivno vlogo udeležencev in omogočajo soustvarjanje znanja (Wals 2014, 9–11). Udejanjanje ESD v visokošolskih institucijah je tesno povezano z organizacijskimi praksami in kulturo ustanov. Implementacija trajnostnih načel ni omejena zgolj na pedagoški proces, temveč vključuje tudi načine vodenja, odločanja, sodelovanja in ustvarjanja znanja znotraj organizacije (Lozano et al. 2013). ESD deluje kot katalizator sprememb, ki vplivajo na širše delovanje visokošolskih institucij in njihovo razumevanje družbene odgovornosti.

Kljub normativni moči koncepta ESD številne raziskave opozarjajo na razkorak med deklarativno zavezanostjo trajnostnemu razvoju in dejanskimi praksami v visokošolskem prostoru. Trajnosten razvoj je obravnavan kot dopolnilo obstoječim strukturam, ne pa kot transformativni proces, ki bi zahteval spremembe v načinu ustvarjanja znanja, poučevanja in delovanja organizacije (Sterling 2011, 21–24). To odpira vprašanja o tem, kako se ESD udejanja v praksi ter kakšno vlogo imajo pri tem procesi ustvarjanja znanja.

Raziskovanje ESD v povezavi z ustvarjanjem znanja tako omogoča poglobljen vpogled v to, kako se trajnostni cilji prepletajo z izobraževalnimi in organizacijskimi praksami visokošolskih institucij ter kako institucionalni pogoji vplivajo na njihovo udejanjanje v praksi. Ustvarjanje znanja v visokošolskem prostoru je neločljivo povezano z ekosistemom, v katerem delujejo. Univerze in druge visokošolske ustanove delujejo kot kompleksne organizacije, v katerih se pedagoške in raziskovalne dejavnosti prepletajo z organizacijskimi strukturami, kulturo in vrednotami. Tsoukas (2009, 1) ustvarjanje znanja opredeljuje kot proces, ki je močno odvisen od institucionalnih pogojev, kot so stopnja sodelovanja, odprtost za inovacije, podpora refleksiji ter možnosti za interdisciplinarno delo.

Z vidika trajnostnega razvoja ima ustvarjanje znanja dodatno razsežnost, saj zahteva preseganje disciplinarnih meja ter vključevanje različnih vidikov. Trajnostni izzivi so po svoji naravi kompleksni in večdimenzionalni, kar pomeni, da njihovo razumevanje in obravnavo temeljita na integraciji znanja z različnih področij ter na sodelovalnih in refleksivnih oblikah učenja in raziskovanja. Wals in Blewitt (2010, 56) opozarjata, da kljub številnim zavezam in deklaracijam o trajnosti v visokošolskem izobraževanju ni prišlo do temeljnega premisleka o poučevanju in učenju, kar kaže na razkorak med normativnimi usmeritvami in dejanskimi institucionalnimi praksami. Ustvarjanje znanja za trajnostni razvoj zato vključuje tudi izrazito vrednotno in normativno dimenzijo, povezano z vprašanji družbene odgovornosti, etike in dolgoročnih posledic izobraževalnih ter organizacijskih praks. Ustvarjanje znanja je proces, ki presega prenos obstoječega znanja in vključuje aktivno soustvarjanje pomenov skozi interakcije, skupno razreševanje problemov in kritično obravnavo obstoječih praks, kar izhaja iz konceptualnega okvira dinamičnega ustvarjanja znanja v organizacijah (Nonaka, Toyama in Konno 2000).

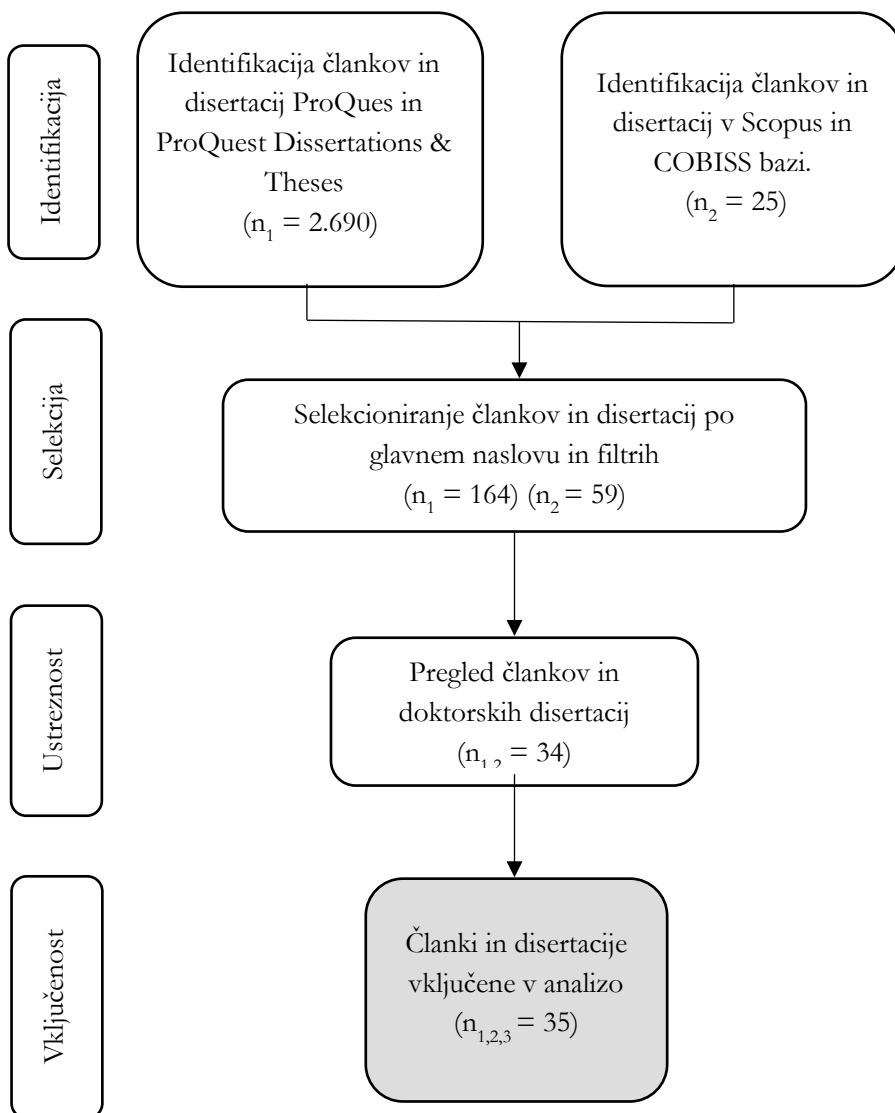
Takšno razumevanje ustvarjanja znanja presega tradicionalne pojme poučevanja in učenja ter poudarja procesno in kontekstualno naravo znanja. V visokošolskem izobraževanju se ustvarjanje znanja kaže tako v raziskovalnih dejavnostih kot tudi v pedagoških praksah, kjer študenti niso zgolj pasivni prejemniki znanja, temveč aktivni soustvarjalci pomenov. Takšen pristop je skladen z razumevanjem visokošolskih institucij kot učečih se organizacij, v katerih se znanje nenehno razvija skozi izmenjavo izkušenj, refleksijo in skupno učenje.

V slovenskem visokošolskem prostoru ne obstaja teoretična ali empirična raziskava, v kateri bi avtorji celovito povezovali institucionalno transformacijo, ustvarjanje znanja in trajnostne prakse. Namen našega prispevka bo predstaviti ugotovitve iz pregleda dosedanjih 35 raziskav o treh navedenih konceptualnih dimenzijah, ki so prisotne v globalnem visokošolskem prostoru.

2 Metodologija

Primarno iskanje znanstvenih člankov je bilo izvedeno v podatkovni bazi ProQuest, z uporabo naslednjega iskalnega niza: (“education for sustainable development” OR ESD OR “sustainable development education”) AND (“knowledge creation” OR “knowledge management” OR “organizational learning”) AND (“higher education” OR university). Iskanje v znanstvenih revijah (scholarly journals) je sprva identificiralo 1.292 zapisov. Po uporabi časovnega filtra (2021–2025), jezikovnega filtra (angleški jezik) in zahteve po dostopu do celotnega besedila se je število zadetkov zmanjšalo na 684, po dodatnem vsebinskem filtru higher education pa na 164 zapisov, ki so bili vključeni v fazo pregleda naslovov in povzetkov. Na podlagi vsebinske ustreznosti je bilo v nadaljnjo presojo celotnih besedil vključenih 25 znanstvenih člankov. Dopolnilno je bilo izvedeno še usmerjeno iskanje v podatkovni bazi Scopus, ki je identificiralo 21 dodatnih zapisov, od katerih sta bila po vsebinski presoji v končno analizo vključena dva znanstvena članka, ki v prvotnem iskanju nista bila zajeta. Skupno je bilo tako v kvalitativno analizo vključenih 27 znanstvenih člankov. Poleg znanstvenih člankov je bil izveden tudi ločen pregled doktorskih disertacij, z namenom poglobitve razumevanja institucionalnih in znanje-ustvarjalnih razsežnosti izobraževanja za trajnostni razvoj v visokošolskem prostoru. Primarno iskanje je potekalo v podatkovni bazi ProQuest Dissertations & Theses, z uporabo enakega vsebinskega iskalnega niza. Začetno iskanje je identificiralo 1.399 zapisov, ki so se po uporabi časovnega filtra (2021–2025) zmanjšali na 477, po vsebinskem filtru higher education na 67, ter po omejitvi na angleški jezik na 59 zapisov. Na podlagi pregleda naslovov in povzetkov je bilo v nadaljnjo analizo vključenih šest doktorskih disertacij. Dopolnilno iskanje je bilo izvedeno tudi v sistemu COBISS, kjer so bile identificirane štiri doktorske disertacije, od katerih je bila po vsebinski presoji ena ocenjena kot ustrezna in vključena v analizo. Poleg tega je bila na podlagi vsebinske relevantnosti v končni nabor dodatno vključena še doktorska disertacija Košmerl (2024), ki izpolnjuje vse vključitvene kriterije, vendar ni bila zajeta z avtomatiziranim iskanjem. Skupno je bilo tako v končno analizo

vklučenih 8 doktorskih disertacij, ki so bile obravnavane kot dopolnilni vir (siva literatura). Postopek selekcije znanstvenih člankov in doktorskih disertacij je prikazan v PRISMA diagramu (Slika 1).



Slika 1: Postopek selekcije člankov in disertacij

Vir: Lasten

3 Rezultati

Tabela 1: Pregled literature

Št.	Avtor(ji), leto	Metodologija	Glavne ugotovitve
1	Wilkinson, Wilber T., 2025	Mešani metodi (anketa in 6 intervjujev).	Trajnostna transformacija temelji na kulturi zaupanja, sodelovanja in refleksije. Ključni dejavniki so učenje, komunikacija in razvoj kompetenc.
2	Weber, R. C., 2025	Mešani metodi (anketa in 8 intervjujev).	Vodje poudarjajo empatijo, refleksijo in prožnost kot temelj trajnosti. Kultura sodelovanja krepi organizacijsko učenje.
3	Sagan, M. A., 2025	Kvalitativna (študija primera in intervjuji).	Voditeljstvo temelji na psihološki varnosti in participaciji. Učenje in refleksija sta gonilo inovacij.
4	Hou, V., 2025	Mešana (anketa in intervjuji).	Ključne kompetence so: odpornost, jasnost, etika in povezovanje. Holistični pristop omogoča trajno voditeljstvo in kulturo zaupanja.
5	Arriaza, J., 2025	Kvalitativna (intervjuji).	Pandemija je spremenila paradigmo vodenja: empatija, fleksibilnost, zaupanje. Voditelji gradijo kulturo učenja in digitalne povezanosti.
6	Lear, Denean Y., 2025	Kvalitativna (intervjuji z vodji podjetij).	Voditelji MSP gradijo trajnost z znanjem, mreženjem in razvojem kompetenc. Ključne zmožnosti: človeški, družbeni in finančni kapital.
7	Palmer, Chase Kip, 2025	Kvalitativna (intervjuji z vodji in deležniki).	Adaptivno voditeljstvo krepi sodelovanje in komunikacijo. Vključenost udeležencev izboljšuje odločanje in skupno odgovornost.
8	Košmerl, T., 2024	Mešana (anketiranje in polstrukturirani intervjuji).	V slovenskih organizacijah izvajajo izobraževalne prakse avtonomno. Prevladujejo emancipatorni, participativni didaktični pristopi.
9	Schaap, L. idr., 2025	Pregled literature (91 člankov).	Inovativna zmogljivost je odvisna od voditeljstva, organizacijske kulture in učeče se skupnosti. Družbeni kapital je ključni dejavnik trajnostne spremembe.
10	Mardani, A. idr., 2017	Pregled literature (171 člankov).	SEM omogoča integracijo okoljskih, organizacijskih in vedenjskih dejavnikov v enoten model.
11	Faisal, S., 2023	Pregled literature (31 empiričnih raziskav).	Ključni dejavniki: zeleno zaposlovanje, usposabljanje, nagrajevanje, vodenje in kultura. Sposobnosti, motivacija in priložnosti vodijo k zelenemu vedenju.
12	Semenets-Orlova, I. idr., 2023	Pregled literature.	Voditeljstvo in skupno učenje sta ključna za odpornost in trajnost izobraževalnih institucij v kriznih razmerah.
13	Grabara, J., Hussain, H. I. in Szajt, M., 2020	Kvantitativna (vprašalnik).	Delovno okolje deluje kot moderator, ki krepi učinek inovacij na trajnost univerze.

Št.	Avtor(ji), leto	Metodologija	Glavne ugotovitve
14	Abon, J. K. in Jean-Francois, E., 2023	Kvalitativna (intervju).	Internacionalizacija kurikulumov zahteva učiteljsko iniciativo, refleksijo in vključevanje študentov za sooblikovanje učnih vsebin.
15	Rusok, N. H. M., Samy, N. K. in Bhaumik, A., 2023	Kvantitativna (vprašalnik, n = 366)	Krepitev stalnega učenja, dialoga in voditeljstva spodbuja inovativnost in organizacijsko odpornost v VŠ.
16	Alharbi, H. S. idr., 2025	Kvantitativna (vprašalnik, n = 81).	Zavedanje je edini pomemben napovednik trajnostnega vedenja. Študenti višjih letnikov izkazujejo višjo stopnjo ozaveščenosti o trajnosti.
17	Villena-Martínez, D. idr., 2024	Kvantitativna (vprašalnik, n = 206).	Empatija ni povezana s poklicnim statusom, delovno dobo ali krajem poučevanja, kar nakazuje, da gre za univerzalno kompetenco.
18	Ochoa-Jiménez, S. idr., 2021	Kvantitativna (vprašalnik, n = 492).	Management znanja ima močan pozitiven učinek na inovacije. Inovacije pozitivno vplivajo na trajnost.
19	Mohammadi, Y. idr., 2023	Mešana, pregled 2.532 študij in vprašalnik (n = 289).	Voditeljstvo in kultura univerze močno vplivata na trajnostno izobraževanje, ki krepi znanje, stališča in zavezanost študentov.
20	MuhammedZein, F. A., in Abdullateef, S. T., 2025	Mešane metode, eksperiment.	Zeleni pedagoški pristopi (projektno, participativno in refleksivno učenje) povečujejo znanje, veščine in vrednote študentov o trajnosti.
21	Emere, C. E., Aigbavboa, C. O. in Oguntola, O. A., 2025	Kvantitativna (vprašalnik, n = 281).	Najpomembnejši dejavniki so mentorstvo mladim strokovnjakom in ozaveščenost o okoljskih vprašanjih.
22	Nusraningrum, D. idr., 2024	Kvantitativna (vprašalnik, n = 180).	E-učenje vpliva na zeleno inovativnost in zeleno tehnologijo. Zelena inovacija in tehnologija povezuje e-učenje in zelene menedžerske prakse.
23	Al-Hazaima, H. idr., 2025	Kvantitativna (vprašalnik, n = 375).	Socialne inovacije imajo največjo relativno pomembnost, sledijo UI, digitalna pismenost, ugled institucije pa najmanj.
24	Asif, M.; Yang, L. in Hashim, M., 2024	Kvantitativna (vprašalnik, n = 350).	Digitalna transformacija, kultura in transformacijsko voditeljstvo pozitivno vplivajo na trajnostno uspešnost podjetij.
25	Schaap, L. idr., 2025	Pregled literature (91 člankov).	(1) Inovacijska zmogljivost VŠO vsebuje: voditeljstvo, kulturo, človeški, socialni, strukturni kapital, mrežno učenje, poslanstvo in vizija.
26	Chigbu, B. I. in Makapela, S. L., 2025	Pregled literature (179 člankov).	Povezava med analitiko, SDG-ji in transformacijskim vodenjem ustvarja trajnostni model upravljanja v izobraževanju.
27	Romero-Ochoa, M.-A. idr., 2025	Pregled literature (1.087 člankov).	Digitalne kompetence in odprte izobraževalne prakse spodbujajo inovativno poučevanje.
28	Adhikari, D. R. in Shrestha, P., 2022	Kvalitativna (fokusne	VŠO še niso sistematično vključile managementa znanja v strategije za doseganje SDG 4.7.

Št.	Avtor(ji), leto	Metodologija	Glavne ugotovitve
		skupine, n = 170).	
29	Raudeliunienė, J. in Matar, I., 2022	Kvantitativna (vprašalnik, n = 201).	Vsi procesi MZ so pozitivno in pomembno povezani; najmočnejša povezava je med deljenjem znanja in uporabo znanja.
30	Lenziardi, R. idr., 2025	Pregled literature (13 člankov).	Vrednote (empatija, odgovornost, pravičnost, kulturna občutljivost) so temelj trajnostne pedagogike.
31	Bač, A. idr., 2025	Kvantitativna (analiza 346 dipl. / mag. nalog).	V 40 % analiziranih nalog se omenja trajnostne prioritete, medtem ko so v projekte vselej vključene trajnostne vsebine.
32	Müller, U. idr., 2025	Kvalitativna (intervjuji, n = 55 vodij).	Vodje izobraževalnih organizacij se zavedajo pomena ESD, a se soočajo z omejenimi sredstvi, strukturnimi ovirami in nizkim zanimanjem javnosti.
33	Shahawati Binti Umar idr., 2025	Kvantitativna (vprašalnik, n = 152).	Vzdušje za spremembe in procesi sprememb pomembno vplivajo na znanje in voditeljstvo.
34	Bafon, J. N. idr., 2025	Kvantitativna (vprašalnik, n = 287).	Razvoj digitalnih kompetenc ima najmočnejši vpliv na ESD. Pomanjkanje digitalne infrastrukture in znanja omejuje učinkovitost ESD.
35	Tafese, M. B. in Kopp, E., 2025	Pregled literature (1.013 člankov).	Raziskave dajejo prednost okoljski in gospodarski trajnosti, medtem ko je družbena dimenzija podraziskana, kar ustvarja neravnovesje.

Legenda:

ESD - Education for Sustainable Development

MSP – Majhna in srednja podjetja

MZ – Management znanja

SDG - Sustainable Development Goals

SEM – Structural Equation Modeling

VŠO – Visokošolska organizacija

Vir: Lasten

V naši študiji smo izbrali in upoštevali 27 znanstvenih člankov, predstavljenih v tabeli 1. Poleg tega smo upoštevali tudi osem doktorskih disertacij. Znanstveni članki, vključeni v našo študijo, so iz obdobja med letoma 2017 in 2025, pri čemer 81 % med njimi dejansko izhaja iz obdobja med letoma 2020 in 2025. Doktorske disertacije, upoštevane v naši študiji, so bile objavljene med letoma 2024 in 2025. 23 člankov oz. 85 % vseh člankov je bilo objavljenih v znanstvenih revijah s faktorjem vpliva v kvartilnih skupinah Q1 ali Q2 (IF = 0,4-1,9); dva članka oz. 7,5 % sta bila objavljena v znanstveni reviji s faktorjem vpliva v kvartilni skupini Q4 (IF = 0,19), medtem ko sta bila dva članka oz. 7,5 % vseh člankov objavljena v revijah brez faktorja vpliva.

Med avtorji, vključenimi v našo študijo, jih je 32 oz. 91 % obravnavalo tematike oz. vsebine po navedenih konceptualnih dimenzijah (institucionalno transformacijo, ustvarjanje znanja in trajnostne prakse). Konceptualne dimenzije niso monolitne entitete, ampak skupni konstrukti *organizacijskih sprememb* (npr. inoviranja, kulture organizacije, urejanja zadev in odločanja, stilov in načinov vodenja, HRM ipd.), *managementa znanja* (ustvarjanja, pridobivanja, deljenja, prenosa, uporabe in shranjevanja) in *trajnostnega razvoja* (gospodarskega, družbenega in naravnega ekosistema). Avtorji v obravnavanih raziskovalnih študijah niso poudarili le splošne ugotovitve o treh navedenih konceptualnih dimenzijah, temveč so navedli tudi proučevana načela managementa znanja (izmenjave in deljenja), ne pa tudi preostalih načel (ustvarjanja, pridobivanja, uporabe in shranjevanja) **Tabela 2.**

4 Diskusija

Namen našega prispevka je bil predstaviti ugotovitve iz pregleda 35 raziskav o naslednjih konstruktih obvladovanja organizacije: *institucionalni transformaciji, managementu znanja in trajnostnega razvoja.*, ki so prisotni v globalnem visokošolskem prostoru. Z izvedbo sistematičnega pregleda strokovne literature in doktorskih disertacij smo naš namen tudi dosegli, ker smo na podlagi 15 virov pojasnili povezavo med institucionalno transformacijo, managementom znanja in trajnostnim razvojem.

Na podlagi analize in sinteze naslovov, ključnih besed in vsebine raziskav povzamemo, da se institucionalna transformacija odraža v celovitih spremembah na različnih področjih, kot so npr. učeča se organizacija, digitalizacija, ravnanje z ljudmi (HRM), inoviranje, podjetništvo, raznolikost, strategije, vodenje in organizacijska kultura. Management znanja vsebuje procese ustvarjanja, pridobivanja, deljenja, prenosa, uporabe in shranjevanja. Management znanja je povezan s pedagoškimi procesi tudi z izobraževanjem, usposabljanjem in učenjem. Trajnostni razvoj obsega gospodarski, družbeni in okoljski vidik, zeleni prehod ter uspešnost organizacije. Ugotovili smo, da v nobeni izmed analiziranih raziskav na področju managementa znanja se avtorji niso ukvarjali s procesom ustvarjanja znanja. Opravljeni sta bili zgolj dve empirični raziskavi, v katerih sta avtorja proučevala deljenje (Emere, Aigbavboa, & Oguntona, 2025) in izmenjavo (Abon & Jean-Francois, 2022) znanj. Identificiran raziskovalni problem je v tem, da obstaja vrzel o ustvarjanju znanja v globalnem visokošolskem prostoru.

Ob raziskovanju izbranih konstruktov za obvladovanje organizacij (gospodarskih družb in drugih ustanov) smo se soočali z vsebinskimi in metodološkimi omejitvami. Vsebinske omejitve so nam predstavljale ključne besede, institucionalna transformacija, management znanja in trajnostni razvoj, ki smo jih subjektivno izbrali. Zaradi velikega števila zadetkov v bazah podatkov smo ključne vsebine s pomočjo filtrov skrčili te teme, ki se povezujejo s procesi ustvarjanja znanja in na visokošolske institucije.

Raziskovanje bi bilo mogoče nadgraditi na različne načine tako vsebinsko kot tudi metodološko. Ker je večina raziskav kvantitativnih (50 %), predlagamo v nadaljnjih raziskavah uporabo mešanih (23 %) ali kvalitativnih (27 %) znanstvenoraziskovalnih metod, s pomočjo katerih bi bolj celovito in poglobljeno analizirali obravnavano tematiko.

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SISTEMATIČNE REŠITVE ZA ZAGOTAVLJANJE KOMPETENTNEGA KADRA NA PODROČJU KIBERNETSKE VARNOSTI: ANALIZA DOBRIH PRAKS V IZBRANIH DRŽAVAH

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Pomanjkanje strokovnjakov za kibernetsko in informacijsko varnost predstavlja enega ključnih izzivov digitalne preobrazbe, skladnosti z zakonodajo in izboljšanja nacionalne odpornosti. Prispevek predstavlja pripravljalno študijo za doktorsko raziskavo, katere cilj je razviti konceptualni model za zmanjšanje vrzeli med visokim šolstvom in potrebami gospodarstva na področju kibernetske varnosti v Sloveniji. Izhodišče so rezultati preliminarne raziskave na vzorcu 235 slovenskih organizacij, ki je pokazala izrazite kompetenčne vrzeli, strukturne ovire pri razvoju kadrov ter vpliv zakonodaje (NIS2, ZInfV-1) na organizacijske in kadrovske ukrepe. Za umestitev ugotovitev v širši kontekst je izvedena primerjalna analiza Estonije, Finske, Nizozemske, Irske in Kanade. Rezultati potrjujejo kadrovske primanjkljaje v analiziranih državah ter izpostavljajo dobre prakse, kot so nacionalni kompetenčni centri, modeliranje potreb in sistematično spremljanje trga dela. Primerjalna analiza omogoča identifikacijo ključnih elementov, ki lahko služijo kot podlaga za oblikovanje slovenskega modela. Prispevek predstavlja prvi korak k razvoju podatkovno podprtega pristopa za krepitev razpoložljivega kompetentnega kadra v Sloveniji.

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SYSTEMATIC SOLUTIONS FOR ENSURING A COMPETENT CYBERSECURITY WORKFORCE: A COMPARATIVE ANALYSIS OF BEST PRACTICES IN SELECTED COUNTRIES

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Keywords:

competences,
cybersecurity,
information security,
skills gap,
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workforce development

The shortage of cyber security and information security professionals is a key challenge of digital transformation, regulatory compliance, and national resilience. This paper presents a preparatory study for a doctoral research project aimed at developing a conceptual model to reduce the gap between higher education and labour market needs in cyber security in Slovenia. It builds on findings from a preliminary survey of 235 Slovenian organisations, revealing significant competence gaps, structural barriers to workforce development, and the impact of legislation (NIS2, ZInfv-1) on organisational and HR measures. To place the findings in a broader context, a comparative analysis of Estonia, Finland, the Netherlands, Ireland, and Canada was conducted. The results confirm workforce shortages across the analysed countries and highlight good practices such as national competence centres, needs modelling, and systematic labour market monitoring. The paper represents a first step toward a data-driven approach to strengthening cyber security competences in Slovenia.



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1 Uvod

Kibernetska varnost predstavlja eno temeljnih področij sodobne informacijske družbe, saj je neposredno povezana z zanesljivim delovanjem organizacij, varstvom podatkov in zagotavljanjem neprekinjenega poslovanja. Digitalna preobrazba, povečana odvisnost od informacijskih sistemov ter vse bolj kompleksne kibernetske grožnje so v zadnjih letih bistveno povečale potrebo po ustrezno usposobljenem kadru na področju informacijske in kibernetske varnosti. Hkrati številne države in organizacije poročajo o izrazitem pomanjkanju strokovnjakov, kar postaja velika ovira pri doseganju strateških ciljev na področju varnosti in digitalnega razvoja.

Pomanjkanje strokovnega kadra na področju informacijske in kibernetske varnosti ni zgolj posledica tehnološkega napredka, temveč odraža širše strukturno neskladje med izobraževalnimi sistemi, potrebami trga dela in regulatornimi zahtevami. Uveljavljanje novih zakonodajnih okvirov, kot je direktiva NIS2, dodatno povečuje zahteve glede razpoložljivosti ustreznih kompetenc, saj od organizacij zahteva višjo stopnjo formalizacije procesov, jasno razmejene odgovornosti ter strokovno podporo pri obvladovanju kibernetskih tveganj. V tem kontekstu se vprašanje razvoja kibernetskih kompetenc vse pogostejše umešča v širši okvir nacionalne varnosti, odpornosti kritične infrastrukture in dolgoročne konkurenčnosti gospodarstva.

Mednarodne raziskave in poročila kažejo, da je pomanjkanje strokovnjakov za kibernetsko in informacijsko varnost razširjen pojav, ki presega posamezne nacionalne kontekste. Kljub podobnim izzivom se države razlikujejo v načinu, kako sistematično pristopajo k razvoju in zagotavljanju ustreznega kadra. Nekatere so vzpostavile nacionalne strategije in institucionalne mehanizme za spremljanje ter načrtovanje potreb po kompetencah, druge pa problem obravnavajo predvsem z delnimi ali kratkoročnimi ukrepi, ki ne naslavlajo temeljnih vzrokov kadrovskih vrzeli.

Namen prispevka je analizirati sistematične pristope in dobre prakse, s katerimi izbrane države naslavlajo pomanjkanje kompetentnega kadra na področju kibernetske varnosti. Primerjalna analiza vključuje Estonijo, Finsko, Nizozemsko in Irsko kot predstavnice evropskega prostora ter Kanado kot primer širšega mednarodnega okolja. Izbor držav temelji na razpoložljivosti relevantnih

nacionalnih dokumentov, razvitih politik razvoja kompetenc ter obstoju institucionalnih rešitev, namenjenih usklajevanju izobraževanja, trga dela in varnostnih zahtev.

2 Teoretična izhodišča

Znanstvena literatura navaja, da ne bo dovolj ustrezno usposobljenih ljudi na področju informacijske in kibernetske varnosti, kar kaže na sistemski problem, ki vpliva ne le na nekaj organizacij, temveč na celoten gospodarski sistem, javno upravo in nacionalno varnost. Nekateri raziskovalci to pojasnjujejo kot kvantitativno pomanjkanje specialistov, medtem ko drugi opozarjajo na kompetenčno pomanjkanje, saj razkorak v znanju in veščinah presega zgolj kvantitativno pomanjkanje kadrov na področju kibernetske varnosti (German Blažič, 2021; Dupont et al., 2023). Sistematična narava problema se odraža tudi v mednarodnih pregledih (ISC2, 2024), ki poudarjajo večmilijonsko pomanjkanje strokovnjakov na področju kibernetske varnosti po vsem svetu in priznava, da se to kljub številnim pobudam in prizadevanjem ne zmanjšuje, temveč se z digitalizacijo, porastom kibernetskih napadov in zaostrovanjem zakonodaje celo stopnjuje. S tem se potrjuje hipoteza, da pomanjkanje strokovnjakov na področju kibernetske varnosti ni zgolj začasno neravnovesje na trgu dela, temveč predstavlja strukturno in dolgoročno stanje, ki zahteva sistemske in trajnostne rešitve. Literatura, ki obravnava strukturo in vsebino kibernetskih kompetenc, pomembno teoretično prispeva k razumevanju tega vprašanja. Sistematični pregledi literature opozarjajo, da kompetenčna vrzel ne zajema zgolj tehničnih znanj, temveč tudi širše dimenzije, kot so obvladovanje tveganj, upravljanje varnosti, zagotavljanje skladnosti z regulativo ter obvladovanje organizacijske kompleksnosti (Nkongolo et al., 2023).

Takšna širša konceptualizacija predstavlja ključno izhodišče za celovito razumevanje kompetenc, ki presegajo ozko osredotočenost na tehnično usposabljanje. Literatura izpostavlja tudi omejitve tradicionalnih pedagoških pristopov. Hitrost tehnološkega razvoja in dinamika znanja nakazujeta, da formalno izobraževanje samo ne more zagotavljati dolgoročne ustreznosti kadrov. Zato je vse bolj poudarjen pomen vseživljenjskega učenja, prekvalifikacij ter tesnejšega povezovanja izobraževalnih ustanov, gospodarstva in države v okviru kontinuiranega razvoja kompetenc (German Blažič, 2021; ENISA, 2020).

3 Konceptualni analitični okvir nacionalnega sistema razvoja kibernetских kompetenc

Za namen primerjalne analize nacionalnih pristopov k razvoju kibernetских kompetenc je bil zasnovan konceptualni analitični okvir, ki omogoča strukturirano, pregledno in primerljivo obravnavo izbranih držav. Okvir ne predstavlja normativnega modela, temveč analitično orodje, ki temelji na sintezi znanstvene literature in analizi nacionalnih strateških dokumentov ter poročil s področja razvoja kibernetских znanj in kadrov (Jerma Blažič, 2021; ENISA, 2020; Dupont et al., 2023; ISC2, 2024).

Izhodišče za oblikovanje analitičnega okvira je ugotovitev, da se nacionalni sistemi razvoja kibernetских kompetenc med državami razlikujejo ne le po obsegu vlaganj ali številu izobraževalnih programov, temveč predvsem po načinu institucionalne ureditve, mehanizmih razvoja znanj, stopnji povezovanja s trgom dela ter zrelosti pristopov k spremljanju in dolgoročnemu načrtovanju kadrovskih potreb. Na podlagi pregleda literature in dokumentov je bilo zato identificiranih pet ključnih dimenzij, ki skupaj zajemajo temeljne strukturne značilnosti nacionalnih pristopov.

Prva dimenzija je **institucionalni okvir**, ki se nanaša na razdelitev odgovornosti, koordinacijske mehanizme in stopnjo centralizacije sistema razvoja kibernetских kompetenc. Druga dimenzija vključuje **mehanizme razvoja in nadgradnje kompetenc**, kot so formalno izobraževanje, neformalno usposabljanje, prekvalifikacije in vseživljenjsko učenje. Tretja dimenzija se nanaša na **povezavo med izobraževalnim sistemom in trgom dela** ter stopnjo vključenosti delodajalcev v oblikovanje in izvajanje izobraževalnih poti. Četrta dimenzija obravnava **spremljanje in načrtovanje kadrovskih potreb**, torej uporabo podatkov, analiz in (potencialno) napovednih mehanizmov za razumevanje sedanjih in prihodnjih potreb. Peta dimenzija se nanaša na **dolgoročno vzdržnost sistema**, zlasti na vpetost razvoja kibernetских kompetenc v širše nacionalne strategije, stabilnost financiranja in kontinuiteto politik.

Razširjeni analitični okvir, ki povezuje navedene dimenzije s sistemskim, nacionalnim in organizacijskim vidikom, je povzet v Tabeli 1. V nadaljevanju je ta okvir uporabljen kot osnovno orodje za primerjalno analizo izbranih držav v 4.

poglavju, kjer posamezne dimenzije služijo kot struktura za sistematično in vsebinsko primerljivo obravnavo nacionalnih pristopov.

Tabela 1: Razširjen analitični okvir primerjalne analize nacionalnih pristopov

Analična dimenzija	Sistemsko-nacionalni vidik	Organizacijski vidik	Teoretična podlaga
Institucionalni okvir	Koordinacija politik, nosilci odgovornosti, stabilnost sistema	Preglednost okolja, dostop do podpornih struktur	Jerman Blažič (2021); Dupont et al. (2023)
Mehanizmi razvoja kompetenc	Nacionalni programi, usposabljanja, preusposabljanja	Razpoložljivost in nadgradnja znanj zaposlenih	Nkongolo et al. (2023); ENISA (2020)
Povezava izobraževanja in trga dela	Partnerstva, prilagajanje izobraževalnih programov	Ustreznost znanj kadra	Jerman Blažič (2021)
Spremljanje in načrtovanje potreb	Analize trga dela, napovedni mehanizmi	Zmanjšanje kadrovskih tveganj	Dupont et al. (2023); ISC2 (2024)
Dolgoročna vzdržnost	Vključitev v strategije, stabilno financiranje	Stabilnost kadrovskega okolja	ENISA (2020)

Vir: lasten

4 Primerjalna analiza izbranih držav

Primerjalna analiza nacionalnih pristopov k razvoju kompetentne delovne sile na področju informacijske in kibernetske varnosti temelji na analitičnem okviru, predstavljenem v prejšnjem poglavju. Namen analize ni podati opisni prikaz posameznih nacionalnih ureditev, temveč identificirati ključne razlike in skupne značilnosti med državami glede sistemske organizacije razvoja kibernetskih kompetenc ter njihovih učinkov na organizacije in kadrovske sisteme. Analiza vključuje primere iz Estonije, Finske, Nizozemske, Irske in Kanade, ki predstavljajo različne modele institucionalnih ureditev, ravni vključenosti deležnikov in pristope k razvoju in upravljanju kibernetskih kompetenc.

4.1 Institucionalni okvir razvoja kibernetskih kompetenc

Institucionalni okvir predstavlja temelj nacionalnega sistema razvoja kibernetskih kompetenc, saj določa razdelitev odgovornosti, mehanizme koordinacije med ključnimi akterji ter stabilnost podpornega okolja za organizacije. Znanstvena literatura poudarja, da imajo države z jasno opredeljenimi institucionalnimi vlogami

in učinkovitimi koordinacijskimi strukturami večjo sposobnost dolgoročnega in sistematičnega naslavljanja kadrovskih ter kompetenčnih vrzeli na področju kibernetске varnosti (Jerman Blažič, 2021; Dupont et al., 2023).

Primerjalna analiza nacionalnih dokumentov kaže, da analizirane države uporabljajo tri osnovne tipe institucionalnih ureditev: (1) bolj centraliziran in državno koordiniran model, (2) medresorski ali partnerski model ter (3) hibridni model, ki združuje nacionalne in sektorske ravni. Estonija predstavlja primer izrazito centraliziranega pristopa, v katerem ima država močno koordinacijsko vlogo, razvoj kompetenc pa umešča v širši okvir nacionalne kibernetске odpornosti (Estonian Cyber Security Strategy, 2024; Estonia Cybersecurity Skills Needs Analysis, 2023). Finska uporablja medresorski model, kjer so odgovornosti razdeljene med več državnih organov, poudarek pa je na dolgoročnem usklajevanju in skupnem strateškem okviru (Finland's Cyber Security Strategy, 2024).

Nizozemska in Irska temeljita predvsem na partnerskih in sektorsko usmerjenih institucionalnih ureditvah, v katerih ima pomembno vlogo sodelovanje med državo, industrijo ter izobraževalno-raziskovalnimi institucijami. V nizozemskem primeru je razvoj kompetenc organiziran prek javno-zasebnih partnerstev in mrežnih struktur (Security Delta, 2023), medtem ko je na Irskem poudarek na razvoju kibernetskega ekosistema in vlogi industrijskih pobud pri usklajevanju potreb trga dela in izobraževanja (State of the Cyber Security Sector in Ireland, 2022). Kanada predstavlja hibridni model, kjer nacionalni strateški okvir dopolnjujejo sektorski in regionalni pristopi, kar povečuje raznolikost podpornih mehanizmov in kompleksnost institucionalnega okolja (Cybersecurity Skills Canada, 2023).

Kljub razlikam v stopnji centralizacije in organizaciji institucionalnih ureditev primerjalna analiza kaže, da so uspešnejši in vzdržnejši tisti sistemi, ki zagotavljajo jasno razmejene odgovornosti, stabilne koordinacijske mehanizme in dolgoročno kontinuiteto politik. Takšni institucionalni okviri organizacijam omogočajo bolj predvidljivo okolje za načrtovanje razvoja kadrov ter zmanjšujejo tveganja, povezana s pomanjkanjem ključnih znanj. Povzetek ključnih značilnosti institucionalnih ureditev v izbranih državah je prikazan v Tabeli 2.

Tabela 2: Institucionalni okvir razvoja kibernetских kompetenc v izbranih državah

Država	Stopnja centralizacije	Ključni nosilci	Tip institucionalnega pristopa
Estonija	Visoka	Državne in varnostne institucije	Centraliziran
Finska	Srednja	Več resorjev	Medresorski
Nizozemska	Nizka	Javno-zasebna partnerstva	Mrežni
Irska	Srednja	Industrijski in državni akterji	Sektorski
Kanada	Nizka–srednja	Zvezni, sektorski in regionalni akterji	Hibridni

Vir: lasten

4.2 Mehanizmi razvoja in nadgradnje kibernetских kompetenc

Mehanizmi razvoja in nadgradnje kompetenc so osrednji operativni element nacionalnih sistemov za zagotavljanje ustrezno usposobljenega kadra na področju informacijske in kibernetiske varnosti. Medtem ko institucionalni okvir določa organizacijo in odgovornosti, ti mehanizmi neposredno vplivajo na to, kako hitro in učinkovito se znanja razvijajo, posodablajo in prilagajajo potrebam organizacij (Nkongolo et al., 2023; ENISA, 2020).

Primerjalna analiza nacionalnih dokumentov kaže, da kljub skupnemu cilju zmanjševanja kompetenčnih vrzeli obstajajo pomembne razlike v organizaciji razvoja znanj. Na podlagi analiziranih primerov je mogoče identificirati tri prevladujoče tipe pristopov k razvoju kibernetских kompetenc: (1) državno koordiniran in formaliziran model, (2) model, ki temelji na vseživljenjskem učenju in stalni nadgradnji znanj, ter (3) tržno-partnerski model, ki poudarja prilagodljive, modularne in industrijsko usmerjene oblike usposabljanja.

Estonija predstavlja primer prvega tipa, kjer ima država močno vlogo pri usmerjanju razvoja znanj, formalno izobraževanje, specializirana usposabljanja in ciljno usmerjeni programi pa so vključeni v nacionalno usklajen okvir (Estonia Cybersecurity Skills Needs Analysis, 2023). Finska se bolj približuje drugemu tipu, saj nacionalna strategija izrecno poudarja koncept vseživljenjskega učenja, stalno posodabljanje znanj in prilagodljivost izobraževalnih poti (Finland's Cyber Security Strategy, 2024). Nizozemska, Irska in Kanada v večji meri sledijo tretjemu tipu pristopa, kjer razvoj kompetenc temelji na sodelovanju med državo, industrijo in izobraževalnimi institucijami, z izrazitim poudarkom na modularnih programih,

certifikacijah in ciljno usmerjenih usposabljanjih (Security Delta, 2023; State of the Cyber Security Sector in Ireland, 2022; Cybersecurity Skills Canada, 2023).

Ne glede na izbrani model primerjalna analiza kaže, da so uspešnejši sistemi, ki združujejo več različnih učnih poti in omogočajo fleksibilen prehod med formalnim izobraževanjem, dodatnim usposabljanjem in prekvalifikacijami. Takšni pristopi organizacijam omogočajo hitrejšo prilagajanje novim zahtevam področja kibernetske varnosti in zmanjšujejo njihovo odvisnost od izključno dolgoročnih izobraževalnih ciklov. Povzetek ključnih značilnosti mehanizmov razvoja kompetenc v izbranih državah je prikazan v Tabeli 3.

Tabela 3: Mehanizmi razvoja in nadgradnje kibernetskih kompetenc v izbranih državah

Država	Prevladujoči mehanizmi	Vloga države	Organizacijski učinki
Estonija	Formalno izobraževanje, ciljno usmerjena usposabljanja	Visoka	Stabilna baza znanj
Finska	Vseživljenjsko učenje, stalna nadgradnja	Srednja–visoka	Aktualna znanja zaposlenih
Nizozemska	Modularni programi, industrijsko sodelovanje	Srednja	Hitro prilagajanje potrebam
Irska	Certifikacije, industrijska usposabljanja	Srednja	Hiter odziv trga
Kanada	Formalno izobraževanje, preusposabljanje	Raznolika	Širša kadrovska baza

Vir: lasten

4.3 Povezava izobraževalnega sistema in trga dela

Eden ključnih strukturnih vzrokov za pomanjkanje kadra na področju kibernetske varnosti ni zgolj obseg izobraževalnih programov, temveč predvsem razkorak med znanji, ki jih izobraževalni sistem zagotavlja, in dejanskimi potrebami organizacij (Jerman Blažič, 2021; ENISA, 2020). Primerjalna analiza nacionalnih dokumentov zato posebno pozornost namenja mehanizmu, s katerimi države poskušajo sistematično povezovati izobraževanje in trg dela.

Analiza kaže, da vse obravnavane države prepoznavajo vključevanje delodajalcev kot ključen element zmanjševanja tega razkoraka, vendar se bistveno razlikujejo v stopnji formalizacije in institucionalne vpetosti teh mehanizmov. V bolj strukturiranih modelih, kot je estonski, so delodajalci vključeni v oblikovanje učnih izidov, razvoj programov in izvajanje praktičnega usposabljanja v okviru nacionalno

koordiniranega sistema (Estonia Cybersecurity Skills Needs Analysis, 2023). Podobno, vendar v bolj partnerski obliki, Nizozemska in Irska razvijata sodelovanje med izobraževalnimi institucijami in industrijo prek sektorskih pobud in mrežnih struktur (Security Delta, 2023; State of the Cyber Security Sector in Ireland, 2022). V drugih primerih, zlasti v Kanadi, je povezovanje izobraževanja in trga dela bolj razpršeno in poteka prek kombinacije nacionalnih, sektorskih in regionalnih pobud, kar povečuje prilagodljivost sistema, hkrati pa zmanjšuje njegovo preglednost in enotnost (Cybersecurity Skills Canada, 2023). Finska se v tem kontekstu osredotoča predvsem na prožnost izobraževalnih poti in koncept vseživljenjskega učenja, s katerim poskuša omogočiti hitrejšo prilagajanje znanj spreminjajočim se potrebam trga dela (Finland's Cyber Security Strategy, 2024).

Skupna značilnost večine analiziranih pristopov je premik od togih, dolgoročnih izobraževalnih programov k bolj modularnim in prilagodljivim oblikam usposabljanja, ki omogočajo hitrejšo zapolnjevanje specifičnih vrzeli v znanjih. Primerjalna sinteza dokumentov kaže, da bolj formalizirani in sistemsko vpeti mehanizmi sodelovanja med izobraževalnim sistemom in gospodarstvom prispevajo k večji usklajenosti med ponudbo znanj in potrebami organizacij ter zmanjšujejo obseg dodatnega usposabljanja, ki ga morajo organizacije zagotavljati po zaposlitvi. Ključni poudarki nacionalnih pristopov so povzeti v Tabeli 4.

Tabela 4: Ključni poudarki nacionalnih dokumentov glede povezave izobraževanja in trga dela

Vidik povezovanja	Povzetek ugotovitev iz dokumentov	Primeri virov
Vloga delodajalcev	Soustvarjanje programov, praktično usposabljanje	Estonia Cybersecurity Skills Needs Analysis (2023); Security Delta (2023); Cybersecurity Skills Canada (2023)
Prilagodljivost poti	Modularni programi, vseživljenjsko učenje	Finnish Government (2024); Cybersecurity Skills Canada (2023)
Sektorski pristopi	Industrijska združenja, partnerske mreže	State of the Cyber Security Sector in Ireland (2022)
Sistemske	Centralizirani in razpršeni modeli	Estonia Cybersecurity Skills Needs Analysis (2023); Cybersecurity Skills Canada (2023)

Vir: lasten

4.4 Spremljanje in načrtovanje kadrovskih potreb

Spremljanje in načrtovanje kadrovskih potreb predstavlja ključen element sistemskega upravljanja kompetenc na področju informacijske in kibernetske varnosti. Medtem ko razvoj izobraževalnih mehanizmov in mehanizmov za usposabljanje naslavlja obstoječe vrzeli, spremljanje potreb omogoča razumevanje dinamike trga dela in predstavlja osnovo za pravočasno prilagajanje politik, programov in organizacijskih praks. Literatura s področja upravljanja kompetenc poudarja, da brez sistematične informacijske podlage nacionalni pristopi ostajajo pretežno reaktivni in omejeni na odzivanje na že zaznane pomanjkljivosti (Jeran Blažič, 2021; ENISA, 2020).

V tem poglavju je spremljanje in načrtovanje kadrovskih potreb analizirano na podlagi nacionalnih strategij in poročil, s poudarkom na mehanizmi zbiranja, analize in uporabe podatkov o potrebah po kibernetskih kompetencah. Analiza se ne osredotoča na obseg primanjkljaja kadra, temveč na vprašanje, ali in kako dokumenti opredeljujejo sistematične pristope k razumevanju sedanjih in prihodnjih potreb trga dela.

Analizirani dokumenti večinoma izpostavljajo uporabo analiz trga dela in poročil o kompetenčnih vrzelih kot osnovni vir informacij za oblikovanje politik. Ta poročila praviloma temeljijo na kombinaciji statističnih podatkov, anket med delodajalci in strokovnih ocen, pri čemer je poudarek predvsem na identifikaciji trenutnega stanja in zaznanih pomanjkljivosti (Estonia Cybersecurity Skills Needs Analysis, 2023; Cybersecurity Skills Canada, 2023). Takšen pristop omogoča razmeroma dobro razumevanje obstoječih potreb, vendar dokumenti le redko navajajo uporabo formaliziranih napovednih modelov za dolgoročno načrtovanje.

Nekateri dokumenti poleg splošnih analiz trga dela omenjajo tudi sektorske ali tematske ocene potreb, ki omogočajo bolj ciljno usmerjen vpogled v posamezne dele kibernetskega ekosistema. Sektorska poročila poudarjajo pomen sodelovanja z industrijo in strokovnimi združenji pri prepoznavanju specifičnih znanj, ki so v določenem obdobju najbolj iskana (State of the Cyber Security Sector in Ireland, 2022). Ti pristopi izboljšujejo relevantnost podatkov, vendar so pogosto omejeni na posamezne sektorje in niso nujno povezani v celovit nacionalni sistem spremljanja.

V nacionalnih strategijah so zaznana prizadevanja za bolj kontinuirano spremljanje potreb po kibernetiskih kompetencah, vendar so ti mehanizmi večinoma opisani le na konceptualni ravni. Strategije poudarjajo pomen podatkovno podprtih odločitev in rednega spremljanja trga dela, vendar redkeje navajajo konkretne metodologije, odgovorne institucije ali formalizirane procese napovedovanja prihodnjih potreb (Finnish Government, 2024; Security Delta, 2023). To kaže na razkorak med deklarativnimi cilji in operativno implementacijo sistematičnega načrtovanja kadrovskih potreb.

Pomembna ugotovitev analize je tudi razlika med bolj centraliziranimi in razpršenimi pristopi k spremljanju potreb. V nekaterih dokumentih je spremljanje kadrovskih potreb umeščeno v nacionalne analitične ali koordinacijske strukture, drugod pa je razpršeno med več institucij, sektorjev ali regij (Cybersecurity Skills Canada, 2023). Razpršeni pristopi povečujejo fleksibilnost in prilagodljivost, vendar otežujejo primerljivost podatkov in dolgoročno usklajevanje politik na nacionalni ravni.

Primerjalna sinteza analiziranih dokumentov kaže, da je spremljanje in načrtovanje kadrovskih potreb na področju kibernetске varnosti v večini primerov še vedno pretežno usmerjeno v opis trenutnega stanja. Čeprav dokumenti pogosto prepoznavajo pomen dolgoročnega načrtovanja in napovedovanja prihodnjih potreb, so konkretni mehanizmi za sistematično izvajanje teh nalog redko natančno opredeljeni. Posledično nacionalni sistemi razvoja kompetenc ostajajo v veliki meri reaktivni.

Za organizacije to pomeni omejeno predvidljivost kadrovskega okolja in večjo odvisnost od lastnih mehanizmov spremljanja potreb ter razvoja kompetenc. Z vidika systemskega upravljanja kompetenc se kot ključni izziv izkazuje prehod od občasnih analiz in poročil h kontinuiranemu, podatkovno podprtemu spremljanju in načrtovanju, ki bi omogočalo bolj usklajene in dolgoročno vzdržne pristope k razvoju kibernetiskega kadra.

4.5 Dolgoročna vzdržnost nacionalnih pristopov k razvoju kibernetских kompetenc

Ko govorimo o pomanjkanju strokovnjakov na področju informacijske in kibernetске varnosti, hitro postane jasno, da posamezni ukrepi ne morejo prinesiti trajnih rešitev. Novi študijski programi ali kratkoročna usposabljanja lahko začasno ublažijo najbolj pereče težave, vendar sami po sebi ne spremenijo dejstva, da gre za dolgoročen in strukturni izziv. Da bi imeli takšni ukrepi trajen učinek, morajo biti del širšega, stabilnega in prilagodljivega sistema, ki zna spremljati spremembe v okolju in se nanje pravočasno odzivati (Jermań Blažič, 2021; ENISA, 2020).

Pri pregledu nacionalnih dokumentov izbranih držav se pokaže, da dolgoročna vzdržnost ne temelji na eni sami rešitvi, temveč na kombinaciji več med seboj povezanih elementov. Med najpomembnejšimi so predvsem kontinuiteta institucij, sistematično spremljanje potreb ter sposobnost povezovanja različnih politik in deležnikov v bolj usklajeno celoto. Države, ki razvoj kibernetских znanj umeščajo v širše strategije digitalnega in družbenega razvoja, s tem praviloma gradijo stabilnejši okvir, ki ne razpade ob koncu posameznega projekta ali političnega cikla (Finnish Government, 2024; Security Delta, 2023).

Eden pomembnejših premikov, ki bi jih bilo treba doseči, je prehod od predvsem reaktivnega k bolj proaktivnemu pristopu. Analiza kaže, da večina dokumentov še vedno izhaja iz opisa trenutnega stanja in že zaznanih vrzeli. Čeprav se pogosto omenja potreba po boljšem napovedovanju prihodnjih potreb, so konkretni mehanizmi za to – kdo, kako in s katerimi orodji naj to izvaja – večinoma še slabo razviti ali ostajajo na ravni splošnih usmeritev (Estonia Cybersecurity Skills Needs Analysis, 2023; Cybersecurity Skills Canada, 2023). Brez takšnih zmogljivosti sistemi težko pravočasno prilagajajo svoje politike, kar dolgoročno resno omejuje njihovo vzdržnost.

Zelo pomembno vlogo ima tudi način, kako je urejeno sodelovanje med različnimi akterji. Na deklarativni ravni skoraj vsi dokumenti poudarjajo pomen sodelovanja med izobraževalnimi institucijami, gospodarstvom in javnim sektorjem. V praksi pa se pokaže, da je velika razlika med sistemi, kjer so vloge jasno razdeljene in so vzpostavljeni trajni mehanizmi usklajevanja, ter tistimi, kjer večina sodelovanja poteka projektno ali znotraj posameznih sektorjev. Prvi praviloma izkazujejo večjo

stabilnost in predvidljivost, drugi pa so precej bolj odvisni od trenutnih pobud in razpoložljivih sredstev (State of the Cyber Security Sector in Ireland, 2022; Security Delta, 2023).

Pri tem ne gre spregledati, da vprašanje dolgoročne vzdržnosti ni zgolj stvar državnih strategij, temveč ima tudi zelo konkretne posledice za organizacije. Kadar nacionalni okvir ne zagotavlja dovolj stabilnega in predvidljivega razvoja kompetenc, so organizacije prisiljene prevzeti večino bremena nase, od lastnih programov usposabljanja do iskanja kadrov na zelo omejenem trgu. To pomeni večje stroške, več negotovosti in večje tveganje, da ključna znanja v določenem trenutku preprosto niso na voljo. V bolj usklajenih sistemih je to tveganje manjše, saj imajo organizacije boljšo osnovo za dolgoročno načrtovanje kadrov in so manj odvisne od improviziranih rešitev.

Če vse to povežemo, se izriše precej jasna slika: dolgoročno vzdržni nacionalni pristopi temeljijo na stabilnih institucionalnih okvirih, sposobnosti sistematičnega spremljanja in načrtovanja potreb ter na dejanskem, ne zgolj deklarativnem sodelovanju ključnih deležnikov. Kadar kateri od teh elementov manjka, obstaja resno tveganje, da politike ostanejo razdrobljene in usmerjene predvsem v kratkoročno »gašenje požarov«, kar dolgoročno ne more bistveno zmanjšati kompetenčnih vrzeli na področju kibernetike varnosti.

5 Sklep

Pomanjkanje strokovnega znanja na področju informacijske in kibernetike varnosti predstavlja kronično in strukturno težavo, ki presega zgolj vprašanje števila razpoložljivega osebja. Namen prispevka je bil izvesti primerjalno analizo sistemskih pristopov na podlagi različnih javno dostopnih nacionalnih dokumentov, v katerih so izbrane države zabeležile razvoj kibernetike kompetenc, ter odkriti morebitne dobre prakse, ki bi jih bilo smiselno prenesti v slovenski prostor. Rezultati so pokazali, da med državami prevladuje raznolikost na ravni sistematičnosti in težnja po dolgoročni perspektivi razvoja in uporabe kibernetike kompetenc. Nacionalni sistemi, ki razvoj znanja o kibernetiki umeščajo v širši institucionalni in strateški kontekst, izkazujejo višjo raven kontinuitete in večjo povezanost med izobraževanjem, trgom dela in potrebami organizacij. Strategije, osredotočene predvsem na programe ali sektorske dejavnosti, pa so preveč razdrobljene, da bi bile

trajnostne v spreminjajočem se okolju. Ena ključna ugotovitev prispevka je, da večina pregledanih dokumentov poudarja, da je sistematično spremljanje in načrtovanje potreb osebja nujno, čeprav so empirična orodja za dolgoročno napovedovanje potreb po kompetencah redka ali zgolj konceptualno opredeljena. Ti nacionalni sistemi razvoja kibernetskih kompetenc ostajajo večinoma reaktivni, saj jim primanjkuje sposobnosti hitrega prilagajanja spreminjajočim se tehnološkim in varnostnim okoljem. Študija je tudi pokazala, da dolgoročna trajnost nacionalnih pobud izhaja iz robustnih institucionalnih modelov organizacije, formaliziranega sodelovanja med deležniki ter uporabe podatkov kot orodja za usmerjanje odločanja. Države z rednimi koordinacijskimi okviri med javnim sektorjem, akademskimi institucijami in gospodarstvom so lahko bolj sposobne zmanjšati vrzeli v kompetencah in narediti okolje osebja v organizacijah bolj predvidljivo.

Z vidika Slovenije te ugotovitve nakazujejo, da bi bilo smiselno okrepiti strukturirano spremljanje in dolgoročno načrtovanje potreb po kibernetskih kompetencah ter bolj poenotiti politike, programe in deležnike, ki že obstajajo. Medtem ko bi bilo treba prenos najboljših praks iz tujine prilagoditi nacionalnemu kontekstu, zlasti na ravni institucionalnih ureditev in razpršenosti kompetenc, bo treba proces gradnje kibernetskih kompetenc obravnavati kot strateško in kot ne operativno vprašanje. Pomembna omejitev prispevka je, da analiza temelji izključno na javno dostopnih nacionalnih dokumentih, kar pomeni, da ne zajema dejanskega izvajanja politik in njihovega vpliva v praksi.

Primerjalni pristop prav tako ne omogoča kvantitativne ocene, v kolikšni meri posamezni nacionalni pristopi dejansko prispevajo k zmanjševanju kadrovske vrzeli. Te omejitve nakazujejo smeri nadaljnjih raziskav, zlasti potrebo po empiričnih študijah, poglobljenih analizah primerov ter razvoju celovitih konceptualnih modelov za ocenjevanje prihodnjih potreb po kompetencah na obravnavanem področju.

Kljub navedenim omejitvam prispevek ponuja strukturiran in primerjalno utemeljen vpogled v sistemske ukrepe za razvoj kibernetskih kompetenc ter predstavlja izhodišče za nadaljnje raziskave in strokovno razpravo v slovenskem prostoru.

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DIGITALNA PREOBRAZBA IN ODPORNOST SLOVENSКИH MSP

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Digitalna preobrazba krepi odpornost mikro, malih in srednje velikih podjetij, saj jim omogoča ohranjanje poslovanja ob motnjah, racionalizacijo procesov ter učinkovitejše sodelovanje s strankami in dobavitelji. Kljub temu pa omejena sredstva in pomanjkanje znanja pogosto zavirajo njihovo zmožnost, da bi v celoti izkoristila potencial digitalnih tehnologij. Čeprav Statistični urad Republike Slovenije, Eurostat, Evropska komisija in OECD spremljajo uporabo digitalnih rešitev, ostaja premalo raziskano, kako so podjetja v zadnjih letih digitalno preobrazila svoje poslovanje ter kakšna je njihova odpornost. Raziskava, ki temelji na 159 veljavnih odgovorih, analiziranih z orodjem SPSS, kažejo določene premike v smeri digitalne preobrazbe slovenskih mikro, malih in srednje velikih podjetij. Čeprav večina podjetij digitalizacijo že vključuje v svojo poslovno strategijo, obstajajo pomembne razlike med mikro, malimi in srednje velikimi podjetji glede stopnje digitalne preobrazbe in dosežene odpornosti.

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DIGITAL TRANSFORMATION AND RESILIENCE OF SLOVENIAN SMES

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Digital transformation increases the resilience of micro, small, and medium-sized enterprises by enabling them to maintain their business during disruptions, to streamline processes, and to engage more effectively with customers and suppliers. However, limited resources and skills often prevent them from taking full advantage of digital technologies. Although the use of digital technology is monitored by Eurostat, the European Commission, and the OECD, there is still insufficient research on how micro, small, and medium-sized enterprises have digitally transformed their business in recent years and how resilient they are. Therefore, this study focuses on exploring the digital transformation and resilience of micro, small, and medium-sized enterprises and the differences between them. The survey, based on 159 valid responses, analysed using SPSS, shows certain shifts towards digital transformation in Slovenian micro, small, and medium-sized enterprises. Although most companies already include digitization in their business strategy, there are significant differences between micro, small, and medium-sized enterprises in terms of the degree of digital transformation and resilience achieved.



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1 Uvod

Eno od pomembnih gonil produktivnosti in konkurenčnosti podjetij je pospešena digitalna preobrazba (Llopis-Albert et al., 2021). Digitalna preobrazba je več kot le tehnološki premik. Širše jo lahko opredelimo kot "proces temeljnih sprememb, ki ga omogoča inovativna uporaba digitalnih tehnologij, ki jo spremlja strateški vzvod ključnih virov in zmogljivosti, s ciljem radikalnega izboljšanja poslovanja in ponovne opredelitve njegove ponudbe vrednosti za deležnike" (Gong & Ribiere, 2021, p. 12). Digitalna preobrazba je torej širša od zgolj pretvorbe analognih podatkov v digitalne in digitalizacije procesov, čeprav je to pogoj za uspešno digitalno preobrazbo. Intenzivna in inovativna uporaba digitalne tehnologije prinaša priložnosti za zmanjšanje stroškov poslovanja, povečanje učinkovitosti dela, okrepitev inovacijske zmogljivosti, izboljšanje vključenosti potrošnikov in nove priložnosti za širitev poslovanja na nov trg (Ko et al., 2021). Lahko rečemo, da podjetja s pomočjo digitalne preobrazbe zagotavljajo organizacijsko odpornost (Cannas, 2023).

Digitalizacija v malih in srednje velikih podjetjih (MSP) je nižja kot v velikih podjetjih (OECD, 2021). To ni povezano le s pomanjkanjem finančnih sredstev, digitalnih znanj in spretnosti ter digitalnih kompetenc, temveč tudi z njihovimi manj jasnimi ambicijami za digitalno preobrazbo (Barann et al., 2019; Marolt, Zimmermann, et al., 2022). Za spodbujanje uvajanja in uporabe digitalnih tehnologij v MSP obstajajo različne pobude na evropski in nacionalni ravni. Te pobude lahko razdelimo na finančne (znižanje davkov, finančna podpora), tehnološke (nadgradnja varnosti) in človeške (razvoj spretnosti) (Stamatopoulos et al., 2022). Poleg tega obrtne zbornice in zbornice malih podjetij, gospodarske zbornice ter središča za digitalne inovacije z MSP delijo znanje in izkušnje o različnih vidikih digitalne preobrazbe.

V zadnjih letih so se nekatere raziskave (Humphries et al., 2020; Mishra & Singh, 2022; Priyono et al., 2020) osredotočile na izzive, ki jih prinaša dinamično in nepredvidljivo poslovno okolje in na to, kako se MSP na različne načine odzivajo na te izzive. Čeprav uporaba digitalnih tehnologij za MSP predstavlja številne priložnosti, je malo znanega o tem, kako so v zadnjih letih izkoriščali digitalne tehnologije (Winarsih et al., 2020) in gradili svojo odpornost. Poleg tega so v teh študijah običajno spregledana mikropodjetja, čeprav predstavljajo več kot 90-odstotni delež vseh podjetij v Evropski uniji (OECD, 2021). Namen raziskave je bil

zagotoviti vpogled v to, kako so MSP v zadnjih letih digitalno preobrazila svoje poslovanje in kakšna je njihova odpornost.

2 Teoretična izhodišča

Digitalne tehnologije imajo v manjših podjetjih edinstveno in strateško pomembno vlogo (Proksch et al., 2024), zlasti pri preoblikovanju in optimizaciji poslovnih procesov (Elia et al., 2020). Von Briel et al. (2018) ugotavljajo, da digitalne tehnologije prispevajo k učinkoviti optimizaciji notranjih in medorganizacijskih procesov, kar prinaša številne koristi za podjetja. Bharadwaj et al. (2013) opredeljujejo digitalno tehnologijo kot kombinacije informacijskih, računalniških, komunikacijskih in povezovalnih tehnologij, ki skupaj spreminjajo poslovno strategijo in procese. Poleg tega Warner & Wäger (2019) poudarjata širši pomen digitalnih tehnologij, ki se odraža v razvoju digitalnih artefaktov, digitalnih platform in digitalnih infrastruktur, ki skupaj tvorijo osnovo za nadaljnje digitalne inovacije.

Uporaba digitalnih tehnologij ustvarja pozitivne učinke za podjetja, saj omogoča večjo prilagodljivost, spodbuja organizacijske inovacije (Yoo et al., 2012), izboljšuje uspešnost (Bruque & Moyano, 2007) in povečuje produktivnost (Kleis et al., 2012). Poleg tega digitalne tehnologije omogočajo boljše zbiranje, analizo in uporabo podatkov, kar podpira informirano odločanje v negotovih in dinamičnih okoljih. Proksch et al. (2024) in Warner & Wäger (2019) poudarjajo, da digitalna preobrazba pomembno prispeva k razvoju organizacijske agilnosti, saj podjetjem omogoča hitro prilagajanje poslovnih modelov, procesov in virov glede na zunanje spremembe.

Ta agilnost je povezana z organizacijsko odpornostjo, ki predstavlja sposobnost organizacije, da se prilagodi, vzdrži in hitro okreva po kriznih dogodkih (Hillmann & Guenther, 2021). Odpornost se lahko razvija na več ravneh, vključno z ravno posameznikov, timov in celotne organizacije (Raetze et al., 2021). V kriznih razmerah se podjetja soočajo z visoko stopnjo negotovosti, časovnimi pritiski in povečanimi tveganji za svoje preživetje (Vaaler & McNamara, 2004). Zlasti MSP se zaradi operativnih omejitev ter omejenih finančnih, kadrovskih in tehnoloških virov soočajo z večjo ranljivostjo in izrazitejšimi izzivi v času kriz (Marolt et al., 2024). Kljub temu se lahko v primerjavi z večjimi podjetji zaradi manj kompleksnih organizacijskih struktur in večje prilagodljivosti na spremembe v okolju odzovejo

hitreje, kar predstavlja pomembno prednost pri prilagajanju in zagotavljanju dolgoročne konkurenčnosti.

Digitalna preobrazba predstavlja ključen mehanizem za krepitev odpornosti MSP (Martín-Rojas et al., 2026). Digitalne tehnologije omogočajo hitrejše zaznavanje sprememb v okolju, učinkovitejše usklajevanje notranjih procesov ter večjo fleksibilnost pri prilagajanju poslovnih strategij. S tem podjetjem ne pomagajo zgolj pri kratkoročnem obvladovanju kriz, temveč tudi pri dolgoročnem učenju, prilagajanju in trajnostnem razvoju, kar digitalno preobrazbo postavlja v središče sodobnih razprav o organizacijski odpornosti (He et al., 2022).

3 Metodologija

Cilj te raziskave je preučiti digitalno preobrazbo in odpornost MSP v zadnjih letih. Za doseg tega cilja smo izbrali kvantitativno raziskovalno strategijo, pri čemer smo podatke zbirali s pomočjo anketnega vprašalnika. Spletno anketo smo izbrali zaradi njene učinkovitosti in ekonomičnosti, kar omogoča zbiranje podatkov v relativno kratkem času (Lefever et al., 2007). Poleg tega omogoča hitrejšo pripravo podatkov za nadaljnjo analizo (Bakla et al., 2013).

Pri razvoju vprašalnika smo upoštevali več smernic. Uporabili smo izključno vprašanja zaprtega tipa, katerih odgovori omogočajo enostavnejšo obdelavo. Poskrbeli smo, da so bila vprašanja jasno zastavljena in osredotočena na obravnavano področje. Vprašalnik je bil strukturiran v sklope, ki so bili ustrezno poimenovani. Dodali smo tudi jasna navodila, ki so anketirancem olajšala navigacijo in izpolnjevanje (Reynolds, 2006). Prvi sklop je vseboval vprašanja o podjetju in uporabi digitalnih tehnologij, drugi sklop se je osredotočil na digitalno preobrazbo, tretji sklop pa na odpornost organizacije. Vprašalnik smo oblikovali na podlagi prejšnjih raziskav.

Iz slovenskega poslovnega registra smo naključno izbrali 1500 mikro, 1000 malih in 1000 srednje velikih podjetij. Vzorec je vključeval več mikropodjetij, saj so pretekle raziskave pokazale, da mikropodjetja manj pogosto sodelujejo v raziskavah v primerjavi z malimi, srednje velikimi in velikimi podjetji. Podjetja smo razvrstili v skupine glede na število zaposlenih in letni promet. Vsem naključno izbranim MSP smo poslali vabilo, ki je vključevalo kratek opis raziskave in povezavo na spletni

vprašalnik. Pridobili smo 159 v celoti izpolnjenih vprašalnikov, podatke pa smo analizirali s pomočjo programa SPSS. Rezultati so predstavljeni v naslednjem poglavju.

4 Rezultati

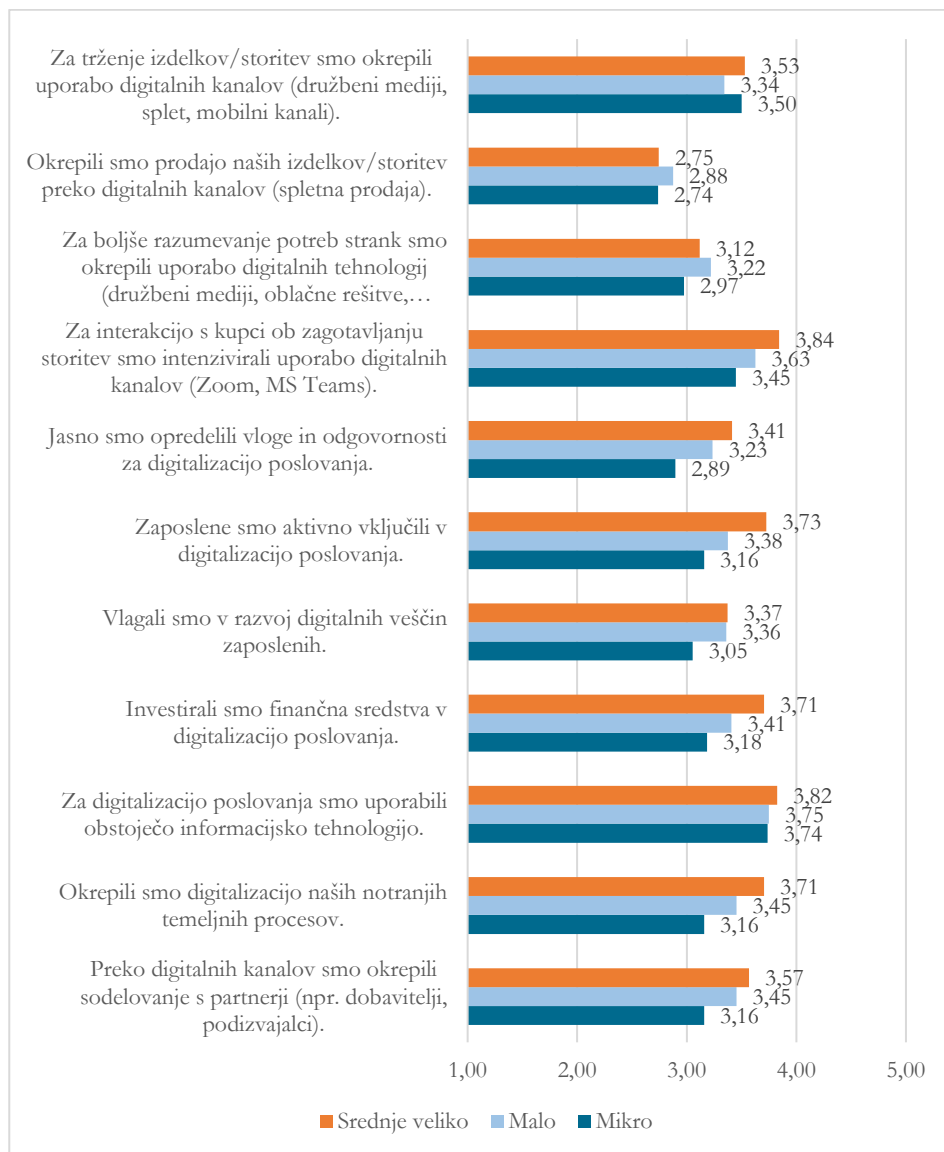
V raziskavi je sodelovalo 26 % mikropodjetij, 41 % malih podjetij in 33 % srednje velikih podjetij. Od tega je bilo 67 % podjetij v zreli fazi, 31 % podjetij v fazi rasti, 1 % startup podjetij in 1 % podjetij v fazi zmanjševanja. Največ podjetij prihaja iz Osrednjeslovenske regije (34 %), sledita Gorenjska in Podravska regija (12 %), nato Savinjska (11 %) in Jugovzhodna regija (9 %). Iz ostalih regij je sodelovalo manj kot 5 % podjetij. 54 % podjetij je prejelo vladno pomoč v času pandemije COVID-19.

V kar 84 % podjetjih je digitalizacija del njihove poslovne strategije. Večina podjetij uporablja rešitve za komuniciranje (npr. MS Teams, Zoom) (82 %), računovodski program (70 %), družbene medije (53 %) in celovite programske rešitve (52 %). Mobilne aplikacije uporablja le 38 % podjetij, programske rešitve za upravljanje odnosov s strankami 34 %, programske rešitve za poslovno analitiko pa 32 % podjetij. Podatki dodatno kažejo, da je del teh podjetij določene digitalne rešitve začel uporabljati šele po izbruhu pandemije COVID-19, in sicer 10 % računovodske programe, 9 % podjetij celovite programske rešitve, 7 % orodja za poslovno analitiko, ter 6 % rešitve za upravljanje odnosov s strankami. Najizrazitejše povečanje uporabe je zaznati pri rešitvah za komuniciranje, ki jih je v času pandemije COVID-19 začelo uporabljati kar 76 % podjetij, ter pri uporabi družbenih medijev, kjer je takšen porast zaznati pri 22 % podjetij.

4.1 Obseg digitalne preobrazbe MSP

Podjetja lahko digitalizirajo različna področja svojega poslovanja. Pri tem ne gre le za uvedbo različnih digitalnih tehnologij, ampak tudi za »netehnološke« spremembe, ki se odražajo v organizacijskih spremembah. Analizirali smo povprečje in standardni odklon šestih trditev, ki se nanašajo na digitalno preobrazbo podjetja. Rezultat kaže, da se MSP najbolj strinjajo s trditvijo, da so okrepili digitalizacijo notranjih temeljnih procesov ($\bar{x} = 3,44$), da so zaposlene aktivno vključili v digitalizacijo poslovanja ($\bar{x} = 3,44$) in da so preko digitalnih kanalov okrepili sodelovanje s partnerji ($\bar{x} = 3,43$). Najmanj pa se strinjajo s trditvama, da so za boljše

razumevanje potreb strank okrepili uporabo digitalnih tehnologij ($\bar{x} = 3,13$) in da so jasno opredelili vloge in odgovornosti za digitalizacijo poslovanja ($\bar{x} = 3,22$).



Slika 1: Raven digitalizacije poslovanja glede na velikost podjetja

Vir: Lasten

Na sliki 1 prikazujemo strinjanje z enajstimi trditvami glede različnih vidikov digitalne preobrazbe. Največja stopnja strinjanja je razvidna pri srednje velikih podjetjih (označenih s sivo). Mala podjetja bistveno ne zaostajajo za njimi, medtem ko tega ne moremo trditi za mikropodjetja, zato smo s pomočjo analize variance (ANOVA) preverili razlike v stopnjah digitalne preobrazbe med njimi.

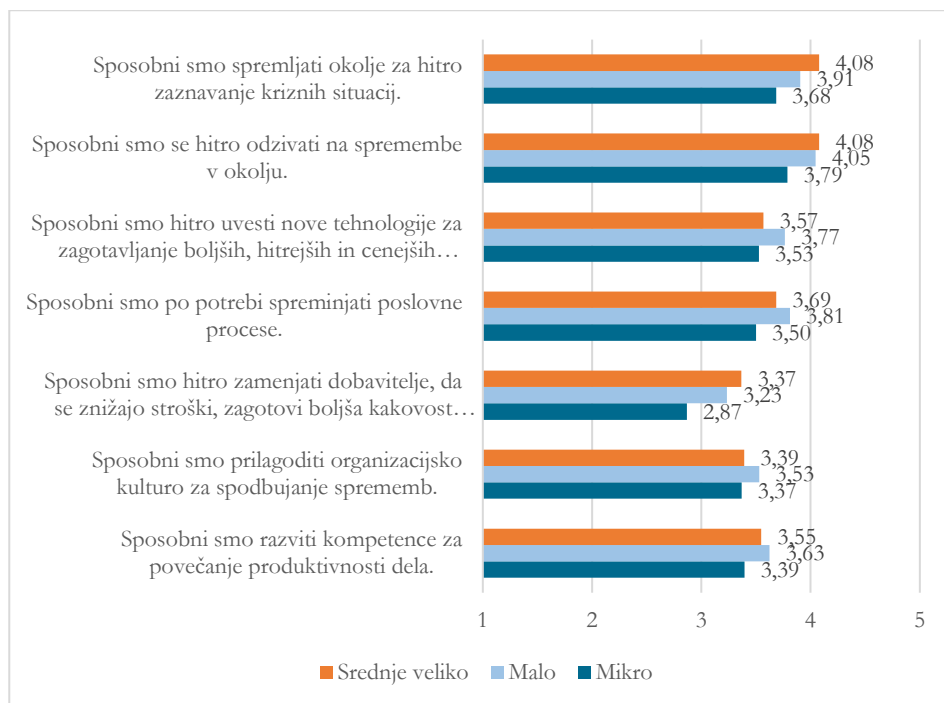
Rezultati ANOVE kažejo, da obstajajo statistično pomembne razlike pri nekaterih trditvah glede digitalne preobrazbe. V nadaljevanju podajamo le tiste rezultate, kjer smo ugotovili, da obstajajo statistično značilne razlike pri 5 % stopnji pomembnosti. Statistično pomembna razlika pri 5 % stopnji pomembnosti obstaja pri trditvah »Zaposleni smo aktivno vključeni v digitalizacijo poslovanja« ($t = 3,101, p = 0,048 < 0,05$) »Investirali smo finančna sredstva v digitalizacijo poslovanja« ($t = 3,203, p = 0,044 < 0,05$) in »Okrepili smo digitalizacijo naših notranjih temeljnih procesov« ($t = 3,737, p = 0,026 < 0,05$). Večkriterijska primerjava po Gabrielovem postopku kaže, da pri vseh treh trditvah obstajajo statistično pomembne razlike med mikro in srednje velikimi podjetji, in sicer pri trditvi »Zaposleni smo aktivno vključeni v digitalizacijo poslovanja« s $p = 0,048$, pri trditvi »Investirali smo finančna sredstva v digitalizacijo poslovanja« s $p = 0,037$ in pri trditvi »Okrepili smo digitalizacijo naših notranjih temeljnih procesov« s $p = 0,049$.

4.2 Odpornost MSP

Podjetja lahko z digitalno preobrazbo krepijo svojo odpornost. Analizirali smo povprečja in standardne odklone sedmih trditev o odpornosti podjetja. Rezultat kaže, da se MSP najbolj strinjajo s trditvijo, da so se sposobni hitro odzvati na spremembe v okolju ($\bar{x} = 3,99$), da so sposobni spremljati okolje za hitro zaznavanje kriznih situacij ($\bar{x} = 3,91$) in da so po potrebi sposobni spreminjati poslovne procese ($\bar{x} = 3,70$). Najmanj pa se strinjajo s trditvama, da so sposobni hitro zamenjati dobavitelja, da se znižajo stroški, zagotovi boljšo kakovost ali dostavo ($\bar{x} = 3,19$) in da so sposobni prilagoditi organizacijsko kulturo za spodbujanje sprememb ($\bar{x} = 3,45$).

Če pogledamo razlike med MSP glede odpornosti, lahko na sliki 2 vidimo, da se z nekaterimi trditvami bolje strinjajo mala podjetja, z nekaterimi pa srednje velika podjetja. Mikropodjetja se nekoliko manj strinjajo z danimi trditvami v primerjavi z malimi in srednje velikimi podjetji. Da bi ugotovili, ali obstajajo statistično značilne

razlike pri 5 % stopnji pomembnosti med mikro, malimi in srednje velikimi podjetji, smo to preverili s pomočjo ANOVE.



Slika 2: Raven odpornosti glede na velikost podjetja

Vir: Lasten

Rezultati ANOVE kažejo, da obstajajo statistično pomembne razlike pri nekaterih trditvah glede digitalne preobrazbe. Statistično pomembne razlike pri 5 % stopnji pomembnosti se kažejo le pri trditvi »Sposobni smo spremljati okolje za hitro zaznavanje kriznih situacij« ($t = 3,885$, $p = 0,023 < 0,05$). Večkriterijska primerjava po Gabrielovem postopku kaže, da pri slednjem obstajajo statistično pomembne razlike med mikro in srednje velikimi podjetji, in sicer z verjetnostjo $p = 0,017$.

5 Razprava in zaključek

Raziskava, ki je zajela 159 MSP, daje vpogled v digitalno preobrazbo in odpornost podjetij v Sloveniji. Sodeč po rezultatih, je večina podjetij digitalizacijo že vključila v svojo poslovno strategijo, kar kaže na široko prepoznavanje pomena digitalne

preobrazbe v sodobnem poslovnem okolju. To ni presenetljivo, saj digitalna preobrazba omogoča podjetjem povečanje učinkovitosti, prilagodljivosti in odzivnosti, kar so ključni dejavniki za ohranjanje konkurenčnosti in preživetje v hitro spreminjajočem se okolju.

Analiza variance je razkrila pomembne razlike v stopnji digitalne preobrazbe med MSP. Srednje velika podjetja so dosegla najvišje rezultate glede digitalizacije notranjih procesov, kar kaže na večjo zrelost in pripravljenost za implementacijo digitalnih rešitev. Na drugi strani pa mikropodjetja nekoliko zaostajajo, kar nakazuje na večje ovire, s katerimi se soočajo pri prehodu na digitalne tehnologije. Statistično pomembne razlike so se pokazale pri vključevanju zaposlenih v digitalizacijo, vlaganju finančnih sredstev v digitalizacijo in krepitvi notranjih procesov, kar potrjuje tezo, da so večja podjetja bolje pripravljena za spopadanje z digitalno preobrazbo.

Raziskava je prav tako pokazala, da MSP menijo, da so na splošno dobro pripravljena na odzivanje na krizne razmere. Večina podjetij je izrazila visoko stopnjo strinjanja s trditvami, ki so se nanašale na sposobnost hitrega odziva na spremembe v okolju in spremljanje okolja za zgodnje zaznavanje kriz. To nakazuje, da so MSP že razvila nekatere ključne lastnosti odpornosti, ki jim omogočajo preživetje v negotovih okoliščinah. Kljub temu se je pokazalo, da manjša podjetja še vedno težje hitro menjajo dobavitelje ter imajo težave pri prilagajanju organizacijske kulture za učinkovito spodbujanje sprememb. Te pomanjkljivosti lahko omejujejo njihovo dolgoročno odpornost, zlasti v primerih, ko so hitre prilagoditve ključne za preživetje.

Na podlagi rezultatov te raziskave je mogoče identificirati več ključnih področij, na katerih lahko MSP okrepijo svojo stopnjo digitalne preobrazbe, ter posledično izboljšajo organizacijsko odpornost. MSP bi morala okrepiti uporabo naprednejših digitalnih tehnologij, da bi boljše razumela potrebe in vedenje strank, učinkoviteje optimizirala poslovne procese ter sprejemala bolj informirane in pravočasne odločitve, kar je ključno za dolgoročno prilagodljivost in odpornost v negotovih razmerah. Uspešna uvedba teh tehnologij zahteva sistematična vlaganja v razvoj digitalnih kompetenc zaposlenih ter izboljšanje dostopnosti in uporabnosti digitalnih rešitev, zlasti z razvojem modularnih, prilagodljivih in cenovno dostopnih orodij, prilagojenih omejenim virom MSP. Poleg tehnoloških vidikov je nujen tudi razvoj

celovitih strategij digitalne preobrazbe, ki vključujejo organizacijske in kulturne spremembe ter krepijo sposobnost hitrega prilagajanja spremembam v poslovnem okolju, na primer pri upravljanju dobavnih verig, zamenjavi dobaviteljev in prilagajanju poslovnih modelov. Ključno vlogo ima organizacijska kultura, ki spodbuja odprtost za spremembe, eksperimentiranje in učenje iz izkušenj, ob tem pa morajo MSP vzpostaviti ustrezne procese in strukture, ki omogočajo hitro in učinkovito odzivanje na nepredvidljive dogodke. Vlaganja v digitalne tehnologije, ki podpirajo sodelovanje s poslovnimi partnerji, upravljanje dobavnih verig in fleksibilne oblike dela, tako pomembno prispevajo k večji operativni agilnosti in dolgoročni odpornosti podjetij.

V rezultatih so zaznane razlike med mikropodjetji ter malimi in srednje velikimi podjetji, kar odpira pomembne priložnosti za nadaljnje izboljšave in poglobljeno raziskovanje. V prihodnje bi bilo smiselno te razlike podrobneje analizirati ter zagotoviti višjo stopnjo odzivnosti, zlasti pri mikropodjetjih. Raziskava, usmerjena izključno na mikropodjetja, bi lahko ponudila bistveno bolj poglobljen vpogled v izzive in priložnosti segmenta, ki je v slovenskem gospodarskem prostoru najštevilčnejši. Dodatno bi kvalitativni pristopi, predvsem poglobljeni intervjuji, omogočili boljše razumevanje dejanske uporabe digitalnih tehnologij, zaznanih koristi ter ovir pri digitalni preobrazbi in krepitvi odpornosti. Nadaljnje raziskave bi se prav tako lahko osredotočile na natančnejšo analizo vpliva digitalne preobrazbe na organizacijsko odpornost ter na identifikacijo ključnih dejavnikov, ki spodbujajo ali zavirajo digitalno preobrazbo in odpornost podjetij. To področje tako ne predstavlja zgolj pomembnega raziskovalnega izziva, temveč ponuja konkretno dodano vrednost za strokovnjake iz prakse, saj lahko MSP na podlagi empiričnih ugotovitev lažje in bolj ciljno načrtujejo prihodnje aktivnosti ter naložbe, usmerjene v digitalno preobrazbo in dolgoročno odpornost.

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TRENDS IN ICT SPECIALISTS' INCOMES IN THE CZECH REPUBLIC

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Our contribution addresses the topic of ICT specialists' remuneration (regardless of the economic sector in which they operate) in comparison with income trends in the Czech economy for the period from 2015 to 2025. We conduct this analysis for both the business sector and the non-business sector. The data source used for the analyses is the database of Trexima, a.s., a company which collects data on employee incomes regularly once a year, in the second quarter of each relevant year. This amounts to approximately 2,000,000 records from around 20,000 economic entities per year. Our findings indicate that the earnings of ICT professionals are growing significantly faster than those of other employees, with a difference between business and non-business sector earnings of around 75%. This fact is also reflected in the nation's gender pay gap, which is decreasing very slowly over time.

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1 Introduction

Digitalisation is among the key mantras of today when it comes to building a democratic civil society. This trend stems from the European Union's strategy and is enshrined in its strategic documents (European Commission, 2023).

On the other hand, the introduction of digital applications into everyday life is only a technological issue. The actual acceptance of these technologies by workers or citizens is another matter – and that is the true face of digitalisation. ChatGPT and other elements of artificial intelligence are a key phenomenon of today, and they facilitate digital transformation by improving communication between people and technologies, automating routine tasks and providing personalised support in education and healthcare, and thus simplifying access to information and services, thereby promoting a more efficient and connected digital society. However, another dimension to keep in mind is that digitalisation can never be achieved without sufficient human potential in the form of skilled workers – that is, ICT professionals (Nedomova, Maryska and Doucek, 2024) – who are willing and able to work in ICT and, moreover, work efficiently and effectively. This dimension is closely linked to the remuneration system for ICT professionals in both the business and non-business sectors (Segovia-Pérez, 2019). Another challenge in attracting ICT professionals is the low representation of women in this sector of the economy (Oskrdal, Pavlíček and Jelínková, 2011).

From the perspective of the intended digitalisation of the Czech economy, including public and state administration, we were interested in how the earnings of ICT professionals are developing in comparison with other sectors of this economy – RQ1 and RQ2. Meanwhile, we also analyse the gender pay gap (GPG) (EC, 2025) among the earnings of ICT professionals in the business and non-business sectors – RQ3.

The paper offers answers to the following research questions:

- RQ1: How do the earnings of ICT professionals compare to those of workers in the Czech Republic overall?

- RQ2: How have ICT professionals' earnings in the business and non-business sectors in the Czech Republic developed over time, and how has the gap between them changed?
- RQ3: How does the gender pay gap differ between the earnings of ICT professionals in the business and non-business sectors in the Czech Republic?

2 Methodology

The methodology used in this paper builds on data from our long-term research into the status of ICT professionals and their remuneration in the Czech economy. It likewise harnesses our years of research into the development of the gender pay gap both in the Czech economy and among all groups of ICT professionals.

2.1 Methodological approach and research design

This paper is designed as an empirical analysis of the changes in earnings in the business and non-business sectors in the Czech Republic, with a particular focus on the position of ICT professions within the overall labour market. Its research design assumes that earnings in the ICT sector are not only an indicator of the technological sophistication of the economy, but also a sensitive signal of structural changes in the demand for skilled labour, the institutional organisation of the labour market and gender inequalities.

The methodological approach we have chosen combines an extensive database with multidimensional segmentation, which allows for the analysis of developments in earnings not only in absolute terms, but above all in terms of structure and dynamics over time. We emphasize long-term comparability and the ability to capture differences between individual groups of employees.

2.2 Nature and representativeness of the data

The empirical analysis is based on aggregated earnings data for approximately 2 million employees in the Czech Republic, which corresponds to roughly 35% of the economically active population. Such an extensive data set provides sufficient

statistical power to track long-term trends and structural differences between individual labour market segments.

From a research design perspective, the sample size is particularly important for the analysis of ICT professions. They are a minority, and yet they form an economically significant segment of total employment. The large scope of the data allows us to distinguish between individual professional categories in ICT, economic sectors and gender without significantly reducing the informative value of the results.

For the purposes of this article, we distinguish between the three groups of professionals that the economy needs for the operation of information technology. According to the International Labour Organisation (2024) classification, these roles are defined as follows.

- ICT Managers (ISCO 133);
- ICT Specialists (ISCO 25); and
- ICT Technicians (ISCO 35).

Job descriptions for each group of ICT professionals and their educational requirements are listed in the International Labour Organisation (2024).

2.3 Time frame and international comparability

The study covers the period from 2015 to 2025, which makes it possible to capture not only normal cyclical fluctuations in earnings, but also the extraordinary macroeconomic events and structural breaks that affected the Czech labour market during this period. These include the Covid-19 pandemic and the subsequent inflationary and wage pressures after 2021.

To increase international comparability, all indicators of earnings in the business and non-business sectors are expressed in euros. The conversion from Czech koruna is done using the average annual CZK/EUR exchange rate, which reflects the long-term level of the currency relationship between the two currencies and limits the impact of short-term exchange rate fluctuations. This approach allows the results to be interpreted not only in a Czech context but also in a broader European context, without disrupting the consistency of the time series.

2.4 Segmentation logic and analytical perspectives

The basic conceptual starting point of this study is the assumption that developments in earnings cannot be adequately interpreted without detailed labour market segmentation. Therefore, the data is structured on the basis of several key dimensions. Together, these form a multidimensional analytical framework.

The first dimension is the distinction between ICT professions and the overall labour market. This comparison makes it possible to identify the extent to which the ICT sector differs in terms of pay levels and growth dynamics, and whether its earnings premium is increasing, stabilising or decreasing over time.

The second dimension is gender segmentation, which reflects the long-standing debate on gender inequalities in earnings. In the context of ICT professions, this perspective is particularly relevant, as it is a sector with relatively low representation of women and, at the same time, significant differentiation in earnings. The analysis therefore focuses not only on absolute differences, but also on their development over time.

The third dimension is the institutional division between the business and non-business spheres. This division allows us to examine the different mechanisms driving earnings in the private and public sectors, particularly as regards ICT roles, where the levels of market competition, remuneration flexibility and institutional constraints differ.

The fourth dimension is the professional hierarchy within ICT, divided into ICT managers, ICT specialists and ICT technicians. This division reflects different levels of responsibility, qualifications and bargaining power in the labour market and makes it possible to analyse whether growth in earnings in the ICT sector is evenly distributed across professions or is driven only by selected groups.

2.5 Selection of wage indicators and interpretation of results

The study works with both average earnings and median earnings. This choice is based on our assumption that wage distribution, especially in ICT professions, is highly asymmetrical and influenced by high incomes at the top of the distribution.

The median is therefore understood as a more robust indicator of “typical” earnings, while the average earnings provide information on the overall wage level and wage polarisation.

Combining the two indicators allows us to more deeply interpret the results, especially when comparing individual occupational groups, sectors and genders. The differences between the average and the median are used as an indicator of inequality in earnings and the concentration of high incomes.

3 Results

We have divided up the results of our study based on our research questions. Within this work, we present partial results which we have further analysed, parts of which are presented in the text or will be included in the conference presentation.

3.1 RQ1 – Development of ICT professionals’ earnings compared to the Czech Republic’s economy

- *RQ1: How do the incomes of ICT professionals compare to the earnings of workers in the Czech Republic?*

The results of the comparison of incomes between ICT professionals and the level of incomes in the Czech economy can be seen in Figure 1 below.

Figure 1 shows that even the lowest-paid group of ICT professionals – ICT technicians – have a higher income than the median income of workers in the Czech economy, with a difference ranging from 36.5 percentage points in 2015 to 23.3 percentage points in 2025. The lowest difference was 19.3 percentage points in 2021, apparently due to the Covid-19 epidemic. For other groups of ICT professionals, this difference is even greater. For ICT specialists, the range is from 67.8 percentage points in 2021 to 86.5 percentage points in 2024. The current value in 2025 is 86.2 percentage points.

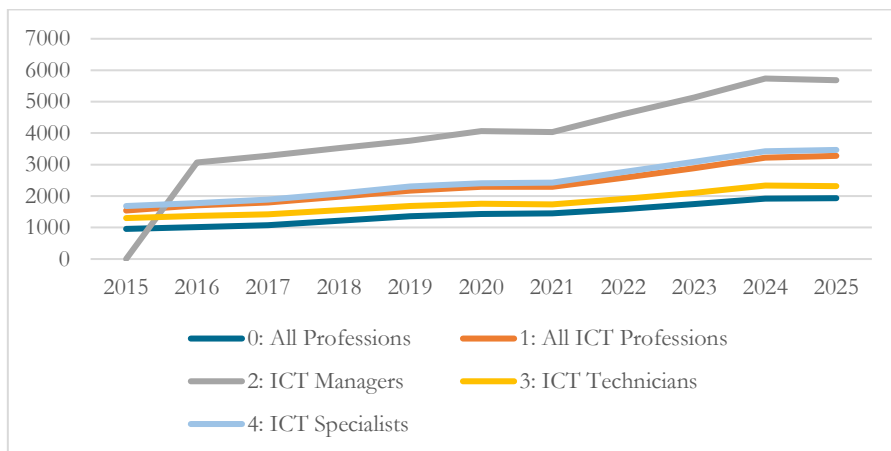


Figure 1: Development of the earnings of ICT professionals in comparison to the incomes of workers in the Czech Republic – median

Source: Own Data: (ISPV, 2025)

The incomes of ICT managers, meanwhile, are on a completely different level. Here, the difference between their incomes and the median income of the overall economy ranges from 158.9 percentage points in 2019 to 200.5 percentage points in 2025.

3.2 RQ2 – Development of ICT professionals' earnings in the business and non-business sectors in the Czech Republic and the earnings gap between them

- *RQ2: How has the earnings gap between ICT professionals and other professions changed over time in the business and non-business sectors in the Czech Republic?*

Figure 2 shows how the earnings gap between ICT professionals in the business and non-business sectors has changed over time compared with other professions in the economy. The upper portion of Figure 2 contains data for the non-business sector, and the lower portion has data for the business sector. More detailed analyses of the difference are then shown in Figure 3 and Figure 4.

Let us first focus on earnings in the non-business sector (the upper portion of Figure 2). Here we see a relatively small difference between the earnings of ICT professionals and average earnings. In the Czech Republic, this is mainly because earnings in the non-business sector are determined by tables and pay grades. In other words, the difference observed is de facto embedded in the system of remuneration for workers by profession in the non-business sector.

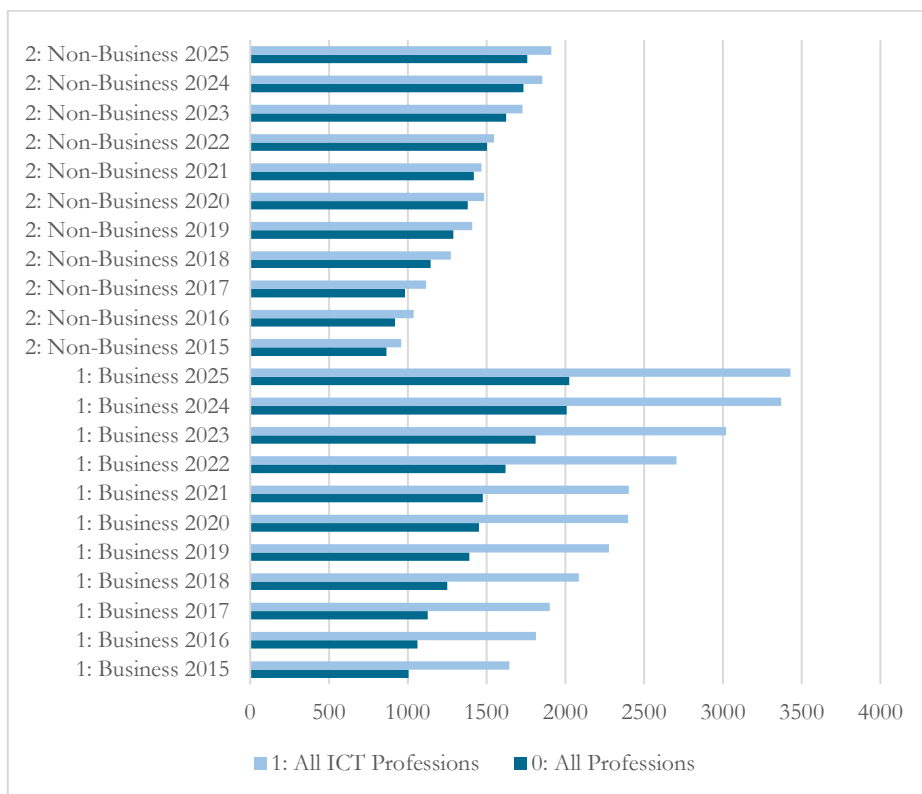


Figure 2: Average earnings – ICT professionals vs all professions, business and non-business sectors, Czech Republic

Source: Authors' calculations Data: (ISPV, 2025)

The trend for this difference is evident from Figure 3, which shows that as a consequence of the Covid-19 pandemic, the difference between the earnings of ICT professionals and other professions in the non-business sector is gradually increasing.

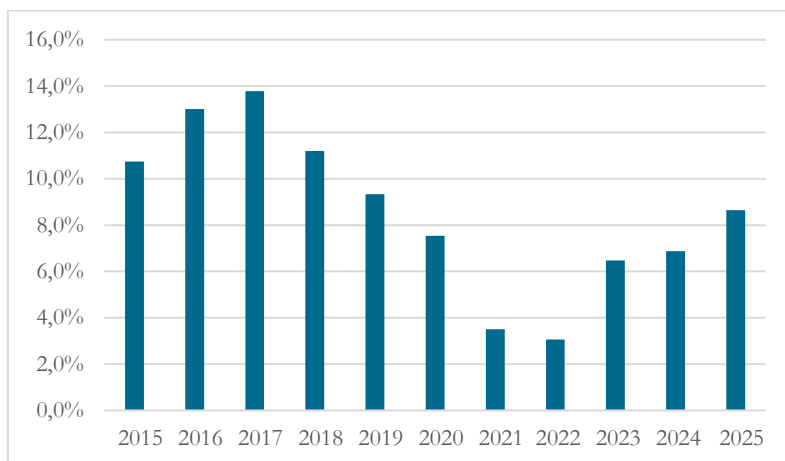


Figure 3: Development of the difference in the non-business sector (average earnings of ICT professionals vs average earnings)

Source: Authors' calculations Data: (ISPV, 2025)

The lower portion of Figure 2 presents the differences in earnings in the business sector. Here, as can be seen at first glance, the difference is significantly greater.

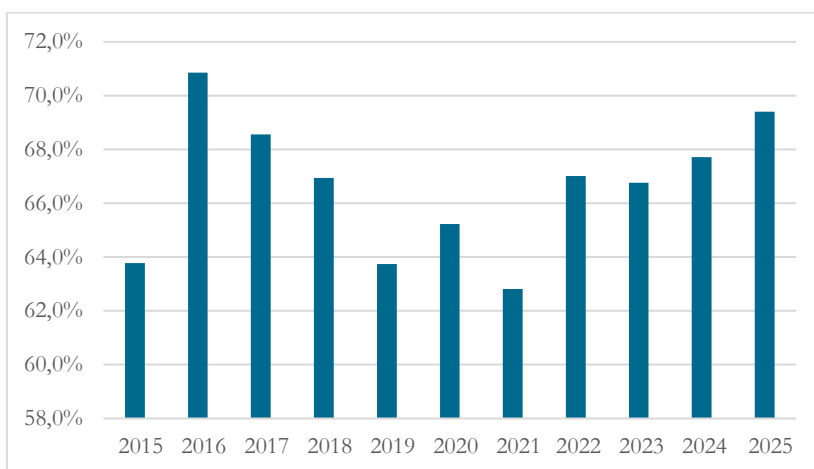


Figure 4: Development of the difference in the business sector (average earnings of ICT professionals vs average earnings)

Source: Authors' calculations Data: (ISPV, 2025)

Figure 4 shows that the difference has remained between 63 to 71 percentage points over the long term. This difference is a very good incentive for ICT professionals to work in the business sector. At the same time, it also motivates students to enrol in ICT-oriented study programmes, thereby increasing the number of ICT professionals in the economy.

3.3 RQ3 – Gender Pay Gap for ICT Professionals

- *RQ3: How does the gender pay gap differ between the earnings of ICT professionals in the business and non-business sectors in the Czech Republic?*

The development of the gender pay gap among ICT professionals in both the business and non-business sectors is shown in Figure 5 below.

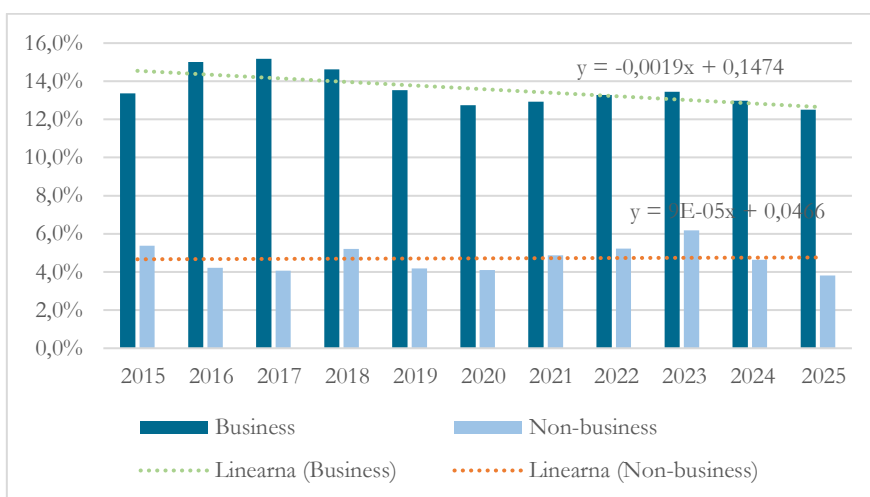


Figure 5: Gender pay gap for ICT professionals – average

Source: Authors' calculations Data: (ISPv, 2025)

In the business sector, the difference is significantly higher, ranging between 15% and 12.5% in the period under review. The trend is declining steadily, but very slowly. In contrast, in the non-business sectors, the gender pay gap is between 4% and 6%, which is a de facto stable trend (the coefficient of the linear approximation function of GPG development is practically zero (-0.5×10^{-9})). Figure 5 shows that

the gender pay gap is essentially embedded in the remuneration system and reducing it is a very long-term process (Nedomova, Maryska and Doucek, 2017).

4 Conclusions

The overall conclusions from our study regarding digitalisation are largely positive.

RQ1 – The reported earnings of ICT professionals are higher than the average earnings of workers in the Czech economy. This is particularly true for ICT managers and ICT specialists. The role of ICT specialists is crucial for digitalisation, both in analysing market needs and in developing and implementing appropriate applications in the non-business and business sectors.

RQ2 – The differences between the earnings of ICT professionals in the business and non-business sectors are somewhat alarming. They tell us that the incomes of ICT professionals in the non-business sector are significantly lower than those in the business sector. This leads to the employment of higher-quality ICT professionals in the business sector and to more limited performance by the ICT professions in the non-business sector. Another feature here is the outsourcing of ICT services by non-business organisations to business organisations and the de facto permanent payment of state funds to the business sphere. On the other hand, this means that the business sector will increasingly participate in digitalisation.

RQ3 – The Czech Republic is one of the countries with the largest gender pay gap in Europe (Equal Pay Day, 2024; Nedomova, Maryska and Doucek, 2017). The gap's level varies significantly between the business and non-business sector. In ICT, the gap is less obvious than usual – its values of 12.5%–15% in the business sector and 4%–6% in the non-business sector are not in line with the Equal Pay Day (2024) findings.

In ICT, the GPG also varies based on the age of the employees. For the youngest, incoming generation, it is significantly lower than for older employees.

In addition, the gender pay gap in the Czech economy continues to fluctuate, but it is essentially encoded in the remuneration system, which is why significantly reducing (or eliminating) it is a very long-term process (Figure 5).

4.1 Limitations of this study

One limitation of our analysis (and thus our conclusions) is that we use second-quarter earnings data for each year in both the business and non-business sectors. This period is notable because it is when minimum-wage adjustments take effect and holiday pay is disbursed, and it is also a time when very few extraordinary bonuses are awarded to employees.

If we were to look at annual income including all compensation, regular and extraordinary bonuses, we would probably find a greater difference between the income of ICT professionals and the average income in the Czech economy. Meanwhile, the same applies to the gender pay gap – and according to some European sources, this gap is as high as 22% (Equal Pay Day, 2024; Picatoste, Mesquita and González, 2023).

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ERGONOMIC ANALYSIS OF WAREHOUSE WORK USING SCALEFIT

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Warehouse work often involves frequent handling, awkward postures, and repetitive actions that can raise long-term risk for back, neck, and shoulder pain. This matters more in a longevity society, where firms need safe work design that supports work ability across the whole workforce. This paper presents a practical workflow that links wearable full-body motion capture (Xsens) with Scalefit reports to assess physical load in real warehouse conditions. We record a worker during normal work and split the recording into work blocks that match how the job actually runs. The system then produces Excel-based outputs that summarize posture and movement over time, highlight peak-load moments, and flag body regions with higher strain. We use the outputs to rank work blocks by risk, compare work done with different load demands, and point to changes that an employer can act on (layout, shelf height, load limits, tools, and work rotation). The main contribution is a repeatable, on-site method that turns sensor data into clear ergonomics findings that support safer work design and longer working lives.

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1 Introduction

Musculoskeletal disorders (MSDs) are prevalent in occupations involving manual and repetitive material handling (Balantič et al., 2016). In warehouse work, it is no different – repetitive lifting, carrying, and awkward postures are well-known risk factors for injuries to the lower back, shoulders, and other body regions (Barim & Lu, 2020; Zhao et al., 2022). Effective ergonomic risk assessment is therefore critical to improve worker safety and reduce injury rates. Traditional assessment methods – for example, observational tools and checklists like OWAS, RULA, or REBA – provide qualitative or categorical evaluations of posture and load, but they often rely on expert observation and can be subjective or time-consuming (Rybníkář et al., 2022; Medved et al., 2025).

Recent advances in wearable sensor technology offer a means to augment or, in some cases, replace these traditional methods with more objective, data-driven analyses (Lind et al., 2023). In particular, inertial measurement unit (IMU)-based motion capture systems allow continuous 3D tracking of a worker's body segment positions and joint angles throughout actual work tasks (Simon et al., 2024). Such systems can vastly improve the precision of exposure measurements compared to manual observation, capturing dynamic movements and peak exertions that might be missed or underestimated by human assessors. Moreover, new sensor fusion and machine learning approaches are improving automated scoring accuracy and reducing analyst workload (Krishnan et al., 2024). Research has also shown that wearable motion capture provides superior accuracy in measuring trunk and limb postures and enables real-time and automated ergonomic analysis (Humadi et al., 2021; Lind et al., 2023).

This paper explores the use of a wearable motion capture system paired with specialized ergonomic analysis software to evaluate the physical stresses of warehouse work. The Scalefit Industrial Athlete system – a biomechanical assessment tool integrating IMU sensors, biomechanical modeling, and ergonomic evaluation metrics – was used in this study. The system adheres to relevant ergonomic standards (e.g., DIN and ISO guidelines) to evaluate postures, movements, and physical loads in real time (Lind et al., 2023; Simon et al., 2024). It computes objective risk indicators such as joint angle excursions, velocities, and estimated spinal loads, and summarizes these in an ergonomic risk score

accompanied by a color-coded risk classification (from low to high risk). By analyzing several distinct warehouse tasks, we aim to (1) identify peak-risk patterns in each task, (2) compare the overall task demands and risk levels, and (3) demonstrate how the quantitative outputs from the motion capture analysis support ergonomic decision-making. The goal is to illustrate how data-driven insights can guide interventions – whether through redesigning tasks and workstations or providing targeted training – to mitigate the highest risks in warehouse jobs.

2 Methodology

This study is a single-subject pilot conducted to test a practical workflow for field ergonomic assessment. One healthy adult female warehouse worker performed four representative tasks: (1) placing and retrieving a 16 kg box on and from a mid-level shelf, (2) retrieving a lightweight box from a high shelf with and without a ladder, (3) lightweight box packing, and (4) carrying a 10 kg box downstairs (from 3rd to 1st floor). The worker (Figure 1) performed tasks in a realistic manner to capture typical postures and peak-load moments.

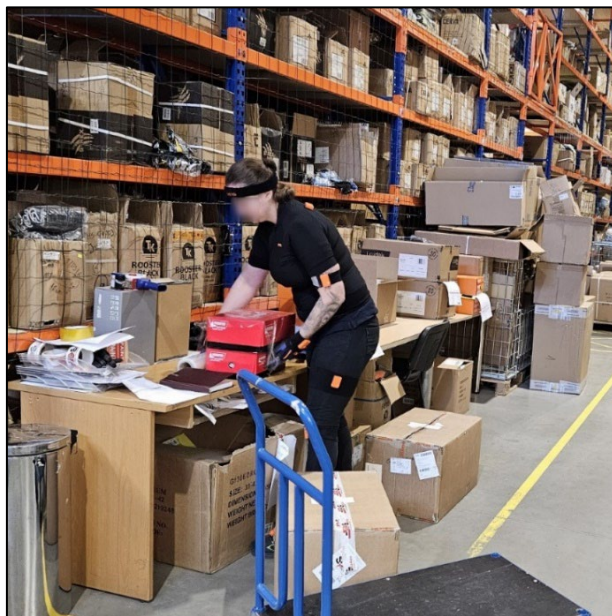


Figure 1: Warehouse worker packing a box

Source: Own

Full-body kinematics were recorded using an IMU-based motion capture suit (Xsens). Motion data were processed in Scalefit, which applies a scaled biomechanical model and known external loads (object masses entered as 16 kg, 10 kg, and 2 kg) to generate ergonomic indicators and summary reports in Excel.

We used the software outputs to describe and compare:

- peak joint angles (e.g., trunk flexion, shoulder elevation),
- time spent in predefined posture risk zones (green for low risk, yellow for moderate risk, red for high risk),
- frequency of high-risk events,
- estimated loads (e.g., lumbar compression and joint moments), and
- an overall composite MSD risk score.

Because this is a single-subject, short-duration pilot, we report descriptive comparisons only (no statistical testing). We focus on how tasks differ in peak-load risk (short, high-intensity events) versus cumulative postural exposure (longer, repeated non-neutral postures), and we use these patterns to point to practical workplace changes (layout, heights, loads, tools, and task rotation).

3 Results

3.1 Placing and retrieving a 16 kg box on and from a mid-level shelf

Overall, the two 16 kg tasks produced a very similar ergonomic profile. Both were rated as significantly increased risk for MSDs with a score of 32 or higher (e.g., placing the box was scored with 36,88), which indicates that:

- Physical overstrain is possible even for normally resilient individuals.
- Complaints (pain) may occur with dysfunction, usually reversible, without morphological manifestation.

In both cases, the low back was the primary contributor to the score. The peak low-back loading looked like this:

- Peak lumbar disc compression reached 5,3 kN during the main lift phase.
- The software flagged this lift moment as a high or even extreme risk low-back event, as seen in Figure 2.

Force exposure	Score	Stress	NIOSH Action Limit, DGUV-traffic light
Cervical disc compression (Max.)	1	low	
Cervical disc compression (Duration)	1	low	
Lumbar disc compression (Max.)	3,5	extreme	
Lumbar disc compression (Duration)	3	high	
Shoulder moment left (Max.)	3	high	
Shoulder moment right (Max.)	3,5	extreme	
Shoulder moment left (Duration)	2	medium	
Shoulder moment right (Duration)	3	high	
Load (Max.)	2	medium	
Load (Duration)	2	medium	

Figure 2: NIOSH action limits for placing a 16kg box onto a mid-level shelf

Source: Own

Trunk posture and twisting:

- Peak trunk inclination was about 77° (noted during reaching/pulling and handling).
- Trunk rotation remained limited, so twisting did not appear to drive risk in these trials.
- Most of each task stayed in green/yellow zones, with red-zone exposure concentrated around the lift moment.

Upper-limb and neck posture:

- Arm elevation peaked at around 106°, therefore shoulder moments and durations also posed a high risk in this activity.
- Neck posture stayed largely neutral, and the neck was not highlighted as a key risk region for these tasks.

3.2 Retrieving a lightweight box from a high shelf with and without a ladder

This comparison shows a clear posture shift when the worker uses a ladder. The overall MSD risk score was reduced from 33 (no ladder) to 31 (with ladder). Using the ladder removed the brief high-load moments at the low back and reduced the peak compression value:

- Time spent in the red zone was eliminated: from 7 minutes and 59 seconds to zero.
- Peak value (max): reduced from 4,2 kN to 3,4 kN.

There was also an improvement in the trunk inclination:

- Time spent in red zone was reduced from 5 minutes 53 seconds to 0 seconds and in the yellow zone from 35 minutes 53 seconds to 13 minutes and 8 seconds.
- Peak trunk inclination: from 79° to 37°.

As can be seen in Figures 3 and 4, the ladder reduced both the peak overhead reach and the time spent in the highest arm-elevation zone.

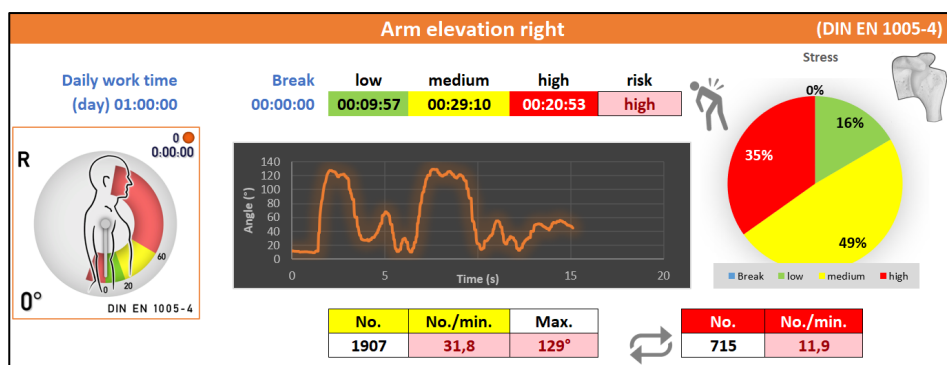


Figure 3: Arm elevation of the right hand without the ladder

Source: Own

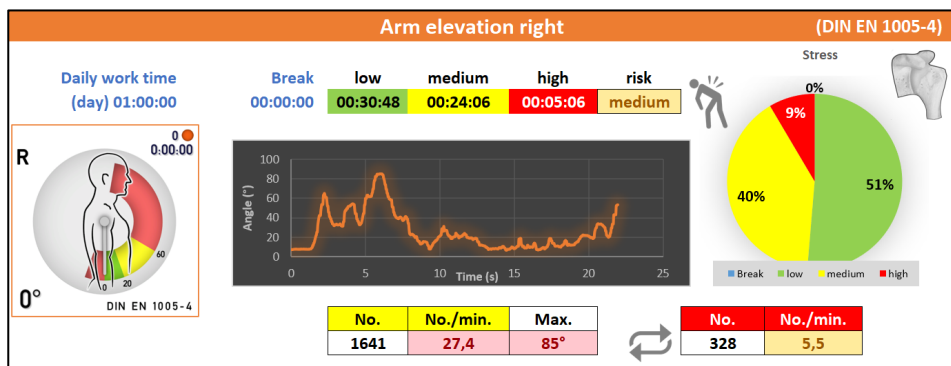


Figure 4: Arm elevation of the right hand with the ladder

Source: Own

The only trade-off was the radial/ulnar deviation of left wrist - likely due to grip/hand positioning during reach or placement of the ladder:

- The percentage in the yellow zone increased from 12 % to 56 %.
- Number of individual red events increased from 4 to 8.
- Peak deviation (max): from 19,6° to 26,2°.

3.3 Lightweight box packing

This task produced the clearest cumulative exposure pattern: low external load, but frequent and sustained non-neutral postures, especially for the low back and shoulders. Figure 5 shows the results of analysis with the score of 31,75, which falls into the moderately increased risk zone, this implies the following:

- Physical overstrain is possible in individuals with reduced resilience.
- Fatigue, minor adjustment complaints that can be compensated during leisure time.

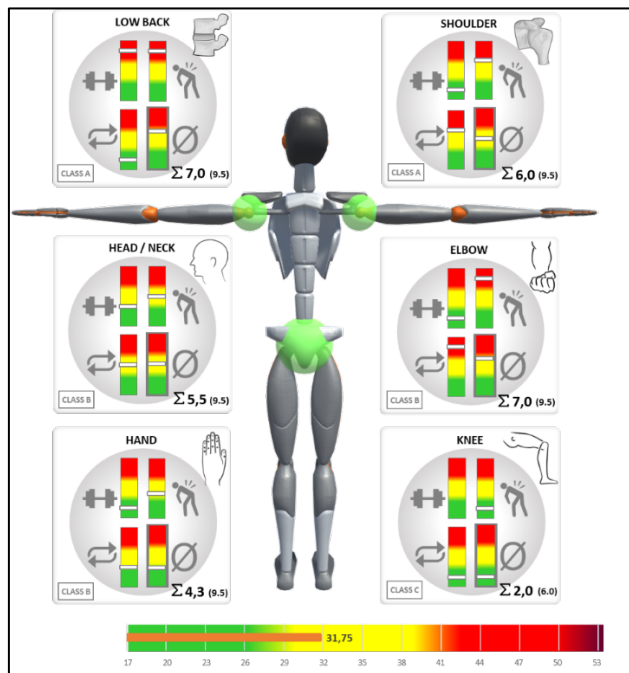


Figure 5: General analysis of lightweight box packing

Source: Own

Unlike the 16 kg lifts, the score was driven by time in awkward postures and repetition, not force. The key feature was how much of that time the worker spent away from neutral posture (yellow/red exposure accumulating across many small actions). If we look at the low-back and trunk posture, we come across the following:

- Peak trunk flexion reached about 86°, especially when the worker bent to pick items from a low location (e.g., near floor level).
- Cumulative exposure was substantial:
- about 21 % of task time in red-zone trunk posture,
- and about 39 % in yellow-zone moderate flexion.
- Lumbar compression forces stayed out of the red zone (less than 3,4 kN) for 73 % of the task time, so the risk came mainly from repeated bending and sustained flexion rather than heavy load.

The shoulders and arms were also at higher risk for MSD risk:

- Reaching and placing actions increased shoulder demand.
- The left shoulder peak elevation reached 92° during higher or farther reaches.
- The right shoulder showed many yellow events, consistent with frequent reach cycles during packing.

Neck posture alternated between forward flexion (looking down during bending) and neutral while working at the table; neck flexion around 30° occurred during bent phases and contributed to moderate exposure. Left wrist abduction also appeared during the packing, with multiple moderate and high-risk events when the wrist moved outside the neutral position.

3.4 Carrying a 10 kg box downstairs (from 3rd to 1st floor)

DATABASE (time-weighting and daily dose)							Break 0:00 (h:m)
PHYSICAL STRESS	low (75%)		medium (25%)		high (10%)		0%
	Time %	Dose/day (h:m:s)	Time %	Dose/day (h:m:s)	Time %	Dose/day (h:m:s)	Risk level (MSD)
Trunk inclination	89%	00:53:08	11%	00:06:52	0%	00:00:00	low
Lumbar disc compression	86%	00:51:28	8,2%	00:04:55	6,0%	00:03:38	low
Load	54%	00:32:24	46%	00:27:36	0%	00:00:00	medium
Head torsion	82%	00:49:25	15%	00:08:52	3%	00:01:42	low
Head inclination	34%	00:20:32	32%	00:19:27	33%	00:20:01	high
Cervical disc compression	73%	00:43:45	25%	00:14:44	3%	00:01:30	low
Arm elevation left	50%	00:30:13	42%	00:25:22	7%	00:04:25	medium
Arm elevation right	53%	00:31:49	44%	00:26:17	3%	00:01:54	medium
Shoulder moment left (STA)	0%	00:00:00	0%	00:00:00	0%	00:00:00	N/A
Shoulder moment left (DYN)	80%	00:48:15	20%	00:11:45	0%	00:00:00	low
Shoulder moment right (STA)	0%	00:00:00	0%	00:00:00	0%	00:00:00	N/A
Shoulder moment right (DYN)	84%	00:50:31	16%	00:09:29	0%	00:00:00	low
Above-shoulder work left	94%	00:56:07	3%	00:01:35	4%	00:02:18	low
Above-shoulder work right	95%	00:56:56	3%	00:01:56	2%	00:01:08	low
Velocity	84%	00:50:07	13%	00:07:40	4%	00:02:11	low
Wrist flexion/extension left	93%	00:56:01	7%	00:03:59	0%	00:00:00	low
Wrist flexion/extension right	94%	00:56:26	6%	00:03:28	0%	00:00:07	low
Wrist abduction left	63%	00:37:57	26%	00:15:28	11%	00:06:35	high
Wrist abduction right	99%	00:59:15	1%	00:00:45	0%	00:00:00	low
Knee flexion left	72%	00:42:57	24%	00:14:31	4%	00:02:32	low
Knee flexion right	70%	00:42:15	26%	00:15:36	4%	00:02:09	medium
Forearm rotation left	23%	00:13:32	19%	00:11:40	58%	00:34:48	high
Forearm rotation right	56%	00:33:28	19%	00:11:42	25%	00:14:51	high
Grasp space left	N/A	00:00:00	N/A	00:00:00	N/A	00:00:00	N/A
Grasp space right	N/A	00:00:00	N/A	00:00:00	N/A	00:00:00	N/A

Figure 6: Times and MSD risks of carrying a box down the stairs

Source: Own

This task showed a different pattern than the 16 kg lifts: no single extreme peak but sustained moderate load and repetition over the period of the task. Figure 6 shows the risk levels for MSDs for different body sections and the time spent under different physical stress zones, if we consider that the task is repeated many times throughout the worker's day.

The overall MSD risk score was 32,75 points (significantly increased risk). Risk came from duration under load and repeated stepping, not from brief high-force spikes. A single task lasted 1 minute and 13 seconds (down two flights of industrial stairs).

We synthesized the following information for low-back loading and trunk posture:

- Lumbar compression stayed around 1,5-2,0 kN during most of the descent, which is lower than the heavy-lift peaks but sustained.
- Trunk angle varied with each step (small cycles rather than a single bend-and-return) but mostly stayed in the neutral position.

Knees went through repeated flexion-extension cycles across the stair steps, with knee flexion peaking at 75° during stepping. The software did not flag the knee angles as extreme, but the repetition count contributed to the overall risk profile (repeated cycles under load). Arms and shoulders stayed relatively stable while holding the box close (generally low risk compared with packing or overhead work). Neck posture showed a strong forward flexion (looking down the stairs), around 20-25° for much of the task, with 32 % in the yellow zone and 33 % in the red zone.

4 Discussion

This study shows how wearable full-body motion capture combined with Scalefit outputs can describe warehouse task demands in a way that supports practical changes. Across tasks, the overall scores clustered in the moderately to significantly increased risk range for MSDs, which is in line with similar research (Zhao et al., 2022; Adhaye & Jolhe, 2023). The 16 kg box handling tasks were defined by short peak-load events (mainly low back), while packing showed longer time in non-neutral postures (low back and shoulders) with low external force. High-level picking without a ladder shifted risk to overhead shoulder and trunk posture, whereas using

a ladder reduced upper-body load but introduced some wrist strain. The stair-carrying task sat between these patterns, with sustained moderate load over a longer duration. These differences matter because they imply different controls: reducing peak spinal load for heavy handling versus reducing reach and bend time for packing.

The 16 kg box handling tasks reflect a **peak-load** risk profile. The overall rating stayed moderate because tasks were short, but the lift phase produced high low-back loading close to common action thresholds used in practice (e.g., values often referenced in NIOSH-based guidance) (Barim & Lu, 2020; Matijevich et al., 2021). This matters because repeated exposure to short high-load events can raise risk even when most of the task looks acceptable by posture time alone. Controls should aim to reduce peak spinal load: store heavier items near waist height, keep the load close, reduce load mass per lift, and use aids and/or ergonomic tools when frequency is high.

For the following task, using the **ladder reduced overall risk** and, more importantly, shifted the task away from high trunk and low-back loading and from sustained overhead reaching. In the no-ladder condition, the main exposure came from reaching high from the floor, which drove high trunk inclination and shoulder elevation. With the ladder, those upper-body demands dropped to mostly moderate levels, but the main trade-off appeared at the hand: the ladder condition increased left wrist deviation, likely due to grip and hand position during handling at height. In practice, this supports using ladders or step platforms for high picking, but pairing them with simple changes that protect the wrist (better handholds, two-hand grip, and placing the load closer to the body) (Hilmi, Hamid, & Ibrahim, 2024).

The packing task reflects a **cumulative exposure** profile. Loads were low, but the worker spent a large share of time in non-neutral trunk and shoulder postures. That matches the broader point in ergonomics literature that “light” work can still cause MSDs through repeated bending and reaching (Zhao et al., 2022). The practical priority is workstation and layout change: raise pickup points, keep high-use items in near reach, and set work height to limit shoulder elevation. Rotation and short breaks can help when packing runs for long periods, but redesign should come first when the layout is the main driver of the worker’s posture (Sahu & Pandit, 2025).

The stair-carrying task showed **sustained moderate load** over a longer duration. It did not create one large peak, but continuous carrying and repeated stepping under load can drive fatigue and steady low-back demand. Practical options include reducing manual carries between floors, using lifts or routes that avoid stairs, and setting limits on carry duration and frequency.

Regarding the methodology used, the workflow supports faster and more objective assessment than purely observational approaches (Medved et al., 2025). Wearable motion capture can capture dynamic postures and peak events that are easy to miss by eye and can support rapid post-task reporting for decisions in the field (Lind et al., 2023; Humadi et al., 2021). Systems that give clear summaries and visual feedback can also support training and communication with managers and workers (Lind et al., 2020).

This study also had some limitations. This is a single-subject pilot with short trials, so results reflect one worker's technique and one setup. More workers and longer recordings would represent variation and fatigue across the shift and offer greater generalizability (this is also the main idea for future studies). Also, the overall risk score relies on a proprietary composite; the most defensible reporting approach is to show the core exposures (time in posture zones, peaks, estimated loads) alongside the score, using the score mainly for within-study comparison (Ciccarelli et al., 2025).

5 Conclusion

This study presents a practical field workflow that links wearable full-body motion capture (Xsens) with Scalefit outputs to describe physical load in warehouse work in a way that supports ergonomic action. Although the overall MSD risk scores clustered in the moderate to high range, the task profiles differed: 16 kg box handling showed short peak low-back loading, high-level picking without a ladder shifted risk to overhead shoulder and trunk posture, lightweight packing showed longer exposure to non-neutral trunk and shoulder postures, and stair-carrying showed sustained moderate demand over time. These differences matter because they imply different controls: reducing peak load for heavy handling (weight, storage height, aids), using a ladder when reaching higher shelves, reducing bend and reach time for packing (work height and layout), and reducing stair-carrying where possible (routing and lifts).

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PRIMERJALNA ANALIZA PILOTNIH PROJEKTOV KROŽNEGA GOSPODARSTVA V PODONAVSKI REGIJI

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Pilotni projekti krožnega gospodarstva so pomembno orodje za trajnostne prehode, vendar njihova raznolikost otežuje primerjavo in prenos rezultatov. Prispevek predstavlja primerjalno analizo osmih pilotnih projektov krožnega gospodarstva v Podonavski regiji, ki zajemajo tekstilni, embalažni, pametno-mestni, e-odpadniški ter živilski in kmetijski sektor. V vseh primerih je bil uporabljen enoten dokumentacijski in modelirni okvir, ki je vključeval skupne predloge, večperspektivno modeliranje in centraliziran repozitorij. Na podlagi večprimerjalne analize ugotavljamo, da si pilotni primeri kljub različnim kontekstom delijo podobne cilje in izzive, kot so zagotavljanje stabilne oskrbe s sekundarnimi materiali, visoki začetni stroški, regulativne zahteve in omejeno sprejemanje na trgu. Med ključnimi dejavniki uspeha izstopajo partnerske mreže, sistemi vračanja in lokalna podpora. Prispevek pokaže, da standardizirano dokumentiranje omogoča prepoznavanje ponavljajočih se vzorcev izzivov in dejavnikov uspeha ne glede na sektor, s čimer podpira primerljivost, prenos znanja in dokazno podprto odločanje v krožnem gospodarstvu.

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COMPARATIVE ANALYSIS OF CIRCULAR ECONOMY PILOT PROJECTS IN THE DANUBE REGION

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Circular economy pilot projects are an important tool for sustainable transitions, but their diversity makes it difficult to compare and transfer results. This paper presents a comparative analysis of eight circular economy pilot projects in the Danube region, covering the textile, packaging, smart city, e-waste, and food and agriculture sectors. In all cases, a uniform documentation and modeling framework was used, which included common templates, multi-perspective modeling, and a centralized repository. Based on a comparative analysis, we conclude that, despite their different contexts, the pilots share similar goals and challenges, such as ensuring a stable supply of secondary materials, high initial costs, regulatory requirements, and limited market acceptance. Key success factors include partner networks, return systems, and local support. The paper shows that standardized documentation enables the identification of recurring patterns of challenges and success factors across sectors, thereby supporting comparability, knowledge transfer, and evidence-based decision-making in the circular economy.



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1 Uvod

Krožno gospodarstvo se uveljavlja kot osrednji okvir za zmanjšanje rabe primarnih surovin, podaljševanje življenjske dobe izdelkov ter ohranjanje vrednosti materialov v gospodarstvu. Med glavnimi zgodnjimi prispevki, ki so krožno gospodarstvo utemeljili tudi z ekonomskega in poslovnega vidika, izstopa Ellen MacArthur Foundation (2013). Na ravni Evropske unije prehod dodatno usmerjajo strateški dokumenti in zakonodajni paketi, zlasti Akcijski načrt za krožno gospodarstvo iz leta 2015 (European Commission, 2015), Evropski zeleni dogovor (European Commission, 2019) ter novi Akcijski načrt za krožno gospodarstvo iz leta 2020 (European Commission, 2020). Skupni poudarek teh dokumentov je potreba po sistemskih spremembah, ohranjanju vrednosti (ang. value retention) in na dokazih podprtem oblikovanju politik.

Pilotni projekti so pomemben mehanizem za preverjanje krožnih rešitev v praksi, saj omogočajo testiranje poslovnih modelov, organizacijskih ureditev in izvedbenih poti v realnih okoljih. Vendar primerjava pilotov pogosto ni enostavna: pilotni primeri potekajo v različnih sektorjih, uporabljajo različne kazalnike in poročajo z različno stopnjo podrobnosti, kar otežuje sintezo rezultatov in prenos dobrih praks. Zato projekti, ki želijo zbirati in primerjati dokaze med partnerji, praviloma vzpostavijo strukturiran sistem dokumentiranja, ki zagotavlja doslednost, sledljivost in ponovno uporabnost gradiv (European Commission, 2021; OECD Development Assistance Committee, 2019). Pri tem je koristno slediti preverjenim usmeritvam zasnove študij primerov, ki podpirajo ponovljivost in transparentno povezavo med podatki, analizo in sklepi (Yin, 2018), ter podatkovnim praksam, ki povečujejo odkrivanje in ponovno uporabo gradiv (Wilkinson et al., 2016).

V okviru projekta DECIDE, v katerem sodeluje 16 partnerjev iz 10 držav (Slika 1), je delovni paket WP 1.4.1 vzpostavil enoten dokumentacijski okvir za osem pilotnih primerov v različnih državah in sektorjih. Dokumentacija povezuje pilotne primere z metodami projekta (predloge, modeliranje, usposabljanja) ter ustvarja skupno osnovo za kasnejšo primerjalno analizo in sintezo. Vsak pilotni primer je obravnavan kot študija primera z usklajenimi elementi dokumentiranja in modeliranja, kar omogoča primerljiv prikaz strateških, procesnih, vrednostnih in dinamičnih vidikov (npr. BMC, BPMN, e3Value, System dynamics) (Gordijn & Akkermans, 2003; Object Management Group, 2011; Osterwalder & Pigneur, 2010; Sterman, 2000).

Namen tega prispevka je povzeti ključne ugotovitve, ki izhajajo iz zbiranja pilotne dokumentacije in primerjalne analize, ter pokazati, kako standardiziran pristop podpira učenje med primeri in dokazno podprto odločanje. Prispevek najprej predstavi okvir in pristop, nato strne skupne vzorce in izzive med piloti ter zaključi s priporočili za oblikovalce politik.



Slika 1: Sodelujoče države v projektu DECIDE

Vir: DECIDE Consortium (2024)

2 Metodologija

Empirični podatki v tej študiji temeljijo na projektni dokumentaciji in notranjih poročilih, pripravljenih v projektu DECIDE (Interreg Danube Region Programme). V delovnem paketu WP 1.4.1 smo vzpostavili enoten okvir za dokumentiranje osmih pilotnih projektov krožnega gospodarstva v različnih državah in sektorjih. Pilotne primere smo obravnavali kot študije primerov z usklajenimi elementi opisa, modeliranja in poročanja, kar je zagotovilo primerljivost med primeri (DECIDE Consortium, 2025).

Ker smo bili odgovorni za zbiranje in urejanje celotne dokumentacije pilotov, smo izvedli dve vrsti analize. Prvič, uporabili smo zasnovano večprimerjalno študijo (multiple-case study) z osmimi primeri, kar omogoča sintezo rezultatov in

primerjavo vzorcev med piloti. Drugič, na podlagi izkušenj zbiranja gradiv smo analizirali tudi proces dokumentiranja ter izpostavili ključne izvedbene izzive in ukrepe za njihovo reševanje.

Za vse pilote je bil uveden standardiziran protokol dokumentiranja: partnerji so uporabljali enake predloge in obrazce ter pripravljali ključne dokumente (npr. predstavitev in poster) po enotni strukturi. S tem je bilo zagotovljeno, da so ključne informacije zapisane v primerljivem formatu in da lahko neposredno primerjamo iste vsebinske sklope med pilotnimi primeri. Poleg opisne dokumentacije je bilo v vseh primerih uporabljeno večperspektivno modeliranje z istim naborom modelov: (1) Business Model Canvas (BMC) za strateški pogled, (2) BPMN za procesni pogled, (3) e3Value za vrednostni pogled oz. pregled ustvarjanja dodane vrednosti in (4) System dynamics za dinamični pogled predlaganega poslovnega modela krožnega gospodarstva.

Vso dokumentacijo in modele smo hranili v centraliziranem repozitoriju (MS Teams) z enotno strukturo map. Uvedli smo osnovna pravila za poimenovanje in nadzor različic (status in datum) ter poleg izvornih datotek zbirali tudi datoteke za ogled (npr. slike ali PDF), da so bili modeli dostopni tudi partnerjem brez nameščenih ustreznih programskih orodij. Koordinacijska ekipa je sproti preverjala popolnost paketov po pilotnih primerih in usklajevala odprte točke, da smo do zaključka delovnega sklopa zbrali skladen nabor gradiv za vseh osem primerov.

3 Rezultati

3.1 Predstavitev posameznih pilotnih projektov

V Podonavski regiji je bilo izvedenih osem pilotnih projektov krožnega gospodarstva v različnih sektorjih (tekstil, embalaža, baterije, pametna mesta, hrana), ki so vsi sledili opisanemu enotnemu pristopu dokumentiranja. Vsak pilot je na svojem področju uveljavljal principe krožnega gospodarstva in preizkušal nove poslovne modele. Po abecednem redu držav in z uporabo izvornih angleških poimenovanj so povzeti ključni vidiki posameznega primera (DECIDE Consortium, 2025):

- **Avstrija (Making flags from old textiles):** Proizvajalec zastav Fahnen-Gärtner je uvedel sistem vračanja rabljenih poliestrskih zastav in transparentov. Del zbranega materiala predelajo v nove izdelke (npr. torbe), pri novih zastavah pa povečajo delež recikliranega poliestra. Pilot poroča o velikem zmanjšanju emisij CO₂ in občutnem zmanjšanju tekstilnih odpadkov. Glavni izzivi so logistika zbiranja in zagotavljanje stalne kakovosti recikliranega materiala.
- **Bosna in Hercegovina (Products made of recycled or biodegradable materials):** Podjetje Weltplast je zasnovalo skoraj brezodpadno proizvodnjo, v kateri interne ostanke plastike sistematično vrača v proizvodnjo. Poleg tega odkupuje odpadno plastiko iz okolja in jo predela v sekundarno surovino. Poudarek je na velikih količinah predelanih materialov in zmanjšanju odvisnosti od primarnih surovin. Kot ključne ovire izpostavljajo stabilno dobavo kakovostnega postpotrošniškega materiala ter širše razmere na trgu dela in regulativne spremembe.
- **Hrvaška (Work integration through textile waste management):** Socialno podjetje Humana Nova zbira tekstil iz gospodinjstev, podjetij in javnih tokov. Uporabna oblačila prodaja, del neuporabnih frakcij predela v čistilne krpe, preostalo usmeri v reciklažo. Model združuje okoljske koristi (manj tekstila na odlagališčih) s socialnimi, saj zaposluje ranljive skupine. Izzivi so stroški in zahtevnost sortiranja ter obvladovanje nizkokakovostnih delov zbranega tekstila, kjer so možnosti predelave omejene.
- **Nemčija (Sourcing energy from biomass):** Pilot razvija lokalni energetski koncept v mestu Spaichingen, ki uporablja kmetijske in gozdne ostanke ter jih preko pirolize pretvarja v energent za soprodukcijo elektrike in toplote. Namen je okrepiti lokalno oskrbo in dopolniti druge obnovljive vire. Prednosti vidijo v izrabi ostankov (namesto odprtega sežiga) in zmanjšanju fosilnih virov. Glavni izziv je visoka kompleksnost: tehnološka integracija in usklajevanje deležnikov (kmetje, občina, industrija, dobavitelji ...).
- **Madžarska (PLA filaments to replace traditional materials):** Pilot podjetja Filaticum razvija PLA filament iz obnovljivih virov kot bolj trajnostno alternativo klasičnim materialom za 3D tisk. Ključna prednost je možnost kroženja: odvečne ali uporabljene izpise/modele je mogoče ponovno predelati v nov filament, poleg tega lahko filament prilagodijo z

dodatnimi lastnostmi. Rešitev cilja na manjšo odvisnost od petrokemičnih plastik in večjo fleksibilnost proizvodnje. Izzive predstavljajo dobavna odvisnost od surovin, pomanjkanje znanja/kadrov in stroški energije, ki vplivajo na konkurenčnost.

- **Moldavija (Household-level battery recycling):** Pilot podjetja Renergy vzpostavlja sistem zbiranja gospodinjstskih baterij in recikliranja, pri čemer izločajo uporabne kovine ter jih vračajo v proizvodne tokove. Okoljski argument je močan: zmanjšanje tveganj zaradi strupenih snovi in manj potrebe po primarnem pridobivanju surovin. Uspeh je tesno vezan na učinkovitost zbiranja pri prebivalstvu. Največje ovire so logistika, stroški in zahtevnost tehnologije ter stalna potreba po skladnosti s pravili ravnanja z nevarnimi odpadki.
- **Romunija (Making dehydrated fruits and vegetables from leftovers):** Startup Nature Flavor Green uporablja presežno ali neprodano sadje in zelenjavo ter jih predela v izdelke z daljšo obstojnostjo (sušeni prigrizki, praški ipd.). S tem zmanjšuje živilske odpadke in odpira dodaten prihodkovni tok, hkrati pa krepi povezave z lokalnimi dobavitelji. Pomemben del je tudi ozaveščanje o problemu zavržene hrane. Izziv ostaja stabilna dobava vhodnih presežkov, ki se sezonsko spreminjajo, ter potreba po ustreznem načrtovanju kapacitet za širitev.
- **Slovenija (From tomato stems to paper bags):** Pilot Inštituta za celulozo in papir preverja možnost, da se paradižnikova stebela po žetvi uporabijo kot vir celuloznih vlaken za papir in embalažo, delno namesto lesne celuloze. Prednosti so v lokalni rabi odpadne biomase in zmanjšanju pritiska na primarne vire. Dokaz koncepta je uspel, a so se pokazale omejitve: nižja kakovost vlaken in prisotnost nečistoč, ki zahtevajo dodatno predobdelavo. Za nadaljnji razvoj je ključno izboljšanje kakovosti in ekonomika obsega pri industrijski izvedbi.

3.2 Skupne značilnosti pilotnih projektov

Kljub različnim sektorjem in materialnim tokovom imajo vsi piloti skupen cilj: zmanjšati uporabo primarnih surovin in količino odpadkov z lokalnimi ali regionalnimi krožnimi zankami. V praksi se večina primerov ponavlja po podobnem vzorcu: (1) zajem odpadnega toka ali stranskega produkta, (2) sortiranje/predobdelava, (3) predelava v nov material ali izdelek in (4) prodaja ali

ponovna distribucija, pogosto ob podpori sheme vračanja. V osmih različnih pilotnih primerih je bilo ugotovljenih naslednjih devet ponavljajočih se skupnih točk (DECIDE Consortium, 2025):

- Osnovni cilj: zmanjšanje porabe novih surovin in odpadkov z lokalnim kroženjem materialov (tekstil, plastika, kmetijski ostanki, baterije, biomasa).
- Oblika poslovnega modela: zbiranje, sortiranje/predobdelava, pretvorba (recikliranje, nadgradnja, dehidracija, pulpa, piroliza), izdelava proizvoda/storitve, prevzem ali ponovna uporaba.
- Partnerji: lastniki virov (državlani, kmetije, mala in srednja podjetja), predelovalci, proizvajalci, logistika ter prodaja; en koordinator določi pravila in spremlja stanje.
- Vrednostna ponudba: manj CO₂ in odpadkov, potencialni prihranki pri stroških zaradi sekundarnih surovin, lokalna delovna mesta in hitrejša lokalna oskrba.
- Stroškovni dejavniki: naložbe v novo opremo, poraba energije, povratna logistika in skladnost (varnost, živila, kemikalije).
- Tržna tveganja: sprejemljivost kakovosti/cene, sezonskost in nestabilni prihodkovni tokovi.
- Spodbujevalci: preproste ponudbe za prevzem, standardni formati/oznake, vnaprej dogovorjene pogodbe z dobavitelji in odjemalci.
- Vrzeli v podatkih: izhodiščne vrednosti vpliva, razponi donosa/kakovosti in stroški na enoto na posamezni stopnji; vsi primeri imajo koristi od majhnega niza standardnih meril.
- Zahteve politike: boljše sortiranje/zbiranje, zeleno javno naročanje ter krediti ali subvencije za naložbe in širitev.

Kljub raznolikosti se med pilotnimi primeri ponavljajo štiri glavne skupine izzivov. Prvi je stabilna dobava sekundarnih materialov in nihanje njihove kakovosti (onesnaženost, neenotne lastnosti, sezonskost), kar neposredno vpliva na zanesljivost procesov. Drugi izziv je ekonomsko-tehnične narave: visoki začetni stroški opreme, energetska intenzivnost procesov in težko dosegljiva cenovna konkurenčnost v primerjavi z linearnimi rešitvami. Tretji sklop predstavljajo regulativne zahteve (varnost, okolje, standardi izdelkov), ki povečujejo kompleksnost in stroške, zlasti pri baterijah, hrani in materialih z visokimi zahtevami

glede kakovosti. Četrty izziv je sprejemanje trga, saj je treba kupce prepričati o kakovosti izdelkov iz sekundarnih virov in jih spodbuditi k sodelovanju v vračilnih sistemih.

Kot ključni dejavniki uspeha se dosledno izkazujejo močna partnerstva vzdolž vrednostne verige in jasna koordinacija materialnih tokov. Pomembno vlogo imajo tudi preproste zbirne in vračilne sheme, vnaprej dogovorjeni pogodbeni odnosi ter osnovni standardi kakovosti sekundarnih materialov, ki zmanjšujejo operativna in tržna tveganja. Prednost imajo pilotni primeri, ki so dobro vpeti v lokalno okolje in imajo podporo skupnosti ali lokalnih oblasti.

Skoraj vsi pilotni primeri razkrivajo tudi izrazite podatkovne vrzeli: pogosto manjkajo izhodiščne (»baseline«) meritve, enotni kazalniki uspešnosti ter sistematično beleženje izkoristkov procesov in stroškov po fazah. To otežuje zanesljivo primerjavo med primeri in dokazovanje dejanskih učinkov, zato analiza poudarja potrebo po majhnem, skupnem naboru kazalnikov (npr. preusmerjeni tokovi materialov, zmanjšanje CO₂ izpustov, strošek na enoto, ustvarjena delovna mesta).

Enotno dokumentiranje in skupni modelirni pristopi v okviru projekta DECIDE so omogočili, da so bili cilji, procesi, deležniki in rezultati pilotov opisani v primerljivem in sledljivem formatu. To je bistveno olajšalo prepoznavanje skupnih vzorcev, razlik med primeri ter oblikovanje prenosljivih priporočil za bodoče projekte.

3.3 Izzivi in rešitve pri zbiranju dokumentacije pilotnih projektov

V spodnji tabeli so povzeti glavni izzivi, s katerimi smo se soočili med izvajanjem našega delovnega paketa, ukrepi, ki smo jih sprejeli za njihovo reševanje, ter izkušnje za prihodnje pilotno dokumentiranje in izvajanje.

Tabela 1: Glavni izvedbeni izzivi in predlagani ukrepi pri zbiranju dokumentacije

Področje	Problem	Rešitev	Ukrepi za naprej
Čas	Pilotni partnerji niso imeli na voljo toliko časa, kot ga zahteva standardna implementacija krožnega poslovnega modela.	Določitev minimalno potrebne vsebine, uvedba kratkih rokov "zamrznitve" za posamezne pilote ter kratki tedenski usklajevalni sestanki.	Zgodnejša omejitev obsega pilotov, vnaprej rezervirani časovni bloki za pregleda ter načrtovana dodatna iteracija za validacijo z deležniki.
Različice in statusi	Veliko vzporednih različic in pogoste spremembe statusov (osnutki, delne združitve, pozni vnosi), ki so zahtevale stalno usklajevanje.	Uporaba ene delovne datoteke na pilot in dosledna raba sledenja spremembam.	Že na začetku opredeliti statusne oznake in pravila poimenovanja, uvesti skupni dnevnik sprememb ter omogočiti napredovanje datotek le po dogovorjenem toku statusov.
Formati	Potrebni so bili različni formati (besedilo, slike, modeli, podatki), partnerji pa so oddajali mešane tipe datotek.	Poenotenje formatov: DOCX/PDF za besedilo, PNG/SVG za slike ter izvirne datoteke modelov.	Na začetku objaviti kratek vodič za formate in izvoze z zahtevanimi formati za posamezne vrste vsebin ter primerom celotnega paketa.
Orodja za odpiranje modelov	Uporaba dveh orodij (ADOxx in Vensim PLE) je povečala napor pri namestitvi in povzročila težave pri izvozu določenih izpisov nekaterih partnerjev.	Zagotovljene so bile tako izvirne datoteke modelov kot tudi datoteke za ogled (PNG/PDF), skupaj z navedbo orodja in različice.	Razmisliti o standardizaciji enega orodja za modeliranje. Če sta potrebni dve, uporabiti odprte izmenjalne formate in zagotoviti preverjen seznam orodij za ogled.
Skupni repozitorij	Dokumentacija je bila naložena na več lokacijah; kontekst in zadnji status pogosto nista bila jasna.	Usmeritev ekip na skupno strukturo map in shranjevanje končnih datotek v osrednjem repozitoriju MS Teams.	Uporaba enotnega repozitorija za vso pilotsko dokumentacijo (delovne in končne verzije), s fiksno strukturo map in obveznimi metapodatki.

Vir: DECIDE Consortium (2025)

4 Diskusija

Primerjalna analiza osmih pilotnih primerov krožnega gospodarstva potrjuje, da standardizirano dokumentiranje in modeliranje v večprojektnem okolju bistveno izboljšata preglednost, primerljivost in učenje med primeri. Uporaba skupnih dokumentacijskih standardov in usklajenih analitičnih okvirjev je omogočila, da so bili vsi piloti – kljub sektorskim razlikam – opisani znotraj enotne strukture, kar je olajšalo neposredno primerjavo procesov in rezultatov. Centraliziran repozitorij s skupnimi predlogami je zagotovil, da so bile ugotovitve posameznih pilotov hitro dostopne in razumljive drugim partnerjem, s čimer se je okrepila izmenjava znanja.

Tak pristop je skladen z ugotovitvami literature, ki poudarja pomen sledljivosti in ponovljivosti študij primerov za prenosljivost in dokazno podprto učenje (Yin, 2018).

V primerjavi z obstoječimi študijami, ki pilotne projekte krožnega gospodarstva večinoma obravnavajo posamično ali sektorsko, ta analiza prispeva sistematično primerjavo osmih pilotov iz različnih sektorjev na osnovi enotnega dokumentacijskega in modelirnega okvira. Ključna dodana vrednost ni v posameznih tehničnih rešitvah, temveč v dokazu, da standardizirano dokumentiranje omogoča prepoznavanje ponavljajočih se vzorcev izzivov in dejavnikov uspeha, ne glede na sektor ali državo. S tem prispevek presega opis posameznih primerov in ponuja prenosljiv analitični pristop, ki podpira učenje med piloti in z dokazi podprto odločanje.

Ugotovitve iz pilotov hkrati potrjujejo znane ovire pri prehodu v krožno gospodarstvo. Ponavljajo se izzivi, povezani z nestabilno dobavo sekundarnih materialov, nihajočo kakovostjo vhodov, visokimi začetnimi stroški, zahtevno regulativo ter omejenim sprejemanjem na trgu. Posebej izrazita je sistemska težava zbiranja in obratne logistike: krožni modeli so učinkoviti le toliko, kolikor so učinkoviti sistemi zbiranja. Dejstvo, da so številni piloti morali vzpostavljati lastne zbirne sheme, kaže na vrzel v obstoječem linearnem sistemu. To potrjuje potrebo po javnih politikah, ki krepijo ločeno zbiranje, razširjeno odgovornost proizvajalcev in druge mehanizme, ki omogočajo stabilne materialne tokove.

Pomembno prečno spoznanje analize je tudi pomanjkanje podatkov in enotnih kazalnikov. Večina pilotov ni razpolagala z izhodiščnimi meritvami ali primerljivimi podatki o izkoristkih, kakovosti in stroških, kar omejuje možnost zanesljive primerjave in dokazovanja učinkov. Brez poenotenih meril bo spremljanje napredka in učinkov krožnega prehoda ostalo omejeno, kar potrjujejo tudi nedavne študije (Serna-Guerrero et al., 2022).

5 Zaključek

Študija je s primerjalno analizo osmih pilotnih primerov/projektov krožnega gospodarstva v Podonavski regiji pokazala, da enoten pristop k dokumentiranju in analiziranju pomembno prispeva k preglednosti, primerljivosti in prenosljivosti

spoznanj. Standardizirane predloge, skupni repozitorij in uporaba več komplementarnih modelirnih tehnik so omogočili sintezo skupnih vzorcev ter dokazno podprto primerjavo zelo raznolikih pilotov. Rezultati potrjujejo, da so krožni poslovni modeli izvedljivi v različnih sektorjih, vendar se pri tem ponavljajo podobni izzivi, zlasti glede dobave sekundarnih materialov, stroškov uvedbe, regulativnih zahtev in tržne sprejemljivosti. Hkrati se kot ključni dejavniki uspeha dosledno kažejo partnerstva, sistemi vračanja in lokalna podpora, medtem ko pomanjkanje standardiziranih kazalnikov ostaja pomembna omejitev. Na tej podlagi študija podaja naslednja praktična priporočila za oblikovalce politik in odločevalce:

- Okrepite zbiranje in obratno logistiko: z razširjeno odgovornostjo proizvajalcev, kavcijskimi sistemi in komunalnimi programi zbiranja.
- Zagotovite finančne spodbude za širitev: nepovratna sredstva, ugodna posojila in davčne olajšave za investicije in povečevanje obsega.
- Vzpostavite standarde za sekundarne materiale: jasni kakovostni in varnostni standardi povečajo zaupanje trga.
- Uporabite zeleno javno naročanje: javni sektor lahko ustvari povpraševanje in stabilnost za krožne izdelke.
- Podprite delitev znanja: odprte platforme in podatkovne baze povečajo učinek posameznih pilotov prek regij in sektorjev.

Skratka, primerjalni pristop omogoča prepoznavanje ponavljajočih se vzorcev izzivov in rešitev tudi med sektorsko različnimi piloti ter podpira načrtovanje podpornih mehanizmov in poslovnih strategij za širitev krožnih modelov. Za pospešitev prehoda ostajata ključna predvsem krepitev sistemov zbiranja dokumentacije ter razvoj enotnih kazalnikov, ki omogočajo zanesljivo spremljanje učinkov in primerjavo pristopov.

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IZZIVI DOLGOŽIVE DRUŽBE KOT PRILOŽNOST ZA PRESTRUKTURIRANJE ORGANIZACIJE

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Osnovi namen tega članka je preučiti demografske premike in staranje prebivalstva kot pomemben strukturni in organizacijski izziv za sodobne organizacije. Osredotoča se na večgeneracijsko delovno silo, vključno z generacijami X, Y in Z, ter njen vpliv na strateško, organizacijsko in kadrovsko prestrukturiranje organizacije. Na podlagi temeljitega pregleda novejših znanstvenih literature in specializiranih publikacij je razvit konceptualni model organizacijske prenove v družbi dolgoživosti. Model vključuje večgeneracijsko diagnozo, generacijsko občutljivo strateško načrtovanje, digitalno podprte procese in organizacijsko preobrazbo, upravljanje znanja ter razvoj vključujoče organizacijske kulture. Članek poskuša dokazati, da organizacije, ki demografske izzive vidijo kot priložnost za rast, krepijo svojo odpornost, inovacijsko sposobnost in dolgoročno trajnost.

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CHALLENGES OF A LONG-LIVED SOCIETY AS AN OPPORTUNITY FOR RESTRUCTURING ORGANIZATIONS

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Demographic change and population ageing are among the key structural forces shaping the future of organizations. Longer working lives, the coexistence of multiple generations in the workplace, and rapid digital transformation create complex challenges while also offering significant development opportunities. Modern organizations simultaneously employ members of Generations X, Y, and Z, who differ in work values, competencies, attitudes toward technology, and leadership expectations. This article examines the long-lived and multigenerational workforce as a strategic opportunity for organizational restructuring at the strategic, process, and human resources levels. Based on a review of contemporary literature on age diversity, knowledge management, ergonomics, and digitalization, a descriptive conceptual model of organizational renewal is proposed. The model includes multigenerational diagnosis, generation-sensitive strategic planning, process and organizational redesign, competency and human resource adaptation, and the development of an inclusive organizational culture and communication. The findings suggest that organizations which view demographic challenges as a source of development potential achieve greater resilience, innovation capacity, and long-term sustainability.



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1 Uvod

Dolgoživost prebivalstva je eden najpomembnejših družbenih megatrendov 21. stoletja, ki močno vpliva na delovanje organizacij, trge dela in strukture znanj in spretnosti. Podaljšana delovna doba in padajoča rodnost sta privedla do situacije, s katero se številne organizacije soočajo s pomanjkanjem delovne sile, starajočo se delovno silo in velikimi spremembami v pričakovanjih glede kariere in delovnega okolja (Solem et al., 2024). Scott (2024) poudarja, da podaljšana življenjska doba zahteva sistemske prilagoditve, vključno z večfaznimi kariernimi potmi, fleksibilnimi modeli dela in vseživljenjskim učenjem, kar postavlja nove zahteve nacionalnim sistemom, podjetjem in posameznikom.

Istočasno pa se organizacije soočajo s hitrim tehnološkim napredkom in digitalno preobrazbo, ki spreminjata naravo dela, proizvodne in poslovne procese ter strukture upravljanja (Ris & Puvača, 2023). Čeprav digitalizacija ponuja priložnosti za večjo učinkovitost in inovacije, pa sproža tudi tveganja za starejše delavce in različne generacije delovne sile.

Ta članek se osredotoča na interakcijo med demografskimi spremembami, generacijsko raznolikostjo in digitalno transformacijo ter razvija konceptualni model za poslovno transformacijo, ki predlaga celovit in vključujoč pristop k reševanju izzivov dolgožive družbe.

2 Dolgoživa, večgeneracijska delovna sila kot organizacijski izziv in razvojna priložnost

Družba dolgoživosti ima številne posledice za organizacije, ki se morajo prilagoditi starajoči se delovni sili in spremljajočim spremembam v strukturi znanj, vrednot in poklicnih pričakovanj zaposlenih. Staranje delovne sile ni homogen pojav, temveč zelo raznolik, ki zahteva strateško in sistematično načrtovano organizacijsko prilagajanje. Berg in Piszczek (2025) poudarjata, da organizacije pogosto napačno pristopajo k staranju, saj ga obravnavajo kot enoten pojav, namesto da bi prepoznale potencial starejših delavcev kot nosilcev izkustvenega in tihega znanja ter uvedle mehanizme, ki omogočajo njegov prenos na mlajše generacije.

Empirične raziskave kažejo, da staranje zaposlenih ni nujno povezano z upadom produktivnosti, ampak da je njegov učinek močno odvisen od organizacijskih praks, delovnih pogojev in kulture vodenja. Schneid, Isidor, Steinmetz in Kabst (2016) ugotavljajo, da ni linearne povezave med starostjo in delovno uspešnostjo, kar spodbuja bolj niansiran in večdimenzionalen pristop k staranju v organizacijah. Takšna perspektiva omogoča oblikovanje fleksibilnih poklicnih vlog, ki upoštevajo različne faze delovne zmožnosti skozi celotno življenje zaposlenih.

Značilnost sodobnih organizacij je stabilnost večgeneracijske strukture delovne sile, v kateri različne generacije sobivajo in sodelujejo hkrati. Raziskave kažejo, da se generacije razlikujejo po vrednotah, motivacijah in kariernih preferencah, vendar so te razlike dinamične in nanje močno vpliva organizacijski kontekst (Kupczyk, Górski, Urbańska, Ucieklak-Jeż in Wierzbiński, 2024). Zato generacijskih razlik ni primerno obravnavati kot statične ali deterministične, temveč kot posledico interakcije med posamezniki, organizacijskimi praksami in širšim družbenim okoljem.

Generacijski stereotipi pogosto vodijo do neprimernih odločitev na področju človeških virov in povečujejo tveganje za konflikte in izključenost, medtem ko lahko zavestno in premišljeno upravljanje generacijske raznolikosti prispeva k večji inovativnosti, večji angažiranosti in izboljšani organizacijski uspešnosti (Harvard Business Review, 2023). Pri tem imajo ključno vlogo jasni cilji, podpora vodstva in ustvarjanje psihološko varnega delovnega okolja.

Empirični pregledi in metaanalize potrjujejo, da učinki starosti in generacijske raznolikosti na organizacijsko uspešnost niso niti splošno pozitivni niti negativni, temveč so odvisni od specifičnih organizacijskih struktur, procesov in praks (Horwitz & Horwitz, 2007; Schneid et al., 2016). Raznolikost lahko spodbuja inovacije in učenje, če organizacija spodbuja sodelovanje, spoštovanje razlik in sistematičen prenos znanja.

Upravljanje starostne in generacijske raznolikosti zato zahteva celovit pristop, ki vključuje premišljene politike človeških virov, fleksibilne ureditve dela, možnosti vseživljenjskega učenja in strukturirane mehanizme za prenos znanja med generacijami. Burmeister, Wang in Hirschi (2020) poudarjajo, da medgeneracijski prenos znanja ne prispeva le k ohranjanju organizacijskega znanja, temveč tudi krepí

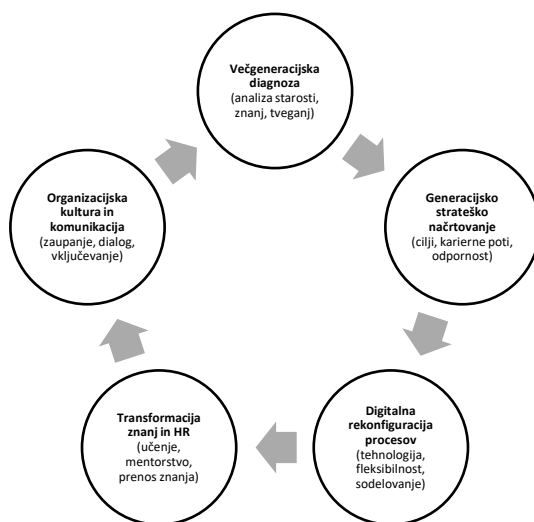
motivacijo, občutek vrednosti in učenje med starejšimi in mlajšimi delavci. Na ta način se dolgoživa, večgeneracijska delovna sila iz potencialnega vira napetosti spremeni v pomembno gonilo razvoja in konkurenčnosti organizacij.

3 Digitalna transformacija kot organizacijsko orodje

Digitalna transformacija ni omejena le na uvedbo tehnologij, temveč predstavlja celovito organizacijsko prenovo, ki zajema procese, vloge, spretnosti in odnose z deležniki. Ris in Puvača (2023) poudarjata, da uspešna digitalna transformacija zahteva integracijo strateških ciljev, procesov in človeških virov, kjer digitalne rešitve niso izolirani silosi, temveč sestavni del skladne organizacijske strategije.

Podobno Podobno *Handbook on Business Process Management and Digital Transformation* poudarja, da je povezava med pristopi k upravljanju poslovnih procesov (BPM) in digitalno transformacijo bistvena za doseganje trajnih sprememb v delovnih procesih (Grefen & Vanderfeesten, 2024). Digitalizacija procesov omogoča večjo fleksibilnost pri delovnih nalogah, boljšo usklajenost z digitalnimi spretnostmi zaposlenih in lažje prilagajanje potrebam večgeneracijske delovne sile.

4 Koncept modela prenove podjetja v dolgoživi družbi



Slika 1: Model prenove podjetja v dolgoživi družbi

Vir: Lasten

Na podlagi pregleda sodobne literature na področju upravljanja starosti, organizacijskih sprememb in digitalne transformacije je bil razvit konceptualni model, ki opisuje poslovno transformacijo. Ta model je zasnovan kot ciklični, petfazni proces. Temelji na predpostavki, da demografske spremembe niso enkraten pojav, temveč dolgoročen strukturni trend, ki zahteva nenehno prilagajanje organizacijskih praks. Različne faze so medsebojno povezane in ponavljajoče se, kar organizacijam omogoča nenehno učenje, postopno prilagajanje in izboljšanje obstoječih rešitev.

4.1 Faza 1 : Večgeneracijska diagnoza

Prva faza modela se osredotoča na sistematično analizo večgeneracijske strukture organizacije. To vključuje preučevanje starostne sestave zaposlenih, generacijske porazdelitve ključnih znanj in prepoznavanje tveganj, povezanih z izgubo kritičnega znanja zaradi upokojitve, fluktuacije zaposlenih ali prezgodnjih odhodov iz delovne sile.

Bistveno je, da ocena presega zgolj kvantitativne demografske kazalnike. Vključevati mora tudi kvalitativne vidike, kot so poklicne vrednote, pričakovanja, motivatorji, učni slogi in odnos do tehnologije, značilne za različne generacije. Takšen celovit pristop omogoča globlje razumevanje resničnih izzivov in potenciala večgeneracijskega delovnega mesta ter zagotavlja trdno podlago za nadaljnje strateške in operativne odločitve.

4.2 Faza 2 : Generacijsko strateško načrtovanje

Na podlagi rezultatov ocene se začne faza generacijskega strateškega načrtovanja, ki povezuje demografske trende z dolgoročnimi cilji organizacije. Strategije za razvoj delovne sile, inovacije in konkurenčnost morajo upoštevati, da imajo zaposleni, odvisno od njihove življenjske faze, različne spretnosti, potrebe in pričakovanja.

Scott (2024) poudarja, da sodobno strateško načrtovanje zahteva opustitev linearne karijerne poti v korist večfaznih kariernih poti, ki omogočajo prehode med intenzivnimi, mentorsko usmerjenimi vlogami in manj zahtevnimi funkcijami. Takšen pristop spodbuja zadrževanje zaposlenih, zmanjšuje tveganje za izgubo znanja in prispeva k večji organizacijski odpornosti v družbi dolgoživosti.

4.3 Faza 3 : Digitalno podprta rekonfiguracija procesov

Tretja faza modela se nanaša na rekonfiguracijo delovnih procesov, ki jih podpirajo digitalne tehnologije, ki morajo biti usklajeni z večgeneracijsko realnostjo organizacije.

Digitalna orodja morajo biti zasnovana tako, da izboljšajo fleksibilnost dela, zagotovijo preglednost informacij in spodbujajo medgeneracijsko sodelovanje. Posebna pozornost je namenjena ergonomiji orodij, podpori pri učenju in postopnemu uvajanju tehnologij za premostitev digitalnega razkoraka in povečanje sprejemanja sprememb med zaposlenimi različnih starosti.

4.4 Faza 4 : Transformacija človeških virov in znanj

Transformacija človeških virov in znanj je osrednji operativni steber modela. Organizacije morajo sistematično vlagati v vseživljenjsko učenje, razvoj znanj in spretnosti ter medgeneracijski prenos znanja. V zvezi s tem imajo ključno vlogo strukturirano mentorstvo, obratno mentorstvo in timski učni programi, saj omogočajo izmenjavo tihega in eksplicitnega znanja (Burmeister et al., 2020; Li et al., 2025).

Ti programi ne prispevajo le k ohranjanju znanja, temveč tudi k krepitevi medgeneracijskih vezi, spodbujanju občutka pripadnosti in razvoju kulture učenja. Politika človeških virov mora biti zato proaktivna, prilagodljiva in dolgoročno usmerjena.

4.5 Faza 5 : Organizacijska kultura in komunikacija

Ključni element predlaganega modela je razvoj vključujoče organizacijske kulture, ki temelji na zaupanju, odprtem dialogu in psihološki varnosti. Raziskave o starostni in generacijski raznolikosti kažejo, da so konflikti med generacijami pogostejše posledica neustrezne komunikacije, pomanjkanja razumevanja in nejasnih vlog kot pa starosti same (Harvard Business Review, 2023). Organizacijska kultura, ki spodbuja sodelovanje in medsebojno učenje, omogoča, da se generacijske razlike preoblikujejo v komplementarne vire znanja, izkušenj in inovativnosti. Zelo pomenbna je vloga

vodij, saj delujejo kot mediatorji med generacijami, nosilci sprememb in zgled vključujočega vedenja.

Učinkovita komunikacija sprememb mora biti transparentna, dosledna in prilagojena različnim generacijskim skupinam. Posebej pomembno je poudarjanje skupnih ciljev, smisla prenove ter koristi tako za posameznike kot za organizacijo kot celoto. Takšen pristop zmanjšuje odpor do sprememb, krepi zaupanje zaposlenih in povečuje verjetnost uspešne implementacije prenove podjetja v dolgoživi družbi.

5 Zaključek

Demografske spremembe, zlasti staranje prebivalstva in spreminjanje starostne strukture zaposlenih, postajajo eden najvplivnejših dejavnikov, ki oblikujejo prihodnost organizacij. V sodobnem poslovnem okolju, zaznamovanem z negotovostjo, hitrimi tehnološkimi spremembami, globalnimi krizami in kompleksnostjo družbenih procesov, je razumevanje demografskih trendov nujen pogoj za dolgoročno stabilnost in uspešnost podjetij. Organizacije, ki pravočasno prepoznajo te spremembe, razvijejo ustrezne strategije in prilagodijo svoje poslovne modele, lahko ne le zmanjšajo tveganja, temveč izkoristijo tudi nove priložnosti za rast in razvoj.

Izvedena razširjena analiza je pokazala, da demografske spremembe niso izoliran pojav, temveč del širše mreže družbenih, gospodarskih in organizacijskih dejavnikov, ki vplivajo na delovanje podjetij. Učinkovito prestrukturiranje v takšnih pogojih zahteva celovit model, ki vključuje natančno diagnozo demografskih trendov, oceno tveganj in priložnosti, strateško načrtovanje, operativno prilagajanje procesov, vzpostavitev medgeneracijskega sodelovanja ter stalno evalvacijo učinkov. Tak holistični pristop organizacijam omogoča, da postanejo prožne, učeče se in odporne na prihodnje spremembe.

Prav tako je ključnega pomena krepitev komunikacije. Transparentna, pravočasna in empatična komunikacija zmanjšuje odpor zaposlenih, krepi zaupanje in podpira stabilnost v obdobjih sprememb. Organizacije, ki vlagajo v razvoj komunikacijskih strategij, lažje premagujejo izzive, povezane z reorganizacijo, ter ohranjajo pozitivne odnose z notranjimi in zunanji deležniki. Literatura jasno nakazuje, da je komunikacija eden najpomembnejših dejavnikov uspešne reorganizacije (McCarthy,

2018; Heidari-Robinson & Heywood, 2016) Na podlagi pregleda teoretičnih izhodišč in oblikovanega modela lahko zaključimo, da demografske spremembe predstavljajo tako izziv kot priložnost. V organizacijah, ki se prestrukturiranja lotevajo proaktivno in strateško, demografski trendi lahko spodbudijo inovacije, povečajo organizacijsko odpornost, pospešijo digitalizacijo in prispevajo k trajnostnemu razvoju. Po drugi strani organizacije, ki teh sprememb ne upoštevajo, tvegajo izgubo ključnih kadrov, zmanjšanje konkurenčnosti in povečanje operativnih motenj.

Sklepno lahko poudarimo, da organizacije, ki bodo znale povezati potencial vseh generacij zaposlenih, vzpostaviti kulturo učenja ter prilagoditi svoje poslovne modele realnostim sodobne družbe, bodo med najuspešnejšimi v prihodnosti. Demografske spremembe tako niso grožnja, temveč pomembna razvojna priložnost, ki lahko vodi v trajnostno rast in strateško prenovu podjetij.

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THE ROLE OF HR MANAGEMENT IN DEVELOPING INNOVATION CULTURE IN TECH STARTUPS

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The aim of this paper is to examine the role of HRM in development of innovation culture in technology startups. The research was conducted through a questionnaire and included 94 respondents employed in the field of technology entrepreneurship and HR. All data were processed in SPSS software, the Kolmogorov-Smirnov test was used to assess data distribution and descriptive statistics, and ANOVA to determine differences between groups. The analyses of differences and correlations indicate that the “levers” that best support innovation culture are employee involvement, the quality of performance appraisals and meaningful rewards. These HR dimensions are consistently associated with the implementation context, market orientation, value creation and creative empowerment.

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1 Introduction

In recent decades, research in the field of human resource management (HRM) has increasingly emphasized that employees, their competencies, motivation and initiative are key drivers of innovation and development of organizational culture. The literature largely agrees that HR activities and organizational culture are two pillars that together shape the innovative capacity of technology startups. HR provides capabilities, motivation and opportunities, while culture provides norms, meanings and expectations that guide behavior towards innovation (Appelbaum et al., 2000; Schein, 2010). However, the literature also indicates that in practice, coherent HR packages that link recruitment, training, appraisal and reward with behaviors that lead to innovative outcomes are often lacking (Collins & Smith, 2006; Subramony, 2009). The problem analyzed in this paper is the gap between the declarative orientation of startups towards innovation and the internal conditions that should ensure the conversion of ideas into value for users.

The research therefore focuses on the role of HR management in shaping innovation culture in technology startups, with particular attention to practices such as employee involvement in decision-making, linking training to strategy, fair reward systems and clear performance criteria. These practices are viewed in conjunction with cultural dimensions such as adaptability, inclusion and learning orientation, which have been shown to foster creativity and organizational effectiveness (Hartnell et al., 2011). The aim is to empirically examine the extent to which HR activities in technology startups support key dimensions of innovation culture (e.g. implementation context, organizational consistency, learning, market orientation), and to determine the strength and manner of their interrelationships.

The purpose of this research was to examine internal organizational factors that influence the development of an innovation culture in a technology startup, with a particular emphasis on the role of HR activities and how employees perceive these practices. In particular, the goal was to determine whether there is a statistically significant relationship between the perception of HR practices and the level of innovation culture, i.e. whether more positive perceptions of HR activities correlate with more pronounced innovative behavior and climate within the organization.

2 Innovation culture in startups

Innovation culture has been developed from classical approaches to organizational culture, which viewed culture as a set of values, norms, and beliefs that shape employee behavior and organizational outcomes. Early work suggested that culture acts as an “operating system” for an organization, providing guidance on desirable behavior and how mistakes, risk, and collaboration are interpreted. This perspective was later expanded by models that quantitatively link cultural dimensions to effectiveness and innovation (Denison & Mishra, 1995; Hartnell et al., 2011).

Contemporary discussions on innovation culture connect these classical frameworks with the logic of digital innovation: modularity of solutions, platform architectures, while continuous improvement increase the importance of a culture that enables rapid reuse of knowledge and expertise (Yoo, et al. 2010; Tiwana, 2014). In this setting, innovation culture is not just a “set of values,” but a set of practical rules, how ideas are reported, who evaluates them, how they are tested, and how contributions are rewarded. Finally, the literature on innovation climate and culture emphasizes the need to measure and manage these aspects systemically. Validated scales have been developed that capture dimensions such as learning orientation, implementation context, and market orientation (Muñoz van den Eynde et al, 2015, Dobni, 2008), allowing for the empirical linking of cultural patterns to innovation outcomes. In practice, this means that short iterative cycles (sprints, MVP) rely on values that reward collaborative learning and discipline in execution, rather than just spontaneous creativity (Schein, 2010).

The ambidexterity perspective adds that culture should simultaneously legitimize exploration (exploration of new opportunities) and exploitation (deeper exploitation of existing solutions). Startups often “slip” towards one side; therefore, clear context-breaking routines are needed, e.g. different rhythms for ideation and for introducing standards, different success indicators for research and for operational efficiency (O’Reilly & Tushman, 2013). Research shows that it is precisely the balance between these two modes that best correlates with performance in dynamic conditions, where innovation culture is in this sense the “glue” that holds this balance: it normalizes experimentation, but also introduces discipline in the standardization of successful practices.

3 The role of HR management in developing innovation culture

Human resource management in technology startups plays an important role in shaping a culture that encourages innovation. The selection and recruitment of personnel with a penchant for innovation enables the entry of new ideas and technological competencies into the organization. Training and professional development programs ensure the continuous adoption of new technologies and work methods, which enables the rapid implementation of innovations. Also, reward and recognition systems for innovative results encourage motivation and orientation towards entrepreneurial activities. Furthermore, involving employees in decision-making and providing space for expressing ideas creates an organizational context that supports creativity and experimentation. Additionally, the role of HR is to introduce the startup's brand strategy among employees (Nikam, 2023).

Empirical research confirm that HR practices, when complementary, significantly increase the innovative performance of firms (Laursen & Foss, 2003; Collins & Smith, 2006). Especially in technology startups, where human capital is the main resource, HR activities act indirectly through the construction of knowledge, motivation and an organizational climate that encourages innovation (Jiang et al., 2012). A work environment in startups should encourage creativity, inclusivity, diversity of thought, open dialogue and embracing failure as a catalyst for growth, as every decision holds the potential to shape the future (Maria, 2024).

The synergy between HR practices and culture is particularly important, as it enables the development of an environment in which employees actively contribute to innovation and accept risk, which is necessary for technological entrepreneurship (Bowen & Ostroff, 2004; Schneider et al., 2013). For the startup context, the key is a “light” and scalable design of the HR package, basic selection rules, short training cycles, a simple feedback system and transparent incentives. Such configurations are more effective than copying heavy corporate procedures (Cardon & Stevens, 2004; Harney & Dundon, 2006). The routine of work can hinder innovation in the organization, so the role of organized training is to avoid this by encouraging creative thinking and creating a stimulating work atmosphere that can sometimes compensate for the lack of significant rewards for creative work (Çera et al., 2023).

Given that startups rapidly change priorities and structures, it is expected that the alignment of HR practices and cultural patterns will enable faster conversion of knowledge into prototypes and products to be launched on the market (O'Reilly & Tushman, 2013; Jansen, Van Den Bosch, & Volberda, 2006). Of particular importance are the conditions that make innovations sustainable in small teams: psychological safety for presenting ideas, important results (team performance), and incentives (ESOP, innovation bonuses) that translate contributions into rewards (Edmondson, 1999; Sun et al., 2007). Also, by using proven instruments, for example HR Activity Assessment Scale and the Multidimensional Innovation Culture Scale, it is possible to measure relationships in a structured manner and provide more precise guidelines for practice (Appelbaum et al., 2000; Muñoz van den Eynde, et al., 2015). In this context managers are recommended to consult directly with employees regarding practices that motivate them (Boudlaie, 2022).

Many HR activities have a direct role in building an innovation culture. Selection and recruitment provide employees with a predisposition for teamwork and creativity, while training and professional development programs enable the adoption of new technological knowledge. It is important to create an environment that is supporting new knowledge and skills, innovative thinking and confidence in implementing creative ideas (Çera et al., 2023). Start-up companies with small teams could develop inclusive and innovation-oriented work culture, with individual approach to employees and their development (Rismayadi, 2024). Knowledge management systems, should provide that valuable insights and experiences are accessible to all employees, enhancing a culture of continuous learning and innovation. Quick reactions and response are possible with agile practices, iterative development, rapid prototyping, and continuous feedback (Kartika, 2022).

Activities such as mentoring and project rotations facilitate quality knowledge transfer. In technology startups, it is also useful to implement agile HR practices, short feedback cycles, experimental budgets for prototypes, and HR analytics that track indicators such as the team's learning rate, the rate of internal knowledge sharing, and the time from idea to MVP (minimum viable product). Such analytics enable the focus of HR resources on areas that have the greatest impact on innovation performance (Jiang et al., 2012; Yoo et al., 2010).

4 Research focus and methodology

The main problem that this paper explores is the mismatch between the technical potential of teams (knowledge, skills, technology) and their actual ability to systematically build and maintain an innovation culture, i.e. a set of values, norms and practices that encourage experimentation, rapid iteration and knowledge sharing. The subject of the research is to examine the impact of specific HR practices on the formation and maintenance of an innovation culture in a technology startup, as well as to identify operational and cultural barriers that reduce the effectiveness of these practices. The research aims to provide empirically grounded guidelines for the design of HR policies that support agile teams, foster psychological safety, and enable faster conversion of ideas into market results (Teece et al., 1997; Shipton et al., 2005).

The starting point of this research was the understanding that in technology startups, innovation performance is not based solely on technical resources, but primarily on the way in which HR practices and cultural norms are “assembled” in the daily work of the team. Therefore, the problem was operationalized through two related questions: (a) to what extent are employees’ perceptions of key HR activities (selection, onboarding, training and development, performance management, rewards, involvement in decision-making, and job security) related to the dimensions of innovation culture; and (b) which cultural elements most mediate the relationship between HR practices and innovation behavior (Denison & Mishra, 1995; Bowen & Ostroff, 2004; Jiang et al., 2012).

The context of the research was a segment of technology startups in which products and services were created through short iterative cycles (lean, agile) and where limited resources required precise prioritization of HR interventions. The focus was on teams whose work involved a high level of interdependence, rapid knowledge exchange and frequent collaboration with users/clients and conditions in which culture and HR most visibly affect the speed and quality of innovation (Ries, 2011; Yoo et al, 2010).

The empirical focus was on employee perceptions, because it was through them that the “signal strength” of the HR system and the actual cultural patterns in everyday work were manifested. It was particularly relevant to examine whether positive

attitudes towards HR practices were accompanied by a higher level of innovation culture in domains such as implementation context, organizational consistency, learning, market orientation and creative empowerment.

For the purposes of the research, an online questionnaire was created in which the questions were grouped into three segments: (1) Demographic characteristics, (2) Questionnaire A – Human Resources Management Policies and Practices Scale and (3) Questionnaire B – Innovation Culture Scale. All attitudes were measured on a five-point Likert scale (1 – “strongly disagree” to 5 – “strongly agree”). Valid questionnaires were collected from 94 respondents. The condition for participation was that the respondent was employed in the technology or HR sector. Responses were collected from 57 men and 37 women, of different ages, younger than 25 years (30.9%), 26–40 years (60.6%), 41 and older (8.5%). According to the length of work experience, 26.6% had less than 1 year of work experience, 34.0% had 1 to 3 years, 20.2% had 4–7 years, 8.5% had 8–15 years, and 10.6% had more than 15 years of work experience.

5 Results and discussion

Due to space limitations, this paper will not present the results of descriptive statistics, but rather the correlations determined through ANOVA tests and Spearman's correlation analysis.

5.1 Results based on ANOVA test

This section shows the differences between respondents based on age category.

Based on a one-way ANOVA analysis, statistically significant differences were found by age group in seven domains (Table 1). In the domains “Training and development” and “Organizational learning”, the youngest respondents have the highest ratings, while the oldest group has the lowest. Younger respondents enter new roles more intensively and use upskilling/reskilling programs faster, while older respondents more often lack tailored content (advanced curricula, mentoring routes) and time for learning. This suggests that it is cost-effective to adapt training design to career stages and include reverse mentoring and communities of practice. “Employee involvement”, “Implementation context” and “Value creation

orientation” are highest in the 26–40 age group, which is typically the “operations driver”. It is necessary to expand the channels of influence to the oldest group (project sponsorship, co-leading initiatives) and give young people more structured opportunities to participate in decision-making. All of the above is also reflected in the overall "Innovation Culture" index, which is highest in the 26–40 age group, followed by the youngest, and the oldest lag behind. Where training and organizational learning are most pronounced (mostly among the youngest), a greater willingness to experiment and faster adaptation is seen, while the most experienced lack adapted content and time for learning. The operational translation of ideas into solutions and the orientation towards value creation are strongest in the 26–40 age group, this is the "innovation driver" that drives implementation every day.

Table 1: Subsample differences based on age (ANOVA)

Domain / subscale	<25 y. (M±SD)	26–40 y. (M±SD)	>41 y. (M±SD)	p
HR — Recruitment and selection	3,7±0,8	3,9±0,7	3,6±0,9	0,290
HR — Training and development	4,1±0,7	3,8±0,8	3,5±0,9	0,021
HR — Performance appraisal	3,5±0,9	3,6±0,8	3,4±0,9	0,660
HR — Rewards and compensations	3,4±0,9	3,6±0,8	3,5±0,8	0,470
HR — Employee involvement	3,6±0,8	3,9±0,7	3,5±0,8	0,036
HR — Job stability	3,3±0,9	3,6±0,8	3,9±0,7	0,023
Innovation culture — Implementation context	3,5±0,8	3,8±0,7	3,4±0,8	0,022
Innovation culture — Organization consistency /participants	3,7±0,7	3,8±0,7	3,6±0,8	0,410
Innovation culture — Organizational learning	3,9±0,7	3,7±0,8	3,3±0,9	0,013
Innovation culture — Market orientation	3,6±0,8	3,8±0,7	3,5±0,8	0,216
Innovation culture — Innovation tendency	3,7±0,8	3,9±0,7	3,6±0,8	0,144
Innovation culture — Orientation towards value creation	3,8±0,7	4,0±0,6	3,5±0,8	0,008
Innovation culture — Creativity and empowerment	3,9±0,7	3,8±0,7	3,6±0,8	0,235
HR — Total index	3,6±0,6	3,8±0,5	3,6±0,6	0,098
Innovation culture — Total index	3,7±0,6	3,9±0,5	3,5±0,6	0,018

Legends: M±SD – mean and standard deviation.

5.2 Results based on Spearman's correlation analysis

This section presents the results of determining the correlation between HR management role and development of innovation culture in technology startups.

Table 2: The relationship between HR management and development of innovation culture in technology startups

HR → Innovation culture ↓	Selection	Training/deve lopment	Performance appraisal	Reward, compensation	Involvement	Job stability	General impression HR
Implementation context	0.21	0.11	r=0.411 0.04	0.24	r=0.410 0.03	0.28	r=0.456 0.03
Organization consistency / participants	r=0.101 0.05	0.21	0.39	r=0.187 0.05	0.31	r=0.161 0.05	r=0.176 0.05
Organizational learning	r=0.345 0.04	r=0.451 0.03	0.19	r=0.289 0.05	0.2	0.21	r=0.336 0.04
Market orientation	0.27	r=0.451 0.05	0.43	r=0.287 0.05	r=0.311 0.05	r=0.301 0.05	r=0.332 0.05
Innovation tendency	0.21	0.30	r=0.511 0.03	r=0.380 0.05	r=0.611 0.02	0.18	r=0.506 0.03
Orientation towards value creation	0.29	0.19	0.33	r=0.366 0.04	r=0.376 0.04	r=0.111 0.05	r=0.345 0.04
Creativity and empowerment	0.18	0.16	0.30	r=0.251 0.05	0.21	r=0.289 0.05	r=0.341 0.05

Legend: r – strength of correlation.

The analysis shows that “Implementation context” is most strongly correlated with the “General impression of HR” ($r=0.456$; $p=0.03$), “Performance appraisal” ($r=0.411$; $p=0.04$) and “Involvement” ($r=0.410$; $p=0.03$). The result indicates that the willingness to turn ideas into projects occurs where people participate in processes, where there are clear performance monitoring criteria and where the entire HR system is perceived as consistent and fair. “Organizational learning” is most strongly correlated with “Training/development” ($r=0.451$; $p=0.03$) and, to a lesser extent, with “Selection” and “Reward/compensation”, suggesting that job-oriented training and systematic selection of competent profiles build the basis for continuous acquisition and application of knowledge. When it comes to “Market orientation”, stable, albeit moderate, relationships are obtained with “Training/development”, “Reward/compensation”, “Involvement”, “Job stability” and “General impression of HR” (all $p \approx 0.05$), which is in line with the expectation that sensitivity to client needs relies on both: trained people and fair evaluation systems. The most pronounced finding relates to “Innovation Tendency”: it correlates strongly with “Involvement” ($r=0.611$; $p=0.02$) and “Performance appraisal” ($r=0.511$; $p=0.03$), and significantly with “Reward/compensation” and

“General impression of HR”. In practice, teams show more initiative and risk-taking where they are involved in decisions, receive clear feedback, and where progress is recognized and rewarded. The dimension “Value orientation” is primarily correlated with “Involvement” ($r=0.376$; $p=0.04$), “Reward/compensation” ($r=0.366$; $p=0.04$), and “General impression of HR” ($r=0.345$; $p=0.04$), indicating that the focus on customer value is reinforced through systems that reward contribution and give employees a voice. “Creativity and empowerment” have lower but significant correlations with “Reward/compensation”, “Job stability”, and “General impression of HR” ($p\approx 0.05$), suggesting that both security and fair incentives increase willingness to make original suggestions.

6 Conclusion

Based on the conducted conducted, it is concluded that the basic levers of the HR system in the technological startup environment are in place and support innovation, but it is necessary to more consistently link evaluation, reward and post-training with the expected innovation behaviors. It is also important to strengthen formal mechanisms for faster transfer of ideas into market value. Analysis of differences and correlations indicates that the “levers” that best support an innovation culture are employee involvement, quality of performance appraisal and meaningful reward. By age, the 26–40 year old group consistently reports the most favorable ratings for evaluation, reward and innovation orientation; older employees most strongly recognize stability and consistency, while the youngest need more structure, feedback and mentoring support. Theoretically, the research contributes to the integration of two fields that are often viewed separately, HR practices and innovation culture, in the specific context of technology startups. It offers an operationalized framework that shows how selection, training, evaluation and reward translate into dimensions of innovation culture (learning, market sensitivity, implementation context). For practice, the findings can be directly translated into a “diagnostic panel” for managers: where HR practices are weakest, there is the need for intervention (clear performance criteria, consistent reward for outcomes, alignment of training with strategy, active coaching after training).

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Summary

The paper examines the role of HRM in development of innovation culture in technology startups. The research was conducted through a questionnaire and included 94 respondents employed in the field of technology entrepreneurship and HR. All data were processed in SPSS software, the Kolmogorov-Smirnov test was used to assess data distribution and descriptive statistics, and ANOVA to determine differences between groups. The analyses of differences and correlations indicate that the “levers” that best support innovation culture are employee involvement, the quality of performance appraisals, and meaningful rewards. These HR dimensions are consistently correlated with the implementation context, market orientation, value creation, and creative empowerment.

IDENTITETA ORGANIZACIJE IN VLOGA KOMUNIKACIJE PRI GRAJENJU ZAUPANJA

JOVAN MILOSAVLJEVIĆ, IZTOK PODBREGAR,
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Sodobne organizacije delujejo v okolju, kjer javnost pričakuje transparentnost, jasne vrednote in odgovorno ravnanje. Te zahteve povečujejo pritisk na organizacije, da svojo identiteto ne le oblikujejo, temveč jo tudi dosledno komunicirajo. Problem nastane, ko organizacijska identiteta in komunikacija nista usklajeni in ko je razlika med tem, kar organizacija sporoča, in tem, kako dejansko deluje. Ta neujemanja lahko vodijo v izgubo zaupanja, negativno javno podobo in oslABLJENO legitimnost. Zato je razumevanje povezave med identiteto, komunikacijo in zaupanjem ključno za učinkovito delovanje organizacij v sodobni družbi. Namen raziskave je bil predstaviti, kako identiteta organizacije oblikuje način njenega delovanja in kako komunikacija povzroča, krepi ali zmanjšuje zaupanje javnosti. Cilj je bil analizirati, na kakšen način dosledna, transparentna in strateško usmerjena komunikacija podpira verodostojnost organizacije, ter prikazati, zakaj sta identiteta in komunikacija neločljivo povezani pri grajenju dolgoročnega zaupanja. Raziskava ponuja jasen vpogled v ključne koncepte in praktične smernice, ki lahko pomagajo organizacijam pri načrtovanju učinkovite komunikacije.

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ORGANIZATIONAL IDENTITY AND THE ROLE OF COMMUNICATION IN BUILDING TRUST

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Modern organisations operate in an environment where the public expects transparency, clear values and responsible behaviour. These demands increase the pressure on organisations not only to shape their identity, but also to communicate it consistently. Problems arise when organizational identity and communication are not aligned and when there is a discrepancy between what the organization communicates and how it actually operates. These discrepancies can lead to a loss of trust, a negative public image, and weakened legitimacy. Therefore, understanding the link between identity, communication, and trust is crucial for organizations to function effectively in modern society. The purpose of the research was to present how an organization's identity shapes the way it operates and how communication creates, strengthens, or diminishes public trust. The goal was to analyze how consistent, transparent, and strategically focused communication supports an organization's credibility and to show why identity and communication are inextricably linked in building long-term trust. The study offers a comprehensive insight into key concepts and practical guidelines that can help organizations plan effective communication.



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1 Uvod

Zaupanje javnosti v organizacije danes ni več samoumevno, temveč je vse bolj povezano z njihovo sposobnostjo, da delujejo odprto, odgovorno in skladno z vrednotami, ki jih javno zagovarjajo. V okolju, kjer so informacije hitro dostopne in kjer so ravnanja organizacij nenehno pod drobnogledom, postaja doslednost med tem, kar organizacija predstavlja navzven, in njenim dejanskim delovanjem izjemno pomembna. Kadar se komunikacija organizacije ne ujema z njeno notranjo identiteto in praksami, se pojavijo razpoke v verodostojnosti, ki lahko vodijo v dvom, izgubo zaupanja in slabšanje javne podobe. Takšna neskladja ne vplivajo zgolj na ugled organizacije, temveč tudi na njeno legitimnost v širšem družbenem kontekstu. Prav zaradi tega je celostno razumevanje odnosa med organizacijsko identiteto, načinom komuniciranja in zaupanjem javnosti ključno za uspešno delovanje organizacij v sodobni družbi.

Organizacijska identiteta se ne oblikuje zgolj skozi uradne dokumente, strategije ali javna sporočila, temveč predvsem skozi vsakodnevne prakse, odločitve in vedenje zaposlenih. Prav zaposleni so pogosto prvi stik organizacije z javnostjo, zato njihovo razumevanje vrednot in ciljev organizacije pomembno vpliva na to, kako je organizacija zaznana navzven. Če notranje razumevanje identitete ni jasno ali ni usklajeno z zunanjo komunikacijo, se tveganje za nesporazume in izgubo verodostojnosti še poveča.

Poleg tega ima sodobna komunikacija vlogo dvosmernega procesa, v katerem organizacije ne zgolj posredujejo sporočila, temveč tudi poslušajo in se odzivajo na pričakovanja ter kritike javnosti. Digitalni mediji in družbena omrežja so ta proces še okrepili, saj omogočajo hitro širjenje informacij in hkrati povečujejo vidnost morebitnih neskladij med obljubami in dejanskimi ravnanji organizacij. V takšnem okolju postajajo transparentnost, pristnost in konsistentnost ključni elementi za gradnjo dolgoročnega zaupanja.

Zaupanje se namreč ne vzpostavi zgolj s preiščljenimi komunikacijskimi strategijami, temveč se gradi postopoma, skozi ponavljajoče se izkušnje javnosti z organizacijo. Kadar so sporočila skladna z dejanji, organizacija utrjuje svojo kredibilnost in krepí legitimnost svojega delovanja. Nasprotno pa lahko že posamezni primeri neodgovornega ravnanja ali neiskrene komunikacije dolgoročno

škodujejo odnosom z javnostmi in zahtevajo dolgotrajne napore za ponovno vzpostavitev zaupanja.

Članek temelji na pregledni analizi strokovne literature s področja organizacijske identitete, strateškega komuniciranja in upravljanja zaupanja. Pregled vključuje ključna teoretična dela uveljavljenih avtorjev in novejša raziskave, objavljene v mednarodnih znanstvenih revijah in monografijah. Analiza je zasnovana kot narativni pregled, katerega cilj je sinteza temeljnih konceptov in identifikacija osrednjih povezav med identiteto, komunikacijo in zaupanjem v sodobnih organizacijah.

Prispevek predstavlja konceptualno sintezo obstoječih teoretičnih pristopov k organizacijski identiteti, strateški komunikaciji in zaupanju ter jih povezuje v celostni okvir, ki poudarja pomen skladnosti med notranjimi vrednotami, komunikacijskimi praksami in zaznanim vedenjem organizacije. Namen prispevka ni empirično preverjanje odnosov, temveč oblikovanje analitične podlage, ki lahko služi kot izhodišče za nadaljnje empirične raziskave na področju zaupanja v organizacijskem in komunikacijskem kontekstu.

2 Identiteta organizacije

Za lažje razumevanje v nadaljevanju najprej obravnavamo temeljne koncepte organizacijske identitete, nato pa njihovo vlogo v širšem kontekstu ugleda in zaupanja.

Identiteta organizacije odgovarja na vprašanje, kdo smo kot organizacija, in predstavlja skupek temeljnih prepričanj, vrednot in značilnosti, s katerimi se člani organizacije prepoznajo in razlikujejo od drugih. Cornelissen (2020) poudarja, da je treba razlikovati med organizacijsko identiteto (kako je organizacija razumljena od znotraj, v očeh zaposlenih) in korporativno identiteto (kako se organizacija predstavlja navzven, preko simbolov, komunikacije in vedenja).

V praksi sta ti dve plati istega kovanca - notranja samopodoba določa, kakšno podobo lahko organizacija verodostojno projicira navzven. Identiteta ima tako kognitivno kot simbolno dimenzijo. Kognitivni vidik se nanaša na skupen "okvir pomenov", prepričanja, zgodbe in asociacije, ki jih imajo člani organizacije o tem,

kaj njihova organizacija je in zakaj stoji. Simbolni vidik pa se izraža v jeziku, vizualnih elementih (logotip, barve, dizajn), ritualih, vodstvenem slogu in vsakdanjem vedenju zaposlenih (Cornelissen, 2020). Ko so ti vidiki skladni, identiteta deluje kot notranje “lepilo”, ki povezuje zaposlene in usmerja odločitve.

Jedro identitete tvorijo poslanstvo, vizija in vrednote organizacije. Poslanstvo opredeljuje osnovni namen obstoja organizacije in odgovarja na vprašanje, kaj prispevamo družbi in komu. Vizija predstavlja želeno prihodnost in smer razvoja, aspiracijo, kam želi organizacija dolgoročno. Vrednote pa določajo, kako naj bi organizacija dosegala svoje cilje in kakšna vedenja so zaželena oziroma nesprejemljiva (npr. integriteta, odgovornost, inovativnost) (Cornelissen, 2020).

Ti elementi se konkretizirajo v organizacijski kulturi, v vsakdanjih rutinah, normah, odnosih in načinu odločanja. Hatch in Schultz (2001) opozarjata, da je identiteta prepričljiva šele, ko so vizija vodstva, dejanska kultura zaposlenih in zunanja podoba medsebojno usklajene, v nasprotnem primeru se pojavijo vrzeli med retoriko in realnostjo, ki vodijo v cinizem in nezaupanje.

V kontekstu korporativnega pomena identiteta deluje kot izhodišče za oblikovanje “dežnikove znamke”, pod katero organizacija povezuje vse svoje produkte, storitve in komunikacijske aktivnosti. Cornelissen (2020) navaja, da močne korporativne znamke temeljijo na vrednotah, ki so obenem avtentične (izvirajo iz resnične kulture organizacije) in distinktivne (organizacijo jasno ločijo od konkurence). Zaposleni imajo pri tem ključno vlogo, saj nastopajo kot “ambasadorji znamke”. Način, kako ravnaajo z uporabniki, partnerji ali skupnostjo, neposredno odraža identiteto organizacije v praksi.

Identiteta organizacije je izhodiščna točka za oblikovanje ugleda (reputacije) in zaupanja pri ključnih deležnikih. Fombrun in Van Riel (2004) razumeta ugled kot strateško pomembno neoprijemljivo sredstvo: močan ugled prinaša organizaciji prednost “prve izbire” pri kupcih, investitorjih in zaposlenih ter deluje kot vir konkurenčne prednosti, ki ga je težko posnemati. Tak ugled pa nastane predvsem takrat, ko je komunikacija organizacije prepoznavno vidna, dosledna, avtentična in pregledna, torej ko so identiteta, podoba in vedenje usklajeni.

Szyszka (2013) dodatno pojasni, da sta ugled in podoba obliki socialnega kapitala organizacije, ki se v okolju izražata kot stopnja socialnega zaupanja. Zaupanje temelji na pričakovanju, da bo organizacija delovala predvidljivo in skladno s svojimi deklariranimi vrednotami. Če to pričakovanje izpolnjuje, deležniki zmanjšajo nadzor in ji podelijo več manevrskega prostora. Ko pa se pojavi razkorak med obljubljenimi identiteto in dejanskim vedenjem, se socialno zaupanje hitro zmanjšuje, kar oteži delovanje in poveča tveganja za konflikte in krize.

Hatch in Schultz (2001) v svojem "tool kitu" za korporativno znamko predlagata, da organizacije sistematično preverjajo tri ključne vrzeli: med vizijo in kulturo (ali zaposleni verjamejo v isto zgodbo kot vodstvo), med kulturo in zunanjo podobo (ali zaposleni delujejo v skladu s pričakovanji deležnikov) ter med vizijo in zunanjo podobo (ali smer razvoja podpira tisto, kar deležniki pričakujejo ali cenijo). Zapiranje teh vrzeli ni zgolj vprašanje trženja, temveč predpogoj za dolgoročno zaupanje, saj deležniki ocenjujejo organizacijo predvsem po skladnosti med besedami in dejanji.

Na tej osnovi lahko zaključimo, da identiteta organizacije ni dekorativni element, temveč strukturna os celotnega komuniciranja in izgradnje zaupanja. Jasno opredeljene in notranje sprejete vrednote, poslanstvo in vizija omogočajo, da organizacija razvije verodostojno korporativno identiteto, iz katere rastejo stabilen ugled, socialni kapital in dolgoročna legitimnost v očeh javnosti (Cornelissen, 2020; Fombrun & van Riel, 2004; Hatch & Schultz, 2001; Szyszka, 2013).

3 Vloga komunikacije pri grajenju zaupanja

Pri grajenju zaupanja ima pomembno vlogo tudi notranja komunikacija. Men in Bowen (2019) poudarjata, da zaposleni niso zgolj prenašalci sporočil, temveč aktivni soustvarjalci organizacijske identitete. Kadar so zaposleni ustrezno informirani, vključeni in razumejo vrednote organizacije, je večja verjetnost, da bodo v interakcijah z zunanjimi javnostmi delovali skladno z želeno identiteto, kar pozitivno vpliva na zaznavanje zaupanja.

Čeprav je identiteta organizacije temelj njenega delovanja, sama po sebi ne zagotavlja razumevanja, sprejemanja ali zaupanja v širšem družbenem okolju. Brez ustrezne komunikacije identiteta ostaja le notranji koncept, ki ga deležniki ne prepoznajo ali pravilno interpretirajo. Komunikacija je zato ključni mehanizem za povezovanje

notranje realnosti organizacije in zunanjih pričakovanj javnosti. Skozi komunikacijske procese se identiteta ne le prenaša, temveč se tudi oblikuje, preverja in potrjuje v vsakodnevnih interakcijah z okoljem (Cornelissen, 2020).

V sodobnih organizacijah komunikacija presega zgolj funkcijo posredovanja informacij in postane strateški proces upravljanja odnosov. Organizacije so danes nenehno izpostavljene javnemu nadzoru, kar pomeni, da vsak komunikacijski nastop, bodisi prek uradnih sporočil, družbenih omrežij ali vedenja zaposlenih, prispeva k oblikovanju zaznane verodostojnosti. Deležniki ne sodijo organizacij zgolj po vsebini sporočil, temveč tudi po njihovem tonu, doslednosti, odzivnosti in usklajenosti z dejanskim vedenjem. Komunikacija tako deluje kot filter, skozi katerega deležniki interpretirajo identiteto organizacije in na podlagi tega oblikujejo raven zaupanja.

Sodobni pristopi k strateškemu komuniciranju poudarjajo, da komunikacija ni zgolj podporna funkcija, temveč osrednji upravljavski proces, ki neposredno vpliva na odnose z deležniki. Zerfass, Verčič, Nothhaft in Werder (2018) komunikacijo opredeljujejo kot strateški vir organizacije, s katerim ta oblikuje pomen, usmerja zaznave in dolgoročno gradi legitimnost. V tem kontekstu komunikacija postane ključno orodje za vzpostavljanje in ohranjanje zaupanja, saj omogoča usklajevanje organizacijske identitete z družbenimi pričakovanji.

Poleg tega komunikacija omogoča dvosmerno izmenjavo pomenov, saj deležniki s svojimi odzivi, pričakovanji in kritikami soustvarjajo razumevanje organizacije v družbenem prostoru. Organizacije, ki ta dialog ignorirajo ali zanemarjajo, tvegajo, da bo njihova identiteta dojeta kot oddaljena, neavtentična ali celo manipulativna. Komunikacija zato igra ključno vlogo pri gradnji zaupanja: omogoča preverjanje skladnosti med tem, kar organizacija govori, in tem, kako dejansko deluje, ter tako neposredno vpliva na dolgoročno legitimnost organizacije.

Zaupanje je temeljni rezultat učinkovite komunikacije. Deležniki razvijejo zaupanje, ko organizacija komunicira jasno, dosledno in predvidljivo ter ko so sporočila skladna z njenimi dejanji. Fombrun in Van Riel (2004) trdita, da je ugled kot povzetek ocene organizacijskega vedenja neposredno povezan s tem, kako dobro organizacija izpolnjuje pričakovane norme transparentnosti in odgovornega vedenja.

Doslednost pomeni, da organizacija skozi čas ohranja isto zgodbo identitete. Ko se sporočila pogosto spreminjajo ali si nasprotujejo, deležniki začnejo dvomiti o pristnosti organizacije. Cornelissen (2020) poudarja, da je doslednost ključna za "kognitivno stabilnost" deležnikov. Organizacijo je treba dojemati kot predvidljivega akterja v svojem okolju.

Preglednost je še posebej pomembna v digitalni dobi, kjer je večina organizacij pod stalnim nadzorom javnosti. Szyszka (2013) poudarja, da se v takšnem okolju zaupanje oblikuje kot družbeni kapital, ki ga je mogoče pridobiti le s stalno vidljivostjo, odprtostjo in pripravljenostjo pojasniti razloge za odločitve.

Verodostojnost se ustvari, ko sta komunikacija in vedenje v sinergiji. Če organizacija komunicira družbeno odgovornost, vendar deluje v nasprotju s temi deklaracijami, deležniki hitro izgubijo zaupanje. Fombrun in Van Riel (2004) zato poudarjata, da je verodostojnost "najmočnejši steber ugleda", ker je odvisna od skladnosti med obljubami in dejanji.

Razumevanje zaupanja v organizacijskem kontekstu dodatno pogloblja integrativni model zaupanja, ki so ga razvili Mayer, Davis in Schoorman (1995). Avtorji zaupanje opredeljujejo kot pripravljenost posameznika, da postane ranljiv na ravnanja druge strani, pri čemer izpostavljajo tri ključne dimenzije: sposobnost, dobronamernost in integriteto. Komunikacija organizacije ima pomembno vlogo pri zaznavanju vseh treh dimenzij, saj skozi sporočila, odzivnost in konsistentnost omogoča oceno kompetentnosti organizacije, njenih namenov ter skladnosti med vrednotami in dejanji. Kadar komunikacija ne podpira teh zaznav, se zaupanje ne more trajno vzpostaviti, ne glede na formalno izraženo identiteto organizacije.

4 Povezanost identitete in komunikacije pri grajenju zaupanja

V praksi se organizacijska identiteta in njena komunikacija ne kažeta kot ločena ali neodvisna procesa, temveč kot tesno prepletena dejavnika, ki skupaj oblikujeta zaznavanje zaupanja med deležniki. Identiteta določa, kdo je organizacija, katere vrednote predstavlja in kakšen namen zasleduje, komunikacija pa omogoča, da se ti elementi predstavijo, razložijo in ocenijo v družbenem okolju. Zaupanje se torej ne oblikuje na podlagi enkratnih izjav ali formalno zapisanih vrednot, temveč z dolgoročno zaznano skladnostjo med organizacijsko identiteto, komunikacijo in

dejanskim vedenjem (Hatch & Schultz, 2001). Medsebojno razmerje med organizacijsko identiteto, komunikacijo in zaupanjem je mogoče razumeti kot dinamičen proces, v katerem se notranje vrednote organizacije skozi komunikacijske prakse prevajajo v zaznave deležnikov. Tabela 1 povzema ključne elemente tega odnosa in prikazuje, kako posamezni vidiki prispevajo k oblikovanju zaupanja.

Tabela 1: Povezava med identiteto, komunikacijo in zaupanjem

Element	Opis	Vpis na zaupanje
Organizacijska identiteta	Vrednote, poslanstvo, vizija, kultura	Ustvarja pričakovanja o ravnanju
Komunikacija	Način, ton, doslednost in preglednost sporočil	Omogoča preverjanje skladnosti
Vedenje organizacije	Dejanska ravnanja in odločitve	Potrjuje ali spodkopava identiteto
Zaupanje deležnikov	Dolgoročna zaznava verodostojnosti	Krepi legitimnost in ugled

Vir: avtorska sinteza na podlagi Cornelissen (2020), Hatch in Schultz (2001) in Mayer in drugi (1995)

Kot prikazuje Tabela 1, se zaupanje deležnikov oblikuje na presečišču organizacijske identitete, komunikacijskih praks in dejanskega vedenja organizacije. Posamezni elementi delujejo medsebojno povezano: identiteta ustvarja pričakovanja, komunikacija omogoča njihovo interpretacijo, vedenje pa jih potrjuje ali zanika. Zaupanje je zato rezultat dolgoročnega procesa, v katerem deležniki na podlagi ponavljajočih se izkušenj presojujejo skladnost med deklariranimi vrednotami in konkretnimi ravnanji organizacije.

V tem kontekstu je zaupanje rezultat ponavljajočih se izkušenj, ki jih imajo deležniki z organizacijo prek različnih stičnih točk. Vsaka komunikacijska interakcija, bodisi notranja, kot je komunikacija z zaposlenimi, bodisi zunanja, kot je javna komunikacija ali odzivanje na krize, prispeva k oblikovanju celostne podobe organizacije kot zaupanja vrednega ali nezanesljivega akterja. Če organizacija dosledno potrjuje svojo identiteto z jasnimi sporočili in odgovornim vedenjem, zaupanje postopoma raste in se prevede v dolgoročno podporo deležnikov.

Še posebej v digitalni družbi, kjer so informacije lahko dostopne in javno preverljive, postane vrzel med sporočili in dejanji takoj opazna. Organizacije so zato pod stalnim nadzorom, kar pomeni, da mora biti komunikacija tesno povezana z dejanskimi praksami in odločitvami. Ko identiteta in komunikacija delujeta v harmoniji, se

oblikujejo stabilni temelji za ugled, socialni kapital in legitimnost organizacije v družbi. Nasprotno pa neskladje med deklarirano identiteto in dejanskim vedenjem vodi v erozijo zaupanja, ki ga je kasneje težko obnoviti (Fombrun & van Riel, 2004).

Razmerje med identiteto, komunikacijo in zaupanjem je mogoče razumeti tudi kot povratni proces, v katerem odzivi deležnikov vplivajo na nadaljnje prilagajanje komunikacijskih praks in v nekaterih primerih tudi na redefinicijo organizacijske identitete. Ta dinamičnost poudarja, da zaupanje ni statičen rezultat, temveč stalno preverjan odnos med organizacijo in njenim okoljem.

Verodostojnost organizacije je neposredna posledica skladnosti med tem, kar govori, in tem, kar dejansko počne. Cornelissen (2020) navaja tri ključne dejavnike, ki gradijo verodostojnost: doslednost, preglednost in avtentičnost. Doslednost pomeni, da so sporočila usklajena na vseh kanalih; preglednost zahteva jasnost in odprtost pri zagotavljanju informacij; avtentičnost pa odraža resnično utelešenje vrednot, ki jih organizacija javno zastopa.

Hatch in Schultz (2001) poudarjata, da je verodostojnost mogoča le, če je notranja kultura dovolj močna, da podpira javno predstavljeno identiteto. Če na primer organizacija sporoča vrednote trajnosti, vendar jih ne izvaja v svojih dobavnih verigah ali odnosih z zaposlenimi, se verodostojnost takoj zmanjša.

Szyszka (2013) dodaja, da se verodostojnost poveča, ko organizacija omogoči dvosmerni dialog z deležniki, s čimer pokaže pripravljenost poslušati povratne informacije in prilagajati vedenje. Takšna interakcija krepi zaznavanje pravičnosti in spoštovanja, ki sta pomembna temelja zaupanja.

Fombrun in Van Riel (2004) povezujeta verodostojnost z vlogo vodenja: vodje, ki delujejo kot moralni vzorniki, krepijo zunanje zaznavanje integritete. Ko vodstvo deluje v skladu z vrednotami in transparentno sporoča tudi neprijetne informacije, deležniki hitreje razvijejo zaupanje v celotno organizacijo.

Ti dejavniki skupaj ustvarjajo temelje, na katerih se gradi trajna verodostojnost:

- jasna identiteta,
- dosledna komunikacija,
- etika in integriteta vodenja,
- avtentičnost organizacijske kulture,
- odprt dialog z javnostjo.

Ti elementi neposredno vplivajo na to, kako deležniki dojemajo organizacijo in koliko ji zaupajo v krizah in obdobjih stabilnosti.

Krizne situacije so eden najzahtevnejših preizkusov zaupanja v organizaciji. V takšnih okoliščinah se razkrije, ali so identiteta, vrednote in komunikacija organizacije resnično ponotranjene ali so le formalno izražene. Fombrun in van Riel (2004) poudarjata, da se ugled in zaupanje ne oblikujeta v stabilnih razmerah, temveč se njuna moč najbolj jasno pokaže v krizah. V trenutkih krize deležniki posebno pozornost namenjajo načinu, kako organizacija komunicira, kako hitro reagira in ali prevzema odgovornost za svoja dejanja.

Krizne situacije dodatno razkrivajo pomen skladnosti med identiteto in komunikacijo. Coombs (2021) poudarja, da deležniki v času krize ne presojujejo zgolj učinkovitosti odziva, temveč tudi njegovo skladnost z vrednotami, ki jih organizacija sicer zagovarja. Organizacije, katerih komunikacija v krizah odraža jasno identiteto in prevzemanje odgovornosti, imajo večjo verjetnost, da ohranijo ali celo okrepijo zaupanje javnosti.

Hatch in Schultz (2001) pravita, da mora biti krizno komuniciranje skladno z identiteto organizacije. Če organizacija v normalnih okoliščinah komunicira vrednote odgovornosti in odprtosti, v krizi pa deluje obrambno ali netransparentno, se vrzel med identiteto in vedenjem hitro pokaže. Takšna neskladja imajo pogosto dolgoročne negativne posledice za ugled.

Po Szyszki (2013) je krizno komuniciranje pomembno tudi z vidika dialoga z javnostjo. Organizacije, ki omogočajo dvosmerno komunikacijo v krizah in upoštevajo skrbi deležnikov, povečujejo zaznavanje pravičnosti in spoštovanja, kar

pozitivno vpliva na ponovno vzpostavitev zaupanja. Krize tako ne predstavljajo le grožnje, temveč tudi priložnost, da organizacija z ustrezno komunikacijo potrdi svojo identiteto in dolgoročno okrepi zaupanje.

5 Glavne ugotovitve in zaključek

Organizacijska identiteta in njeno komuniciranje sta neločljivo povezana procesa, ki skupaj tvorita osnovo zaupanja med deležniki. Analiza je pokazala, da lahko organizacije z jasno opredeljenimi vrednotami, poslanstvom in kulturo zlahka razvijejo prepričljivo identiteto, ki služi kot usmeritev navznoter in kot cilj navzven. Vendar pa identiteta sama po sebi ni dovolj; le dosledna, transparentna in pristna komunikacija zagotavlja, da deležniki to identiteto prepoznajo, razumejo in sprejmejo.

V današnjem digitalnem okolju, kjer se informacije hitro in pogosto nenadzorovano širijo, postane verodostojnost komunikacije ključni identifikator. Organizacije, ki svoje izjave uskladijo z dejanskim vedenjem in vzdržujejo dialog z javnostjo, krepijo svoj ugled in ustvarjajo stabilen družbeni kapital. Nasprotno pa neskladje med sporočili in dejanji vodi v erozijo zaupanja, ki ga je kasneje težko obnoviti.

Zato lahko sklepamo, da uspešne organizacije niso tiste, ki največ komunicirajo, temveč tiste, ki največ komunicirajo v skladu s tem, kdo v resnici so. Identiteta je njihov notranji kompas, komunikacija pa most do javnosti. Ko sta oba elementa usklajena, se ustvari verodostojnost, ki je ključni predpogoj za dolgoročno legitimnost in stabilen položaj organizacije v družbi.

Prispevek ima tudi praktične implikacije za vodstva organizacij, saj poudarja pomen strateškega usklajevanja identitete, komunikacije in dejanskega vedenja. Vodje imajo pri tem ključno vlogo kot nosilci vrednot in zgledi, saj njihova ravnanja pomembno vplivajo na zaznavo integritete organizacije. Raziskava temelji na pregledni analizi literature, kar predstavlja njeno omejitvev, hkrati pa odpira priložnosti za nadaljnje empirične raziskave, zlasti na področju zaznavanja zaupanja v digitalnih okoljih in v kriznih situacijah. Nadaljnje študije bi lahko z uporabo kvantitativnih ali kvalitativnih metod dodatno preverile povezave med zaznano identiteto, komunikacijskimi praksami in stopnjo zaupanja med različnimi skupinami deležnikov.

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4Q V DOLGOŽIVI DRUŽBI: MODEL NOTRANJE ARHITEKTURE, PRETOČNOSTI IN ROBUSTNOSTI ORGANIZACIJ

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V dolgoživi družbi, kjer se delovna doba podaljšuje, postaja notranja trajnost ključna za dolgoročno učinkovitost organizacij. Prispevek uvaja avtorski model 4Q, ki integrira štiri dimenzije inteligenc – racionalno (IQ), čustveno (EQ), duhovno (SQ) in fizično (PQ) – v celostni pristop k razvoju posameznika in organizacijskega sistema. Osrednje orodje modela predstavlja vitalni kvocient (VQ), kazalnik razmerja med obremenitvijo in regeneracijo, ki omogoča zavestno upravljanje psihofizične energije. Teoretična zasnova se naslanja na uvide Scheina, Argyrisa, Druckerja in Csikszentmihalyija, ob tem pa poudarja pomen globokih psihosocialnih procesov za trajnostno organizacijsko kulturo. Avtorski model 4Q krepi pretočnost, notranjo koherenco in prilagodljivost sistema, kar je ključno za delovanje v razmerah stalnih sprememb.

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4Q IN A LONGEVITY SOCIETY: A MODEL OF ORGANIZATIONS' INTERNAL ARCHITECTURE, FLOW, AND ROBUSTNESS

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In a longevity-oriented society, where working lives are steadily extending, inner sustainability is becoming a decisive factor in the long-term effectiveness of organisations. This paper introduces the 4Q model, an original conceptual framework that integrates four dimensions of intelligence—rational (IQ), emotional (EQ), spiritual (SQ), and physical intelligence (PQ)—into a comprehensive approach to the development of both individuals and organisational systems. At the core of the model lies the Vital Quotient (VQ), a metric that captures the dynamic relationship between load and regeneration, enabling the conscious management of psychophysical energy within organisations. The theoretical foundation of the model draws on the work of Edgar H. Schein, Chris Argyris, Peter F. Drucker, and Mihaly Csikszentmihalyi, while simultaneously emphasising the importance of deeper psychosocial processes in shaping sustainable organisational cultures. The proposed 4Q framework strengthens flow, internal coherence, and systemic adaptability, capacities that are essential for organisational functioning in conditions of continuous change and increasing complexity.



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1 Uvod

V dolgoživi družbi, kjer se delovna doba podaljšuje in narašča kompleksnost organizacijskih zahtev, postaja vprašanje notranje trajnosti ključna točka sodobnega menedžmenta. Metodologija povezovanja inteligenc 4Q ponuja integrativni model razvoja posameznika in organizacije, ki temelji na sočasni aktivaciji racionalne (IQ), čustvene (EQ), duhovne (SQ) in fizične inteligence (PQ). Osnovno teoretično izhodišče izhaja iz uvida, da organizacijska kultura ni nekaj, kar organizacija ima, temveč nekaj, kar organizacija je (Schein, 2005), kar pomeni, da je dolgotrajna učinkovitost odvisna od globljih psihosocialnih procesov, ne zgolj od strukture in sistema nagrajevanja. Znano je, da se organizacije pogosto »branijo pred učenjem«, kar povzroča sistemsko utrujenost in stagnacijo. Zato 4Q obravnava organizacijo kot ekosistem, kjer se psihološki, vedenjski in fizični procesi stekajo v enoten tok delovanja.

V dolgoživi družbi je ključni premik prehod od linearne operativnosti k zavestnemu upravljanju notranje arhitekture. Drucker (1954) poudarja, da je voditeljstvo predvsem odgovornost, kar v 4Q pomeni sposobnost vodje, da skrbi za vitalnost in jasnost celotnega sistema. Csikszentmihalyi (1990) dodaja, da optimalno delovanje nastane tam, kjer se srečata visoka izzvanost in visoka notranja energija, kar 4Q operacionalizira v praksi s krepitvijo povezljivosti vseh štirih dimenzij.

Prispevek pokaže, kako lahko 4Q omogoči večjo psihološko odpornost, nižjo latentno izgorelost in čistost presoje, kar v dobi dolgoživosti postaja temelj organizacijske konkurenčnosti. S svojo večdimenzionalno strukturo podpira pretočnost – sposobnost delovati stabilno in smiselno tudi ob nenehnih spremembah. Pretočnost nastane z usklajenim delovanjem štirih inteligenc, ki ustvarjajo notranjo koherenco sistema. 4Q hkrati razkriva robustnost organizacije, saj pokaže skrite napetosti, energijske tokove in točke, kjer se mikropsihologija preliva v strategijo.

2 Teoretična izhodišča

Model 4Q je zasnovan kot interdisciplinarni konceptualni okvir, ki povezuje organizacijsko teorijo, psihologijo, filozofijo in sistemsko misel. Njegova teoretična podlaga izhaja iz razumevanja organizacije kot živega, komunikacijskega in

kulturnega sistema, katerega vitalnost je odvisna od notranje koherence posameznikov, ki ga soustvarjajo. Temeljno izhodišče modela 4Q izhaja iz razumevanja organizacijske kulture kot ontološke strukture delovanja organizacije, kjer kultura ni zgolj skupek vrednot ali norm, temveč sistem temeljnih predpostavk, ki oblikujejo percepcijo, mišljenje in vedenje članov organizacije (Schein, 2005). Organizacija torej ni nekaj, kar kulturo ima, temveč nekaj, kar kultura je, zato dolgoročna učinkovitost organizacij ni primarno odvisna od formalne strukture, temveč od globinskih psihosocialnih procesov.

Hkrati model upošteva spoznanja o organizacijskem učenju in obrambnih rutinah, ki lahko preprečujejo refleksijo in transformacijo sistema (Argyris, 1993). Neuravnoteženost med miselnimi, čustvenimi, telesnimi in etičnimi procesi posameznika lahko krepí organizacijske obrambne mehanizme, medtem ko njihova integracija omogoča globlje, refleksivno učenje. Koncept pretočnosti izhaja iz teorije optimalne izkušnje, kjer ravnovesje med izzivom in kompetenco omogoča stanje toka (Csikszentmihalyi, 1990); model 4Q to idejo razširi na organizacijsko raven in pretočnost razume kot rezultat usklajenega delovanja več dimenzij inteligence. Voditeljstvo je v tem kontekstu razumljeno kot odgovornost za celoto sistema in za oblikovanje kulture, ki podpira koherenco med strategijo, vrednotami in odnosi (Drucker, 1954; 1994).

Organizacija je obenem komunikacijski sistem, ki se reproducira skozi tok pomenov in odločitev (Luhmann, 1984), zato je kakovost komunikacije neposredno povezana z notranjo integracijo posameznikov. Epistemološki okvir modela se navezuje na integralno razumevanje človeka kot večnivojskega bitja, ki deluje hkrati na individualni in kolektivni, notranji in zunanji ravni (Wilber, 2002). Etična razsežnost delovanja izhaja iz odgovornosti do Drugega kot temeljne človeške držé (Lévinas, 2001), medtem ko humanistična psihologija poudarja pomen samouresničitve, smisla in avtentičnega bivanja (Maslow, 1966; Frankl, 1994, 2006; Fromm, 1976).

Model 4Q torej sintetizira ta teoretična izhodišča v integrativni okvir, ki predpostavlja, da je notranja trajnost organizacij neposredno povezana z ravnovesjem in medsebojno povezanostjo miselnih, čustvenih, telesnih in duhovno-etičnih procesov posameznikov.

3 Raziskovalni model 4Q

Na podlagi predstavljenih teoretičnih izhodišč razvijamo raziskovalni model 4Q, ki predpostavlja, da notranja trajnost organizacij izhaja iz integriranega delovanja štirih dimenzij inteligence: racionalne (IQ), čustvene (EQ), duhovno-etične (SQ) in fizične (PQ). Model predvideva, da stopnja usklajenosti teh dimenzij vpliva na organizacijsko vitalnost, ki jo operacionaliziramo prek koncepta vitalnega kvocienta (VQ).

Vitalni kvocient (VQ) opredeljujemo kot razmerje med zaznano obremenitvijo in zaznano regeneracijo posameznika oziroma sistema. Višja raven VQ pomeni večjo sposobnost prilagajanja, nižjo stopnjo latentne izgorelosti in večjo organizacijsko pretočnost.

Model predpostavlja:

- da posamezne dimenzije inteligence delujejo medsebojno povezano,
- da njihova neuravnoteženost vodi v organizacijsko fragmentacijo,
- da njihova integracija spodbuja notranjo koherenco sistema.

Na tej podlagi oblikujemo naslednja raziskovalna vprašanja.

Raziskovalna vprašanja (RQ)

RQ1: Kakšna je povezava med posameznimi dimenzijami modela 4Q (IQ, EQ, SQ, PQ) in zaznano organizacijsko vitalnostjo (VQ)?

RQ2: Ali višja stopnja integracije štirih dimenzij inteligence napoveduje višjo stopnjo organizacijske pretočnosti?

RQ3: Ali obstajajo razlike v organizacijski koherenci med posamezniki z uravnoteženim 4Q-profilom in posamezniki z izrazito dominantno eno dimenzijo?

RQ4: V kolikšni meri 4Q-model pojasnjuje zaznano zmanjšanje izgorelosti in povečano psihološko odpornost zaposlenih?

Hipoteze

H1: Obstaja statistično značilna pozitivna povezava med stopnjo integracije 4Q in vitalnim kvocientom (VQ).

H2: Posamezniki z višjo stopnjo čustvene in duhovne inteligence (EQ in SQ) poročajo o višji ravni organizacijske koherence.

H3: Neuravnoteženost med dimenzijami 4Q je pozitivno povezana z zaznano stopnjo izgorelosti.

H4: Integrirani 4Q-profil pomembno napoveduje organizacijsko pretočnost tudi ob kontroli demografskih dejavnikov.

4 Lastnosti sodobnih organizacij

Vsaka organizacija deluje znotraj lastne **notranje ekologije** – kompleksnega sistema miselnih, čustvenih, vedenjskih in fizičnih vzorcev, ki oblikujejo njeno vitalnost in sposobnost prilagajanja. Nekatere organizacije so pretočne, žive in ustvarjalne, druge pa toge, utrujajoče ali celo toksične, čeprav se navzven zdijo uspešne. Razlika ni nujno v strukturi ali strategiji, temveč v tem, **kako organizacija »diha«** – v ritmu odnosov, procesov in v kakovosti komunikacijskih tokov, ki vzdržujejo ali izčrpavajo njen organizacijski organizem.

Sistemi teoretik **Niklas Luhmann (1984)** opozarja, da organizacije ne obstajajo zaradi posameznikov, temveč zaradi **komunikacije**. Po njegovem razumevanju so organizacije **avtopoietični sistemi**, ki se reproducirajo izključno skozi komunikacijo – skozi neprekinjen tok pomenov, odločitev in odzivov, ki ohranjajo njihovo identiteto in koherenco. Ko se komunikacija vsebinsko izprazni in postane formalna, sistem postopoma izgublja vitalnost. Organizacijska izčrpanost je zato pogosto simptom komunikacijske zaprtosti – stanja, v katerem kroži veliko informacij, a malo smisla.

Izčrpavajoča organizacija se ne izraža le v izgorelosti posameznikov, temveč v **kolektivni utrujenosti**: v nenehnih sestankih brez stika, besedah brez teže, odločitvah brez pravega soglasja. Takšne organizacije se pogosto utrudijo pod težo

lastnega diskurza, kjer komunikacija obstaja kot oblika, ne pa kot povezovalna funkcija. Vzroki za to niso le materialni (strukture, procesi, protokoli), ampak so predvsem **nematerialni – čustveni, miselni in duhovni**. Ti oblikujejo subtilno »organizacijsko polje«, ki ga vsi zaznavajo, a o njem redko kdo govori.

Vsaka organizacija nosi sledi svojih preteklih odločitev, vrednot in prepričanj, ki se nalagajo skozi čas in ustvarjajo **kolektivne usedline pomenov** – vzorce, ki določajo, kako sistem komunicira sam s seboj in s svojim okoljem. Zdrava notranja ekologija zahteva zavedanje teh vzorcev in sposobnost zaznavanja nevidnih dinamik, ki presegajo formalno hierarhijo.

Ravnovesje med štirimi dimenzijami človeške inteligence – **IQ (razumsko), EQ (čustveno), SQ (duhovno-etično) in PQ (telesno)** – je temelj pretočnosti organizacije. Kadar prevladuje le racionalna komponenta, brez čustvene in telesne resonance, se organizacija spremeni v stroj, ki izgublja občutek za ritem življenja. To vodi v pojav tihe odpovedi, čustvene ločenosti in sistemske izgorelosti. Vitalna energija se porazdeli neenakomerno: preveč se je usmeri v analizo, premalo pa v občutenje in smisel.

Kot poudarja **Otto Scharmer (2009)**, se sistemi ne zlomijo zato, ker bi ljudje želeli slabo, temveč zato, ker **ne zaznajo celote**. **Peter Drucker (1994)** pa bi k temu dodal, da »**kultura pojé strategijo za zajtrk**«, s čimer je nakazal, da notranja koherenca sistema določa njegovo dolgoročno učinkovitost v večji meri kot formalna struktura. Prav tu vstopa **4Q-pristop** – okvir, ki omogoča celosten vpogled v organizacijsko dinamiko in spodbuja pretočnost med različnimi ravni inteligence. Krize motivacije, konflikti in izgorelost tako niso zgolj operativne prepreke, ampak so simptomi **porušene notranje ekologije** – izgube smisla, stika in pretočnosti.

Organizacija, ki zdravi, ne teži k popolnosti, temveč k **ravnovesju in pretočnosti**. Razume razliko med strukturirano komunikacijo in avtentično povezanostjo, med nadzorom in dialogom. Čustva obravnava kot del strateškega kapitala, telo kot senzor resnice sistema, duhovno orientacijo pa kot notranji kompas, ki presega logiko dobička. Kot piše **Margaret Wheatley (1999)**, se notranji tokovi življenja sprostijo šele, ko organizacija preneha nadzorovati in začne poslušati.

5 Ekosistem, ki diha s človekom

Celostnost postaja eksistencialna nuja, saj sodobne organizacije pogosto silijo v ločevanje misli, čustev, telesa in smisla, kar vodi v razdrobljenost posameznika in sistema.

4Q-človek, ki ga kot pojem postavljamo v jedro pričujočega prispevka, združuje štiri ključne inteligence – miselno moč (IQ), čustveno zrelost (EQ), telesno vitalnost (PQ) in duhovno-etično orientacijo (SQ) – v pretočno, zavestno delovanje. Tak voditelj zna prepoznati signale telesa, uravnavati čustva, misliti jasno in odločati iz notranjega smisla, pri tem pa ostaja človeški, prizemljen in odprt za povezovanje. V ospredje stopa čustvena resonanca, saj navdih prihaja bolj iz prisotnosti in notranje koherence kot iz količine znanja, kar omogoča ustvarjanje zaupanja in sodelovanja. Nova paradigma uspešnosti temelji na kulturi, ki jo sooblikujejo celostni posamezniki, sposobni dihati s seboj, z drugimi in organizacijo kot živim ekosistemom. Sodobne organizacije so več kot zgolj sistem dela. So prostor preživetja, pogosto tudi izgorevanja, včasih pa prostor preboja in inovacije. Prevečkrat pa postanejo prostor tihega razkroja – tam, kjer človek postopoma izgublja stik s seboj.

Prispevek se osredotoča na posameznika znotraj organizacijskih struktur, pri čemer analizira štiri ključne dimenzije njegove prisotnosti: telesno, čustveno, kognitivno in eksistencialno. Zaposleni so pogosto fizično prisotni, a njihova notranja doživljanja ostajajo prezrta. Čustvene stiske niso izražene zaradi pomanjkanja varnega prostora za komunikacijo. Kognitivna preobremenjenost zmanjšuje zmožnost učinkovitega odločanja. Eksistencialna vprašanja, kot so smisel in vrednote, so redko vključena v organizacijski diskurz. Takšna fragmentacija vodi v zmanjšano dobrobit in nižjo trajnostno učinkovitost zaposlenih.

Za voditelje, podjetnike in menedžerje to ni obrobna tema – je bistvo. Organizacije se ne gradijo le s strategijo in procesi, temveč s prisotnostjo, empatijo in zavestjo. In kultura je prav to – nevidno tkivo človeških interakcij, ki organizacijo bodisi poživí bodisi izprazni.

Kot avtorica v tem prispevku predstavljam Model povezovanja inteligenc 4Q – štiri temeljne dimenzije, ki oblikujejo človeka in s tem organizacijsko tkivo:

- IQ kot miselna moč in sposobnost analize,
- EQ kot čustvena zrelost in empatična prisotnost,
- SQ kot duhovna usmerjenost, notranji smisel in etika,
- PQ kot telesna modrost, zdravje in pretočnost.

Ko teh štirih inteligenc ne prepoznamo in jih zanemarimo, človek prične ugašati – najprej v sebi, nato v odnosih, nazadnje v organizaciji. Ko pa jih aktiviramo, se človek začne vračati k sebi, s tem pa začne dihati tudi tim, ekipa, celotno podjetje. Kot je zapisal Viktor Frankl, ko človek ve, »zakaj«, zmore prenesti skoraj vsak »kako«. Smisel in notranja povezanost postaneta temelj odpornosti posameznika in sistema.

Tudi raziskave psihologije organizacij kažejo, da je ravno človek v središču trajnostnega uspeha. Abraham Maslow je opozoril, da če imaš le kladivo, se ti vse zdi kot žebelj. Vodenje, ki temelji le na enodimenzionalnem pristopu (denar, nadzor, KPI-ji), ne more zajeti kompleksnosti človeka. Edgar Schein (2005) pa je poudaril, da je najpomembnejša stvar, ki jo morajo voditelji razumeti, ta, da je njihova edina resnična naloga oblikovanje in negovanje kulture. Daniel Goleman (2001 in 2007), oče koncepta čustvene inteligence, pa dodaja, da se najboljši voditelji ne razlikujejo po IQ-ju, ampak po EQ-ju.

Organizacija, ki želi preživeti, mora postati več kot struktura: postati mora ekosistem, ki diha s človekom. Ekosistem, kjer se nahaja prostor za dih, čustvo, misel, intuicijo in odločitev, je vtkan v prihodnost pametnih organizacij. V okviru tega človek ni »delovni vir«, temveč »sobitje«. Delo ni izguba energije, temveč prispevek k skupnemu dobremu, poleg rezultatov pa so pomembne tudi sinergije timov in notranja uigranost posameznika – najprej s seboj, nato z drugimi.

Le takšna organizacija lahko dolgoročno uspeva, ker ne temelji le na kapitalskih vložkih, temveč na največjem kapitalu – človeku. Danes vemo, da se organizacije ne gradijo le s strategijo, temveč s prisotnostjo, empatijo, zavestjo pa tudi s telesom, ki še zna brati simbole, občutke in smisel.

Fiktivni primer:

Podjetje X, srednje veliko podjetje s približno 150 zaposlenimi, je imelo še pred nekaj leti vse značilnosti navidezno uspešne organizacije. Njegova rast prihodkov je bila stabilna, produkti konkurenčni, menedžment je imel jasno zastavljeno strategijo. A pod površjem so se kazali znaki razkroja, ki jih vodstvo sprva ni želelo videti:

- **visoka fluktuacija:** več kot 25 % zaposlenih je v letu dni zapustilo podjetje, predvsem mlajši kadri, ki niso našli smisla in perspektive;
- **izgorelost in absentizem:** poraslo je število bolniških odsotnosti, pogovori ob odhodu pa so razkrivali občutke izčrpanosti in zanemarjenosti;
- **slaba komunikacija med oddelki:** konflikti so se stopnjevali, projekti so se vleкли, ker ljudje niso zaupali drug drugemu;
- **vodstvo v »mehurčku«** – prepričani so bili, da so težave začasne in da jih bodo rešili s strožjo kontrolo KPI-jev.

Ko je vajeti prevzela nova direktorica, je ugotovila, da klasični menedžerski prijemi ne zadostujejo. Potrebna je bila globlja sprememba – sprememba organizacijske kulture in odnosa do ljudi. Zato so uvedli pristop, ki temelji na 4Q-modelu povezovanja inteligenc.

1. **Čustvena inteligenca (EQ):** Organizirali so delavnice čustvene pismenosti, kjer so zaposleni spoznali, kako stres vpliva na njihovo vedenje, in se naučili metod za bolj konstruktivno reševanje konfliktov. Vodje so pridobili veščine aktivnega poslušanja in vodenja s sočutjem.
2. **Duhovna inteligenca (SQ):** Vsak mesec so uvedli refleksivne pogovore, kjer so skupaj razmišljali o smislu projektov, vrednotah podjetja in etičnih dilemah. Ti dialogi so ustvarili občutek skupne vizije in ponosa.
3. **Fizična inteligenca (PQ):** Poslovne prostore so preuredili tako, da so spodbujali gibanje, sprostitve in stik z naravo. Uvedli so fleksibilne urnike in programe za ohranjanje telesnega zdravja. Zaposleni so dobili občutek, da podjetje skrbi za njihovo dobrobit.
4. **Racionalna inteligenca (IQ):** Procesi in cilji so ostali jasno zastavljeni, a so jih dopolnili z »mehkejšimi« indikatorji – zadovoljstvom zaposlenih, stopnjo sodelovanja med oddelki in inovativnimi predlogi.

Rezultati po dveh letih:

- fluktuacija se je znižala na 10 %;
- zadovoljstvo zaposlenih se je z ocene 3,1 dvignilo na 4,4 (po interni Likertovi lestvici);
- število inovacijskih predlogov se je skoraj podvojilo;
- bolniške odsotnosti so se zmanjšale za 30 %;
- v anketah so zaposleni izpostavili dve največji spremembi (*»Počutimo se slišane.«* in *»Končno imamo občutek, da delo ni le naloga, ampak prispevek.«*).

Direktorica je ob zaključku drugega leta dejala: *»Na začetku smo iskali hitre rešitve. Na koncu smo ugotovili, da je prava rešitev v tem, da smo dovolili ljudem dihati – s seboj in drug z drugim. Ko smo začeli obnavljati človeka, se je začelo obnavljati tudi podjetje.«*

6 Kdo je 4Q-človek: za notranjo arhitekturo pretočnosti

V času razpršene zavesti, ko organizacijski sistemi pogosto zahtevajo ločenost misli, občutka, telesa in smisla, se ponovno poraja vprašanje celosti. Ne kot utopična ideja ali zgolj še ena sodobna poslovna fraza, temveč kot eksistencialna nujnost. Vstopamo v obdobje, kjer fragmentacija ni več vzdržna – ne za posameznika ne za kolektiv. In prav na tej točki se pojavi ideja 4Q-človeka, in sicer ne kot koncept, ki bi želel prepričati, temveč kot nujnost, ki želi prebuditi.

4Q-človek ni popoln, je pa buden. Ne išče gotovosti, temveč pretočnost. Je posameznik, ki presega okvire enodimenzionalne kompetentnosti. Je strokoven, a ni odrezan od svojega telesa. V sodobnih organizacijah smo pogosto naučeni delovati »od vratu navzgor« – misliti, analizirati, odločati, ne da bi prisluhnili telesu. A telo je naš prvi senzor: opozarja nas na stres, napetost, izgorelost pa tudi na intuicijo in ustvarjalne prebliske. Odrezanost od telesa pomeni, da vodimo in delamo, kot da smo zgolj stroji misli. Posledice tega so izguba vitalnosti, kronična utrujenost in odtujenost od sebe. 4Q-človek se zna ustaviti, ozavestiti svoj dih, prepoznati signale telesa in jih vključiti v svoje odločitve. To mu omogoča, da ostane učinkovit, a hkrati zdrav in celosten.

Njegova inteligenca ni parcialna, ampak je pretočna. Večina ljudi uporablja svoje intelligence fragmentirano: v službi razum, doma čustva, v krizi telo, v samoti duhovnost. 4Q-človek pa razume, da prava moč prihaja iz pretočnosti – iz sposobnosti, da se te dimenzije prelivajo druga v drugo glede na situacijo. Pretočna inteligenca pomeni, da razum lahko sodeluje s čustvi, da telo podpira duha in da etika usmerja logiko. To je stanje, kjer intelligence ne tekmujejo, temveč sodelujejo. Kot je zapisal Mihaly Csikszentmihalyi (1990), ko so naše sposobnosti in izzivi v ravnovesju, vstopimo v tok. Pretočnost je tisti »flow«, kjer človek ni razpršen, pač pa deluje kot celota.

4Q-človek je čustveno razvit, a ni sentimental. Ima duhovno orientacijo, toda ostaja prizemljen, in razpolaga z razumom, ki ni zgolj analitičen, temveč tudi moder in sočuten.

Njegova notranja arhitektura biti sledi štirim plastem bivanja: intelektualni (IQ), čustveni (EQ), duhovni (SQ) in fizični (PQ). Gre za integrirano zmožnost mišljenja, čutenja, orientacije in utelešene prisotnosti. Ken Wilber (2002) bi temu rekel integralna zavest, Erich Fromm pa bi v njem prepoznal zmožnost življenja iz biti in ne iz imetja (Fromm 1976). 4Q-človek ne deluje iz manka, temveč iz notranje sinhronije. Njegova moč ni v tem, da izstopa, ampak v tem, da povezuje.

Kot je zapisal Abraham Maslow: »Človek mora biti tisto, kar je sposoben postati« (Maslow 1966, str. 93 wikipedija). 4Q-človek je torej tisti, ki uresničuje svoje potenciale na način, da ne ločuje med delom in življenjem, racionalnim in čustvenim ter smislom in telesom, temveč jih prepleta v organsko celoto. Daniel Goleman je opozoril, da voditelji, ki navdihujejo, niso tisti, ki imajo največ znanja, ampak tisti, ki znajo ustvariti čustveno resonanco (Goleman 2002). A 4Q-človek dodaja še tretjo in četrto dimenzijo: telesno vitalnost in duhovno orientacijo.

4Q-človek je voditelj nove dobe – ne nujno zato, ker zaseda vodilno funkcijo, temveč zato, ker zna povezovati razpršene tokove življenja v pretočno enoto. Edgar Schein (2010) je zapisal, da je edina resnična naloga voditelja ustvarjanje in ohranjanje kulture. 4Q-človek to nalogo izpolnjuje na način, da kulturo gradi s seboj – s svojim načinom bivanja, ki je prežet s celovitostjo.

V praksi to pomeni, da 4Q-človek ni zasvojen z rezultati, ampak z rastjo. Ne meri uspeha zgolj z ekonomskimi kazalniki, temveč z vprašanjem: »*Ali sem v tem, kar počnem, cel?*« In prav tu se dotaknemo srčike sodobne organizacijske psihologije: kultura in uspeh sta vedno odvisna od človeka, ki stoji v središču. Kot pravi Viktor Frankl (1994 in 2006), je med dražljajem in odzivom prostor, v katerem leži naša moč, da izberemo svoj odziv. V naši izbiri pa se nahajata naša svoboda in naša rast. 4Q-človek torej ni idealizirana figura, temveč je praktična možnost. Je arhetip človeka prihodnosti – povezan, pretočen, integriran. Človeka, ki zna dihati s seboj, drugimi in z organizacijo.

6.1 Z vezmi, ki dihamo in podpirajo dolgoživost družbe

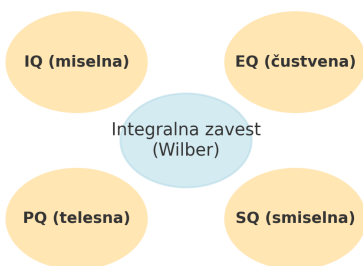
Vsaka organizacija je več kot seštevek oddelkov, procesov in ciljev. Je mreža odnosov, nevidnih tokov in subtilnih energij, ki odločajo, ali sistem diha ali se duši. Tam, do koder strategije ne sežejo, kjer pravila ne zaležejo in kjer strukture odpovejo, odločajo osebnostne vezi – tiste nevidne niti med ljudmi, ki prinašajo občutek smisla in povezanosti.

V organizaciji 4Q-človek deluje kot vezno tkivo: tiho, a ključno. Njegova prisotnost ni glasna, a ustvarja prostor. Zna govoriti jezik števil, ne da bi pri tem izgubil občutek za tišino med besedami. Zna voditi brez dominacije. Zna prisluhniti, ne da bi izginil. Je figura, ki uteleša vertikalno integracijo – povezanost z lastno notranjo osjo, ki presega horizontalne razprtije vlog in statusov.

Podobno kot koncept integralne zavesti, kot ga predstavi Ken Wilber (2002), 4Q ponuja pomemben teoretski okvir za razumevanje človeka kot celostnega voditelja. Integralna zavest presega parcialno dojetje resničnosti in omogoča usklajeno zaznavanje notranjih in zunanjih dimenzij človeške izkušnje – od individualne psihologije do kolektivnih sistemov. Podobno kot Wilberjev model vključuje različne razvojne ravni in perspektive (jaz–ti–to–mi), tudi 4Q-pristop združuje miselno (IQ), čustveno (EQ), duhovno-etično (SQ) in telesno (PQ) inteligenco v pretočno celoto. Tak pristop ne vodi zgolj k osebni koherenci, temveč tudi k višji stopnji organizacijske zavesti, kjer voditeljstvo ne temelji le na funkciji, temveč na sposobnosti prepoznavanja in usklajevanja kompleksnih človeških in sistemskih vzorcev. Integralna zavest tako kot osnove 4Q paradigme – ne kot idealizirana

transcendenca, temveč kot operativna zmožnost, prepoznava večplastnosti realnosti in delovanja iz integritete.

Povezava 4Q modela z integralno zavestjo



Slika 1: Model 4Q-človeka (IQ, EQ, SQ, PQ), ki se združuje v središču – integralni zavesti po Kenu Wilberju

Kot je opozoril francoski sociolog Pierre Bourdieu (2004), je vsak posameznik nosilec *habitusa* – strukture zaznavanja, presojanja in delovanja, ki se vpisuje v družbeno polje (4Q-človek to polje zaznava z večjo subtilnostjo, ker zaznava sebe. In tam, kjer človek zazna sebe, zazna tudi druge. Carl Gustav Jung je podobno poudarjal, da kdor pogleda navzven, sanja; kdor pogleda navznoter, se prebudi (Jung 1989).

Kultura, ki podpira takšne ljudi, je kultura prihodnosti. To ni več kultura nadzora in ocenjevanja, temveč kultura zavedanja in sodelovanja. Raziskave organizacijske dinamike kažejo, da težave organizacij pogosto ne izvirajo iz pomanjkanja podatkov, temveč iz izgube skupnega smisla. Kadar zaposleni ne razumejo konteksta svojega delovanja ali ne zaznavajo pomena svojega prispevka, pride do dezorientacije, pasivnosti in erozije zaupanja. Ključni premiki se zato ne zgodijo le na ravni strategij ali struktur, temveč izhajajo iz kakovosti odnosov in pomenljivih pogovorov med ljudmi. Povezanost, občutek skupne odgovornosti in smiselno sodelovanje predstavljajo temelj za resnične spremembe v organizacijskem okolju. V tej luči ima 4Q-človek posebno vlogo: ne le da zaznava kompleksnost sistemov, temveč tudi aktivno oživlja smisel – znotraj sebe, v odnosih in kulturi, ki jo soustvarja.

Čeprav 4Q-človek deluje kot tiho vezivno tkivo, njegova prisotnost ne ostaja omejena na notranji svet. Njegova moč se najbolj pokaže v odnosih – tam, kjer organizacije največkrat razpadajo. Ko 4Q-človek vstopi v dialog, ne prinaša zgolj svojega znanja, temveč tudi notranji psihološki prostor, v katerem se lahko drugi izrazijo. Je tisti, ki zna povezati racionalno presojo finančnika s subtilno zaskrbljenostjo sodelavke v stiski. Zna prepoznati, da ni dovolj imeti prave odgovore, če ni pravega vzdušja, v katerem jih lahko izrečemo.

Človek se v odnosih izraža prek drugih, zlasti v socialnem svetu, ki ga naseljujejo številni pomeni in spomini, 4Q-človek gradi odnose, ki niso zgolj orodje za doseganje ciljev, ampak prostor, kjer se cilji sploh lahko snujejo. V organizaciji to pomeni, da sodelovanje ni stranski produkt, temveč je pogoj za uspeh. Hkrati pa 4Q-človek razume tudi pomen kolektivne zavesti. Edgar Morin opozarja, da kompleksni sistemi preživijo le, če razvijejo sposobnost refleksije o sebi (Morin 2008). 4Q-človek je prav to – ogledalo sistema, ki opozarja na skrite tokove in pomaga skupnosti, da se ne izgubi v lastnih slepih pegah.

Bistvo njegovega delovanja je, da diha skupaj z ekosistemom: ne izčrpa ga, ampak oplaja. Ne tekmuje, temveč soustvarja. Ne kopiči moč, temveč jo razpršuje, deli. In prav v tem se kaže razlika med klasičnim »junakom« in 4Q-človekom: prvi išče zmago zase, drugi zmago za skupnost.

Tak človek ne potrebuje umetne avtoritete. Njegova moč je mehka, a stabilna. Njegovo znanje ni strogo razumsko, temveč je prepojeno z izkušnjo in ponotranjeno presojo. Zna razlikovati med nujnim in bistvenim, med odzivom in reakcijo, med delom in delovanjem. Kot je pisal Max Weber, etična odgovornost posameznika izhaja iz notranje konsistence, ne iz posledic dejanja.

6.2 4Q-človek kot filozofski arhetip

4Q-človek ni le integriran posameznik, temveč je figura, ki pooseblja odprtost do drugačnega. Zanj drugačnost ni grožnja, temveč priložnost za razširitev horizonta. Ne zapira se v en sam način razmišljanja, temveč dopušča, da ga soočenje z drugim obogati. V tem smislu je njegova drža blizu misli Emmanuela Lévinasu (2001), ki je zapisal, da je obraz Drugega prostor, kjer se rojeva etika.

Emmanuel Lévinas kot eden najvplivnejših etičnih mislecev 20. stoletja preusmeri filozofsko pozornost od ontologije k etiki kot prvi filozofiji. V nasprotju s tradicijo, ki svet razume kot totaliteto objektov za mišljenje in obvladovanje, Lévinas uvaja koncept Drugega kot tistega, ki presega vsak poskus ujetja v sistem. V središče etične misli postavi srečanje z Obrazom Drugega – neposrednim, neizogibnim pozivom k odgovornosti, ki se ne začne z jazom, temveč z obvezujočo prisotnostjo Drugega. Obraz ni zgolj fizična entiteta, temveč fenomen, ki v subjekt vpisuje moralno zahtevo: *Ne ubijaj me*. Etika pri Lévinasevu ni rezultat racionalne presoje ali univerzalnega moralnega načela, temveč je odzivnost na ranljivost drugega človeka, ki je radikalno drugačen, a hkrati temelj moje lastne subjektivnosti. S tem Lévinas razširi polje razumevanja etike iz formalnih norm na področje človeškega odnosa, soodvisnosti in odgovornosti, kar je neposredno povezljivo s sodobnimi pristopi k voditeljstvu, dialogu in organizacijski kulturi. V 4Q-modelu, ki združuje miselno (IQ), čustveno (EQ), duhovno-etično (SQ) in telesno (PQ) inteligenco, ta poziv resonira v dimenziji SQ – kot sposobnost zaznave moralne ranljivosti drugega in pripravljenosti nanjo odgovoriti s prisotnostjo ter skrbjo. Integralna etika, ki ni utemeljena v normi, temveč v odnosu, s tem postane notranja sila vodenja. Voditelj, ki uteleša 4Q, ne vodi zgolj z orodji upravljanja, temveč s sposobnostjo biti prisoten v odnosu, kjer etika ni zunanji kodeks, temveč vsakdanja praksa odzivnosti. Tak voditelj ni v središču zaradi moči, temveč zaradi globokega posluha za pomen, ki ga soustvarja v odnosih – in to je temelj trajnostnega vodenja.

Njegova odprtost pa ne pomeni naivnega sprejemanja vsega. 4Q-človek zna kritično presojati, razlikovati med tistim, kar je avtentično, in tistim, kar je zgolj površinski signal. Odprtost zanj ni pasivno prilagajanje, ampak dejavno oblikovanje prostora dialoga, kjer lahko različnosti obstajajo, ne da bi se izničile.

4Q-človek je tudi kreativen – ne v smislu zgolj umetniškega izražanja, temveč kot ustvarjalec novih oblik sistema, kjer drugi vidijo zgolj omejitve. Njegova kreativnost je pretočna, saj združuje racionalno analizo, čustveno resonanco, duhovni smisel in telesno vitalnost. Tako postaja tvorec oblik sodelovanja, ki niso hierarhične, temveč mrežne, odprte in živahne.

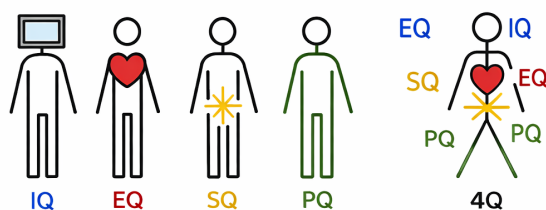
Kot osebnost je interdisciplinaren – razume, da svet ni enodimenzijski in da resnica nikoli ne pripada samo eni disciplini. V njem se prepletajo antropologija, filozofija, ekonomija, psihologija in umetnost, saj 4Q-človek ve, da življenje presega

meje specializacije. A ta interdisciplinarnost ni površinska, temveč je zasidrana v praksi: pomeni sposobnost prevesti ideje iz enega polja v drugo in jih udejanjiti v konkretnih projektih.

4Q-človek nikoli ni ujetnik predsodkov. Prepozna, da so predsodki le oklep, s katerim se ščiti ego, in da svoboda nastopi, ko dopustimo, da nas dotakne tudi to, kar je neudobno. Je figura, ki zna živeti s protislovji – ne kot z napako, temveč kot z virom vitalnosti. Kot bi rekel Zygmunt Bauman (2008), negotovost ni problem, ki ga je treba rešiti, temveč stanje, ki ga je treba sprejeti.

Obenem 4Q-človek ni izoliran posameznik, ampak je člen skupnosti. Njegova moč se ne meri po tem, koliko doseže sam, temveč koliko zna okrepiti druge. Njegova integracija se razodeva v podpori, ne v tekmovalstvu. Njegova resnična avtoriteta ni vsiljena, temveč je podeljena – ker drugi prepoznajo, da ob njem rastejo.

4Q-človek torej presega zgolj psihološki ali organizacijski opis. Je filozofska orientacija, ki nas uči, da prava moč ni v dominaciji, ampak v povezovanju; ne v gotovosti, ampak v pretočnosti; ne v monologu, ampak v dialogu. V njem se kaže možnost, da prihodnost ne bo zgolj hitrejša ali učinkovitejša, temveč tudi humanejša.



Slika 2: Podobe 1, 2, 3, 4, 5

Podoba 1: Človek-stroj uporablja izključno **IQ**. Njegova glava je računalnik – analizira, računa, optimizira, a nima stika s čustvi ali telesom. Je učinkovit, vendar odtujen, brez notranje povezanosti in empatičnega stika z drugimi.

Podoba 2: Človek-srce uteleša predvsem **EQ**. V središču so sočutje, empatija in čustvena odprtost, a mu primanjkuje kognitivne stabilnosti, fizične osredotočenosti

in duhovne usmerjenosti. Je mehko odziven, vendar premalo strukturiran za kompleksne sisteme.

Podoba 3: Človek-smisel izrazito simbolizira **SQ** – notranjo luč, orientacijo v vrednotah in transcendenci, a brez čustvene, racionalne in telesne utemeljenosti ostaja vizionar brez izvedbene moči.

Podoba 4: Človek-telo temelji na **PQ**. Je močan, vitalen in telesno prisoten, toda brez razumske refleksije, čustvene globine in etične orientacije. Usmerjen je v akcijo, ne pa v smisel ali celostno delovanje.

Podoba 5: 4Q-človek predstavlja celovito integracijo vseh štirih razsežnosti: **IQ** (razum – modro), **EQ** (srce – rdeče), **SQ** (smisel – rumeno sonce) in **PQ** (telo – zeleno). Inteligenca deluje pretočno, kar omogoča povezanost s seboj, z drugimi in z organizacijo kot celoto.

Tabela 1: Tabela podob

Obraz človeka	Temeljna usmeritev	Moč	Omejitev	Organizacijski učinek
Človek-stroj (IQ)	Racionalnost, analitičnost, kalkulacija	Logika, natančnost, sposobnost strukturiranja	Odtujenost, čustvena hladnost, zanemarjanje telesa in smisla	Učinkovit v operativnih nalogah, a šibak v odnosih in dolgoročni viziji
Človek-srce (EQ)	Čustva, empatija, sočutje	Sposobnost povezovanja, občutljivost za ljudi	Pomanjkanje strukture, težave pri odločanju, nestabilnost	Krepi odnose, a lahko ohromi izvedbo in rezultate
Človek-smisel (SQ)	Duhovna orientacija, etika, notranji kompas	Vizija, vrednote, občutek smisla in poslanstva	Sanjaštvo, oddaljenost od realnosti, neoperativnost	Navdihuje druge, a brez drugih dimenzij ostaja neizvedljiv
Človek-telo (PQ)	Fizična moč, vitalnost, akcija	Vzdržljivost, energija, operativna učinkovitost	Pomanjkanje refleksije, lahko grobost, impulzivnost	Hiter v izvedbi, a lahko povzroča konflikte in izčrpavanje
4Q človek	Integracija IQ, EQ, SQ in PQ	Pretočnost, celovitost, sposobnost povezovanja razuma, čustev, telesa in smisla	Ni popoln, a je buden in celostno naravn	Graditelj kulture, ki povezuje učinkovitost, odnose, smisel in vitalnost v trajnostni uspeh

7 Pet obrazov človeka v praksi (praksa dolgoživosti)

Vsaka organizacija deluje kot dinamičen sistem, katerega temeljno komponento predstavljajo posamezniki s svojimi kognitivnimi, čustvenimi, telesnimi in duhovno-etičnimi vzorci delovanja. Ti vzorci določajo, kako posamezniki zaznavajo, interpretirajo in sooblikujejo organizacijsko realnost. Model štirih inteligenc (4Q) ponuja konceptualni okvir za razumevanje različnih načinov človeškega delovanja – miselnega (IQ), čustvenega (EQ), telesnega (PQ) in duhovno-etičnega (SQ) – ter njihovega vpliva na organizacijsko kulturo in procese vodenja. Spodnji primeri ponazarjajo, kako prevlada posamezne dimenzije inteligence vpliva na delovno klimo, kakovost odločanja in dolgoročno stabilnost organizacijskih sistemov.

1. Človek-stroj (IQ): V podjetju za finančne storitve vodja oddelka briljira v analizi podatkov in obvladovanju stroškov. Njegova moč je v natančnosti in racionalnem razumevanju kompleksnih situacij. Toda ker daje prednost številkam pred ljudmi, se težje sooča z vprašanji motivacije, pripadnosti in konfliktov. Sistem deluje kot dobro uglasen stroj, a ostaja ranljiv ob soočenju s subtilnejšimi človeškimi potrebami.

2. Človek-srce (EQ): V nevladni organizaciji za pomoč beguncem direktorica ustvarja občutek varnosti in pripadnosti. Njena empatija in iskreno zanimanje za ljudi krepi zaupanje v ekipo. Včasih pa se pokaže, da toplina brez jasnih prioritet otežuje odločanje in strateško usmeritev. Organizacija je prežeta s sočutjem, a potrebuje dodatne strukture, da bi ohranila trajnost.

3. Človek-smisel (SQ): V kulturnem zavodu vodja navdušuje z vizijami o vlogi umetnosti v družbi. Zna povezati delo z občutkom poslanstva in spodbuditi ustvarjalnost. A ker vizija ni vedno podprta s sistematično izvedbo, projekti pogosto zaostajajo. Navdih je močan, toda brez opore v strukturah in procesih ostaja delno neizkoriščen.

4. Človek-telo (PQ): V proizvodnem podjetju je vodja izmene znan po tem, da je vedno ob stroju skupaj z delavci. Njegova fizična prisotnost daje občutek enotnosti in zanesljivosti. V kriznih trenutkih njegova energija vleče ekipo naprej, a včasih se preveč zanaša na disciplino in moč, kar lahko privede do napetosti. V normalnih razmerah je motor ekipe, v krizah pa deluje preveč na silo.

5. 4Q-človek: V tehnološkem zagonskem podjetju soustanovitelj povezuje različne dimenzije: analitično razume tržne podatke (IQ), ustvarja povezovalno vzdušje v ekipi (EQ), usmerja podjetje k trajnostnim ciljem (SQ) in skrbi za zdravje ter energijo sodelavcev (PQ). Njegova moč je v pretočnosti – sposobnosti, da se glede na kontekst pojavi kot analitik, poslušalec, vizionar ali nosilec energije. Prav ta celovitost omogoča, da podjetje uspeva ne le zaradi produktov, temveč zaradi kulture, ki diha skupaj z ljudmi.

Analiza različnih oblik inteligence kaže, da nobena posamezna dimenzija ne zadostuje za kompleksnost sodobnih organizacijskih sistemov. Prevlada racionalno-analitične usmerjenosti brez čustvene in etične občutljivosti vodi v instrumentalno delovanje brez človeške povezanosti. Po drugi strani prekomerna empatija brez strukture oslabi izvedbeno moč, duhovna vizija brez telesne in kognitivne osredotočenosti izgubi operativni učinek, medtem ko zgolj telesna energija brez refleksije vodi v prekomeren nadzor.

Model 4Q-človeka predstavlja integrativni okvir, ki združuje različne ravni inteligence v funkcionalno celoto. Tak posameznik je sposoben delovati racionalno in analitično, hkrati pa ohranja čustveno resonanco, telesno vitalnost in etično orientacijo. Na organizacijski ravni 4Q-pristop omogoča prehod od linearnega, kratkoročnega upravljanja k celostnemu voditeljstvu, ki povezuje učinkovitost z notranjo koherenco sistema.

Dolgoživost organizacij v tem kontekstu ni rezultat zgolj stabilne strukture ali finančne vzdržnosti, temveč predvsem zmožnosti nenehne regeneracije – sposobnosti, da se organizacija uči, prilagaja in ohranja notranjo vitalnost skozi čas. Takšna organizacija deluje kot živ ekosistem: uravnava svoje energijske in komunikacijske tokove, prepoznava spremembe v okolju in jih pretvarja v priložnosti za razvoj. Ključ za njeno dolgoživost je pretočno ravnovesje med racionalnim in intuitivnim, med rezultati in odnosi, med strukturo in smislom.

V tem smislu 4Q-pristop ne prispeva le k razumevanju posameznika, temveč predstavlja tudi teoretski in praktični okvir za evolucijo organizacij, ki so sposobne dolgoročno ohranjati vitalnost, relevantnost in etično delovanje v nenehno spreminjajočem se okolju. Dolgožive organizacije so tiste, ki razumejo, da učinkovitost brez smisla ni trajna in da je smisel brez izvedbe neuresničljiv. Ravno v

sožitju teh dveh polov – med notranjo zrelostjo posameznika in kolektivno pretočnostjo sistema – se oblikuje prihodnost organizacij, ki ne le preživijo, temveč tudi živijo v polnosti.

Epilog: Celostni človek v pretočni organizaciji

V središču sodobnih izzivov organizacij ne stoji več vprašanje učinkovitosti, temveč vprašanje celovitosti. Naše raziskovanje je pokazalo, da sodobni sistemi – bodisi posamezniki bodisi organizacije – ne propadajo zaradi pomanjkanja znanja ali orodij, temveč zaradi izgube notranjega ravnovesja in smisla.

V prvem delu smo predstavili koncept **4Q-človeka** kot modela celostnega bivanja, ki presega fragmentiranost sodobne zavesti. 4Q-pristop združuje štiri dimenzije človeške inteligence – **miselno (IQ)**, **čustveno (EQ)**, **telesno (PQ)** in **duhovno-etično (SQ)** – v pretočno celoto, kjer razum sodeluje s srcem, telo podpira duha, etika usmerja logiko, vse skupaj pa deluje kot živ organizem. 4Q-človek ni popoln, temveč je **prisoten** – sposoben zaznavati kompleksnost življenja in nanjo odgovarjati z zavestjo in sočutjem.

V drugem delu smo osvetlili **notranjo ekologijo organizacij** – subtilno dinamiko odnosov, energij in pomenov, ki določajo vitalnost sistemov. Ugotovili smo, da so organizacije, podobno kot posamezniki, živi sistemi, katerih zdravje je odvisno od **ravnovesja med strukturo in pretočnostjo**. Organizacije, ki gojijo le racionalno inteligenco, izgubijo stik z življenjem; tiste, ki znajo povezati razum, čustva, telo in smisel, pa razvijejo odpornost, ustvarjalnost in notranjo povezanost. Kot opozarja Otto Scharmer, se sistemi ne sesujejo zaradi slabih namenov, temveč zato, ker **ne vidijo celote** – in prav 4Q-pogled to celoto vrača v zavest.

Tretje poglavje je pokazalo, da organizacija ni zgolj tehnični sistem, temveč je **komunikacijski prostor**, kot je poudaril Niklas Luhmann. Organizacije obstajajo le toliko časa, kolikor med ljudmi kroži smiselna komunikacija. Ko se komunikacija izprazni, sistem izgubi svojo avtopoetično moč – svojo sposobnost, da se obnavlja iz pomena. Tu se poveže etična misel **Emmanuela Lévinasa**, ki uči, da se resnična etika ne začne v pravilih, temveč v **odnosu do Drugega**. 4Q-človek s svojo duhovno-etično inteligenco (SQ) ravno to uteleša – zmožnost odgovornosti in poslušanja kot osnovne oblike vodenja.

Na tej poti se dotaknemo še **Wilberjeve integralne zavesti**, ki presega parcialno mišljenje in odpira možnost, da človek zaznava resničnost na več ravneh – kot sočasno fizično, čustveno, miselno in duhovno izkušnjo. Integralna zavest predstavlja epistemološki okvir 4Q-modela: ni le stanje duha, temveč **operativna zmožnost delovanja iz koherence**.

Tudi **Maslow** in **Frankl** sta opozorila, da človek ne išče le preživetja, temveč izpolnitev; **Fromm** je razlikoval med načinom »imeti« in načinom »biti«; **Jung** nas je spomnil, da se notranje ravnotežje vzpostavlja v dialogu s senco; **Bauman** pa, da moramo v »tekočih časih« sprejeti negotovost kot novo stalnico. Vsi ti misleci se srečajo v istem presečišču: človek se lahko uresniči le, če je sposoben **povezovati nasprotja** – red in kaos, razum in srce, moč in ranljivost, jaz in drugega.

V tem smislu 4Q-človek in 4Q-organizacija predstavljata **evolucijski korak v razvoju zavesti**. Ne gre za model uspeha, temveč za **ново antropologijo vodenja** – takšno, ki temelji na pretočnosti, zavedanju in medsebojni soodvisnosti. Organizacija prihodnosti ne bo učinkovita zato, ker bo bolj digitalna, temveč zato, ker bo bolj **človeška** in ker bo znala uravnavati svojo notranjo ekologijo, negovati čustveno in etično koherenco ter komunicirati iz prostora prisotnosti.

Prispevek je izhajal iz vprašanja, kako v dolgoživi družbi zagotoviti notranjo trajnost organizacij ter kako konceptualno povezati psihološke, etične, telesne in kognitivne dimenzije posameznika v integriran organizacijski okvir. Na tej podlagi smo razvili model 4Q ter oblikovali raziskovalna vprašanja in hipoteze, ki usmerjajo njegovo empirično preverjanje.

Analiza raziskovalnih vprašanj:

RQ1: Kakšna je povezava med posameznimi dimenzijami modela 4Q in zaznano organizacijsko vitalnostjo (VQ)?

Teoretična analiza kaže, da posamezne dimenzije inteligence niso izolirane spremenljivke, temveč medsebojno povezani procesi. Organizacijska vitalnost je konceptualno odvisna od njihove usklajenosti. Racionalna komponenta (IQ) prispeva k jasnosti odločanja, čustvena (EQ) k stabilnosti odnosov, duhovno-etična

(SQ) k smislu in vrednotni koherenci, fizična (PQ) pa k regenerativni sposobnosti sistema. Vitalni kvocient (VQ) tako predstavlja integrativni indikator teh procesov.

RQ2: Ali višja stopnja integracije štirih dimenzij inteligence napoveduje višjo stopnjo organizacijske pretočnosti?

Model 4Q predpostavlja, da je pretočnost posledica integracije, ne posamezne dominantne inteligence. Organizacije, ki delujejo iz enodimenzionalnega okvirja, so bolj podvržene fragmentaciji, medtem ko integrirani 4Q-profil omogoča prilagodljivost in sistemsko odpornost.

RQ3: Ali obstajajo razlike med uravnoteženim 4Q-profilom in dominantno enodimenzionalnim profilom?

Konceptualna analiza nakazuje, da enodimenzionalni profili vodijo v parcialne organizacijske učinke (npr. visoka učinkovitost brez čustvene koherence ali visoka empatija brez operativne stabilnosti). Uravnotežen profil omogoča večjo notranjo koherenco in zmanjšano tveganje za sistemsko izgorelost.

RQ4: V kolikšni meri 4Q-model pojasnjuje zmanjšanje izgorelosti in povečano psihološko odpornost?

Teoretično model nakazuje, da je izgorelost posledica porušenega ravnovesja med obremenitvijo in regeneracijo. VQ kot razmerje med tema dvema komponentama ponuja operacionalizacijo tega odnosa. Integracija 4Q-dimenzij prispeva k povečani psihološki odpornosti in nižji latentni utrujenosti sistema.

Analiza hipotez na konceptualni ravni:

H1: Pozitivna povezava med integracijo 4Q in VQ

Teoretična izhodišča podpirajo hipotezo, da višja stopnja integracije inteligence povečuje organizacijsko vitalnost. Empirična potrditev zahteva kvantitativno validacijo.

H2: EQ in SQ kot napovednika koherence

Literatura o čustveni inteligenci in etičnem voditeljstvu nakazuje, da imata EQ in SQ pomembno vlogo pri oblikovanju organizacijske koherence. Model predvideva njuno nadpovprečno težo pri razlagi stabilnosti odnosov.

H3: Neuravnoteženost kot napovednik izgorelosti

Hipoteza je skladna s teorijami organizacijskega učenja in psihološke izčrpanosti: sistemska fragmentacija povečuje tveganje za izgorelost.

H4: Integrirani 4Q-profil kot napovednik pretočnosti tudi ob kontroli demografskih dejavnikov

Model predpostavlja, da notranja integracija presega demografske spremenljivke in predstavlja globlji napovedni dejavnik organizacijske dinamike.

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O avtorici

Izr. prof. dr. Lucija Mulej kot sociologinja in antropologinja v slovenskem prostoru utrjuje poslovno antropologijo ter menedžment osebnosti, ki je nadgradnja raznim oblikam procesiranja človeških vsebin. Razvila je metodologijo za proučevanje značajev ter smer psihosinteze, ki temelji na povezovanju inteligentnosti in inteligenc 4 Q (racionalne, čustvene, duhovne in fizične inteligence). K posamezniku pristopa celostno; z različnimi znanji in izkušnjami, ter predvsem s pristopi, kot so povezovanje duhovne in materialne realnosti, vidnega z nevidnim in večnega z minljivim. Kot prva menedžment osebnosti uvaja kot poklicno kategorijo, ki povezuje pristope coachinga, psihoterapije, sociologije, antropologije... V svojih knjigah Skrivnost – zakaj ne deluje pri vas, OnKraj RazKritja ter Heroji, Pogovori z Erosom, raziskuje človekove svetove in duhovno dediščino s težnjo oblikovanja zdrave osebnosti in s tem družbe.

Kot raziskovalka je objavila 237 enot v SICRISu, od tega dve znanstveni monografiji, in sicer Relativizem v sociologiji znanosti (2008) in Metodologija povezovanja inteligenc (2023).

Kot publicistka je objavila številne intervjuje in kolumne. Redno piše za SIOL, OnaPlus, za revije Sensa in Metropolitan, aktivna pa je tudi na mednarodnem področju, kjer piše za Modern Diplomacy.

ENVIRONMENTAL STRESSORS AND OLDER ADULT MORBIDITY: INITIAL FINDINGS FROM UNIVERSITY MEDICAL CENTRE MARIBOR AS PART OF A SLOVENIAN - TURKISH BILATERAL STUDY

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Environmental stressors such as air pollution and weather variability are increasingly recognized as important determinants of health in older adults, yet evidence on their short-term effects in Central Europe remains limited. This study examines associations between meteorological conditions, air pollution, and cardiovascular and respiratory morbidity among adults aged 65 years and older presenting to emergency departments in Slovenia. A retrospective observational analysis of emergency department visits in 2024 (N = 4,870) was conducted, linking ICD-10 diagnoses with daily meteorological and air pollution data (NO₂, PM_{2.5}, PM₁₀, benzene) and analyzed using multivariable regression models adjusted for age, sex, and season. Cardiovascular disease prevalence was primarily age-driven, whereas respiratory morbidity showed clear seasonal patterns and significant associations with NO₂, particularly during the cold season, with higher temperature and humidity showing protective effects. These findings suggest that short-term environmental stressors disproportionately affect respiratory health in older adults and support future cross-country comparative analyses.

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1 Introduction

Population ageing, combined with increasing exposure to environmental stressors, poses a growing public health challenge. Older adults are particularly vulnerable to adverse health effects of air pollution and extreme weather conditions due to physiological ageing, multimorbidity, and reduced adaptive capacity (World Health Organisation, 2024). Cardiovascular and respiratory diseases remain leading causes of morbidity and healthcare utilization in this population (Tran et al., 2023; Xu et al., 2019).

Short-term exposure to air pollutants such as nitrogen dioxide (NO₂) and particulate matter has been linked to acute respiratory exacerbations and cardiovascular events (Meng et al., 2021). However, findings vary across regions, and evidence from Central and Southeastern Europe remains limited. Slovenia and Türkiye share similar demographic ageing trends but differ in climatic conditions and pollution profiles, providing an opportunity for comparative research.

This study represents the Slovenian analytical component of a broader bilateral Slovenian–Turkish project investigating environmental determinants of older adult morbidity. This conference paper aims to present initial and extended findings from Slovenia, focusing on associations between meteorological conditions, air pollution, and cardiovascular and respiratory disease burden among older adults presenting to emergency departments.

2 Materials and Methods

2.1 Study Design and Population

A retrospective observational study was conducted using anonymized emergency department records from the University Medical Centre Maribor, Slovenia. The study population included all adults aged 65 years and older who presented to the emergency department during 2024 (N = 4,870). The demographic characteristics and disease profiles of the study population are summarized in Table 1.

2.2 Health Outcomes

Diagnoses were classified using ICD-10 codes and grouped into:

- Cardiovascular diseases (I-codes),
- Respiratory diseases (J-codes),
- Disease-specific outcomes (e.g., heart failure, atrial fibrillation, pneumonia, COPD, asthma),
- Multimorbidity, defined as the presence of two or more diagnosed conditions.

2.3 Environmental Exposures

Daily environmental data were obtained from the Slovenian Environment Agency and included:

- Mean daily temperature (°C),
- Relative humidity (%),
- Air pollutants: NO₂, PM_{2.5}, PM₁₀, and benzene (µg/m³).

Environmental variables were matched temporally with emergency department visits.

2.4 Statistical Analysis

Statistical analyses were performed using the trial version of IBM SPSS Statistics software (IBM Corp., Armonk, NY, USA). Descriptive statistics summarized demographic characteristics, disease prevalence, and exposure distributions. Spearman correlation analyses were used to assess relationships among environmental variables and inform model specifications.

Associations between environmental exposures and health outcomes were examined using:

- Binary logistic regression for disease presence,
- Robust Poisson regression for aggregated outcomes and multimorbidity burden.

All models were adjusted for age, sex, and season (cold vs. warm). Sensitivity analyses included alternative exposure metrics and seasonal stratification. Statistical significance was set at $p < 0.05$.

3 Results

3.1 Population Characteristic

Table 1: Demographic characteristics and disease profiles of older adults presenting to emergency departments, overall and by sex

Variable	Total (N=4,870)	Female (n=2,441)	Male (n=2,429)
Age, years	Median(Q1–Q3; min–max):79 (72–84; 65–103)	Median(Q1–Q3):	Median(Q1–Q3; min–max):79 (72–84; 65–103)
WHO age classification			
65–74 years	1,684 (34.6%)	669 (39.7%)	1,015 (60.3%)
75–84 years	2,003 (41.1%)	1,016 (50.7%)	987 (49.3%)
≥85 years	1,183 (24.3%)	756 (63.9%)	427 (36.1%)
Any cardiovascular disease			
Yes	4,458 (91.5%)	2,248 (92.1%)	2,210 (91.0%)
No	412 (8.5%)	193 (7.9%)	219 (9.0%)
Any respiratory disease			
Yes	2,486 (51.0%)	1,215 (49.8%)	1,271 (52.3%)
No	2,384 (49.0%)	1,226 (50.2%)	1,158 (47.7%)
Multimorbidity (≥2 diseases)			
Yes	3,648 (74.9%)	1,793 (73.5%)	1,855 (76.4%)
No	1,222 (25.1%)	648 (26.5%)	574 (23.6%)
No. of diag. diseases per individual	Median (Q1–Q3; min–max): 3 (2–5; 1–11)	Median (Q1–Q3; min–max): 3 (2–5; 1–10)	Median (Q1–Q3; min–max): 3 (2–4; 1–11)

Continuous variables are presented as median (Q1–Q3; min–max) due to non-normal distributions. Categorical variables are presented as n (%). Multimorbidity was defined as the presence of two or more diagnosed diseases. Cardiovascular and respiratory diseases indicate the presence of at least one ICD-10 diagnosis within the respective disease group. No missing data was observed for variables included in this table.

Table 2: The annual and seasonal distribution of meteorological conditions and air pollution levels corresponding to emergency department visits among older adults

Variable	Annual		Winter		Spring		Summer		Autumn	
	Median (Q1-Q3)	Min-Max	Median (Q1-Q3)	Min-Max	Median (Q1-Q3)	Min-Max	Median (Q1-Q3)	Min-Max	Median (Q1-Q3)	Min-Max
Temperature (°C)	12.3 (7.2–19.5)	–3.1–28.1	5.1 (2.2–8.2)	–3.1–12.6	13.9 (9.5–17.1)	3.0–21.3	46165 (22.0–25.6)	14.6–28.1	12.2 (7.3–16.6)	1.3–25.5
Relative humidity (%)	68.0 (60.8–78.1)	40.8–93.7	69.6 (60.1–79.3)	41.0–91.7	62.6 (55.7–71.0)	40.8–92.1	63.8 (59.6–70.7)	50.5–92.0	77.8 (67.5–85.7)	47.2–93.7
NO ₂ (µg/m ³)	24.5 (19.1–30.2)	5.9–64.6	33.3 (26.0–43.6)	13.1–64.6	24.8 (20.2–28.5)	5.9–46.0	19.5 (14.1–22.1)	10.2–30.4	24.3 (18.7–27.7)	7.1–50.9
PM _{2.5} (µg/m ³)	10.4 (6.9–17.3)	0.9–52.7	18.1 (10.8–24.8)	2.1–52.7	8.3 (5.7–12.4)	2.0–41.3	8.8 (6.6–12.1)	2.9–28.4	12.6 (6.2–21.2)	0.9–47.0
PM ₁₀ (µg/m ³)	17.5 (11.9–28.1)	2.6–131.2	27.1 (16.7–36.4)	5.4–77.3	15.4 (10.2–23.0)	4.5–131.2	14.6 (11.8–18.5)	6.0–67.4	20.6 (10.7–31.8)	2.6–56.2
Benzene (µg/m ³)	0.68 (0.38–1.39)	0.0–4.4	1.60 (1.09–2.23)	0.4–4.1	0.51 (0.39–0.86)	0.1–1.8	0.17 (0.12–0.36)	0.0–2.8	0.93 (0.63–1.50)	0.3–4.4

Environmental variables were summarized at the daily level. Overall values are presented as median (Q1–Q3; minimum–maximum), while seasonal values are presented as median (Q1–Q3). Seasons were defined as winter (December–February), spring (March–May), summer (June–August), and autumn (September–November). No missing data was observed for environmental variables.

Table 1 provides an overview of the demographic characteristics and disease profiles of the study population. The median age of the study population was 79 years, with a balanced sex distribution. Cardiovascular disease was present in 91.5% of individuals, respiratory disease in 51.0%, and multimorbidity in 74.9%.

3.2 Environmental Conditions

Marked seasonal variability was observed (Table 2). Air pollutant concentrations, particularly NO₂ and particulate matter, were higher during the cold season, while temperatures were lowest in winter and highest in summer.

3.3 Cardiovascular Outcomes

Age was the dominant determinant of cardiovascular disease prevalence (Table 3). Each additional year of age was associated with a significant increase in cardiovascular disease burden. Short-term variations in air pollution and meteorological conditions showed no consistent independent associations with aggregated cardiovascular outcomes.

Table 3: Adjusted associations between environmental exposures and cardiovascular disease among older adults

Variable			
Environmental exposures	Adjusted OR	95% CI (Lower–Upper)	p-value
Mean Daily PM _{2.5} (µg/m ³)	0.998	0.992 – 1.005	0.599
Mean Daily PM ₁₀ (µg/m ³)	0.997	0.990 – 1.005	0.470
Mean Daily NO ₂ (µg/m ³)	0.995	0.983 – 1.008	0.490
Mean Daily Benzene (µg/m ³)	1030	0.880 – 1.210	0.720
Covariates			
Age (per 1-year increase)	1072	1.057 – 1.088	<0.001
Sex (female vs male)	0.960	0.781 – 1.181	0.701
Season – Spring vs Winter	1042	0.780 – 1.393	0.779
Season – Summer vs Winter	0.998	0.745 – 1.335	0.987
Season – Autumn vs Winter	1085	0.802 – 1.468	0.597

Binary logistic regression models were used. All models were adjusted for age (continuous), sex, and season (winter as the reference category). Odds ratios (ORs) represent the change in odds of having any cardiovascular disease per unit increase in the corresponding variable. N = 4,870.

3.4 Respiratory Outcomes

Respiratory disease prevalence demonstrated strong seasonal patterns (Table 4). Higher NO₂ concentrations were associated with increased respiratory disease prevalence, particularly during the cold season. Warmer temperatures and higher humidity were inversely associated with several respiratory outcomes, including respiratory failure and pneumonia.

Table 4: Adjusted associations between environmental exposures, age, and respiratory diseases among older adults

Variable			
Environmental exposures	Adjusted OR	95% CI (Lower–Upper)	p-value
Mean Daily PM _{2.5} (µg/m ³)	0.998	0.992 – 1.005	0.599
Mean Daily PM ₁₀ (µg/m ³)	0.997	0.990 – 1.005	0.470
Mean Daily NO ₂ (µg/m ³)	0.995	0.983 – 1.008	0.490
Mean Daily Benzene (µg/m ³)	1030	0.880 – 1.210	0.720
Covariates			
Age (per 1-year increase)	1007	1.000 – 1.014	0.060
Sex (female vs male)	0.882	0.786 – 0.989	0.032
Season – Spring vs Winter	1486	1.264 – 1.747	<0.001
Season – Summer vs Winter	1040	0.885 – 1.223	0.632
Season – Autumn vs Winter	0.893	0.758 – 1.053	0.178

Binary logistic regression models were used to examine the associations between environmental exposures and the presence of any respiratory disease among older adults. All models were adjusted for age (continuous), sex, and season (winter as the reference category). Each environmental exposure was entered separately using a single-pollutant approach. Odds ratios (ORs) and 95% confidence intervals (CI) represent the change in odds of having any respiratory disease per unit increase in the corresponding variable. N = 4,870.

3.5 Multimorbidity

Multimorbidity burden increased steadily with age and was higher during spring compared with winter (Table 5). Overall, multimorbidity showed limited sensitivity to short-term air pollution exposure, although modest associations with NO₂ were observed during the cold season.

Table 5: Associations Between Environmental Exposures and Multimorbidity Burden

Variable	Adjusted IRR	95% CI (Lower–Upper)	p-value
Mean Daily PM _{2.5} (µg/m ³)	0.999	0.997 – 1.001	0.379
Mean Daily PM ₁₀ (µg/m ³)	0.999	0.998 – 1.001	0.262
Mean Daily NO ₂ (µg/m ³)	1000	0.998 – 1.002	0.914
Mean Daily Benzene (µg/m ³)	0.990	0.965 – 1.016	0.459
Age (per 1-year increase)	1008	1.006 – 1.010	<0.001
Sex (female vs male)	0.945	0.913 – 0.977	0.001
Season – Spring vs Winter	1108	1.057 – 1.168	<0.001
Season – Summer vs Winter	1041	0.992 – 1.095	0.106
Season – Autumn vs Winter	0.980	0.926 – 1.029	0.370

Incidence Rate Ratios (IRRs) were obtained from Poisson regression models with a log link function. Each environmental exposure was examined in a separate model to avoid multicollinearity. Pearson chi-square/df values (~0.9) indicated no overdispersion in any model.

4 **Discussion**

This study provides comprehensive evidence on environmental determinants of older adult morbidity in Slovenia using real-world emergency department data. The findings highlight a clear contrast between cardiovascular and respiratory outcomes. While cardiovascular disease prevalence appears primarily driven by age and chronic disease accumulation, respiratory morbidity shows greater sensitivity to short-term environmental stressors(Lai et al., 2025; Liu et al., 2022; Ning et al., 2025).

The observed association between NO₂ and respiratory outcomes aligns with the role of traffic-related pollution in triggering acute respiratory conditions(Meng et al., 2021). Seasonal effects further emphasize the importance of cold-season exposure profiles(Ning et al., 2025). The limited association between air pollution and cardiovascular outcomes may reflect the chronic nature of cardiovascular disease and the use of prevalence-based analyses.

Strengths of this study include the large sample size, detailed diagnostic classification, and robust analytical strategy. Limitations include the single-center design, lack of individual exposure assessment, and inability to infer causality. Moreover, the present study applied conventional regression-based statistical methods, which was appropriate given the predefined exposure variables, and clearly

defined clinical outcomes. As the Slovenian–Turkish project expands to include larger datasets, AI-based techniques could help capture complex interactions among environmental variables and improve predictive risk stratification.

5 Conclusion

Among older adults presenting to emergency departments in Slovenia, short-term environmental stressors—particularly traffic-related air pollution and cold-season conditions—are more strongly associated with respiratory than cardiovascular morbidity. Age remains the primary driver of cardiovascular disease and multimorbidity burden. These findings provide a solid evidence base for the planned Slovenian–Turkish comparative analyses and support the integration of environmental considerations into public health strategies for ageing populations.

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THE INFLUENCE OF THE DESIGN AND PRIOR KNOWLEDGE ON THE INDIVIDUAL LEARNING SUCCESS OF STUDENTS

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In educational practice, various social forms and instructional methods are employed to organize classroom teaching. Research conducted in the context of general education schools has demonstrated that these forms and methods differ in their effectiveness regarding the development of specific competencies. However, the extent to which such findings can be transferred to commercial vocational colleges remains largely unexplored. The present study therefore compared the social forms of group work and teacher-centred instruction in commercial vocational colleges with respect to their effectiveness in fostering professional competence within the framework of a new teaching unit, while taking students' prior knowledge into account. The findings indicate that teacher-centred instruction leads to greater individual learning gains than group work when introducing new subject matter to students without prior knowledge. The second hypothesis, that group work promotes greater individual learning success among students with existing prior knowledge compared to teacher-centred instruction, could neither be supported.

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1 Introduction

Instructional social formats such as whole-class teaching and group work play a central role in shaping school learning processes. While both approaches offer distinct didactic potentials, their effectiveness with regard to students' individual learning outcomes remains a subject of academic debate. In this context, prior subject-specific knowledge is particularly relevant, as learners may benefit differently from instructional formats depending on their previous experience.

Previous studies provide conflicting evidence regarding which social format promotes greater learning success. Moreover, much of the existing research focuses on general education schools, whereas the context of commercial vocational colleges has so far received limited attention — despite the broad range of prior knowledge resulting from heterogeneous educational backgrounds.

Against this backdrop, the present study investigates the relationship between instructional design, prior subject knowledge, and individual learning outcomes in business education at vocational colleges. The aim is to empirically examine whether the effectiveness of whole-class teaching and group work varies depending on students' prior knowledge. The findings are intended to contribute evidence-based insights for more differentiated instructional design.

2 Research question, state of research and research gap

In school practice, various social forms and methods are used to diversify lessons. There are differing views on which methods and social forms are most promising for pupils' individual learning success and on the extent to which this success is related to pupils' prior knowledge. Social forms refer to the way in which communication is organized between teachers and students in the classroom (cf. Meyer 1994: 41f.; Wiater 1997: 229). These can generally be divided into two superordinate categories: self-directed and cooperative forms of learning. In self-directed forms of learning, learning processes are regulated by learners rather than by teachers, but are guided by external structures. Consequently, learning is not entirely self-directed, as it takes place within a sociocultural environment (cf. Breuer, 2000, p. 88). Cooperative learning refers to the collaboration of several group members who pursue learning as a shared goal (cf. Breuer, 2000, p. 92).

According to Meyer (1994: 41f.), Wiater (1997: 229ff.), and Speth and Berner (2018: 185ff.), four social forms of instruction can be distinguished: frontal teaching, individual work, partner work, and group work. In the context of the present study project, the social forms of group work and frontal teaching are of particular relevance, as they are compared with one another.

Frontal teaching refers to a form of instruction in which communication is controlled exclusively by the teacher. Lessons are typically structured as teacher-centered presentations, and interaction among students is largely discouraged (cf. Paape/Maus/Kiereta 2021: 178; Ganser 2015: 80f.; Wiechmann 2011: 24f.). One advantage of frontal teaching is that it enables the transmission of large amounts of instructional content within a comparatively short period of time (cf. Paape/Maus/Kiereta 2021: 179).

By contrast, group work is a form of learning in which students work independently in groups consisting of at least three and no more than seven members on one or more tasks. The individual group members may either work on the same topic or be assigned different, complementary topics (cf. Bönsch 1995: 272ff.; Speth/Berner 2018: 244f.). The use of group work in classroom instruction is emphasized in the literature primarily because of its positive effects on the development of students' social competences and teamwork skills, which may, in turn, have a positive impact on their individual subject-specific learning success (cf. Becker 1994: 107).

In this study, the effectiveness of social forms is understood as their ability to promote subject-specific competence development and individual learning success. Prior knowledge, which in this study is defined as subject-specific prior knowledge, refers to any familiarity with the subject matter as well as relevant knowledge acquired through students' prior schooling that exists before the topic is addressed in the lesson (cf. Thaler 2021: 182f.; Freudenreich/Schulte 2002: 3). With regard to the type of school examined in this study, it can be assumed that students at vocational colleges have a more heterogeneous educational background than students at general education schools. Consequently, the relationship between prior knowledge and individual learning success is particularly relevant in vocational colleges, as some students may already possess relevant subject-specific knowledge, for example in the commercial field.

This leads to the question, especially in the context of vocational colleges, of which social form is most effective for the development of subject-specific competences, depending on students' individual prior knowledge. The research questions guiding this study are therefore as follows: Which social form is most effective for students' individual learning success when no prior knowledge is present? Does this change when students already possess prior knowledge?

Moreover, group work is frequently described as being particularly conducive to the development of social competence and teamwork skills (cf. Becker 1994: 107). However, it remains unclear whether subject-specific competence can be developed to a comparable extent in group work as in frontal teaching when students do not have prior knowledge of the respective topic. Alternatively, it may be the case that the more action-oriented nature of group work enhances learning success compared to frontal teaching, regardless of prior knowledge.

Previous studies examining the general effectiveness of different social forms with regard to individual learning success have yielded contradictory results. Dietrich (1969: 98), for example, identifies group work as a particularly effective social form, especially in terms of knowledge reproduction. Other studies, such as those by Roth (1967) and Meyer (1997), arrive at the opposite conclusion, reporting significantly higher individual learning success in frontal teaching settings (cf. Ganser 2015: 107–108; Meyer 1997: 70). By contrast, a study by Seifried, Brouer, and Sembill (2002: 575), conducted in the subject area of accounting at commercial vocational colleges, found that self-organized learning in group work led to higher learning success than traditional frontal teaching. At the same time, studies investigating the effectiveness of different social forms for individual learning success, including Seifried, Brouer, and Sembill (2002: 588), consistently emphasize the importance of additional influencing factors, such as students' individual prior knowledge.

Empirical findings on the relationship between prior knowledge and individual learning success in group work and frontal teaching remain limited. In the study by Seifried, Brouer, and Sembill (2002), students taught through frontal instruction were not able to achieve higher individual learning success than those working in groups, despite having greater prior knowledge of the subject matter.

The research findings on the effectiveness of frontal teaching and group work discussed above largely focus on direct comparisons between these social forms, while the role of prior knowledge in moderating their effectiveness for individual learning success has so far been only sporadically examined. Furthermore, there is a lack of empirical studies conducted in the context of commercial vocational colleges, as existing research has predominantly focused on general education schools. The extent to which findings from general education contexts can be transferred to vocational colleges therefore remains insufficiently explored. Against this background, the present study investigates how group work and frontal teaching influence individual learning success, with particular consideration of students' prior knowledge in vocational college settings.

3 Generation of Hypothesis

The aim of instruction is to maximize each student's individual learning success through a systematically and sustainably structured sequence of teaching and learning situations. In this process, learners' skills, abilities, and subject-specific knowledge are to be developed (cf. Lipowsky 2015: 70). Through the targeted selection of appropriate social forms, individual learning success can be optimized at different phases of a lesson (cf. Klippert 2001: 264).

Overall, only a limited number of studies have examined subject-specific prior knowledge in relation to the effectiveness of different social forms with regard to individual learning success. One possible reason for this is that subject-specific prior knowledge plays a particularly important role in vocational colleges, despite the fact that this type of school has received relatively little research attention. The study by Seifried, Brouer, and Sembill (2002) addresses prior knowledge only marginally and arrives at results that contradict the prevailing view in the literature, as represented, for example, by Renkl (2015: 213ff.) and Kirschner, Sweller, and Clark (2006: 75). However, the sample size in this study is very small, and the authors themselves acknowledge that its findings are therefore of limited significance (cf. Seifried/Brouer/Sembill 2002: 587ff.). Another study by Seifried (2008: 245f.), which is also based on a small sample, concludes that students with little prior knowledge participate less actively in frontal teaching and consequently achieve lower individual learning success than in group work.

Nevertheless, the literature repeatedly emphasizes the relevance of prior knowledge for individual learning success in self-organized and cooperative learning settings and, in the absence of subject-specific prior knowledge, highlights the advantages of frontal teaching instead (cf. Renkl 2015: 213ff.; Kirschner/Sweller/Clark 2006: 75). According to Meyer, frontal teaching is particularly suitable when students' orientation knowledge first needs to be established or when a new domain of knowledge is introduced (cf. Schmidt 2003: 16). When prior knowledge is already available, however, the focus shifts towards the advantages of group work, as students can draw on their existing knowledge to support the learning process and do not necessarily require the strong instructional guidance characteristic of frontal teaching (cf. Renkl 2015: 213ff.; Kirschner/Sweller/Clark 2006: 75).

As the role of prior knowledge in relation to group work and frontal teaching has so far been insufficiently investigated and existing empirical findings partly contradict dominant theoretical assumptions, the present study examines whether the prevailing position in the literature, as represented by Renkl (2015: 213ff.) and Kirschner, Sweller, and Clark (2006: 75), can be confirmed in practice or whether the contradictory results reported by Seifried, Brouer, and Sembill are replicated. For this reason, the hypotheses are derived from the theoretical literature rather than from the available empirical findings.

On the basis of the literature reviewed, it is assumed that, at commercial vocational colleges, frontal teaching is more effective than group work in promoting subject-specific competence when introducing a new topic to students who have no prior subject knowledge. Accordingly, the first hypothesis is formulated as follows:

Hypothesis 1: *When introducing a new topic, frontal teaching leads to greater individual learning success for students without relevant prior knowledge than group work.*

When students possess a basic level of knowledge in the form of subject-specific prior knowledge, group work is considered to be more effective for their individual learning success (cf. Renkl 2015: 213ff.; Kirschner/Sweller/Clark 2006: 75). In this case, the advantages of group work are assumed to outweigh its potential disadvantages. Group work is theoretically justified by the assumption that knowledge is primarily constructed through interaction among participants engaged in discussion (cf. Renkl 2015: 20f.). Articulating one's own viewpoints and

arguments enables learners to compare their existing knowledge with that of others and, if necessary, to revise and refine their own understanding (cf. Petko/Reusser 2005; Renkl 2015: 20f.; Hannken-Illjes 2018).

The expansion of individual knowledge and understanding is particularly likely when learners already possess a foundational level of subject knowledge and are therefore able to build on an existing knowledge base (cf. Gruber/Stamouli 2015: 32f.). Group work phases in classroom instruction may also enhance the performance of students, especially those who are assumed to have weaker learning performance, by granting a certain degree of freedom for co-construction and active participation. This opportunity to contribute and to assume responsibility for collective group outcomes can support students' personal development, as group work may be experienced as a productive challenge (cf. Euler et al. 2016: 611ff.).

On this basis, the second hypothesis is formulated as follows:

Hypothesis 2: *When introducing a new topic, group work leads to greater individual learning success for students with relevant prior knowledge than frontal teaching.*

4 Research design

To test the hypotheses, a quantitative analysis was conducted based on data collected from students at five different vocational colleges. Two classes from each college were included, resulting in a total sample of $n = 119$ students from ten classes. Specifically, three classes from the Vocational School II (two classes from the Department of Business and Administration and one class from the Department of Wood Technology), four classes from the Higher Commercial School, one class from the Business Grammar School, and two classes from the dual system (one class each for the training occupations of draughtsperson and hairdresser) were examined. In selecting the classes, care was taken to include only the lower grades of multi-year programs to minimize prior knowledge in economics from the ongoing course of study at the vocational college. The random selection of classes and the heterogeneous distribution of prior knowledge resulted in unequal sample sizes for the groups V+, V-, Gru classes, and Fro classes (see Chapters 4.2 and 4.3).

During the study, an “island lesson” on a new teaching topic was conducted in all ten classes. In five classes, the topic was taught using frontal teaching, while the other five classes worked on the same topic in a group work format. For the remainder of this study, the classes that received the content through frontal teaching are referred to as Fro classes, whereas those that engaged in group work are referred to as Gru classes. The teaching materials provided to the students were standardized across all Gru classes, and likewise, uniform materials were used in all Fro classes. Additionally, all ten lessons addressed the same topic to ensure comparability across classes.

During the topic development phase, the Gru classes received three different informational texts on various forms of payment, as well as tables for reproducing and applying the learned knowledge. These materials were worked on collaboratively as part of a group puzzle. In contrast, the Fro classes received the same content through a teacher-led lecture, supported by a digital presentation, followed by joint completion of the same reproduction and application tasks in plenary.

Following the topic development phase, both Fro and Gru classes completed an individual work phase, in which students independently reproduced the acquired knowledge in a questionnaire comprising 12 single-choice items. These questionnaires were collected by the teachers for evaluation. Only the results from this individual work phase were used for data collection and to determine individual learning success. This phase is particularly suitable for assessing individual learning outcomes, as all tasks were completed independently.

Table 1: Overview of lesson design - FroClasses & GruClasses

	5 FroClasses	5 GruClasses
1st teaching phase (topic development)	Frontal teaching	Group work
2nd teaching phase (reproduction/application of learned knowledge)	Individual work	Individual work

In the questionnaires, which the students completed individually during the second phase of the lesson, they were also asked to indicate the school-leaving qualifications they had obtained to date, including the type of school they had attended. Multiple responses were allowed. Additionally, students were asked whether they had

previously received business-related instruction outside of their current course of study. This information was used to assess the students' prior knowledge. The group of students identified as having a high level of prior knowledge is referred to as V+, whereas those with limited prior knowledge are referred to as V-.

5 Results of the study

5.1 Evaluation procedure

The questionnaires, which all classes completed individually following the respective topic development phase, served as the basis for evaluation. These questionnaires were scored individually using a model solution. In addition, students were classified as having either a high or low level of prior knowledge based on their school-leaving qualifications and the types of schools they had attended. This classification was determined according to the presence or absence of economics as a subject in the curriculum of the respective school type (see Table 2). The additional, direct question regarding previous economics lessons in the students' school careers served as a supplementary check and, if necessary, allowed for the correction of the prior knowledge assessment.

Table 2: Assessment of prior knowledge according to school-leaving qualification and type of school attended

Great prior knowledge (V+)	Little prior knowledge (V-)
– Secondary school leaving certificate after grade 9 / grade 10 (at a general education school) – Secondary school leaving certificate after grade 9 / grade 10 (at a vocational college) – Fachoberschulreife/Realschulabschluss (at a vocational college) – Fachhochschulreife (school/complete) (at a vocational college) – General / subject-linked higher education entrance qualification (at a vocational college) – General higher education entrance qualification (at a vocational college) – Completed vocational training as _____ – Abandoned vocational training as _____	– Fachoberschulreife/Realschulabschluss (at a general school) – Fachhochschulreife (school/complete) (at a general school) – General higher education entrance qualification (at a general school)

During the evaluation and scoring of the individually completed questionnaires, two extreme outliers were identified, each achieving only 3 out of 12 points. These cases were attributable to a complete lack of responses on the back of the questionnaire and were therefore excluded from the analysis. This resulted in a final sample of $n = 117$.

To test the hypotheses regarding the relationship between prior knowledge and individual learning success in frontal teaching and group work, an independent samples t-test was conducted. The data met the necessary assumptions for the t-test, namely normal distribution and homogeneity of variance. Homogeneity of variance was verified using Levene's test. The t-test was employed to determine whether the observed differences were statistically significant or could have occurred by chance. A significance threshold of $\alpha \leq 0.05$ was applied, corresponding to a confidence level of over 95 % for a non-random result (cf. Schnell/Hill/Esser 2013: 441ff.).

For hypothesis 1, the t-test compared the results of students with low prior knowledge (V-) in the Fro and Gru classes to determine whether the difference in individual learning success was significant. For hypothesis 2, the results of students with high prior knowledge (V+) in the Fro and Gru classes were compared in the same manner. Following the determination of statistical significance, the effect size was calculated using Cohen's d. Effect sizes are interpreted as follows: $d > 0.2$ represents a small effect, $d > 0.5$ a medium effect, and $d \geq 0.8$ a large effect (cf. Janczyk/Pfister 2015: 80). All statistical analyses were performed using the SPSS software package.

5.2 Results for hypothesis 1

Hypothesis 1: *When introducing a new topic, frontal teaching leads to greater individual learning success for students without relevant prior knowledge than group work.*

The V pupils in the Fro classes and the Gru classes ($n=53$) are compared. Hypothesis 1 is reformulated in the following static form:

$$H0 : \mu_{FroV-} \leq \mu_{GruV-} \text{ and } H1 : \mu_{FroV-} > \mu_{GruV-}$$

In order to be able to accept hypothesis 1, the null hypothesis should be rejected on the basis of the results of the statistical analyses presented here.

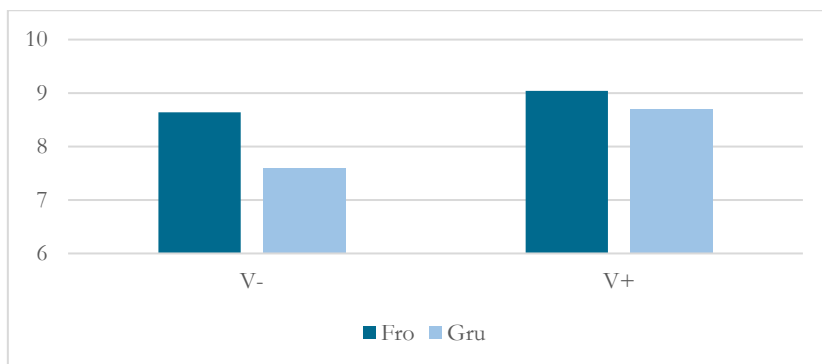


Figure 1: Mean value comparison (general overview)

Table 3: Statistical values for hypothesis 1

Social form	n	Mean value	SD	Standard error of the MW
Fro V-	14	8.64	1.499	.401
Gru V-	39	7.59	1.534	.246

The mean score of the V pupils in the FroK classes is higher (MW=8.64) than the mean score of the Gru classes (MW=7.59). In Figure 1, the mean values are once again visualised in an overall overview (including the mean values of the V+ classes, which are examined in more detail in Chapter 4.3). The standard deviation of 1.499 in the Fro classes and 1.524 in the Gru classes, and thus independent of the social form, is quite homogeneous for all V students.

Table 4: t-test for hypothesis 1

Levene test		t-test for equality of means							Cohen's d
F	Significance	t	df	Sig. (2- sided)	Mean difference	Standard error of the difference	95% confidence interval er difference		
							At	Upper	
.053	.819	2.216	51	.031	1.053	.475	.099	2.007	d=0.66

Since the significance of the Levene test of 0.819 is greater than 0.05, variance homogeneity can be assumed for the sample. The results of the t-test show that the deviating mean values of the V pupils in the Fro and Gru classes are a statistically significant difference, since the two-sided significance of 0.031 is below the specified alpha error of 0.05. The Cohen's d of 0.66 as a measure of variance homogeneity can be assumed for the sample. The Cohen's d of 0.66 as a measure of effect size signals a moderately strong effect.

Thus, for the first hypothesis, the H0 can be rejected and the H1 established in this study can be confirmed.

5.3 Results for hypothesis 2

Hypothesis 2: *When introducing a new topic, group work leads to greater individual learning success for students with relevant prior knowledge than frontal teaching.*

The V+ pupils in the Fro classes and the Gru classes (n=64) are compared here. The same prerequisites for confirming the hypothesis apply here as with hypothesis 1. Thus:

H0 : $\mu_{\text{GruV+}} \leq \mu_{\text{FroV+}}$ and H1 : $\mu_{\text{GruV+}} > \mu_{\text{FroV+}}$

In order to be able to accept hypothesis 2, the null hypothesis should therefore also be rejected here on the basis of the results of the statistical analyses presented below.

Table 5: Statistical values for hypothesis 2

Social form	n	Mean value	SD	Standard error of the MW
Fro V+	38	8.71	1.487	.241
Gru V+	26	9.04	1.562	.306

The mean score of the V+ students in the Gru classes is 9.04, which is only slightly higher than in the Fro classes (MW=8.71). As can be seen in the comparison of means in Diagram 1, the V+ pupils perform somewhat better overall than the V-pupils, although the difference between the means of the Fro classes and Gru classes is significantly less pronounced for the V+ pupils. The standard deviation of 1.487

in the Fro classes and 1.562 in the Gru classes is also quite homogeneous among the V+ pupils.

Table 6: t-test for hypothesis 2

Levene test		t-test for equality of means							Cohen's d
F	Significance	t	df	Sig. (2- sided)	Mean difference	Standard error of the difference	95% confidence interval of the difference		
							At	Upper	
.060	.808	-.849	62	.399	-.328	.386	-1.100	0.444	d=-0.21

The results of the Levene test also signal a homogeneity of variance in the sample due to the significance of 0.808, so that the requirements for the t-test are fulfilled. The two-sided significance of 0.399 determined in the t-test is greater than the specified alpha error of 0.05, so that the results for hypothesis 2 must be evaluated as not statistically significant. The effect size of $d=0.21$ determined using Cohen's d would also only indicate a small effect, even if the result were significant.

Thus, due to the lack of statistical significance of the results, H_0 can be confirmed in this case, so that hypothesis 2 must be rejected.

6 Conclusion, limitations and outlook

Within the framework of this study, it can be concluded that - at least for students without prior knowledge - there is a relationship between individual learning success, prior knowledge, and the didactic design in the development of a new teaching topic in business lessons at vocational colleges. By confirming hypothesis 1, this study provides evidence that students without prior knowledge in economics achieve higher individual learning success when a new topic is developed through frontal teaching rather than through group work. Hypothesis 2, which addressed students with prior knowledge, could neither be confirmed nor refuted based on the data collected. Nevertheless, the markedly different outcomes for students with and without prior knowledge fundamentally underscore the heterogeneity of prior knowledge among vocational college students and highlight the importance of considering this factor in lesson design.

However, this study has several limitations, and the results should therefore be interpreted with caution, serving primarily as indicative rather than conclusive evidence for practice. First, the sample size is relatively small—particularly within the subgroups (FroV-: $n = 14$; FroV+: $n = 38$; GruV-: $n = 39$; GruV+: $n = 26$)—which limits the generalizability of the findings. Future research would benefit from a larger-scale study to validate these results in a more representative sample.

Additionally, individual learning success is a multifactorial construct and cannot be attributed solely to didactic design or the social form employed. Beyond internal learner-related factors, various external factors - such as lesson timing, classroom atmosphere, and teacher-student interactions - also influence individual learning outcomes. In the present study, potential confounding factors included structural variations, such as the students' status as internship participants, as well as differences arising from five different prospective teachers, their individual teaching styles, and the nature of their relationships with the students. Data were collected exclusively through questionnaires, which may also introduce limitations.

Another limitation concerns the procedure for assessing prior knowledge. In this study, prior knowledge was inferred from students' previous educational qualifications, based on the presence or absence of economics in the curriculum of the school type they attended. However, the educational backgrounds classified as "high prior knowledge" or "low prior knowledge" were highly heterogeneous, ranging from programs in which economics was a minor subject taught for a few years, to programs with a strong economic focus where topics were covered intensively, as well as programs with varying thematic emphases in economics. A finer differentiation of prior knowledge (e.g., high, moderate, low, none) would have been possible. More comprehensive and precise assessment methods exist, but they are often time-consuming. Given that the island lesson topic, "payment transactions," represents a very basic element of economics instruction, a simpler approach was adopted for pragmatic reasons.

Despite these limitations, the findings allow for a practical recommendation: the individual prior knowledge of students in business lessons at vocational colleges should be explicitly considered and incorporated into the selection and planning of didactic designs.

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ONLINE PURCHASING HABITS OF THE STUDENTS IN THE ERA OF THE COVID-19 PANDEMIC

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This paper investigates the impact of the COVID-19 pandemic on online purchasing habits among students at the Faculty of Organization and Informatics, University of Zagreb. The quantitative research, conducted via online survey, aimed to analyse whether and to what extent the pandemic altered students' prior online purchasing behaviour. Using a T-test, differences in perceived security, price sensitivity, time-saving aspects, and overall attitudes toward online shopping before and during the pandemic were assessed. The results indicate no statistically significant shift in students' perception of safety regarding online purchases. However, statistically significant differences were identified in price sensitivity, time-saving perceptions, and attitudes toward online purchasing before the pandemic. These findings confirm the main hypotheses, indicating a significant difference in students' online purchasing habits before and during the COVID-19 pandemic. Additionally, the study provides valuable insights into pandemic-induced changes in student behaviour and offers practical implications for marketers and retailers to enhance the efficiency of online shopping and adapt their strategies to evolving consumer needs and preferences, particularly among students.

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1 Introduction

The Internet significantly influences consumer behaviour. Namely, there are significant differences between internet consumers and traditional consumers. Buying products online is under greater control of the consumer; he/she collects and searches for information about products or services on various websites on his/her initiative before making a purchase decision, while in physical stores, the seller can suggest the product and influence the purchase. The main focus of the paper is on how the emergence of COVID-19 has affected students' online purchasing habits before and after the pandemic. The study will explore the significance of security perception, price sensitivity, time-saving, and attitudes towards online shopping before and after the COVID-19 pandemic, representing the specific research subject. First, this paper presents the theoretical background and literature review of online purchase factors that influence purchasing decision making. After that, the hypotheses and the conceptual research model were set. After the theoretical part, the results of quantitative descriptive research were presented. The research was conducted among undergraduate and graduate students of the University of Zagreb, Faculty of organization and informatics. At the end of the paper, the study's implications and the research's most significant conclusions are presented.

In comparison to previous research on similar topics, the contribution of this paper lies in a more detailed examination of factors influencing the purchasing habits of students in an online environment. In contrast, some of the considered factors have yet to be researched or have been researched to a lesser extent thus far. So, the contribution of this paper is to define the impact of basic characteristics (perception of security, price sensitivity, time-saving, and attitudes towards online shopping) on changes in students' purchasing habits caused by the COVID-19 pandemic.

1.1 Perception of security

Many users still do not feel safe when they purchase online, which represents an obstacle for companies acting in e-commerce to acquire new customers. The reason for that insecurity is usually bad personal experiences or negative experiences of their referent group (family, friends, co-workers, etc.) when shopping online (Dillon & Reif, 2004, p. 7). According to Miyazaki & Fernandez (2001, pp. 29–30), many

customers encounter several problems when purchasing online. Those problems are usually connected with: misuse of data, delivery delays, inability to return goods, etc (Miyazaki & Fernandez, 2001). However, from year to year, efforts in e-commerce are being made to increase the security of online purchases, which is evident from the data on the increase in the number of online customers (Statista, 2024). On the other hand, there are still many "unanswered questions", such as, for example, "Internet cookies" those users agree to without thinking that marketers store them in their database and use that data for marketing purposes (Miyazaki & Fernandez, 2001, pp. 29–30). To reduce existing risks to a minimum, various ways of protecting personal data, card numbers, etc., have been developed over the years. It is recommended to read the experiences and reviews of existing customers, which guarantees the safety of successful online purchases. The possibility of returns certainly contributes to raising customer confidence. Considering all of the above, contrary to many opinions, online purchasing is considered an increasingly safe and desirable way of purchasing (Baretić, n.d.). There are also numerous studies in the literature that were conducted to examine safety when purchasing online, and in many studies, a high degree of correlation between online purchasing and perceived risk was obtained as a result. The results of one research show that customers believe that every online transaction carries a certain amount of risk despite detailed site checks and searches (Dillon & Reif, 2004). Furthermore, Ranaweera & Prabhu (2003) found that the lack of trust can affect the trust of customers who may not have the intention to purchase. Therefore, the Internet service provider must build trust among online customers in order to create purchase intention. Also, the existing literature and subsequent research have drawn similar conclusions that the online customer's trust has a positive effect on their online purchase (McKnight et al., 2002; Verhagen et al., 2006).

1.2 Price sensitivity

The price mainly plays a significant role when making a purchase decision by the customer. The price for the customer represents the primary monetary cost to which they are exposed in the purchase process and represents a limiting variable that negatively affects the probability of purchase (Piri Rajh & Lijović, 2017, p. 62). It is important to note that customers do not always choose the product with the lowest price, that is, customers do not necessarily perceive the price only as an economic loss. The role of prices is mostly negative when perceived as a cost, and positive

when perceived as a measure of quality. In addition to the fact that customers differ in how they perceive price in certain situations, they also differ in how much importance they give to price in the process of making a purchase decision, and this is explained by the concept of customer price sensitivity (Piri Rajh & Lijović, 2017, p. 62). Customers who perceive price as a cost are price sensitive, so their demand for a particular product or service falls when the price of the same product or service rises. Goldsmith & Newell (1997) point out that price sensitivity describes how an individual customer reacts to different prices and price changes, while Nagle & Holden (2002) define price sensitivity as the importance the customer attaches to price in the process of making a purchase decision (Piri Rajh & Lijović, 2017, p. 65). Price sensitivity is also mentioned as an important factor in many studies related to purchasing habits. Shankar & Rangaswamy (2001) in their research came to the conclusion that online stores reduce the customer's habit of using price as the main factor when making a purchase decision and reduce the need to search for prices. Furthermore, Arce-Urriza & Cebollada (2009) emphasize that price sensitivity is lower when compared to online purchasers than to traditional purchasers. On the other side, Chiang & Dholakia (2006) in their research pointed out that price perception plays a very important role in making purchase decisions and those customers are more likely to decide to purchase if the price is reasonably perceived. According to Jiang & Rosenbloom (2005) research, it can be concluded that more than half of the respondents of the conducted research changed the product or service due to a wrong perception of prices, and therefore, it can be stated that price perception plays an important role in making online purchase decisions.

1.3 Time-saving

The dominant reason, but one of the biggest advantages of online purchase is time-saving. Compared to physical stores, products in online shops are available to customers 24/7/365. Also, it is really easy to purchase with a few clicks, which saves the time of each customer. Also, time is saved when the customer wants to find a more favourable version of a certain product, and this is possible by typing in the desired specifications. If the customer is insufficiently informed about what a certain product offers, it is also possible to get detailed information in a very short time (Babić et al., 2011, p. 65). Furthermore, saving time is an important factor for young people, who lead a fast-paced lifestyle, dedicated to their careers and obligations. The number of women in the business world is increasing every year, which changes

the perception that women have a lot of time for purchasing. The above facts influence the positive growth of online purchasing every year (Koiso-Kanttila, 2005, p. 63). Many studies have shown that saving time is one of the most important advantages of online purchasing. According to Koiso-Kanttila (2005), most of the customers are looking for opportunities to save and use time whenever possible. In this case, it is saving time spent on purchasing, and is used for other purposes. Also, according to Choudhury (2014), customers who purchase online cite time-saving and 24/7 availability as one of the main advantages of online purchasing.

1.4 Attitude

It should be the goal of every seller to cause customer satisfaction with the purchased product. Namely, it is a well-known fact that the speed of spreading negative comments caused by dissatisfaction with the purchased product is much faster than the speed of spreading positive experiences (Kesić, 1999, p. 318). Therefore, by satisfying customers with the sold product, sellers are also doing themselves a favour. A loyal customer is a type of customer who tends to purchase from the same seller over a long period of time. In addition, they spend most of their money there, which is why they are one of the most interesting segments for sellers (Kesić, 1999, p. 303). Hassanein & Head (2007) emphasize the existence of a positive relationship of attitudes towards online purchase, which can be conditioned by some factors such as perceived risk, sociability, and the appearance of the web. While Eroglu, Machleit & Davis (2001) indicate the existence of negative attitudes towards online purchase due to the created negative affective component of the attitude or due to the perceived violation of security and/or privacy. Furthermore, Lee, Shi, Cheung, Lim & Sia (2011) in their paper emphasize the importance of the influence of attitude on the intention to purchase online. Namely, they state that attitude is an individual's predisposition to respond in a certain way in a certain situation. A similar statement was found in the paper of Limayem, Khalifa & Frini (2000), which emphasizes that it is necessary to investigate the factors that influence the formation of the attitude because it is the attitude towards online purchase that has the strongest influence on the intention to purchase online.

2 Conceptual model and hypotheses

Figure 1 shows a conceptual research model created based on collected secondary data through desk research. The explored variables in this model are the perception of security, price sensitivity, time-saving, and attitude toward online purchasing habits before and during the COVID-19 pandemic.

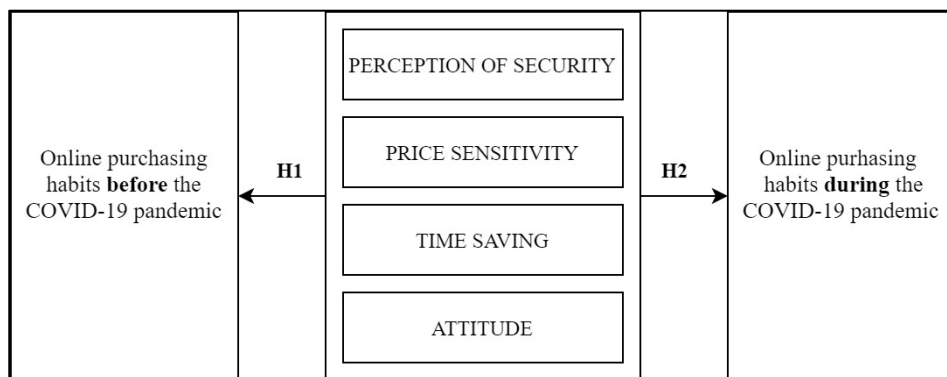


Figure 1: Conceptual model

Source: Own

According to the conceptual research model (Figure 1), the hypotheses of this study are as follows:

H1: There is a significant difference in students' online purchasing habits before the COVID-19 pandemic and the factors of online purchase (perception of security, price sensitivity, time-saving, and attitude).

H1.1: There is a significant difference in students' online purchasing habits before the COVID-19 pandemic and perception of security.

H1.1.2: There is a significant difference in students' online purchasing habits before the COVID-19 pandemic and price sensitivity.

H1.1.3: There is a significant difference in students' online purchasing habits before the COVID-19 pandemic and time-saving.

H1.4: There is a significant difference in students' online purchasing habits before the COVID-19 pandemic and attitude.

H2: There is a significant difference in students' online purchasing habits during the COVID-19 pandemic and the factors of online purchase (perception of security, price sensitivity, time-saving, and attitude).

H2.1: There is a significant difference in students' online purchasing habits during the COVID-19 pandemic and perception of security.

H2.2: There is a significant difference in students' online purchasing habits during the COVID-19 pandemic and price sensitivity.

H2.3: There is a significant difference in students' online purchasing habits during the COVID-19 pandemic and time-saving.

H2.4: There is a significant difference in students' online purchasing habits during the COVID-19 pandemic and attitude.

3 Data and methodology

The main problem of the conducted quantitative descriptive research was to investigate how the emergence of the COVID-19 pandemic affected the purchasing habits of students in the online environment. Therefore, the objectives of the conducted research were to investigate the significance of demographic characteristics, perception of security, price sensitivity, time-saving, and attitudes of customers towards online purchase before and during the COVID-19 pandemic. The students from the Faculty of organization and informatics, University of Zagreb, from both Information and Business Systems program, as well as the students from the Economics of Entrepreneurship program, participated in the research. This research was conducted from July 21, 2020 to August 3, 2020 and a total of 1605 undergraduate and graduate students at FOI constituted the sample. The questionnaire, as an instrument for collecting primary data, was distributed to all students via e-mail, so a non-probabilistic convenience sample was used. A total of 227 respondents approached the questionnaire, but 52 of them did not fully answer all the questions in the questionnaire, and their answers were not taken into

account during the statistical analysis. The survey was administered through an online survey system LimeSurvey. Regarding the age of data presented in this paper, in the literature can be found that the use of old data is justified (a) when examining a past event, (b) when more recent data are not available, or (c) when the data were collected painstakingly (Ketchen et al., 2023). This is precisely why, in this paper, the authors used old data because of its recognizable or exclusive nature, offering invaluable insights that may not be available elsewhere.

The questionnaire for collecting primary data was divided into two parts based on the researched categories: (A) demographic characteristics and purchasing habits, and (B) factors of online purchase behaviour. Category (A) demographic characteristics and purchasing habits refer to general information about the respondents, such as age, gender, study program, employment status, and questions about purchasing habits before and during the COVID-19 pandemic. On the other hand, category (B) factors of online purchase behaviour refer to the perception of security, price sensitivity, time-saving, and attitude.

Items for assessing the factors of online purchase, i.e., perception of safety, price sensitivity, time-savings, and attitudes, are taken from different authors (Ganapathi, 2015; Lester et al., 2007; Pawar et al., 2014) and adapted for this research. All measuring instruments used a five-point Likert scale ranging from 1 to 5 (1 - completely disagree; 5 - completely agree), where the participants had to indicate the degree of their agreement or disagreement with the given statement.

4 Results

Table 2 shows the demographic characteristics of students. From Table 1, it can be concluded that the majority of respondents (49,7%) were between the ages of 22 and 24, that 60.6% were female, that 58.9% were attending an Economics of Entrepreneurship study program, and that 84% of them were employed. It is precisely from these demographic characteristics that the basic research limitations of the conducted research can be recognized.

Table 1: Demographic characteristics

Demographics	Category	f	%
Gender	Male	69	39,4%
	Female	106	60,6%
Age	18-19	10	5,7%
	20-21	57	32,6%
	22-24	87	49,7%
	25-26	10	5,7%
	More than 26	11	6,3%
Major	Information and business systems	103	41,1%
	Economics of Entrepreneurship	72	58,9%
Employment	Yes	28	16%
	No	147	84%

Source: own

Table 2: Reliability Test

Scale	Items	Mean	Std. Deviation	Cronbach's Alpha
Perception of security	PS_T1	3,75	0,769	0,690
	PS_T2	3,97	1,053	
	PS_T3	3,60	1,232	
	PS_T4	3,26	1,326	
	PS_T5	3,65	1,208	
	PS_T6	3,17	1,177	
	PS_T7	2,75	1,126	
	PS_T8	2,54	1,118	
Price sensitivity	CO_T1	4,20	0,897	0,624
	CO_T2	3,95	0,961	
	CO_T3	4,25	1,037	
	CO_T4	2,98	1,101	
Time-saving	UV_T1	3,99	1,085	0,814
	UV_T2	4,15	0,947	
	UV_T3	4,25	0,925	
	UV_T4	4,15	0,941	
	UV_T5	4,10	0,971	
Attitude	ST_T1	3,59	1,161	0,603
	ST_T2	3,29	1,061	
	ST_T3	4,24	0,788	
	ST_T4	4,40	0,743	
	ST_T4	4,08	0,925	

Source: own

Before testing hypotheses, the table below calculates Cronbach's alpha, arithmetic mean, and standard deviation. Through analysis, it is concluded that the arithmetic means range from 2.54 to 4.4, while the standard deviation values indicate a range between 0.743 and 1.326. The reliability test measures the extent to which an instrument and information can be trusted. The higher the value, the more consistent or stronger the questionnaire status is declared. Table 2 shows that the Cronbach's alpha values of all indicators are above 0.60, which indicates that the data is acceptable or indicates good internal consistency. Therefore, it can be concluded that the research instrument is reliable.

4.1 Factors of online purchase before the COVID-19 pandemic

Table 3: The results of t-test analysis for online purchasing habits before the COVID-19 pandemic by factors of online purchase

	F	Sig.	t	df	Sig.	Mean	Std. Error	95% Confidence Interval of the Difference	
								Lower	Upper
Perception of security	0,098	0,754	0,413	173	0,68	0,040086	0,096987	-0,151344	0,231516
Price sensitivity	0,02	0,887	4,586	173	0	0,59828	0,13046	0,34078	0,85577
Time-saving	0,096	0,757	3,201	173	0,002	0,40709	0,12716	0,15611	0,65807
Attitude	0,118	0,732	2,436	173	0,016	0,2669	0,10957	0,05063	0,48317

Source: own

Hypotheses 1 and sub-hypotheses were tested with the t-test using the statistical tool SPSS. Table 3 shows the results of the analysis. The results showed that sub-hypothesis 1.1 was not confirmed, so it can be concluded that there is no significant difference between online purchases during the COVID-19 pandemic and the perception of safety ($p\text{-value} = 0.680$). On the other hand, sub-hypotheses 1.2, 1.3, and 1.4 were confirmed, so it can be concluded that there is a statistically significant difference in online purchase during the COVID-19 pandemic and price sensitivity

(p-value= 0.000), time-savings (p-value = 0.002), and the attitude about online purchase before the COVID-19 pandemic (p-value = 0.016). According to the results of all four sub-hypotheses, the main hypothesis (H1: There is a significant difference in students' online purchasing habits before the COVID-19 pandemic and the factors of online purchase) has been confirmed.

4.2 Factors of online purchase during the COVID-19 pandemic

Table 4: The results of t-test analysis for online purchasing habits during the COVID-19 pandemic by factors of online purchase

	F	Sig.	t	df	Sig.	Mean	Std. Error	95% Confidence Interval of the Difference	
								Lower	Upper
Perception of security	0,013	0,911	1,384	173	0,168	0,135392	0,097815	-0,057672	0,328457
Price sensitivity	6,015	0,015	3,117	173	0,002	0,42472	0,13627	0,15576	0,69367
Time-saving	0,766	0,383	3,301	173	0,001	0,42474	0,12866	0,17079	0,67868
Attitude	0,778	0,379	3,415	173	0,001	0,37336	0,10933	0,15757	0,58914

Source: own

Hypotheses 2 and associated sub-hypotheses were tested with the t-test using the statistical tool SPSS. Table 4 shows the results of the analysis. The results showed that sub-hypothesis 2.1 was not confirmed. According to the results, there is no significant difference between online purchases during the COVID-19 pandemic and the perception of safety (p-value = 0.168). On the other hand, sub-hypotheses 2.2, 2.3, and 2.4 were confirmed. It can be concluded that there is a statistically significant difference in online purchases during the COVID-19 pandemic and price sensitivity (p-value = 0.002), time-savings (p-value = 0.001), and attitude about online purchases before the COVID-19 pandemic (p-value = 0.001). Based on the observed results of all four sub-hypotheses, it can be concluded that the main hypothesis (H2: There is a significant difference in students' online purchasing habits

during the COVID-19 pandemic and the factors of online purchase) has been confirmed.

5 The implication of the study

Marketing experts and specialists can familiarize themselves with and gain a deeper understanding of the factors influencing shopping habits in an online environment. These insights will increase the efficiency of online shopping and predict customer behaviour, in this case, students. Additionally, it is useful information for marketing professionals and merchants to understand how consumers have changed their shopping habits due to the COVID-19 pandemic, facilitating the restructuring and streamlining of their online businesses for consumer safety and cost savings. This paper is useful to both the scientific community and the scientific community, given that there is a relatively scarce pool of scientific papers that can be found in relevant databases that cover the topic of this paper. However, the paper is also useful for practitioners involved in online sales in order to gain insight into the behaviour of their (potential) target group. Therefore, based on the results presented in this paper, recommendations can be given to managers who want to improve sales to the student population.

Following all of the above, the recommendations for managers who want to improve sales towards the student population can be: orientation towards students who are employed, regardless of other demographic characteristics of students, orientation towards price sensitivity, i.e., when advertising on their online stores, managers should use price sensitivity more because it offers more possibilities, orientation to factors related to saving time, i.e., managers should eventually offer shorter delivery times, faster purchase procedures, and the easier finding of what is needed through various filters, and orientation to the attitude of students, i.e. managers should investigate needs and desires from the point of view of the prerequisites for creating positive attitudes because a satisfied customer is also a loyal customer.

6 Conclusion

Online shopping is considered a fast and inexpensive way to purchase a specific product due to its relatively low cost. Additionally, a greater variety of goods and services and the ability to shop 24/7 are advantages of online shopping compared to traditional shopping. On the other hand, there are several risks, such as data and

credit card misuse, the inability to return items, and delivery delays. Conversely, the pandemic caused by the COVID-19 virus has brought about a series of changes in consumer shopping habits, and it is in the interest of every business sector to identify the changes caused by the COVID-19 pandemic and make adjustments accordingly.

This research shows no significant difference in the perception of security regarding online purchases before and during the COVID-19 pandemic. However, there were statistically significant differences in price sensitivity, time-savings, and attitudes towards online purchases before the pandemic. These findings confirm the main hypotheses, indicating a significant difference in students' online purchasing habits before and during the COVID-19 pandemic.

Research limitations should be considered when interpreting the research results. The basic limitation is the distribution of respondents based on their demographic characteristics. First, this research examined 60.6% of female respondents. Second, most respondents (49.7%) included in the research were between 22 and 24 years old. Third, 58.9% of respondents attended an Economics of Entrepreneurship study program.

Moreover, finally, 84% of respondents were employed. So, according to this sample, it is recommended that future research includes respondents from all demographic groups equally to make the results more representative. Also, one limitation is that all the respondents were from FOI. It is recommended that in future research, all faculties of the University of Zagreb are included in the research sample so a bigger picture can be seen to determine if significant statistical differences exist. Likewise, a recommendation for further research is to select a population assumed not to have been inclined to online purchasing habits before the COVID-19 pandemic.

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CARINSKA ASIMETRIJA IN NJENE POSLEDICE ZA EVROPSKO SOLARNO INDUSTRIJO

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Prispevek obravnava carinsko asimetrijo v Evropski uniji, ki otežuje lokalno izdelavo fotovoltaičnih modulov: medtem ko so končni fotovoltaični paneli oproščeni carinskih dajatev (0 %), so ključne sestavne dele obremenjene z dajatvami do 7,5 % ter dodatnimi protidampinškimi ukrepi za uvoz iz Kitajske. Takšna ureditev povečuje stroške za evropske proizvajalce, krepí prevlado uvoženih proizvodov (več kot 90 % vgrajenih modulov) in prispeva k strmemu upadu domače proizvodnje solarnih celic in rezin, ki zdaj pokrivajo manj kot 2 % potreb. V prispevku so podrobno pregledani zgodovinski zaščitni ukrepi (med letoma 2013 in 2018), aktualni tržni kazalniki, vplivi na konkurenčnost, izguba zaposlitev ter napetosti med zaščito domače industrije in podnebnimi ambicijami EU. Zaključni del ponuja predloge za odpravo teh neskladij (med drugim začasne oprostitev, poenostavljene postopke in nove trgovinske dogovore), ki bi lahko zagotovili uravnotežen prehod k zeleni energiji in večjo energetske neodvisnost.

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CUSTOMS ASYMMETRY AND ITS CONSEQUENCES FOR EUROPEAN SOLAR INDUSTRY

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The paper examines the customs asymmetry in the European Union that makes it difficult to manufacture photovoltaic modules locally: while finished PV panels are exempt from customs duties (0%), key components are subject to duties of up to 7.5% and additional anti-dumping measures on imports from China. This arrangement increases costs for European manufacturers, reinforces the dominance of imported products (more than 90% of installed modules) and contributes to the steep decline in domestic production of solar cells and wafers, which now covers less than 2% of needs. The paper examines in detail the historical safeguard measures (between 2013 and 2018), current market indicators, the impact on competitiveness, job losses and the tensions between the protection of domestic industry and the EU's climate ambitions. The final section offers proposals to address these discrepancies that could ensure a balanced transition to green energy and greater energy independence.



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1 Uvod

V zadnjih letih smo priča turbulentnemu dogajanju v svetovnem gospodarstvu - nenadna uvedba carin s strani ZDA, trgovinske vojne in ozemeljske aspiracije različnih velesil so vse dodobra pretresle bolj stabilne usmeritve zahodnih držav k trajnostnostnem poslovanju. V poplavi informacij in na trenutke celo zmed evropskih podjetji pa se le ta na dnevni ravni soočajo z bolj ezoteričnimi problemi, ki so posledica obsežne zakonodajne ureditve Evropske unije. Z enim izmed tovrstnih problemov se sooča evropska fotovoltaična industrija. Gre za asimetrijo na področju carinjenja uvoženih surovin za potrebe svoje proizvodnje.

Trenutna carinska tarifa po Kombinirani nomenklaturi za leto 2025 določa ničelno stopnjo za solarne celice in fotovoltaične module ne glede na poreklo, kar močno olajša uvoz poceni izdelkov iz Azije. Nasprotno pa komponente – solarno steklo, laminacijske (*ang. backsheet*) folije in aluminijasti okvirji – nosijo dajatve med 3 % in 7,5 %, pri uvozu iz Kitajske pa se jim pridružijo še protidampinške in izravnalne dajatve, ki pogosto presegajo 100 %. Ta asimetrija bistveno zvišuje stroške evropskim podjetjem, ki uvažajo komponente in jih v EU sestavljajo v module, medtem ko uvozniki končnih modulov nimajo teh bremen in imajo jasno konkurenčno prednost. Posledica je prevlada uvoza (več kot 90 % nameščenih modulov prihaja iz tujine, predvsem iz Kitajske, Malezije in Vietnama) ter upad domače proizvodnje.

Protidampinški ukrepi iz obdobja 2013 – 2018 so bili odpravljeni zaradi pritiska monterjev sončnih elektrarn, kar je sprožilo val poceni uvoza in zaprtje večine evropskih tovarn. Podobna situacija se ponavlja v letih 2024 – 2025 z novimi preiskavami in začasnimi dajatvami na komponente, a osnovna asimetrija ostaja nerešena. To otežuje vertikalno integracijo in ustvarja konflikt med kratkoročno zaščito industrije ter dolgoročnimi podnebnimi cilji EU, saj višji stroški komponent lahko letno upočasni nova nameščanja za 15 – 25 GW.

V prispevku bomo analizirali zgoraj opisano carinsko asimetrijo, podprto s podatki Eurostata, STO in Evropske komisije, s poudarkom na prostem pretoku blaga v EU, uvozom komponent iz tretjih držav in vplivom protidampinških ukrepov. Zaključili bomo s predlogi za odpravo asimetrij (začasne olajšave, poenostavljeni postopki,

novi sporazumi), ki bi lahko uravnotežili industrijske potrebe in cilje zelenega prehoda ter okrepili energetske suverenost EU.

2 Trenutna carinska struktura in asimetrije v evropski fotovoltaični industriji

Evropska komisija je v juniju 2013 uvedla začasne protidampinške dajatve na uvoz kitajskih fotovoltaičnih modulov, solarnih celic ter silicijevih rezin (*ang. wafer*), pri čemer so začetne stopnje segale od 11,8 % do 67,9 %. Glavni cilj tega ukrepa je bila zaščita evropske industrije pred dampinškim uvozom, ki je resno ogrožal položaj domačih proizvajalcev. S tem so želeli preprečiti množične stečaje in ohraniti zaposlitvene priložnosti, saj je kitajski uvoz takrat zajemal več kot 80 % trga v EU ter med letoma 2009 in 2011 prispeval k približno 40-odstotnemu znižanju cen (Evropska Komisija, 2013).

Decembra 2013 so bile dajatve potrjene z Uredbo Sveta (EU) št. 1238/2013 in št. 1239/2013, s stopnjami med 27,3 % in 64,9 % ter dogovorom o minimalni uvozni ceni (MIP) s Kitajsko. Namen je bil vzpostaviti poštene konkurenčne pogoje, spodbuditi trajnostno rast evropske fotovoltaične industrije in zmanjšati odvisnost od uvoza, na podlagi pritožbe združenja EU ProSun (Svet EU, 2013).

Ti ukrepi so bili uvedeni v času, ko je Kitajska do leta 2012 nadzirala približno 70 % globalnega trga fotovoltaičnih proizvodov, medtem ko je evropska proizvodnja doživela približno 60-odstotni upad. Namen je bil vzpostaviti ravnotežje na trgu, spodbuditi inovacije ter uskladiti s cilji evropske energetske politike, čeprav so poznejše študije razkrile le omejen dolgoročni učinek pri revitalizaciji lokalne proizvodnje. (Curran et al., 2021; Poitiers et al., 2024).

Septembra 2018 se je Evropska komisija odločila, da ne podaljša omenjenih ukrepov, kar je omogočilo neomejen uvoz brez carinskih dajatev in privedlo do več kot 80-odstotnega znižanja cen modulov glede na leto 2013. Čeprav je ta sprememba pospešila vgradnjo fotovoltaičnih sistemov, je hkrati povzročila zaprtje večine evropskih obratov za proizvodnjo solarnih panelov, saj domači izdelovalci niso mogli tekrovati s cenami pod 0,20 EUR/W. Delež uvoza iz Kitajske, Tajvana in Malezije je poskočil na več kot 90 %, kar je oslabilo vertikalno integracijo v evropski panogi in poglobilo odvisnost od azijskih dobavnih poti. (Poitiers et al., 2024).

Leta 2025 je Evropska komisija sprožila pregled izteka protidampinških in protisubvencijskih ukrepov za solarno steklo iz Kitajske, in sicer na pobudo skupine Interfloat, z namenom oceniti morebitna tveganja ponovnega dampinga. Ta pregled lahko traja do 15 mesecev in bi utegnil pripeljati do podaljšanja dajatev za nadaljnjih pet let (Evropska komisija, 2025). V Sloveniji ti ukrepi sicer povečujejo stroške za proizvajalce, vendar hkrati podpirajo prizadevanja za energetske neodvisnost, medtem ko industrijske organizacije predlagajo uravnotežene alternative, denimo subvencije za domačo proizvodnjo. (SolarPower Europe, 2024).

3 Analiza tržnih podatkov in strukture evropske fotovoltaične industrije

Statistični kazalniki razkrivajo, da je Evropska unija v letu 2024 uvozila približno 94,4 GW fotovoltaičnih modulov, kar pomeni okoli 7-odstotni upad v primerjavi z letom 2023 (101,48 GW). Večji del tega uvoza izhaja iz Kitajske, ki je v prvih sedmih mesecih leta 2025 dobavila približno 60,4 GW na evropski trg, kar dodatno izpostavlja trajno odvisnost od azijskih dobaviteljev, čeprav se izvajajo prizadevanja za diverzifikacijo dobavnih verig. (TaiyangNews, 2025).

Kitajska v zadnjih letih obvladuje med 96 in 98 % uvozov, pri čemer je vrednost preseгла 19,7 milijarde evrov v letih 2022 in 2023, medtem ko narašča uvoz iz Malezije in Vietnama zaradi selitve kitajskih proizvodnih obratov z namenom izogibanja carinskim ukrepom; skupni delež teh treh držav presega 90 % (Poitiers & Weil, 2024). Na globalni ravni so v letu 2024 ključni viri surovin zajemali Vietnam (5,84 milijarde USD), Tajsko (3,6 milijarde USD) in Malezijo (3,4 milijarde USD), kar kaže na premik proizvodnje proti jugovzhodni Aziji, čeprav je v EU več kot 90 % modulov še vedno globoko vpeto v kitajsko dobavno verigo (TradeImEX, 2025). Po podatkih Eurostata je vrednost uvoza izdelkov za zeleno energijo v letu 2024 dosegla 14,6 milijarde evrov, od tega 11,1 milijarde za solarne panele. (Eurostat, 2025).

Domača proizvodnja solarnih celic in silicijevih rezin v Evropski uniji zadovoljuje manj kot 2 % domačih potreb, pri čemer letna zmogljivost ne presega 10 GWp, medtem ko povpraševanje sega od 60 do 104 GWp. V Evropi ni več obratov za proizvodnjo silicijevih ingotov ali rezin, kar odraža popolno odsotnost vertikalne integracije in množična zaprtja tovarn po letu 2018 (European Solar Manufacturing Council, 2025). Surovine za evropsko proizvodnjo silicijevih rezin so še vedno skoraj

stoodstotno uvožene iz Kitajske, medtem ko zmogljivost za solarne celice znaša zgolj 2 do 4 GW, brez vidnega napredka k cilju 30 GW do leta 2025. (European Solar PV Industry Alliance, 2023). V Sloveniji manjka domača proizvodnja solarnih celic, kar izpostavlja nujnost pobud, kakršen je Zakon o industriji brez neto emisij (Net-Zero Industry Act), vendar brez oprijemljivih izidov v letu 2025 (PV Tech, 2025).

Carinska ureditev Evropske unije obremenjuje ključne sestavne dele, kot so steklo, folije in okvirji, z dajatvami od 3 do 7,5 %, medtem ko so končni moduli v celoti oproščeni (0 %), kar resno otežuje vertikalno integracijo in krepi uvoz iz Azije, kjer Kitajska prevladuje z 96 do 98 % uvoza v EU (Poitiers & Weil, 2024). Domača pokritost potreb tako ostaja pod 2 % zaradi zgodovinskih zaščitnih ukrepov in njihove ukinitve leta 2018, medtem ko tako imenovane reshoring pobude brez odprave te asimetrije kažejo le omejeno učinkovitost (European parlament, 2021).

Povišani vhodni stroški resno poslabšujejo konkurenčni položaj domačih sestavljalcev, medtem ko bi uvedba carin na fotovoltaične module lahko zmanjšala letne namestitve za 15–25 GW, vendar hkrati okrepila vertikalno integracijo (McKinsey, 2025). Predstavniki industrije se zavzemajo za uravnotežene rešitve, kot so subvencije za lokalno proizvodnjo, ki bi pomagale zmanjšati odvisnost in ublažiti vplive globalnih tarif (SolarPower Europe, 2024).

4 Primerjava konkurenčnosti z uvozniki končnih izdelkov

Carinska neskladja v Evropski uniji postavljajo domače proizvajalce v neenakopraven položaj glede na uvoznike iz Kitajske in jugovzhodne Azije. Ti uvozniki namreč izkoriščajo nižje cene kitajskih izdelkov, kar postopoma zmanjšuje tržni delež lokalnih proizvajalcev, ki se soočajo z višjimi vhodnimi stroški in ne zmorejo doseči cen pod 0,20 EUR/W. Ta dinamika je po letu 2018 bistveno prispevala k zapiranju večine evropskih tovarn. Uvozniki končnih modulov se opirajo na kitajske subvencije in nizke proizvodne stroške, kar v določenih segmentih znižuje evropske cene za približno 17 %, medtem ko evropski proizvajalci trpijo zaradi pomanjkljive vertikalne integracije in odvisnosti od uvoženih sestavnih delov. Uvozniki tako obvladujejo več kot 90 % trga, kar resno ogroža lokalno proizvodnjo in energetske samozadostnost EU (SolarPower Europe, 2024).

V scenarijih globalnih trgovinskih napetosti bi tarife na kitajske module lahko narasle do 47,7 %, kar bi do leta 2050 povečalo stroške uvoznikov za približno 3 % ter upočasnilo rast namestitvev novih sončnih elektrarn za okoli 7 % do leta 2035, obenem pa nekoliko okrepilo položaj evropskih proizvajalcev z manj centraliziranimi dobavnimi verigami. Kljub temu neskladje še naprej daje prednost uvoznikom, saj lokalni izdelovalci ne dosegajo potrebnega obsega za doseganje konkurenčnih cen (McKinsey, 2025). Med posledicami izstopa izguba zaposlitev v EU – od 648.000 v letu 2022 do potencialnih 1,2 milijona do leta 2027 brez uvedbe zaščitnih mehanizmov –, saj trgovinski ukrepi višajo cene in zavirajo napredek, medtem ko uvozniki izkoriščajo preusmerjene kitajske izvoze, ki izhajajo iz ameriških tarif (Kleidon et al., 2024).

Po odpravi protidampinskih ukrepov leta 2018 je prišlo do zaprtja tovarn zaradi poceni uvoza, ki je znižal cene modulov za več kot 40 % do leta 2023. Delež EU v globalni proizvodnji je padel pod 1 %, zaprtje tovarn, kot sta Jabil na Poljskem (2018) in Norwegian Crystals ter Norsun (2023), pa je ogrozilo polovico zmogljivosti za sestavljanje modulov (Poitiers et al., 2024).

Zaposlenost v panogi sončne energije v EU-27 je leta 2022 obsegala 347.000 delovnih mest (zgolj 7 % v proizvodnji, kar 84 % pa v namestitvenih dejavnostih), medtem ko IRENA navaja skupno 517.000 zaposlenih, od tega le 44.200 v proizvodnji (IRENA, 2023). Ta razvoj ogroža cilje zelenega prehoda in ohranjanje delovnih mest. Zakon o industriji brez neto emisij (Net-Zero Industry Act) iz leta 2023 si prizadeva za revitalizacijo sektorja, vendar brez odprave omenjenih neskladij ostajajo izgube primerljive s tistimi v vetrni industriji (Jaeger, 2025).

Na dolgi rok bi uvedba carin na fotovoltaične module lahko zmanjšala nameščeno solarno zmogljivost za 7 % do leta 2035, povečala delež plina v energetske sestavi ter za eno do dve leti prestavila doseganje 86-odstotnega deleža čiste energije, hkrati pa prinesla 3-odstotno rast stroškov prehoda do leta 2050. Kitajska dominacija na področju surovin in fotovoltaičnih modulov dodatno pogloblja ranljivost Evropske unije (McKinsey, 2025). Nedavne ameriške carine še dodatno znižujejo cene kitajskih modulov, kar kratkoročno pospešuje energetske prehod, vendar na dolgi rok podaljšuje zanašanje na fosilna goriva in spodbuja protekcionistične ukrepe, ki nazadnje oslabijo energetske samozadostnost EU. Strukturna odvisnost od uvoza fosilnih goriv (58 %) in kitajske prevlade v kritičnih surovinah (70 %) povečuje

tveganja, slednje pa brez odprave asimetrij ne more zagotoviti uspešnega zelenega prehoda (Rabobank, 2025).

5 Konflikt med industrijsko zaščito in podnebnimi cilji

Dodatne obremenitve, kot je mehanizem za prilagoditev ogljične meje (CBAM), lahko bistveno vplivajo na stroške komponent za fotovoltaične module v Evropski uniji, še posebej pri uvozu iz Kitajske in jugovzhodne Azije. Po razpoložljivih ocenah bi CBAM lahko prispeval od 40 do 50 EUR/kWp v obliki ogljičnih dajatev, kar bi uvozne cene modulov povišalo za 20 do 30 %, medtem ko se kratkoročno pričakuje 5- do 10-odstotno povečanje cen komponent. Ta razvoj znižuje konkurenčnost vgradenj in utegne upočasniti zeleni prehod z zmanjšanjem dostopnosti ključnih tehnologij (Maysun Solar, 2025).

Protidampinški ukrepi iz leta 2013 so občutno zmanjšali letno rast deleža solarne električne energije v Evropski uniji z 0,7 % na 0,2 % v obdobju med 2014 in 2018, hkrati pa prispevali k približno 0,75-odstotnemu porastu emisij CO₂ v elektroenergetskem sektorju; brez njih bi rast deleža utegnila biti višja za 0,5 % na leto. Takšna protekcionistična pristopnost viša cene in ovira širitev obnovljivih virov energije (Ehrentraut et al., 2025).

V začetku leta 2025 so evropski distributerji zabeležili več kot 20-odstotno rast cen modulov zaradi krčenja zalog in napetosti v dobavnih verigah; pri vztrajanju pri izbranih blagovnih znamkah lahko ta porast doseže 20 %, kar dodatno viša stroške komponent, kot so solarne celice in steklo, ter zadržuje uvedbo novih namestitev (PV Magazine, 2025).

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Globalni carinski trendi, denimo ameriške carine na kitajske izdelke, bi lahko dodatno zavrli vgradnje v Evropski uniji za približno 7 % do leta 2035, prestavili doseganje 86-odstotnega deleža čiste energije za eno do dve leti ter povečali stroške

prehoda za 3 % do leta 2050, kar izpostavlja protislovje med zaščito domače industrije in podnebnimi cilji (McKinsey, 2025). V Sloveniji bi takšni trgovinski ukrepi zaradi povišanih cen komponent zmanjšali tempo namestitev in ogrozili nacionalne cilje za obnovljive vire energije (Zelena Slovenija, 2025).

Evropska unija si trenutno prizadeva doseči približno 600 GW nameščene fotovoltaične zmogljivosti do leta 2030, kar bi zahtevalo podvojitev trenutne rasti, vendar se sooča s številnimi ovirami: nestabilnostmi v dobavnih verigah, omejitvami razpoložljivih zemljišč (ki bi zahtevala več milijonov hektarjev), zaostajanjem v razvoju omrežne infrastrukture (kar povzroča upočasnitev za 20–30 GW na leto) ter pomanjkanjem kvalificirane delovne sile in regulatornimi preprekami. Brez ustrezne diverzifikacije, posodobitve omrežja in optimizacije stroškov ostaja ta cilj resno ogrožen (McKinsey, 2025).

6 Zaključek

Carinska asimetrija v Evropski uniji ustvarja sistemsko oviro za razvoj domače proizvodnje. Evropski proizvajalci se soočajo z višjimi stroški, uvozniki pa izkoriščajo poceni azijske dobave, kar krepi prevlado uvoženih izdelkov (več kot 90 % vgrajenih modulov) in prispeva k strmemu upadu lokalne izdelave solarnih celic ter rezin, ki zdaj pokrivajo manj kot 2 % potreb. Protidampinški ukrepi med letoma 2013 in 2018 so sprožili valove poceni uvoza in množičnih zaprtij obratov, dodatne obremenitve pa lahko povišajo cene komponent za 10–20 % ter zmanjšajo letne namestitve za 15–25 GW, kar resno ogroža cilj 600 GW do leta 2030.

Vpliv na konkurenčnost je nedvoumen: evropski izdelovalci nosijo breme povišanih vhodnih stroškov, izgube zaposlitev in pomanjkljive vertikalne integracije, medtem ko uvozniki črpajo prednosti iz kitajskih subvencij in presežne proizvodnje. Na dolgi rok to pogloblja izpostavljenost Evropske unije geopolitičnim tveganjem in zavira prehod stran od fosilnih goriv. Napetost med zaščito domače industrije in podnebnimi cilji je še posebej očitna, saj dodatne dajatve lahko dvignejo cene komponent za 10 do 20 %, kar bi zaviralo letne vgradnje za 15 do 25 GW in ogrozilo cilj približno 600 GW nameščene zmogljivosti do leta 2030. Brez premišljenih intervencij bo Evropska unija težko uskladila kratkoročno potrebo po dostopni energiji z dolgoročno vizijo trajnostne energetske politike.

Za premagovanje teh neskladij je smiselno razmisliti o naslednjih ukrepih: (a) uvedbičasne ničelne carinske stopnje za vse bistvene komponente pri proizvajalcih s sedežem v EU, kar bi znižalo izdatke in spodbudilo lokalno sestavljanje; (b) poenostavitvi postopkov za pridobitev statusa pooblaščenega gospodarskega subjekta (AEO), s čimer bi se olajšala birokracija pri uvozu; (c) sklepanju novih trgovinskih dogovorov z Indijo, Turčijo in državami severne Afrike, ki bi omogočili večjo razpršitev dobavnih poti in zmanjšali odvisnost od Kitajske; (d) ciljanem izkoriščanju mehanizmov IPCEI in Zakona o industriji brez neto emisij za podporo vertikalno integriranim obratom, ki bi pospešili inovacije in rast domače tehnologije. Ti koraki bi zagotovili večjo energetske suverenost, ohranili zagon zelenega prehoda in okrepili evropsko panogo, ne da bi pri tem žrtvovali podnebne cilje. Le s celovitim in uravnoteženim pristopom bo Evropska unija lahko obvladala sedanje izzive in zagotovila trajnostno energetske prihodnost.

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KOMPETENCE ZA ODLOČANJE V POGOJIH MORALNE DILEME

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Moralne dileme predstavljajo eno najzahtevnejših področij človeškega odločanja, saj vključujejo konflikte med temeljnimi vrednotami, normami, čustvi in racionalnimi presojami. Namen tega znanstvenega članka je celovito analizirati kompetence, ki so potrebne za kakovostno odločanje v pogojih moralnih dilem, ter jih umestiti v širši teoretični in empirični kontekst. Članek temelji na interdisciplinarnem pristopu, ki povezuje filozofijo morale, psihologijo moralnega razvoja, kognitivne znanosti in pedagogiko. Posebna pozornost je namenjena kognitivnim, čustvenim, socialnim in vrednotnim kompetencam ter njihovi vlogi v izobraževalnih in profesionalnih okoljih. Prispevek se zaključuje z razpravo o izzivih in možnostih nadaljnega raziskovanja moralnega odločanja.

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COMPETENCIES FOR DECISION- MAKING IN SITUATIONS OF MORAL DILEMMA

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Moral dilemmas represent one of the most challenging areas of human decision-making, as they involve conflicts between fundamental values, norms, emotions, and rational judgments. The purpose of this scientific article is to comprehensively analyze the competencies required for quality decision-making in moral dilemmas and to place them in a broader theoretical and empirical context. The article is based on an interdisciplinary approach that combines moral philosophy, moral development psychology, cognitive science, and pedagogy. Special attention is paid to cognitive, emotional, social, and value-based competencies and their role in educational and professional environments. The article concludes with a discussion of the challenges and opportunities for further research into moral decision-making.



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1 Uvod

Odločanje v pogojih moralnih dilem je neločljivo povezano s sodobnimi družbenimi izzivi, kot so tehnološki razvoj, pluralnost vrednot, globalizacija in kompleksnost družbenih odnosov. Posamezniki se vse pogosteje soočajo s situacijami, v katerih ni enoznačno pravilne rešitve, temveč je vsaka možna odločitev povezana z določenimi negativnimi posledicami ali kršitvami moralnih načel. Moralne dileme so zato pomembno raziskovalno področje tako v filozofiji kot v družboslovju in humanistiki.

V tem kontekstu se postavlja vprašanje, katere kompetence posamezniku omogočajo, da v takšnih situacijah sprejema premišljene, odgovorne in etično utemeljene odločitve. Kompetence za moralno odločanje ne pomenijo zgolj poznavanja pravil in norm, temveč vključujejo sposobnost refleksije, kritičnega presojanja, razumevanja perspektiv drugih ter uravnavanja lastnih čustev. Namen članka je analizirati te kompetence ter pokazati, kako jih je mogoče sistematično razvijati.

2 Teoretični okvir kompetenc

2.1 Uvod v teoretični okvir kompetenc

V sodobni družbi znanja kompetence predstavljajo enega temeljnih konceptov razumevanja uspešnega delovanja posameznikov v izobraževalnem, poklicnem in širšem družbenem okolju. Hiter tehnološki razvoj, digitalizacija, umetna inteligenca ter spremembe na trgu dela zahtevajo od posameznikov nenehno prilagajanje, kar presega zgolj posedovanje formalnega znanja. V tem kontekstu se kompetence uveljavljajo kot celostni konstrukt, ki povezuje znanje, veščine, držanja in sposobnost njihove učinkovite uporabe v konkretnih situacijah (European Commission, 2024).

Namen tega poglavja je predstaviti teoretične osnove pojma kompetenc, pregled sodobnih definicij, ključne teoretične pristope ter aktualne kompetenčne modele in okvirje. Teoretični okvir služi kot temelj za nadaljnjo empirično obravnavo raziskovalnega problema.

2.2 Opredelevanje pojma kompetenc

2.2.1 Sodobne definicije kompetenc

sodobni znanstveni literaturi so kompetence opredeljene kot večdimenzionalen pojem. Avtorji se strinjajo, da kompetence ne zajemajo zgolj znanja, temveč tudi veščine, stališča, vrednote in sposobnost njihove integracije v praksi. Po mnenju sodobnih raziskav kompetence predstavljajo zmožnost učinkovitega delovanja posameznika v kompleksnih in spremenljivih okoliščinah (Myszak & Filina-Dawidowicz, 2025).

Kompetence so pogosto razumljene kot dinamičen proces, ki se razvija skozi izkušnje, refleksijo in vseživljenjsko učenje. V tem smislu ne gre za statično lastnost posameznika, temveč za kontinuiran razvoj, ki je tesno povezan s kontekstom uporabe (Rodríguez-Monforte et al., 2024).

2.2.2 Razlikovanje med znanjem, veščinami in kompetencami

Za jasno razumevanje pojma kompetenc je pomembno razlikovati med znanjem, veščinami in kompetencami. Znanje se nanaša na razumevanje dejstev, konceptov in teorij, veščine pa na sposobnost izvajanja konkretnih nalog. Kompetence predstavljajo sintezo znanja in veščin ter vključujejo tudi motivacijske, etične in socialne dimenzije, ki omogočajo prenos v prakso (Education and Information Technologies, 2024).

2.3 Teoretični pristopi h kompetencam

2.3.1 Kompetenčno usmerjen pristop

Kompetenčno usmerjen pristop izhaja iz predpostavke, da so kompetence ključni dejavnik uspešnosti posameznika in organizacije. Ta pristop poudarja povezavo med kompetencami in merljivimi učnimi ali delovnimi izidi ter omogoča razvoj strukturiranih kompetenčnih modelov, ki služijo kot osnova za izobraževanje, usposabljanje in ocenjevanje (Education and Information Technologies, 2024).

2.3.2 Teorija samoregulacije

Teorija samoregulacije poudarja aktivno vlogo posameznika pri razvoju kompetenc. Kompetence se v tem okviru razumejo kot rezultat načrtovanja, spremljanja in vrednotenja lastnega učenja. Samoregulacija omogoča posamezniku, da prilagaja svoje strategije učenja in delovanja glede na zahteve okolja, kar je ključno v kontekstu vseživljenjskega učenja (ScienceDirect, 2024).

2.3.3 Teorija dinamičnih zmožnosti

Teorija dinamičnih zmožnosti kompetence razume kot sposobnost prilagajanja spremembam in učinkovitega odzivanja na nove izzive. V sodobnem okolju, zaznamovanem z digitalno transformacijo in umetno inteligenco, so dinamične kompetence bistvene za dolgoročno uspešnost posameznikov in organizacij (Sustainability, 2025).

2.4 Sodobni kompetenčni modeli in okvirji

2.4.1 Digitalni kompetenčni okvirji

Eden najvplivnejših sodobnih kompetenčnih okvirjev je evropski digitalni kompetenčni okvir DigComp 2.2, ki opredeljuje ključna področja digitalnih kompetenc, vključno z informacijsko pismenostjo, digitalno komunikacijo, ustvarjanjem digitalnih vsebin, varnostjo ter reševanjem problemov. Posodobitve okvira vključujejo tudi kompetence, povezane z umetno inteligenco in etično rabo tehnologije (European Commission, 2024).

2.4.2 Kompetence na področju umetne inteligence

Razvoj generativne umetne inteligence je spodbudil oblikovanje novih kompetenčnih modelov, ki vključujejo tehnološko razumevanje, kritično presojo, etično odgovornost in pravno zavedanje. Annapureddy in sodelavci (2024) poudarjajo, da kompetence na področju umetne inteligence presegajo tehnično znanje in vključujejo tudi družbene in moralne vidike.

2.4.3 Kompetence za zaposljivost in trajnostni razvoj

Sodobni kompetenčni modeli vse pogosteje povezujejo kompetence z zaposljivostjo in trajnostnim razvojem. Raziskave poudarjajo pomen interdisciplinarnih kompetenc, kot so kritično mišljenje, sodelovanje, prilagodljivost in digitalna pismenost, ki omogočajo uspešno vključevanje posameznikov v trajnostno naravnano družbo (Sustainability, 2025).

2.5 Ključne skupine kompetenc

Na podlagi pregleda sodobne literature lahko kompetence razdelimo v več temeljnih skupin:

- kognitivne kompetence (analitično in kritično mišljenje),
- socialne in komunikacijske kompetence,
- digitalne kompetence,
- metakompetence, kot so učenje učenja, samorefleksija in prilagodljivost.

Takšna razdelitev omogoča sistematično razumevanje kompleksnosti kompetenčnega razvoja (Education and Information Technologies, 2024).

2.6 Vloga kompetenčnih okvirjev v izobraževanju in praksi

Kompetenčni okvirji imajo pomembno vlogo v izobraževalnih sistemih, saj usmerjajo razvoj učnih izidov, kurikulumov in načinov ocenjevanja. Hkrati predstavljajo orodje za delodajalce pri razvoju zaposlenih, upravljanju talentov in načrtovanju kariernih poti (European Commission, 2024).

2.7 Razprava

Teoretični okvir kompetenc razkriva, da so kompetence kompleksen in dinamičen konstrukt, ki združuje znanje, veščine, držanja in metakompetence. Sodobni teoretični pristopi in kompetenčni modeli poudarjajo pomen prilagodljivosti, samoregulacije ter digitalnih in AI-kompetenc. Predstavljeni teoretični okvir predstavlja osnovo za nadaljnjo empirično obravnavo raziskovalnega problema.

3 Odločanje v pogojih moralne dileme: sodobni pristopi in empirične ugotovitve

3.1 Uvod

Odločanje v pogojih moralnih dilem predstavlja osrednje vprašanje v moralni psihologiji in nevroznanosti, saj vključuje konflikt med različnimi moralnimi načeli, kot sta utilitarizem (maksimiranje koristi) in deontologija (prizadevanje za pravila in norme). Takšne dileme so klasično preučevane v kontekstu “trolley problemov”, kjer morajo posamezniki izbirati med dejanjem, ki žrtvuje eno osebo za rešitev več drugih, in ne ukrepanjem, ki ohranja moralno pravilo, a povzroči večjo škodo. Razumevanje tega odločanja ni le teoretično pomembno, temveč tudi ključno za praktične odločitve v medicini, politiki, policijskem in varnostnem delu ter razvoju umetne inteligence.

3.2 Teoretični okvir: fleksibilnost moralne presoje in učenje pravil

Tradicionalno so moralne presoje opisovale dual-procesne teorije, ki razlikujejo hitre intuitivne in počasi racionalne procese. Teoretični modeli znotraj dual-procesnega pristopa ponovno pridobivajo pozornost, vendar sodobni paradigmi izpostavljajo večjo fleksibilnost in učenje moralnih pravil, kot sta utilitarno in deontološko odločanje (npr. učenje iz povratnih informacij).

Najnovejša raziskava je pokazala, da se moralne preference ljudi nenehno spreminjajo na podlagi učenja in konteksta ter da so odločitve bolj prilagodljive, kot je prej domnevan model “trdno utečenih moralnih načel”. Ugotovljeno je bilo, da posamezniki lahko internalizirajo nove moralne norme na podlagi povratnih informacij in jih nato prenesejo na situacije, kjer povratne informacije niso na voljo. Vendar ko novo pravilo nasprotuje utilitarni logiki maksimiranja koristi, se odločajo v skladu z utilitarno logiko, kar kaže na fleksibilno moralno konstrukcijo odločitvenih procesov (npr. težnja k maksimiranju skupnega dobra).

3.3 Nevroznanstveni pristopi: notranja telesna zaznava in moralno odločanje

Nedavne nevroznanstvene študije poudarjajo vlogo interoceptivnih signalov (notranjih telesnih informacij, kot je zaznava lastnega srčnega utripa) v moralnem odločanju. En tak primer je raziskava, ki je s pomočjo EEG merila heartbeat-evoked potential (HEP) in ugotovila, da se interoceptivna obdelava razlikuje glede na to, ali so odločitve bolj utilitarne ali bolj deontološke. To implicira, da notranja telesna zaznava vpliva na izbor moralnih strategij, pri čemer ne gre le za kognitivni izračun, temveč za interakcijo med telesnimi signali in možganskimi strukturami, povezanimi s konfliktno odločanjem.

Poleg tega so raziskave pokazale, da so posamezniki z bolj izraženo zavedanjem telesnih signalov bolj verjetno, da njihovo moralno odločanje sovпада s percepcijo in normami drugih ljudi. To nakazuje, da so resno vpleteni tako notranji telesni procesi kot tudi zunanje socialne norme in konsenz, ki se uveljavlja skozi socialno kognicijo in notranjo zaznavo stanja telesa.

3.4 Skupinske odločitve in moralna percepcija

Moralne odločitve ni mogoče razumeti le na ravni posameznika. Empirične študije kažejo, da moralne presoje skupin pogosto odražajo večjo usmerjenost k utilitarni perspektivi in maksimiranju koristi kot posameznikove odločitve, kar pomeni, da kolektivna percepcija moralnih norm lahko vodi do drugačnih izidov kot individualni konflikt med posledicami in pravili. Ta ugotovitev je podprta s pristopi, ki modelirajo moralno odločanje s številčnimi parametri, kot sta občutljivost na posledice in občutljivost na moralne norme, kar kaže, da imajo skupine večjo pozornost na posledice svojih odločitev kot posamezniki.

3.5 Kognitivna dinamika in zavračanje odločitev

Raziskave o "decision inertia" (odločilna inercija) so pokazale, da je interpretacija situacije in narrativno ogrožje odločilno za stopnjo nezmožnosti akcije, ki vodi k zavlačevanju odločanja in kognitivni paralizi. Izražanje "grim storytelling" (zgodbe, ki predstavljajo realne in očitne posledice) lahko zmanjša odločilno inercijo in tako spodbuja bolj odločne in etično premišljene izbire pod negotovostjo. To kaže, da

kontekst in način predstavitve problema močno vpliva na izid moralnih odločitev in ni le statična lastnost preferenc posameznika.

3.6 Moralno odločanje pod stresom in okoljske spremenljivke

Poleg nevro-kognitivnih in socialnih vidikov se percipiran stres izjemno povezuje z moralnimi odločitvami. Visoka stopnja zaznanega stresa je povezana z večjo verjetnostjo, da bodo posamezniki izbrali lastno koristno strategijo odločanja (personal interest), kar vodi do nižje občutljivosti na socialne norme in višje občutljivosti na posledice odločitev. Ta dinamika kaže, da stres ne samo poveča impulsivnost, temveč spremeni tudi psihološki proces presojanja moralnih dilem.

3.7 Razprava

Sodobna raziskovanja moralnega odločanja kažejo, da je moralna odločitev multikomponentni proces, v katerega so vpleteni kognitivni, čustveni, socialni in telesni sistemi. Ni več mogoče obravnavati moralnih dilem kot enodimenzionalnih presoj, temveč kot dinamičen proces, kjer različni dejavniki – od notranje zaznave, konteksta do socialnih norm – preoblikujejo moralno presojo.

Poleg tega skupinska dinamika, pripovedno oblikovanje in percepcija stresa lahko katalizirajo ali ovirajo odločanje, kar ima implikacije za intervencije v realnem svetu (npr. usposabljanje za krizno odločanje, oblikovanje politik, etično izobraževanje).

V prihodnjih raziskavah je treba nadaljevati integracijo nevroznanstvenih meritev (npr. EEG, fMRI), raziskav socialnih interakcij in kontekstualnih vplivov na moralne odločitve, da bi bolje razumeli, kako se moralni sistemi razvijajo v realnih situacijah, kot so humanitarne krize, polemike v politiki ali razvoj avtonomnih sistemov, ki sprejemajo moralne odločitve.

4 Raziskava

Za raziskavo smo uporabili kvalitativno metodo družboslovnega raziskovanja usmerjeni intervju, kjer smo 5 enakih vprašanj postavili trem izkušenim strokovnjakom.

Raziskava je omejena na tri izkušene strokovnjake, ki so naštet v spodnjih odstavkih.

Prvi strokovnjak je psiholog z dolgoletnimi izkušnjami, ki je tudi psihoterapevt usposobljen za uporabo Transakcijske analize.

Drugi strokovnjak je doktor medicine specialist travmatologije z praktičnimi izkušnjami reševanja iz kriz in dela v urgentni medicini.

Tretji strokovnjak je tudi doktor medicine, kirurg in ginekolog, ki ima bogate kirurške izkušnje in dela z najzahtevnejšimi bolniki na terciarni ravni zdravljenja.

4.1 Predstavitev odgovorov

Odgovori so zbirno predstavljeni v nadaljevanju.

1. *Kakšne osebnosti(temperament, značaj sposobnost) naj imajo krizni odločevalci, za uspešno odločanje v okoliščinah moralne dileme, da moralni stres zmanjšajo na minimum in se čim bolj izognejo moralnim travmam?*

Krizni odločevalci so ljudje katerih naloga je odločanje v situacijah za katere je značilna velika stopnja negotovosti, ki izhaja iz novih pojavov v stvarnosti. . Ljudje navadno ne delamo razlike med pojavi in našim doživljanjem pojava, ali z drugimi besedami med teritorijem in karto teritorija. Stvarnost delimo na objektivno, ki je dosegljiva našim čutilom in merljiva in subjektivno, ki je lastna posameznikom. Socialna realnost temelji na socialnem konsenzu in omogoča stabilnost in nespremenljivost. Vsak od nas si ustvari svojo karto teritorija, kar nam omogoča preživetje in osmišlja zunanji svet. Ljudje nimamo enakih kart. Nekateri imajo zelo aдекватne, ki so v veliki meri skladne z realnostjo in omogočajo lažjo adaptacijo in s tem preživetje. Napake v mapi je težko popravimo sami brez pomoči drugih. Naše vedenje je, razen v primeru grobe fizične sile, utemeljeno na naši karti. Preko vedenja, ki je s stališča posameznikove karte vedno logično in najboljše možno, imamo možnost za dostop do kart različnih ljudi. Pri reševanju problemov je pomembna delitev na rešljive in nerešljive. Klasične napake so iskanje rešitev nespremenljivih problemov , ali na drugi strani, opustitev reševanja rešljivih problemov. Ko ljudje sporočamo vsebino svoje karte drugim, potrebuje prejemnik našega sporočila veliko znanja, sposobnosti za ocenjevanje kaj je možno in kaj ne in

visoko toleranco do obstoja različnih definicij realnosti, ki so lahko resnične, tako kot naša. Vsaka karta oz. referenčni okvir obsega tri polja, polje kdo sem jaz, polje kdo so drugi in polje kaj je svet. Referenčni okvir se oblikuje v otroštvu, kasneje ga bogatimo, vendar bazični principi njegove organizacije ostajajo isti. Polja so med seboj povezana, vsak trenutek obdelujemo vsa tri polja: kaj želim, kaj želijo drugi, kaj zahteva situacija. Nekateri ljudje preprosto ignorirajo eno ali dve polji. Vsak od nas ima nekatera izkrivljanja v enem ali več poljih. Za kriznega odločevalca je pomemben kvaliteten referenčni okvir v vseh poljih. Tega zagotavlja dobro poznavanje sebe in drugih in sveta in upoštevanje realistične odnosne pozicije do sebe, drugih in sveta. To pomeni, da ob pojavu spremembe v situaciji enakovredno obravnavamo vse mape udeležencev ob hkratnem sledenju svoje z nujnimi korekcijami. Krizna situacija namreč odpira mape vseh treh polj, kjer odločevalec naleti na doslej neznane vsebine ali na njihov primanjkljaj. Ker vodja razpolaga z večjo socialno močjo, prevzema tudi večjo odgovornost. Zaželeno je realistična odnosna pozicija, ki je pozicija reševanja problemov. Vzvišena pozicija zahteva od drugih in sveta popuščanje, podredljivost pa popušča in se umika. Brezizhodna odnosna pozicija je značilna za ljudi, ki doživijo velik stres ali niz stresov manjše intenzivnosti in navadno vodi v bolezen. Našo pripravljenost, temperament, značaj in sposobnosti lahko izkoristimo za nujne adaptacije ali za obrambo obstoječega, kljub objektivno novemu stanju. Od naše izbire bo odvisna učinkovitost adaptacije na krizne razmere.

V primeru kriznega vodenja in odločanja in grozeče moralne travme je primeren tip osebnosti z visoko čustveno stabilnostjo, zmerno extravertiran z zmožnostjo hitrega odločanja, komunikativen in povezovalen. Primerna oseba ima empatijo in čustveno stabilnost, s poznavanjem etičnih načel. Odločevalec mora imeti avtoriteto brez agresivnih dejanj in zmožnost hitrega okrevanja po grozeči moralni travmi.

Krizni odločevalci morajo biti mirni, empatični strokovni in delovati hitro, odločno in timsko.

Menim, da mora imeti krizni odločevalec čustveno stabilen temperament, razvito sposobnost obvladovanja stresa ter jasno oblikovan osebni vrednotni okvir. Pomembni so notranja integriteta, odgovornost in sposobnost sprejemanja odločitev tudi takrat, ko so vse možnosti etično nepopolne. Bistvenega pomena je, da je krizni odločevalec sposoben samokritičnosti, saj le ta zagotavlja razumevanje

lastnih omejitev in zmanjšuje tveganje za dolgotrajen moralni stres. Sočutje do prizadetih je nujno, vendar ne sme ohromiti odločanja v težavnih situacijah. Prav tako je nujno potrebna sposobnost relativizacije kompleksnih in težavnih stanj in situacij. Le to je verjetno pomemben korak pri prevenciji razvoja situacije notranjega konflikta pri odločevalcu.

2. *Opreделите katere dodatne kompetence (znanje, veščine) za odločanje v okoliščinah moralne dileme potrebuje odločevalec v odnosu na ostale okoliščine odločanja v negotovostih in krizah.*

Odločevalcem pomagajo vsa znanja in veščine, ki izboljšujejo njihov referenčni okvir in jim ponujajo dodatne vedenjske opcije in omogočajo fleksibilnost. Spoznavanje referenčnih okvirov drugih omili doživljanje stresa pri reakcijah drugih, ki so zanje nepričakovane in učenje od njih. Poznavanje večplastnosti osebnosti znižuje verjetnost stresnega odziva. Enako velja za pridobivanje novih znanj in veščin o svetu. Veščine medosebnega komuniciranja in komuniciranja s svetom so dragoceno orodje za učinkovito reševanje stresnega odziva. Za krizne vodje, ki se želijo zaščititi pred neugodnimi učinki stresnega doživljanja je pomembno, da predhodno klasificirajo svoj vrednostni sistem v odnosu do sebe, drugih in sveta. Pomaga poznavanje lastnega načina moralnega presojanja in poznavanje lastnih podzavestnih obrambnih mehanizmov. Če pa stres že doživljajo, imajo na voljo vrsto različnih tehnik za blaženje emocionalnega odziva. Morda je potrebno posebej opozoriti, da imajo praktično vse tudi svoje temne plati (npr. delo, hrana ipd).

V poštevek pride vse kar izboljšuje skladnost našega referenčnega okvira za vsa tri polja realnosti: literatura, zgodovina, osebne izkušnje in zgodbe drugih ljudi, čim širše splošno znanje, odprtost za druge perspektive itd.

V okoliščinah grozeče moralne travme mora določevalec poznati etične standarde, poznati celoten sistem v katerem deluje in poznati sistem zaščite in reševanja. Poznati mora temelje kriznega in skupinskega komuniciranja in poznati veščine vodenja.

Odločevalec mora posredovati kratke in jasne usmeritve k rešitvi izziva.

V primerjavi z drugimi oblikami kriznega odločanja odločevalec v moralnih dilemah potrebuje dodatna znanja s področja etike, vrednotnih sistemov in načel pravičnosti. Pomembne so veščine strukturirane moralne presoje, prepoznavanja konfliktov

interesov ter zavedanja kognitivnih in čustvenih pristranosti. Poleg tega so ključne komunikacijske sposobnosti, zlasti pri pojasnjevanju težkih odločitev prizadetim in sodelavcem. Odločanje v moralnih dilemah pogosto zahteva več časa za razmislek in več sodelovanja z drugimi strokovnjaki. Zgoraj omenjena znanja pa seveda pomembno doprinejo k racionalizaciji težavnih situacij in dogodkov, ter s tem pripomorejo k pravilnejšim odločitvam za omejitve oz. zmanjšanje potencialne škode ob tovrstnih dogodkih.

3. Kakšen vpliv ima mišljenje in motivacija na odločevalca za odločanje v okoliščinah moralne dileme

Zaželen je čim bolj bogat nabor pojmovnih konceptov ob hkratni zmožnosti fleksibilne izbire po kriteriju »dovolj dobre rešitve«, ne pa insistiranje na popolnih rešitvah. Zmožnost inovativnega združevanja konceptov. Zmožnost sprejemanja dejstva, da so nekateri problemi zanj nerešljivi in usmeritev na rešljive.

Motivacija je odvisna od hierarhije njegovih potreb, pomembna je zmožnost upoštevanja hierarhije potreb drugih in skladnost obojega s situacijo. Upoštevanje dejstva, da stresno okolje ni najbolj ugodno za realizacijo najvišjih potreb v hierarhiji. Upoštevanje predvidenih posledic različnih opcij razrešitev dileme kot dodatni kriterij svoje motivacije. Pomembno je razlikovanje med potrebami in željami, ker je njihovo enačenje močan vir stresnega doživljanja.

Motivacija je temeljni vzvod učinkovitega kriznega vodenja in obvladovanje grozeče moralne krize. Mišljenje je pomembno kot komplementarni element pri timskem delu in nujnem hitrem odločanju pri grozeči moralni dilemi. Primerno osebnost označujejo prilagodljivost, sprejemljivost, zmerna ekstravertiranost, analitičnost uravnoteženost med čustvi in danimi okoliščinami.

Na odločanje v okoliščinah moralne dileme močno vplivata način mišljenja in motivacija pri reševanju zapletenih okoliščin. Bistvenega pomena je uravnotežena presoja med čustvenimi odzivi in strokovnimi merili. Če je motivacija notranja in temelji na vrednotah ter občutku poklicne odgovornosti, se zmanjša tveganje za impulzivne ali obrambne odločitve. Takšna motivacija pomaga tudi pri sprejemanju posledic odločitev in zmanjšuje občutek osebne krivde, ki pogosto spremlja moralno zahtevne situacije.

4. Kakšne usmeritve priporočate za usposabljanje odločevalcev v okoliščinah moralne dileme

Moralne dileme so nujen sestavni del kriznega vodenja. Priprava za vlogo kriznega odločevalca naj bi za to področje obsegala širok nabor izkustvenih usposabljanj, ki ponujajo tudi emocionalno angažiranje posameznika. Smiselno je usposabljanje usmeriti na zgoraj omenjena področja, npr. doživljanje in kontrolo stresa, spoznavanje vrednostnega in motivacijskega sistema udeležencev. Spoznavanje lastnega moralnega sistema. Čim bolj na posameznika usmerjen pristop z možnostjo povratne informacije s strani ostalih udeležencev. Usposabljanja s področja delovanja osebnosti in komunikacije. Seveda pa tudi vsebinska usposabljanja s področja kjer vodja deluje. Z usposabljanje odločevalcev v sistemih kritične infrastrukture priporočam temeljno usposabljanje in veščin komuniciranja, obvladovanja stresa in poznavanja osnov kriznega upravljanja s pridruženim (samo)testiranjem osebnosti odločevalcev.

Usposabljanje odločevalcev za moralne dileme bi moralo temeljiti na praktičnih, realnih primerih in ne zgolj na teoretičnih pravilih. Osnovna podlaga za dodajanje specializiranih znanj bi morala biti osnovna izkušnost in dejansko poznavanje ter delovanje v realnih situacijah in ne zgolj teoretični seznam vseh opravljenih izobraževanj. Smiselne so seveda simulacije etično zahtevnih situacij, vodena refleksija in nadzor, ter analiza in učenje iz praks drugih realnih situacij iz tujih okolij. Pomemben del usposabljanja naj bo razumevanje lastnih vrednot, čustvenih odzivov in meja odgovornosti. V tovrstnih situacijah je seveda, za povečanje kakovosti presoje, nujno multidisciplinarno sodelovanje, ki pa naj bo hierarhično urejeno, sicer je velika verjetnost omejenega in sub optimalnega odločanja, zaradi nasprotujočih si mnenj. Prav tako lahko takšen sistem odločanja pomembno prispeva k zmanjšanju občutka osamljenosti.

5. Kako postopati z odločevalcem, ki je doživel moralno travmo. Ali naj se naprej razvija, kot odločevalec oziroma kako naj gradi kariero?

Kaj se bo dogajalo s kriznim odločevalcem po koncu krize odloča njegova reakcija na rezultate svoje razrešitve moralne dileme. Krize slovijo kot sijajno sredstvo osebnega razvoja. Odločevalec, ki je preživel reševanje moralne dileme, je, ne glede na uspešnost razrešitev dobil možnost razvoja. Če jo želi izkoristiti mora stopiti iz vloge žrtve okoliščin v sprejemanje lastne odgovornosti, ne glede na to, kako majhna

je bila. Na tak način prečistijo svoj vrednostni sistem. Predvsem tisti, ki so sprejemali neustrezne rešitve in povzročili s svojimi odločitvami škodo, rabijo čas za vse faze žalovanja in sprijaznjenje. To jim omogoča pustiti zadevo v preteklosti, kamor spada in živeti dalje v sedanjosti. Če jim to uspe bodo verjetno nadpovprečni v kriznih situacijah v bodoče. Za organizacijo so dragocen kader in vredno je vlagati v njihov profesionalni razvoj in jih podpreti v navedenemu.

Tisti pa, ki tega procesa ne opravijo, se niso naučili nič, in obstoja velika verjetnost, da se bo zgodba ponavljala tako zanje kot za vodene in situacijo saj je njihov vrednostni sistem ostal enak. Verjetno se bodo zatekali v vlogo žrtve in izkušali močne simptome posttravmatskega stresa. Zaradi tega je bolj smotrno, da jih usmerimo na drugačno karierno pot.

PS: raje govorim o stresni reakciji oz. močni stresni reakciji saj so travme redkejšje in se pojavijo ,ko naletimo na do takrat povsem nepojmljivo situacijo. Takih je za izkušenega kriznega odločevalca manj.

Odločevalci, ki sodoživeli moralno travmo se morajo po procesu rehabilitacije razvijati naprej in uporabiti pridobljene izkušnje in znanje v analizi dogodka, ki je povzročil moralno travno. Potrebno jih je aktivno vključiti v nadaljnje usposabljanje kot aktivne deležnike in jim ponuditi primeren položaj na nadaljnji karierni poti.

Z odločevalcem, ki je doživel moralno travmo, je treba ravnati podporno in začrtati časovnico ponovne delovne reaktivacije in nadaljevanja kariere. Ključni so strokovna psihološka pomoč, čas za refleksijo in po potrebi začasna razbremenitev najtežjih odločitev. Odločevalci, ki so že opravili z dejanskim kriznim odločanjem so pomemben vir za optimalno reševanje novih kriznih situacij. Tovrstnim zaposlenim je potrebno ponuditi najvišji nivo multidisciplinarne podpore in poskrbeti za njihovo delovno reaktivacijo na področju, ki ga obvladajo. Nadaljnji razvoj je zagotovljen, v kolikor se poskrbi, da posameznik izkušnjo predela, ji pripiše smisel in jo integrira v svojo poklicno identiteto.

4.2 Razprava

O izsledkih raziskave razpravljamo v znotraj zastavljenih okvirih – odgovorov zgoraj naštetih treh strokovnjakov na zgoraj zastavljena vprašanja.

Uspešno odločanje v moralnih dilemah zahteva celostno razvito osebnost odločevalca, ki združuje čustveno stabilnost, jasno oblikovan vrednotni sistem in sposobnost realistične presoje kompleksnih situacij. Ključna je zmožnost obvladovanja moralnega stresa, sprejemanja nepopolnih odločitev ter prevzemanja odgovornosti brez zdrsa v vlogo žrtve ali v obrambne mehanizme.

Osrednja kompetenca je kakovosten referenčni okvir, ki vključuje uravnoteženo razumevanje sebe, drugih in sveta. Odločevalec mora znati hkrati upoštevati lastne vrednote, potrebe drugih in objektivne zahteve situacije ter biti odprt za različne perspektive. Pomembna je toleranca do negotovosti, sposobnost razlikovanja med rešljivi in nerešljivimi problemi ter usmerjenost k »dovolj dobrim« rešitvam namesto k idealnim.

Na ravni znanj in veščin so ključne:

- etična in moralna presoja, poznavanje vrednotnih sistemov in lastnih moralnih meril,
- zavedanje kognitivnih in čustvenih pristranosti ter lastnih obrambnih mehanizmov,
- komunikacijske in vodstvene veščine, zlasti pri razlagi težkih odločitev,
- obvladovanje stresa in sposobnost hitrega čustvenega okrevanja,
- fleksibilno mišljenje, inovativno povezovanje informacij in timsko odločanje.

Motivacija, ki temelji na notranjih vrednotah, profesionalni odgovornosti in realnem razumevanju hierarhije potreb (lastnih in tujih), zmanjšuje tveganje impulzivnih odločitev in dolgoročnega moralnega bremena.

Usposabljanje za moralne dileme mora biti izkustveno, reflektivno in osebno naravnano, s simulacijami realnih primerov, povratnimi informacijami, razumevanjem lastnih vrednot ter multidisciplinarnim sodelovanjem. Cilj je povečati psihološko odpornost, kakovost presoje in zmanjšati občutek osamljenosti pri odločanju.

Odločevalci, ki doživijo moralno travmo ali močno stresno reakcijo, imajo ob ustrezni podpori, refleksiji in integraciji izkušnje možnost nadpovprečnega profesionalnega razvoja. Če izkušnje ne predelajo, pa obstaja tveganje ponavljanja vzorcev, posttravmatskih odzivov in neustreznega odločanja, zato je v takih primerih smiselna tudi sprememba karierne poti. Odločanje v moralnih dilemah zahteva čustveno stabilnega in vrednotno zrelega odločevalca, ki je sposoben sprejemati odgovornost tudi za nepopolne odločitve ter učinkovito obvladovati moralni stres. Ključna je realistična presoja kompleksnih in negotovih situacij brez zdrsa v obrambne ali žrtvene vzorce.

Osrednja kompetenca je razvit referenčni okvir, ki omogoča uravnoteženo upoštevanje:

- lastnih vrednot in omejitev,
- potreb in perspektiv drugih,
- objektivnih zahtev situacije.

Pomembne so še:

- etična in moralna presoja ter zavedanje lastnih pristranosti,
- toleranca do negotovosti in usmerjenost k »dovolj dobrim« rešitvam,
- komunikacijske in vodstvene veščine pri razlagi zahtevnih odločitev,
- obvladovanje stresa in čustvena regeneracija,
- fleksibilno mišljenje in timsko odločanje.

Učinkovito usposabljanje mora biti izkustveno, refleksivno in osebno naravnano, z realnimi simulacijami, povratnimi informacijami in delom na vrednotah. Pravilno predelana moralna dilema ali stresna reakcija lahko vodi v nadpovprečen profesionalni razvoj, sicer pa v ponavljanje vzorcev in tveganje moralne travme.

5 Zaključek in predlogi za naslednje raziskave

Odločanje v pogojih moralnih dilem predstavlja enega najzahtevnejših vidikov profesionalnega delovanja v sodobni družbi, saj vključuje sočasno delovanje kognitivnih, čustvenih, socialnih in vrednotnih procesov. Prispevek je pokazal, da

moralno odločanje ni zgolj rezultat racionalne presoje pravil ali posledic, temveč dinamičen proces, v katerem se prepletajo osebne značilnosti odločevalca, kakovost njegovega referenčnega okvira, kontekst situacije ter socialne in organizacijske okoliščine.

Analiza teoretičnih pristopov in empiričnih ugotovitev potrjuje, da so za uspešno odločanje v moralnih dilemah ključne kompetence, kot so čustvena stabilnost, sposobnost obvladovanja moralnega stresa, jasno oblikovan in reflektiran vrednotni sistem, etična presoja, komunikacijske in vodstvene veščine ter zmožnost sprejemanja »dovolj dobrih« odločitev v razmerah negotovosti. Posebej pomembna se je izkazala vloga kakovostnega referenčnega okvira, ki omogoča uravnoteženo upoštevanje lastnih vrednot, potreb drugih in objektivnih zahtev situacije.

Rezultati kvalitativne raziskave dodatno poudarjajo pomen izkustvenega usposabljanja, timskega odločanja in organizacijske podpore pri preprečevanju moralnega stresa in razvoja moralne travme. Odločevalci, ki imajo možnost refleksije, strokovne podpore in integracije izkušenj v svojo poklicno identiteto, lahko iz moralno zahtevnih situacij izstopijo okrepljeni ter dolgoročno razvijejo višjo stopnjo profesionalne kompetentnosti in odpornosti.

Na podlagi ugotovitev se odpirajo pomembna izhodišča za nadaljnje raziskovanje. Prihodnje študije bi morale:

- poglobljeno preučiti povezavo med posameznimi osebnostnimi lastnostmi, referenčnim okvirom in pojavom moralnega stresa oziroma moralne travme,
- združevati kvalitativne in kvantitativne pristope ter vključevati longitudinalne raziskave, ki bi omogočile spremljanje razvoja moralnih kompetenc skozi čas,
- vključiti nevroznanstvene metode (npr. EEG, fMRI) za boljše razumevanje telesnih in čustvenih procesov v ozadju moralnega odločanja,
- primerjalno analizirati moralno odločanje v različnih profesionalnih okoljih (zdravstvo, varnostni sistemi, politika, upravljanje umetne inteligence),

- ovrednotiti učinkovitost različnih modelov usposabljanja in intervencij za zmanjševanje moralnega stresa ter krepitev psihološke odpornosti odločevalcev.

Celostno razumevanje kompetenc za odločanje v pogojih moralnih dilem je ključno ne le za izboljšanje individualnega odločanja, temveč tudi za razvoj etično odgovornih organizacij in družbe. Nadaljnje raziskave na tem področju lahko pomembno prispevajo k oblikovanju učinkovitejših izobraževalnih programov, podpornih mehanizmov ter etičnih okvirjev za odločanje v vedno bolj kompleksnem in negotovem svetu.

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COMPLEXITY AND CARE NEEDS OF ELDERLY PATIENTS IN INTERNAL MEDICINE WARDS: A PREVALENCE STUDY

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The progressive ageing of the population increases the clinical and functional complexity of elderly patients admitted to internal medicine wards. This study aims to describe the complexity of elderly patients in internal medicine wards, focusing on their clinical and functional characteristics. A prevalence study was conducted in 19 internal medicine wards in a north-eastern region of Italy, including 700 elderly patients. The assessment covered demographic characteristics, clinical status, comorbidities, Activities of Daily Living, fall risk through Conley scale, pressure injury risk through Norton scale and medical devices. Hospitalised elderly patients present complex clinical and functional profiles, with high comorbidity and moderate risks of falls and pressure injuries. The findings support the need for comprehensive, multidisciplinary care approaches that address patient complexity, maintain autonomy, and integrate hospital-community continuity of care through healthcare team collaboration.

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1 Introduction

Population ageing is one of the challenges facing healthcare systems. Increased life expectancy, combined with the growing prevalence of chronic diseases, has resulted in a progressive rise in the number of elderly patients admitted to hospital, especially in internal medicine wards. These patients often present with complex clinical characteristics, including multimorbidity, reduced physiological capacity, functional impairment, and high vulnerability to adverse events during hospitalisation (Brown et al., 2004; Berger et al., 2025).

Hospitalisation for acute medical illness is a crucial event in the process of functional decline in elderly and frail people (Creditor, 1993). Hospitalisation may represent an additional stressor due to environmental risks, reduced caloric intake, low physical activity or prolonged bed rest, depressed psychological state, and social isolation. In addition, the hospitalisation of older patients could make geriatric syndromes worse and exacerbate existing illnesses. Health status decline during hospitalisation could significantly affect quality of life and in elderly patients it is associated with an increased risk of a longer hospital recovery (Volpato et al., 2016). Older people often experience a loss of physical function, which negatively affects their ability to regain their pre-illness or pre-admission functional status. Consequently, functional decline can lead to a loss of independence and an increased risk of hospital readmission. Patients who are already frail are particularly vulnerable, as their ability to respond to an acute stressor is impaired. Patients in a frail state who are admitted to hospital are more likely to experience poorer health outcomes and longer lengths of stay. Although hospitalisation aims to diagnose and treat illnesses and thereby improve patients' health, returning to pre-admission physical and function could be compromised (O'Brien et al., 2023). In this scenario, internal medicine wards play a central role in caring for older adults, often admitting patients with acute exacerbations of chronic conditions, frailty, and functional limitations. Functional decline and reduced mobility are highly prevalent and critical aspects of patient complexity. Several studies have shown that elderly patients in hospital spend most of their stay in bed, even when their clinical condition would allow them to move around. This contributes to hospital-acquired disability, prolonged length of stay, and increased risk of institutionalisation (Brown et al., 2004; Pedersen et al., 2013). Despite increasing awareness of these issues, there are limited data on the prevalence of functional impairment, immobilisation, and related care needs among elderly

patients admitted to internal medicine wards in Italy. Understanding the extent and characteristics of this complexity is essential to inform multidisciplinary care models aimed at preserving mobility, preventing complications, and improving outcomes.

1.1 Aim

The aim of this study was to describe the clinical and functional complexity and care needs of elderly patients admitted to internal medicine wards, focusing on multimorbidity, functional status, immobilization, and associated risks.

2 Methods

2.1 Study Design

A prevalence study was conducted to describe the clinical and functional characteristics and care needs among elderly patients hospitalized in internal medicine wards. Prevalence studies are particularly suitable for assessing the burden of health conditions and care-related phenomena at a specific point in time, especially in complex hospital populations (Schränk et al., 2013).

2.2 Setting

The study was carried out in 19 internal medicine wards across hospitals belonging to three healthcare authorities in a Northeast region of Italy. These wards represent typical acute care settings for elderly patients with medical complexity.

2.2 Population

The population consisted adult patients hospitalized during the data collection period. Inclusion criteria were age ≥ 18 years, hospitalization in an internal medicine ward, and provision of informed consent. Patients were excluded if they were in palliative sedation, not present in the ward at the time of data collection.

2.3 Data Collection and Instruments

Data were collected from June to September 2025, using a tool specifically developed for the study, as no single validated instrument was able to capture simultaneously the clinical and functional dimensions of patient complexity. The development of the tool was informed by existing literature on mobility, functional assessment, and hospitalization-related risks (Brown et al., 2004; Mani et al., 2022).

Prior to data collection, the tool underwent content validation by nursing experts and pilot testing in one medical ward to ensure feasibility, clarity, and consistency of data recording. Data were collected through review of medical and nursing records and patient observation. Brief interviews were conducted with the reference nurse of the patients, allowing the integration of documented and experiential information related to patient mobility and care needs.

The patient-related variables included demographic, clinical, and social data such as: date of admission, age, gender, main diagnosis for admission, main comorbidities, presence of caregivers at the time of data collection, invasive devices, oxygen therapy, pressure injuries at admission and at the time of assessment, the patient's anthropometric measurements (weight, height, and body mass index), the use of any mobility aids both at home and during hospitalization, and the type of hospitalization (scheduled, emergency room, or transfer from another ward).

In addition, data were collected using validated assessment scales, calculated upon the patient's admission to the hospital and at the time of detection, so that any changes during the hospital stay could be observed. The patient's pain was recorded using the Numerical Rating Scale (NRS), a one-dimensional verbal scale that assesses pain intensity in adults on a rising scale from 0 to 10 (Downie et al., 1978). Risk of falls was evaluated using the Conley scale, which assesses both patient-reported and clinician-observed risk factors and supports the identification of patients requiring preventive interventions (Guzzo et al., 2015). Risk of pressure injuries was assessed using the Norton scale, which evaluates physical condition, mental status, activity, mobility, and continence, and is commonly used in acute care settings for elderly patients (Halek & Mayer, 2002). Functional autonomy was assessed using the Katz Index of Activities of Daily Living (ADL), a widely used and validated tool for evaluating independence in six basic activities: bathing, dressing, toileting,

transferring, continence, and feeding (Katz et al., 1963). Functional impairment is a recognized marker of complexity and a strong predictor of adverse outcomes in hospitalized elderly patients (Brown et al., 2004).

2.4 Statistical Analysis

Descriptive statistical analyses were performed using SPSS version 28. Continuous variables were summarized as means and 95% confidence intervals, while categorical variables were reported as frequencies and percentages.

2.5 Ethical Considerations

The study was approved by the Institutional Review Boards of the Department of Medicine of the University of Udine (protocol no. 190/2025 of 12/06/2025).

The directors of the healthcare authorities were involved and their consent was obtained. The data were collected after adequate information was provided and the informed consent form was signed. All data were processed in a manner that guaranteed complete anonymity.

3 Results

The study sample comprised 700 patients, with a mean age of approximately 79.5 years (95% CI 78.5–80.4), and no significant difference in gender (346 males and 354 females). Patients had a mean body mass index (BMI) of 25 kg/m² (95% CI 24.36–26.09) and a mean body weight of 69 kg (95% CI 67.04–71.36). At hospital admission, 22.6% of patients ($n = 158$) presented pressure injuries; this proportion remained stable, with a slight increase to 23.6% ($n = 165$). Approximately for half of the study sample an anti-pressure ulcer mattress was used during hospitalisation ($n = 338$; 48.3%) and a physical restraint device at the time of observation ($n = 348$; 49.7%). Among restraint devices, about half used bed rails ($n = 327$; 46.7%). Some used bed rails combined with a belt ($n = 6$; 0.9%) or wrist restraints ($n = 4$; 0.6%), and only one patient used bed rails combined with mittens (0.1%). A restraint belt was applied to one patient (0.1%), while the combination of belt, wrist restraints, and bed rails was used in three patients (0.3%). Caregivers were present for 93 patients, corresponding to 13.3%. Almost all patients ($n = 687$; 98.1%) had at least

one device in place (mean 1.34; 95% CI 1.34–1.43), most commonly a venous access device; each patient had on average one venous access (95% CI 0.96–0.99). Furthermore, 215 patients (30.7%) had a urinary catheter, 16 (2.3%) a nasogastric tube, 15 (2.1%) a percutaneous endoscopic gastrostomy (PEG), and two patients had drains (hepatic and peritoneal). In addition, 30 patients (4.2%) had a stoma; the most frequent was nephrostomy ($n = 9$; 1.3%), followed by tracheostomy ($n = 8$; 1.1%). Other types of devices were present in six patients (0.8%), specifically subcutaneous venous ports ($n = 3$; 0.4%), negative pressure wound therapy devices ($n = 2$; 0.3%), and dialysis catheters ($n = 1$; 0.1%). Moreover, 168 patients (24% of the total sample) were receiving oxygen therapy at the time of observation.

Regarding the NRS, on average 95% of patients reported no pain, with a mean score of 1 at admission (0.57; 95% CI 0.46–0.68) and 0 at the time of observation (0.16; 95% CI 0.10–0.22). The Norton scale remained stable between admission and data collection, with a mean score in 95% of the study population of 13.04 (95% CI 12.71–13.38) at admission and 12.92 (95% CI 12.58–13.26) at the time of observation. Similarly, the Conley scale showed relative stability between admission and observation, with a mean score of 3.21 (95% CI 2.98–3.44) at admission and 2.98 (95% CI 2.80–3.16) at the time of observation. The Katz Index of ADL also remained stable between admission (2.98; 95% CI 2.80–3.16) and data collection (2.67; 95% CI 2.31–3.04), with an mean score of approximately 3. Overall, 94.4% of patients had one or more relevant comorbidities, with a mean of approximately three comorbid conditions per patient (3.15; 95% CI 3.03–3.28). Based on the collected data, most hospitalised patients were admitted through the emergency department ($n = 632$; 90.3%), while the remaining 68 patients were admitted via transfer from another facility ($n = 52$; 7.4%) or through planned admission ($n = 16$; 2.3%). The mean length of stay for 95% of the study sample was approximately 10 days (9.96; 95% CI 9.00–10.91). Findings for each variable relating to the patients' characteristics are reported in Table 1.

Table 1: Variables relating to the patients' clinical and care data (n=700)

Variables	700 (100%)
Age, mean (95% CI)	79.5 (78.54–80.40)
Sex, n (%)	
Male	346 (49.4)
Female	354 (50.6)
Weight (kg), mean (95% CI)	69.2 (67.04–71.36)
BMI (kg/m²), mean (95% CI)	25.2 (24.36–26.09)
Pressure injuries at admission, n (%)	
Yes	158 (22.6)
Pressure injuries at observation, n (%)	
Yes	165 (23.6)
Anti-pressure ulcer mattress, n (%)	
Yes	338 (48.3)
Physical restraints at observation, n (%)	
Yes	348 (49.7)
Restraints per patient, mean (95% CI)	0.5 (0.49–0.57)
Type of restraint, n (%)	
Bed rails	327 (46.7)
Bed rails + belt	6 (0.9)
Bed rails + wrist restraints	4 (0.6)
Bed rails + mittens	1 (0.1)
Belt	1 (0.1)
Wrist restraints + belt + bed rails	3 (0.3)
Over-bed table	4 (0.6)
Over-bed table + belt + bed rails	1 (0.1)
Caregiver present at observation, n (%)	
Yes	93 (13.3)
Any medical device in place, n (%)	
Yes	687 (98.1)
Devices per patient, mean (95% CI)	1.4 (1.34–1.43)
Venous access, mean (95% CI)	1.0 (0.96–0.99)
Urinary catheter, n (%)	
Yes	215 (30.7)
Nasogastric tube, n (%)	
Yes	16 (2.3)
Percutaneous endoscopic gastrostomy (PEG), n (%)	
Yes	15 (2.1)
Drains, mean (95% CI)	0.0 (0.00–0.01)
Type of drain, n (%)	
Hepatic	1 (0.1)
Peritoneal	1 (0.1)
Stomas, mean (95% CI)	0.05 (0.03–0.06)
Type of stoma, n (%)	30 (4.2)
Nephrostomy	9 (1.3)
Tracheostomy	8 (1.1)
Ureterostomy	5 (0.5)
Colostomy	4 (0.4)
Pylostomy	4 (0.4)

Variables	700 (100%)
Other devices, n (%)	
Yes	6 (0.8)
Type of other devices, n (%)	
Subcutaneous venous port	3 (0.4)
Negative pressure wound therapy	2 (0.3)
Dialysis catheter	1 (0.1)
Oxygen therapy, n (%)	
Yes	168 (24.0)
Pain at admission (NRS), mean (95% CI)	0.6 (0.46–0.68)
Pain at observation (NRS), mean (95% CI)	0.2 (0.10–0.22)
Norton scale at admission, mean (95% CI)	13.0 (12.71–13.38)
Norton scale at observation, mean (95% CI)	12.9 (12.58–13.26)
Conley scale at admission, mean (95% CI)	3.2 (2.98–3.44)
Conley scale at observation, mean (95% CI)	3.0 (2.80–3.16)
Katz Index of ADL at admission, mean (95% CI)	3.0 (2.80–3.16)
Katz Index of ADL at observation, mean (95% CI)	2.7 (2.31–3.04)
Comorbidities, n (%)	
Yes	661 (94.4)
Number of comorbidities, mean (95% CI)	3.2 (3.03–3.28)
Type of admission, n (%)	
Emergency department	632 (90.3)
Transfer from another facility	52 (7.4)
Planned admission	16 (2.3)
Length of stay (days), mean (95% CI)	10.0 (9.00–10.91)

4 Discussion

A total of 700 patients hospitalised in Internal Medicine wards in hospitals in Friuli-Venezia Giulia were included. The sample did not shown differences in terms of gender and had a high mean age, confirming that most patients admitted to Internal Medicine wards are older adults, as previously reported in the literature (Sonnenblick et al., 2007). Anthropometric measurements were within the normal range, with a mean BMI of 25 kg/m² and a mean body weight of 69 kg. Height was often missing from clinical records, as it is not routinely documented in clinical practice. This finding is consistent with previous studies showing low rates of height documentation in hospital settings (McFall et al., 2019; Therre et al., 2025). About half of the patients were subjected to mechanical restraints, mainly bed rails, which limit mobility and often confine patients to bed. This finding aligns with previous evidence indicating that bed rails are frequently used inappropriately, especially in patients with agitation or cognitive impairment (Atee et al., 2024). Most patients were unaccompanied by a caregiver at the time of observation. Given the advanced

age of the sample, caregiver presence could support patients during their recovery, as reported by Mani et al. (2022).

Norton scores at admission and observation indicate a moderate risk of pressure injuries; the prevalence of pressure injuries did not increase during hospitalisation, likely reflecting the preventive strategies adopted by healthcare staff. The prevalence of pressure ulcers already present at admission suggests that many patients experience prolonged periods of reduced mobility before hospitalisation, reinforcing the need for continuity of preventive strategies across care settings. The risk of falls, assessed by the Conley scale, remained stable, indicating a persistent fall risk, which is consistent with the association between advanced age and falls reported in the literature (Li et al., 2022). The moderate-to-high risk of falls and pressure injuries identified in this study underscores the importance of systematic risk assessment using validated tools such as the Conley and Norton scales (Guzzo et al., 2015; Halek & Mayer, 2002). Pain was not a significant limiting factor, as 95% of patients reported no or well-controlled pain at both admission and observation. The Katz Index of ADL indicated partial dependence in 95% of the sample, with a mean score of 3, highlighting the need for support in daily activities, including mobilisation. Overall, 94.4% of patients were classified as frail, with a mean of three comorbidities per patient. Almost all patients (98.1%) had at least one medical device in place; most had venous access and 30.7% had a urinary catheter. The widespread use of medical devices reflects clinical severity but may also contribute to reduced mobility and increased dependency. Previous studies have shown that devices such as urinary catheters and intravenous lines are frequently perceived as barriers to mobilisation by healthcare professionals, even when not strictly contraindicating movement (Mani et al., 2022; Kirk et al., 2019). Most admissions occurred through the emergency department (90.3%), followed by transfers and planned admissions. The mean length of hospital stay was approximately 10 days, reflecting the clinical complexity of this population. This value is higher than that reported in other contexts, such as Iranian hospitals and South Korean surgical units (Cho et al., 2018; Khammarnia et al., 2023). As reported in literature, length of stay is influenced by admission diagnosis, patient complexity, problems during hospitalisation, and organisational factors; moreover, nursing-related complications and the number of nursing diagnoses have been identified as independent predictors of prolonged hospitalisation (D'Agostino et al., 2019).

4.1 Limitations

This study has several limitations that should be considered when interpreting the findings. First, the study design does not permit causal inferences or evaluation of temporal relationships between clinical complexity and patient outcomes. Second, data were collected in a single Italian region, which may limit the generalisability of the results to other healthcare systems or hospital settings. Third, height was often missing from clinical records, resulting in incomplete anthropometric data and calculation of BMI for only a subset of patients. Therefore, BMI values should be interpreted with caution. Finally, although validated instruments were used, the assessment of functional status and risks at only two time points (admission and observation) may not fully capture the dynamic evolution of patient complexity during hospitalisation.

5 Conclusion

This prevalence study offers a comprehensive overview of clinical and functional complexity, as well as care needs, of elderly patients admitted to internal medicine wards. Findings reveal a population characterized by high age and levels of multimorbidity and frailty, widespread functional dependence and moderate risk of falls and pressure injuries. These findings confirm that, in internal medicine wards, care is primarily directed towards patients with high vulnerability and limited functional reserve. For these patients, hospitalisation is a critical period, and healthcare professionals should pay careful attention in these situations. The prevalence of restraints, low caregiver presence, and extensive device use highlight significant barriers to mobility and autonomy. Overall, the study supports the need for comprehensive, multidisciplinary, and proactive care models focused on early functional assessment, promotion of mobility, prevention of complications, and continuity of care between hospital and community settings. Addressing the complex needs of this population is essential to improve clinical outcomes, preserve functional independence, and optimise the quality of care for hospitalised older adults.

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ON SELECTED METHODS OF MACHINE LEARNING FOR ENVIRONMENT

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Machine learning methods are increasingly used to analyze complex systems in both natural and social environments. In this paper, we present an overview of selected types of machine learning (reinforcement learning, supervised learning, and unsupervised learning), and discuss their applicability to environmental monitoring and simulated social environments. Supervised learning methods are shown to support prediction and classification tasks based on labeled environmental and social data, while unsupervised learning enables the discovery of hidden structures and patterns without prior labeling. We present reinforcement learning as a framework for adaptive decision-making, allowing agents to learn optimal behavior through interaction with dynamic environments. We provide illustrative examples, including weight updates in neural networks and Q-learning updates, to clarify the learning mechanisms. The presented approaches demonstrate the practical relevance of machine learning for modeling, analyzing, and understanding socio-environmental systems.

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1 Introduction

Machine learning methods are increasingly applied in two major environmental contexts: the **natural (ecological) environment** and the **social environment**. In the **natural environment**, machine learning supports the analysis of complex environmental data such as air and water quality measurements, climate variables, satellite imagery, and biodiversity indicators. These data sources are typically high-dimensional, noisy, and heterogeneous, making traditional rule-based approaches insufficient. Machine learning models enable automated pattern detection, prediction of environmental changes, and early warning systems for pollution, extreme weather events, and ecosystem degradation (Reichstein et al., 2019; Rolnick et al., 2019).

In environmental monitoring, supervised learning is commonly used for tasks such as air pollution forecasting, land-use classification, and detection of environmental hazards from remote sensing data (Zhu et al., 2017). Unsupervised learning helps to discover hidden structures in climate and ecological datasets, for example, by identifying climate regimes, anomaly patterns, or clusters of similar ecosystems (Ghaderpour et al., 2021). Reinforcement learning has recently been explored for optimizing energy management, smart grid control, and sustainable resource allocation, where agents learn policies that minimize environmental impact while maintaining system efficiency (Vázquez-Canteli & Nagy, 2019).

In addition to natural environmental systems, machine learning is increasingly applied in the **social environment**, which encompasses interactions among autonomous agents, human-like behavior, and emergent social structures. In simulated social environments, agents are typically equipped with internal states such as goals, memory, beliefs, and social relationships. Rather than relying on explicitly scripted rules such as finite state machines or decision trees, agent behavior emerges dynamically through interaction with the environment and other agents (Wooldridge, 2009). Game-based environments provide controlled experimental settings in which such properties can be systematically studied (Yannakakis & Togelius, 2018).

2 Methods

This study is based on a literature review focusing on selected paradigms of machine learning and their applicability in natural and social environmental contexts. The search was conducted using combinations of keywords such as machine learning, environment, reinforcement learning, unsupervised learning, neural networks, agent-based simulation, and AI sustainability. Priority was given to peer-reviewed journal articles, survey papers, and influential monographs published between 2015 and 2025. Earlier foundational works (e.g., Mitchell, 1997; Sutton & Barto, 2018; Russell & Norvig, 2021) were included to provide theoretical grounding. The selection process consisted of three steps: initial screening based on title and abstract relevance, full-text evaluation of articles focusing on environmental applications, and classification of selected works according to the three primary learning paradigms: supervised learning, unsupervised learning, and reinforcement learning.

3 Machine learning in environment

Machine learning represents an area of artificial intelligence (Fig. 1) focused on the development of algorithms that enable computer systems to learn patterns from data and improve their performance without being explicitly programmed for every task (Russel and Norvig, 2021). Instead of using fixed rule-based logic, machine learning models derive relationships directly from data, making them particularly appropriate for domains such as cybersecurity and environmental monitoring.

Table 1: Main types of machine learning

	Input	Aim
Reinforcement learning	state-action pairs	Maximize future rewards across multiple time steps
Supervised learning	$(\mathbf{x}, y)$ $\mathbf{x}$: values of input attributes y : label	Learn the function to map $\mathbf{x} \rightarrow y$
Unsupervised learning	$\mathbf{x}$ values of attributes no labels	Learn the underlying structure

Source: own table inspired by Russell & Norvig, 2021

Formally, a machine learning system learns from experience E with respect to a class of tasks T and a performance measure P , if its performance at tasks in T , as measured by P , improves with experience E (Mitchell, 1997). This definition highlights the adaptive nature of machine learning systems and their ability to generalize knowledge from observed data to unseen situations.

In recent years, the availability of large-scale datasets, increased computational power, and advances in learning algorithms have significantly expanded the applicability of machine learning. Machine learning methods are commonly categorized into three main groups according to the type of learning process they employ: **supervised learning, unsupervised learning, and reinforcement learning** (Table 1). Each of these paradigms addresses different problem settings and is suitable for distinct types of tasks in both natural and social environmental contexts (Russell & Norvig, 2021).

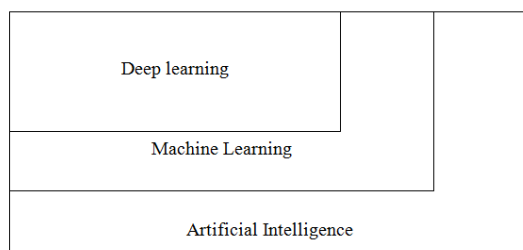


Figure 1: Position of Machine Learning in Artificial Intelligence

Source: Own diagram

3.1 Reinforcement learning

Reinforcement learning focuses on learning optimal behavior through interaction with an environment. An agent observes the current state, selects an action, and receives a reward that reflects the quality of the chosen action (Fig. 2). Over time, the agent learns a policy that maximizes cumulative reward (Sutton & Barto, 2018).

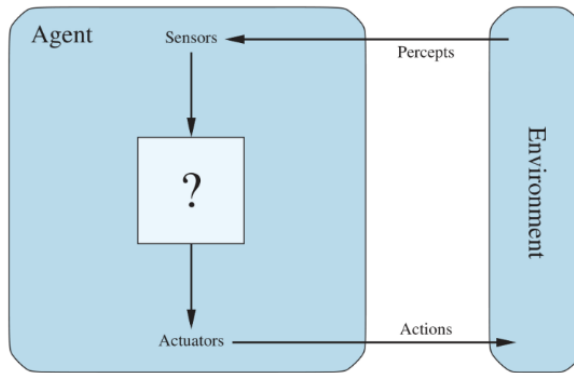


Figure 2: Agents interacting with environment

Source: Russell & Norvig, 2021

One of the most widely used reinforcement learning methods is **Q-learning**, a model-free algorithm that learns the value of taking a specific action in a given state. The learned value function, called the Q-function, estimates the expected cumulative reward for each state-action pair (Russell & Norvig, 2021).

At each time step, the agent observes the current state s , selects an action a , receives a reward r , and transitions to a new state s' . The Q-value is updated according to the following rule:

$$Q(s, a) \leftarrow Q(s, a) + \alpha \left[r + \gamma \max_{a'} Q(s', a') - Q(s, a) \right] \dots \dots \dots (1)$$

where α is the learning rate, γ is the discount factor, r is the received reward, and we compute the estimated optimal future reward in the max part of equation.

In the natural environment, reinforcement learning has been applied to optimize energy management systems, control smart grids, and manage renewable energy resources. For example, a reinforcement learning agent can learn how to balance energy supply and demand in order to minimize emissions while maintaining system stability (Vázquez-Canteli & Nagy, 2019).

In the social environment, reinforcement learning can model adaptive human or agent behavior in simulated societies. Reinforcement learning agents can represent individuals or institutions that learn how to cooperate, compete, or respond to environmental policies. Such simulations help analyze how social dynamics influence sustainability outcomes and collective decision-making processes (Yannakakis & Togelius, 2018).

Consider a simulated social environment in which an agent represents an individual deciding how to behave in a group with respect to environmental cooperation. For example, the decision whether to cooperate (e.g., follow environmental regulations) or defect (e.g., ignore rules for personal benefit). Each agent observes a simplified social state, such as the level of cooperation in its neighborhood.

We can use the following states, actions, and rewards:

States (s): {low cooperation, high cooperation}

Actions (a): {cooperate, defect}

Rewards (r): +1 if cooperation improves social welfare; -1 if defection causes social harm

First, we will define our environment:

State (s = low cooperation): the current level of cooperation in the agent's neighborhood

Action (a = cooperate): The agent's behavioral choice to follow environmental rules

Reward (r = 2): positive reward for contributing to collective welfare

Next state (s' = high cooperation): The observed social state after the action.

Learning rate: $\alpha = 0.1$

The learning rate α controls the extent to which newly acquired information overrides previously learned estimates. A value of $\alpha = 0.1$ provides a balance between stability and adaptability of learning.

Discount factor: $\gamma = 0.9$

The discount factor γ determines the importance of future rewards relative to immediate ones. With $\gamma = 0.9$, the agent strongly considers long-term outcomes, which is particularly suitable for social and environmental decision-making scenarios.

Current Q-values: $Q(s, a) = Q(\text{low cooperation, cooperate}) = 5$

Initially, Q-values are typically initialized to zero or small random values. Through repeated interaction with the environment and exploration of available actions, the agent updates these estimates based on received rewards, gradually learning more accurate Q-values for each state–action pair.

For the next state s' , the agent estimates the Q-values of available actions:

$$Q(s', \text{cooperate}) = 7$$

$$Q(s', \text{defect}) = 4$$

$$\max\{Q(s', \text{cooperate}), Q(s', \text{defect})\} = 7$$

Now, we can update the Q-value base on Eq. (1):

$$Q(\text{low cooperation, cooperate}) = 5 + 0.1 [2 + 0.9 * 7 - 5]$$

$$Q(\text{low cooperation, cooperate}) = 5.33$$

After this single iteration, the estimated value of choosing cooperation in a low-cooperation social context increases from 5 to 5.33, reflecting the positive social and future rewards associated with cooperative behavior.

At the beginning of the learning process, the agent has no prior knowledge about the environment or the consequences of its actions. Therefore, Q-values are typically initialized to zero or to small random values for all state–action pairs. This neutral initialization prevents biased behavior and ensures that the agent does not prefer any action before gaining experience through interaction with the environment.

During learning, the agent explores the environment by selecting actions and observing the resulting rewards and state transitions. Exploration strategies such as the ϵ -greedy policy are commonly employed to balance exploration and exploitation, allowing the agent to try different actions while gradually favoring those that yield higher rewards. Each interaction provides new experience that is used to update the Q-values according to the Q-learning update rule.

Over repeated iterations, the Q-values increasingly reflect the expected long-term cumulative rewards associated with specific state–action pairs. Actions that consistently lead to favorable future outcomes are assigned higher Q-values, while less effective actions receive lower estimates. As a result, the agent progressively improves its policy and learns to select actions that maximize long-term social or environmental benefits, even in the absence of an explicit model of the environment.

Using Q-learning, each agent updates its behavior based on social feedback. When many neighbors cooperate, the effort becomes more rewarding due to social trust and shared benefits. If defection dominates, agents may adapt to protect their own interests. Agents learn policies that reflect emergent social norms, such as increased cooperation when long-term collective benefits outweigh short-term gains.

3.2 Supervised learning

Supervised learning is based on labeled training data, where each input sample is associated with a known target output (Fig. 3). The objective of the learning algorithm is to approximate a mapping function that can accurately predict outputs for unseen inputs (Mitchell, 1997). Typical supervised learning tasks include classification and regression.

In the natural environment, supervised learning is widely used for air quality prediction, climate variable forecasting, water pollution assessment, and land-cover classification from satellite imagery. For example, neural networks and support vector machines can predict concentrations of pollutants such as PM10 or NO₂ based on meteorological and emission data. Similarly, supervised image classification is applied in remote sensing to detect deforestation, urban expansion, and changes in vegetation cover (Zhu et al., 2017).

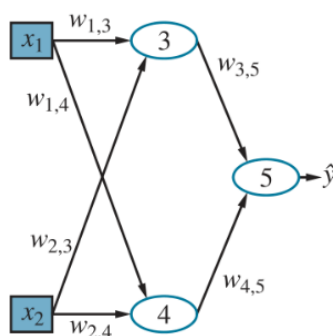


Figure 3: A neural network with two inputs and one output unit

Source: Russell & Norvig, 2021

In the social environment, supervised learning supports the analysis of human behavior, public opinion, and social responses to environmental challenges. Applications include sentiment analysis of social media posts related to climate change, prediction of pro-environmental behavior, and classification of survey responses regarding sustainability policies. These models help policymakers understand societal attitudes and design more effective environmental communication strategies (Lazer et al., 2009; Salganik, 2017).

In simulated social environments, supervised learning can be applied to model and predict agent behavior based on observed internal states and interaction histories. Consider a game-based simulation in which agents possess attributes such as goals, memory, beliefs, and social relationships, and their actions are recorded during repeated interactions (Wooldridge, 2009; Yannakakis & Togelius, 2018).

To illustrate the learning process in supervised learning, consider a simple neural network used to predict agent behavior in a simulated social environment. Let the input vector represent an agent's internal state, for example cooperation tendency and social influence, and let the target output indicate whether the agent cooperates or defects in a given situation.

Assume a single neuron with input x , weight w , and output $y' = w \cdot x$. Given a labeled training example with true target value y , the prediction error can be expressed using the squared error loss function:

$$L = 0.5(y - y')^2 \dots\dots\dots(2)$$

During training, the weight is updated using gradient descent to minimize the loss:

$$w \leftarrow w - \eta \frac{\partial L}{\partial w} \dots\dots\dots(3)$$

where η is the learning rate. For a single training step, the gradient is given by

$$\frac{\partial L}{\partial w} = -(y - y') \cdot x \dots\dots\dots(4)$$

and the weight update becomes

$$w \leftarrow w + \eta(y - y') \cdot x \dots\dots\dots(5)$$

Through repeated exposure to labeled examples, the network gradually adjusts its weights so that predicted agent behavior aligns more closely with observed outcomes. In the context of simulated social environments, this enables the model to learn how internal agent states influence social actions such as cooperation or defection, providing a transparent and interpretable mechanism for behavior prediction.

3.3 Unsupervised learning

Unsupervised learning operates on unlabeled data and aims to discover hidden structures, patterns, or relationships within the dataset. Common techniques include clustering, dimensionality reduction, and anomaly detection.

In the natural environment, unsupervised learning is used to identify climate regimes, detect environmental anomalies, and group ecosystems with similar characteristics. For instance, clustering algorithms can reveal spatial patterns in temperature or precipitation data, while anomaly detection methods can identify unusual pollution events or extreme weather phenomena. Such approaches are valuable for exploratory analysis and early warning systems (Ghaderpour et al., 2021).

In simulated social environments, unsupervised learning can be used to analyze emergent behavioral patterns arising from interactions among autonomous agents. Consider a game-based simulation in which agents are characterized by internal states such as goals, memory, beliefs, and social relationships. During the simulation, agents interact repeatedly without explicitly predefined social roles or group memberships (Wooldridge, 2009; Yannakakis & Togelius, 2018).

To illustrate unsupervised learning in a simulated social environment, consider a set of agents observed over multiple time steps in a game-based simulation. For each agent, a feature vector is constructed from behavioral statistics such as frequency of cooperation, number of interactions with other agents, and average response time. Importantly, no labels or predefined social roles are provided.

A clustering algorithm, such as k -means, is applied to these feature vectors in order to group agents with similar behavioral characteristics. Let x_i denote the behavioral feature vector of agent i , and let μ_k represent the centroid of cluster k . During each iteration of the algorithm, agents are assigned to the nearest cluster centroid, and the centroids are updated as the mean of all agents assigned to the cluster C_k :

$$\mu_k \leftarrow \frac{1}{|C_k|} \sum_{x_i \in C_k} x_i \dots\dots\dots (6)$$

Through repeated iterations, the clustering process converges to a partition of the agent population into behaviorally coherent groups. These clusters may correspond to emergent social roles such as cooperative agents, dominant influencers, or socially isolated individuals, despite the absence of any explicit role definitions.

4 Discussion and conclusion

The comparison of machine learning paradigms highlights distinct advantages and limitations in environmental contexts. Across all paradigms, common challenges include: data scarcity and imbalance, limited interpretability of deep learning models, sensitivity to environmental non-stationarity, transferability issues across geographic regions (e.g., Mitchell, 1997; Sutton & Barto, 2018; Russell & Norvig, 2021).

This paper presented an overview of selected machine learning methods and their applicability in both natural and social environmental contexts. Through illustrative examples, the paper demonstrated how supervised learning enables prediction and classification tasks based on labeled data, how unsupervised learning supports the discovery of hidden structures and emergent patterns, and how reinforcement learning allows agents to adapt their behavior through interaction with dynamic environments. Special attention was given to simulated social environments, where machine learning methods provide a data-driven framework for modeling agent behavior and analyzing social dynamics without relying on predefined rules.

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MAPPING THE LINK BETWEEN ESG PERFORMANCE AND LONGEVITY

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Longevity is increasingly recognized as a key societal objective, yet its relationship with corporate and community-level ESG (Environmental, Social, Governance) performance remains conceptually fragmented and empirically underexplored. Current sustainability frameworks often treat health and longevity as secondary social outcomes, rather than integrating them systematically into ESG impact measurement and decision-making. This paper maps the conceptual linkages between ESG performance and longevity by proposing an exploratory analytical framework that connects sustainability practices to long-term health and life expectancy outcomes. We argue that longevity should be understood not merely as a demographic indicator, but as a cumulative result of environmental quality, social cohesion, preventive health behaviors, and governance structures that sustain well-being over time. The framework stresses the need for measurable, comparable indicators that make longevity-related outcomes visible within ESG assessments and reporting. The paper contributes to sustainability impact measurement and offers practical implications for policymakers, municipalities, firms, and investors in aging societies.

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1 Introduction

Population ageing and the “longevity society” have elevated healthy life expectancy from a purely demographic statistic to a strategic societal objective with direct implications for economic resilience, public finance, and community well-being. At the same time, ESG (Environmental, Social, Governance) has become a dominant framework for structuring sustainability performance and non-financial decision-making across firms, investors, and public actors. Yet, despite the intuitive overlap between “sustainability” and “living longer and healthier,” the relationship between ESG performance and longevity remains conceptually fragmented and only weakly operationalized in mainstream ESG assessment and reporting. This paper emerges from that gap, it responds to the observation that longevity is often treated as a secondary social co-benefit, rather than an integrated outcome that can be systematically linked to E–S–G practices through traceable mechanisms and comparable indicators.

The topic is motivated by two converging developments. First, longevity is increasingly shaped by factors outside healthcare, including environmental exposures, built environments, social cohesion, and institutional capacity—domains that correspond closely to ESG pillars. Second, the rapid institutionalization of ESG measurement has highlighted persistent challenges in indicator selection, comparability, and outcome validity, especially when downstream endpoints are multi-causal and long-horizon. Against this background, the paper positions longevity as an integrative endpoint that can align ESG pillars under a long-term value lens and make explicit the “public value” dimension of ESG beyond reputational or compliance narratives.

Methodologically, the study adopts a concept-building, framework-development approach. Rather than estimating causal effects, it synthesizes relevant strands of literature and organizes them into an exploratory analytical framework that specifies plausible transmission channels from ESG-related inputs and practices to longevity-relevant endpoints. The framework is articulated through a multi-level impact perspective—community (place-based), organizational (firm-based), and program (intervention-based)—to clarify where longevity-relevant indicators can be observed, governed, and meaningfully attributed. Within each level, the paper distinguishes sequential result categories (inputs/activities, outputs, intermediate

outcomes, and ultimate outcomes) to support indicator logic that is measurable and comparable while remaining conceptually linked to life expectancy and healthy life expectancy.

The remainder of the paper is structured as follows. First, it reviews ESG as a performance and measurement domain and highlights the key challenges of comparability and outcome validity. Second, it develops the argument for longevity as an integrated ESG outcome and presents the multi-level analytical lens. Third, it maps longevity-relevant transmission channels across the environmental, social, and governance pillars. Fourth, it derives measurement implications and proposes a level-linked indicator logic to support evaluable, longevity-oriented ESG assessment. The paper concludes by summarizing contributions and outlining priorities for future empirical research.

2 ESG in general

Environmental, Social, and Governance (ESG) has become a dominant umbrella for assessing corporate sustainability performance and investor-relevant non-financial risks and opportunities. In corporate finance and management research, ESG commonly operationalizes the idea that firms create (and destroy) value not only through short-term cash flows, but also through their externalities, stakeholder relationships, and institutional conduct (Gillan et al., 2021; Starks, 2023).

From a theoretical perspective, ESG aligns with stakeholder theory—i.e., the claim that firm performance and legitimacy depend on managing relationships with multiple stakeholder groups, not solely shareholders (Donaldson & Preston, 1995; Freeman et al., 2004). ESG also maps onto the natural-resource-based view of the firm, which positions environmental constraints and eco-capabilities (pollution prevention, product stewardship, sustainable development) as potential sources of durable advantage (Hart, 1995).

At the same time, ESG measurement is contested. A key problem is that ESG ratings across providers often diverge, reflecting differences in scope, weighting, data sources, and the distinction between “what a firm does” versus “what outcomes occur” (Chatterji et al., 2009; Berg et al., 2022; Gibson Brandon et al., 2021). This disagreement makes it difficult to interpret ESG as a consistent proxy for real-world

impact—especially for outcomes that are downstream, long-horizon, and multi-causal, such as health and longevity.

Empirically, many studies support a non-negative association between ESG and corporate financial performance, but the mechanisms vary by sector, geography, and measurement approach (Friede et al., 2015; Eccles et al., 2014; Halbritter & Dorfleitner, 2015). These findings have reinforced ESG’s strategic relevance while leaving open a central question for public value: how (and under what conditions) do ESG practices translate into measurable improvements in population well-being and, ultimately, longer healthy lives?

Building on ESG conceptualizations used in applied assessment work, ESG can be treated as an integrated performance domain (E, S, G) whose indicators can be tailored to organizational context while still enabling comparability across entities. However, even when “health and safety” or “community well-being” appear in social metrics, longevity is rarely framed as an explicit integrated ESG outcome with a defined pathway model and indicator logic.

2.1 ESG and longevity: why longevity should be treated as an integrated ESG outcome

Longevity is often treated as a demographic indicator (e.g., life expectancy at birth, survival rates), yet public health and social epidemiology conceptualize it as a cumulative outcome shaped by environmental exposures, social conditions, and institutional arrangements across the life course (Marmot, 2005). Accordingly, longevity is not “owned” by the health sector alone but is co-produced through policies and practices in energy, transport, housing, food systems, labor markets, and governance—domains that closely map onto ESG’s three pillars.

This paper therefore reframes longevity as an integrated ESG outcome: a long-horizon measure of how environmental quality (E), social cohesion and protective behaviors (S), and governance capacity and integrity (G) jointly enable longer, healthier lives. This approach addresses the conceptual fragmentation of sustainability frameworks in which health is often positioned as a secondary social co-benefit rather than an explicit performance target.

To operationalize the ESG–longevity relationship without causal identification, we propose a multi-level analytical lens spanning place-based community conditions, firm-based organizational practices, and intervention-based programs. Across these levels, we specify plausible pathways whereby ESG inputs (policies, investments, operational changes) shape exposures and behaviors, influence intermediate health outcomes (e.g., cardiometabolic risk, mental well-being, morbidity, premature mortality), and ultimately affect longevity metrics (life expectancy and healthy life expectancy). The paper maps these channels across E, S, and G and derives implications for indicator selection, measurement validity, and comparability in ESG assessment and reporting.

2.2 Environmental (E) aspects of longevity

Environmental conditions shape longevity through chronic exposure pathways (e.g., air pollution, heat, water quality), through the built environment’s structuring of behavioral opportunities (e.g., walkability, green space), and via systemic risks linked to climate change and food-system sustainability. Epidemiological evidence consistently associates long-term PM2.5 exposure with elevated cardiopulmonary mortality and lung cancer risk (Pope et al., 2002), while reductions in PM2.5 have been linked to measurable gains in life expectancy across U.S. settings (Pope et al., 2009); earlier work also documented associations between ambient air pollution and mortality across cities after accounting for individual risk factors (Dockery et al., 1993). These findings translate into ESG-relevant mechanisms across levels: community policies and urban planning that reduce emissions represent “E performance” with direct longevity relevance; organizational pollution prevention and clean production reshape local exposure profiles (Hart, 1995); and program-level interventions (e.g., fleet electrification, industrial filtration) can be monitored via emissions and ambient PM2.5 indicators and subsequently related to premature mortality trends.

Climate change is increasingly framed as a public-health threat through heat stress, extreme events, food security, and infectious disease dynamics, with the 2015 Lancet Commission synthesizing evidence and emphasizing policy responses to protect population health (Watts et al., 2015). Mitigation and adaptation therefore sit naturally within the environmental pillar, while a longevity framing makes the human endpoint explicit: decarbonization policies that also improve air quality can generate

near-term health benefits, and adaptation measures such as heat-action plans and resilient housing can reduce risks among older populations in aging societies. Diet provides another dual pathway, as it is both a determinant of health and a driver of environmental pressures; global dietary transitions can threaten ecosystems while increasing chronic disease burdens (Tilman & Clark, 2014). The EAT–Lancet Commission argues that healthy diets from sustainable food systems can jointly support planetary stability and reduce diet-related disease risks (Willett et al., 2019), and modeling studies estimate substantial health and climate co-benefits from dietary change (Springmann et al., 2016). From an ESG perspective, sustainable agriculture, reduced waste, and lower-emission supply chains can be linked to food-related exposure determinants, while their longevity relevance depends on whether they shift availability, affordability, and norms toward healthier consumption patterns.

Finally, the built environment shapes daily activity patterns and stress exposures. Evidence syntheses associate green space exposure with multiple health outcomes (Twohig-Bennett & Jones, 2018), while physical inactivity has been quantified as a major contributor to the global burden of disease with life-expectancy implications (Lee et al., 2012). Cross-city evidence further links physical activity to urban environmental attributes (Sallis et al., 2016), and urban transport strategies that reduce greenhouse-gas emissions via active travel can deliver public-health benefits through increased physical activity and lower air pollution (Woodcock et al., 2009). Although built-environment design is often treated as a public-sector domain, firms influence these pathways through location decisions, commuting policies, logistics, and community investment; accordingly, environmental ESG measurement can incorporate both place-based indicators (e.g., green space accessibility, mobility-related emissions) and organizational indicators (e.g., employee travel mode share, logistics emissions) aligned with longevity-relevant mechanisms..

2.3 Social aspects of longevity

The social pillar connects most directly to longevity through the social determinants of health: inequality, social cohesion, psychosocial stress, and preventive behaviors shaped by community norms and institutional access.

Health inequalities are systematically patterned by socioeconomic conditions. Marmot (2005) highlights the social gradient in health and the role of social determinants in explaining large differences in life expectancy. Social ESG factors—such as living wage policies, employment security, inclusion and equal-opportunity practices, workforce development, and community investment—can be conceptualized as upstream interventions acting on the social determinants of health. By shaping material conditions, psychosocial stress exposure, and access to protective resources across the life course, these practices may cumulatively influence risk profiles for chronic disease and, ultimately, survival and longevity outcomes.

Social cohesion and trust can matter for mortality at population level. Evidence from U.S. ecological analysis linked social capital and income inequality to mortality patterns (Kawachi et al., 1997). More broadly, social relationships are associated with survival: a meta-analytic review found that stronger social relationships are linked to reduced mortality risk (Holt-Lunstad et al., 2010). In many ESG frameworks, “community engagement” is operationalized primarily as a reputational or license-to-operate construct, emphasizing activities and narratives rather than population-level effects. Reframing the social pillar through a longevity lens redirects analytical focus toward measurable social infrastructure—including community cohesion, volunteering and mutual-aid networks, intergenerational programs, and caregiver support systems—as plausible mechanisms that mitigate social isolation, strengthen psychosocial resilience, and support healthier aging trajectories.

Psychosocial stress and coping resources influence health behaviors and physiological pathways. The stress-buffering hypothesis emphasizes that social support can mitigate the effects of stress on well-being (Cohen & Wills, 1985). Across the life course, prevention culture and intergenerational transmission of health behaviors (nutrition norms, activity habits, help-seeking) can shape long-run morbidity and survival. While this paper does not claim a single canonical causal estimate, the literature supports the plausibility of such pathways and motivates ESG-aligned program design focused on prevention, social support, and health literacy. At the organizational level, the social pillar encompasses occupational health and safety, work–life balance arrangements, mental health and psychosocial support provision, and inclusive workplace practices. These domains can be theorized as determinants of long-run health by shaping cumulative stress exposure, burnout risk,

and the persistence of health-related behavioral patterns over time. At the community level, the social pillar extends to structured partnerships with civil society organizations and local stakeholders to implement prevention-oriented programs and cohesion-building initiatives, which may reduce loneliness and social isolation while strengthening informal support and caregiving networks that are salient for healthy aging.

2.4 Governance (G) aspects of longevity

Governance shapes longevity by determining whether resources are converted into effective, sustained, health-promoting outcomes through institutional quality, integrity, coordination capacity, and measurement systems. A recurrent insight in development economics and public administration is that governance conditions the productivity of public spending: Rajkumar and Swaroop (2008) demonstrate that the impact of public expenditures on development outcomes depends on factors such as corruption and bureaucratic quality, while cross-country evidence in health contexts indicates that corruption is negatively associated with multiple health indicators (Lio & Lee, 2016). Translating this logic to ESG, the governance pillar in corporate settings encompasses anti-corruption and compliance systems, board oversight and accountability structures, enterprise risk management, and ethical conduct standards; in community and public-sector settings it includes transparent procurement, integrity in service delivery, and evidence-informed allocation. Together, these capacities condition whether environmental and social investments are effectively implemented and maintained over time, thereby affecting the likelihood that they generate durable, population-relevant health and longevity benefits.

Because many determinants of longevity lie outside healthcare, governance for longevity requires cross-sector coordination. The Health in All Policies (HiAP) approach explicitly calls for integrating health implications across sectors and levels of government (Health in All Policies Framework for Country Action, 2014; Puska, 2014). HiAP is therefore closely aligned with the multi-level perspective advanced in this paper: by institutionalizing cross-sector integration and legitimizing decision instruments such as health/impact assessment, structured stakeholder participation, and transparency and accountability mechanisms, it provides a practical template for embedding longevity-relevant objectives into ESG strategy and implementation.

Table 1: Multi-level ESG–Longevity integration: where to measure, attribute, and govern impacts

Level	ESG examples	Measures	Attribution logic	Key implication
Community (place-based)	E: low-emission zones, green space expansion, active mobility infrastructure, heat-action planning. S: social infrastructure, community prevention networks, anti-loneliness initiatives. G: transparent procurement, cross-sector coordination bodies, Health-in-All-Policies-style integration	Population-facing exposures and intermediate outcomes (ambient PM2.5/NOx, heat exposure proxies, walkability/mode share, greenspace access; social cohesion/isolation proxies)	Stronger for place-based evaluation designs (before–after, difference-in-differences, natural experiments across comparable areas)	Longevity becomes analytically tractable via shared exposure environments that accumulate over time into mortality and healthy-life-expectancy patterns
Organizational (firm-based)	E: operational decarbonization, emission abatement, sustainable procurement/supply-chain standards. S: living wage, job security, OSH systems, mental health supports, DEI, training. G: anti-corruption and compliance, board oversight, ERM, ethics and reporting controls	Inputs/outputs and near-term outcomes within the reporting boundary (emissions intensity, energy mix, safety incidents, participation/coverage of wellbeing programs; workforce turnover; selected worker health proxies where feasible)	Stronger for within-firm longitudinal designs (panel analyses, matched controls); weaker for downstream population longevity without linkage to community exposure metrics	ESG→longevity linkage strengthens if firms extend reporting toward worker health trajectories and local exposure footprints, not only policies and ratings
Program (intervention-based)	E: retrofit projects, fleet electrification pilots, site-level pollution reduction. S: targeted prevention programs, workplace wellbeing interventions, intergenerational or volunteering initiatives. G: measurement frameworks, integrity/transparency upgrades in program delivery, stakeholder co-governance	Implementation outputs and intermediate outcomes (pollutants reduced; participation/compliance; behavior change such as active commuting; loneliness reduction; service uptake)	Strongest when interventions are evaluable (stepped rollout, quasi-experiments, RCTs where feasible, or robust monitoring with comparison groups)	Programs provide the practical “bridge” by producing measurable intermediate outcomes that plausibly cumulate into longevity impacts at community scale

Source: Authors' own compilation

This is particularly salient for municipalities, infrastructure providers, and large employers, whose policies and operational choices systematically structure everyday exposures, opportunity sets, and risk environments across the life course.

A further governance challenge concerns measurement and accountability. ESG disclosure can drift toward policies and narratives rather than outcomes, and evidence suggests that ratings and disclosure do not automatically capture underlying performance (Chatterji et al., 2009), while divergence across ESG ratings introduces additional interpretive uncertainty (Berg et al., 2022; Gibson Brandon et al., 2021). A longevity-oriented measurement perspective therefore requires an explicit indicator logic that differentiates sequential result levels, distinguishing ESG inputs and activities (e.g., emissions-reduction investments, preventive health initiatives) from outputs (e.g., pollutants reduced, coverage and participation rates) and from intermediate outcomes that reflect changes in exposures and behaviors (e.g., lower ambient PM_{2.5}, increased active commuting, reduced loneliness). These intermediate outcomes constitute the most tractable bridge to ultimate outcomes, where longevity-relevant endpoints are captured by longer-horizon indicators such as premature mortality trends and changes in life expectancy and healthy life expectancy. The goal is not to collapse ESG evaluation into life expectancy alone—which is slow-moving and highly confounded—but to design a traceable results chain in which longevity serves as the coherent endpoint and intermediate indicators are selected to be measurable, comparable, and plausibly connected to survival and healthy aging trajectories.

The level-based perspective in Table 1 provides a coherent way to connect ESG performance to longevity because ESG-related actions are typically enacted at different analytical levels, whereas longevity is a downstream endpoint that emerges from the cumulative interaction of multiple determinants over long time horizons. The community level is crucial for rendering measurable the shared exposure environments—such as ambient air quality, heat risk, active-living infrastructure, and social isolation—that plausibly shape mortality and healthy life expectancy through life-course processes. The organizational level specifies how firm-level E–S–G practices influence both worker health trajectories and local exposure footprints, while also determining the scope for coordination with local stakeholders and public institutions. The program level, in turn, offers the strongest basis for attribution, as discrete interventions generate observable outputs and intermediate outcomes—

such as emission reductions, participation and coverage rates, behavior change, or reduced loneliness—within evaluable time frames. The central implication is that treating longevity as an ESG-relevant outcome requires moving beyond input and output reporting toward an explicit results chain that links program-level intermediate outcomes to community-level exposure metrics, thereby establishing a traceable pathway to longer-run longevity indicators (life expectancy and healthy life expectancy) and strengthening the empirical and governance foundations of longevity-oriented ESG strategies.

3 Conclusion

This paper conceptualizes longevity as a societally salient, integrative endpoint that can align the environmental, social, and governance pillars of ESG within a coherent long-term value framework. The core contribution is the development of a structured transmission-channel map showing how improvements in environmental quality and climate resilience may reduce harmful exposures and expand the conditions for healthy living, how social cohesion, a prevention-oriented culture, and supportive workplace and community environments may attenuate psychosocial stressors and strengthen protective behaviors, and how governance quality—through integrity, coordination capacity, and measurement transparency—conditions whether environmental and social investments are effectively implemented and sustained so that they translate into durable, population-relevant health and longevity outcomes.

The proposed multi-level impact perspective spanning community, organizational, and programmatic levels helps to specify where longevity-relevant indicators can be most meaningfully observed, attributed, and governed. It also clarifies why longevity remains comparatively underexamined within ESG research and practice, given that it is a downstream endpoint shaped by multiple interacting determinants over long time horizons and is frequently situated beyond firms' conventional reporting boundaries. Nevertheless, the literature synthesized in this study supports the plausibility and policy salience of ESG-consistent pathways through which environmental conditions, social determinants, and governance capacities may jointly contribute to longer and healthier lives, particularly in aging societies. Future empirical research can build on this framework by strengthening identification strategies for place-based interventions, extending firm-level ESG analyses to

incorporate worker health trajectories and community exposure metrics, examining whether improvements in transparency and integrity increase the health returns to environmental and social investment, and advancing measurement methodology by developing longevity-linked indicator sets that reduce rating divergence and enhance cross-entity comparability.

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TO BE OR NOT TO BE: AI-ASSISTED WRITING, PLAGIARISM AND ACADEMIC INTEGRITY IN HIGHER EDUCATION

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AI has already changed higher education in very concrete ways – both in how teachers design and deliver their courses and in how students learn, write, and prepare assignments. Along with these changes, questions about academic integrity have become much harder to ignore. Many students are still unsure what counts as misconduct in an AI-assisted context, and where the line is between legitimate support and plagiarism. With that in mind, we conducted a pilot study to explore how often students use ChatGPT, what they mainly use it for, how they understand plagiarism, and whether their AI use is linked to academically dishonest behaviour. We also paid particular attention to environmental courses, where AI tools are increasingly used to explain concepts, summarize materials, and support project work. The study involved undergraduate and master's students from the University of Belgrade – Faculty of Organizational Sciences, Serbia, using an online questionnaire distributed via the 1KA platform during the 2025/2026 winter semester. Findings highlight the need for further research on the role of educators in guiding AI use, addressing digital inequality, ensuring data privacy, and developing instructional frameworks that integrate AI while promoting academic integrity.

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1 Introduction

“The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom.”

—Isaac Asimov

No invention in itself is purely right or wrong, it is the way that we use those inventions that will determine their nature. Such was the case with the invention of gunpowder, and such will be with the rise of artificial intelligence (AI).

AI has quickly become one of the most important technological advancements of the 21st century. It has reshaped whole industries, healthcare, the educational system, and our day-to-day lives (Binns, 2018; Brynjolfsson & McAfee, 2018; Ilcic, 2025). According to the Oxford English Dictionary (n.d.), AI refers to “the capacity of computers or other machines to exhibit or simulate intelligent behaviour”. Despite growing concerns about the use of AI and the clear need for procedures and regulations to guide its application, it should be emphasized that AI remains an excellent tool for necessary innovation and progress, if it is used in a responsible and ethical manner.

The application of AI in education has brought with it many challenges and changes. This affects both teaching practices and the ways students learn and complete their assignments. To this it should be added that all over the world students are increasingly using programs such as ChatGPT, Grammarly, Quill Bot, Scite, etc. (Al Azri et al., 2025; Walid et al., 2025). The adoption of these AI tools has enabled students to learn in a safe and personalized environment for better understanding of the learning material and finishing the lessons (Holmes et al., 2022; Edtech, 2020; Hennekeuser et al., 2024; Vieri & Petrea, 2025).

However, as students use AI more, it raises questions about the quality of their work, the amount of work they put in, and the difference between using AI for help with their studies and copying entire papers. When it comes to “classic plagiarism”, it must be noted that plagiarism as a phenomenon is not a simple issue (Ehrich et al., 2016). Its complexity stems from the fact that people may engage in this unethical behaviour for different reasons, ranging from time pressure and performance anxiety, to weak academic writing skills, unclear rules, and the belief that the risk of

being caught is low. In addition, plagiarism is not defined in a single, universally agreed way. Plagiarism can be defined as “the use of an author’s words, ideas, reflections, and thoughts without proper acknowledgment of the author” (Culwin & Lancaster, 2001; Jereb et al., 2018; Larkham & Manns, 2002), as well as a “form of cheating and theft since in cases of plagiarism one person takes credit for another person’s intellectual work” (Koul et al., 2009). What is certain is that “plagiarism is a widespread issue that undermines academic integrity, intellectual honesty, and innovation” (Amirzhanov et al., 2025).

Having in mind debates about considering the use of AI as plagiarism in generated texts (Susnjak & McIntosh, 2024), educators are increasingly concerned about how to define and detect plagiarism linked to AI tools – especially in contexts where clear institutional rules and procedures are lacking in both areas: AI use and academic integrity (Bozkurt, 2024; Primami & Latifah, 2025). There is an urgent need for clear rules and lessons on how to use AI in an academic and ethical way, because “with the rapid growth of digital content and access to online information, plagiarism has become increasingly sophisticated, requiring equally advanced methods for detection” (Amirzhanov et al., 2025).

When it comes to students, it should be said that their understanding and perception of plagiarism differs and often depends on their digital literacy, the stress they are under at university, and their ethics. Also, many students are not sure that AI-assisted writing constitutes plagiarism, especially in cases where the downloaded text is altered or paraphrased (Prashar et al., 2024).

Considering all the above, the authors of this paper conducted their research on the opinions and attitudes of students towards the use of AI, especially ChatGPT in higher education. BSc and MSc students of the University of Belgrade – Faculty of Organizational Sciences, Serbia were surveyed in the winter semester of the academic year 2025/2026. This research represents the beginning of a future larger research that aims to evaluate the way students use AI in higher education, and define transparent and necessary rules that all higher education institutions should have, which will define what plagiarism is when using AI, and how it can be used while respecting academic integrity.

2 Methodology

For the purpose of this paper, the authors conducted a survey using an online questionnaire distributed via the 1KA platform during the 2025/2026 winter semester. The survey was filled out by 95 anonymous students from the University of Belgrade – Faculty of Organizational Sciences, Serbia. The survey assessed their academic use of different AI tools (but with a focus on ChatGPT), their digital literacy, and their perception of using AI for plagiarism. The responses were collected and analyzed using the IBM SPSS Statistics 26 programme.

The questionnaire consisted of 21 questions, beginning with demographic data such as gender, age, and year of study, and included a combination of single-choice, multiple-choice, and Likert-scale questions. The authors applied descriptive statistics for all variables. Chi-square tests of independence were used to examine associations between gender and different uses of AI (e.g., coding, using it as a search engine, etc.), and between plagiarism blame attribution and personal plagiarism history. Independent samples t-tests compared male and female participants on digital literacy scores and frequency of ChatGPT use. Mann–Whitney U tests were used when normality assumptions were not met (gender differences in frequency of ChatGPT use). One-way ANOVA was then conducted in order to assess the effects of frequent use of ChatGPT on the student's perceived acceptability of AI-generated content. Spearman's rho correlations were also calculated to examine the relationship between digital literacy, ChatGPT use, and attitudes toward AI-generated texts. Multiple Linear Regression was then performed to predict students' perceived acceptability of ChatGPT use based on predictors such as their digital literacy, the frequency of ChatGPT use, their editing and verifying AI data practices, and whether or not students viewed ChatGPT as a form of plagiarism. Exploratory Factor Analysis (EFA) was applied to 15 sub-questions related to reasons for plagiarism, using Principal Component Analysis with Varimax rotation. The Kaiser-Meyer-Olkin (KMO) = .718 and Bartlett's test $p < .001$ confirmed the suitability of the data for factor analysis.

3 Results and Discussion

Out of 95 respondents, 72.6% were female, while 27.4% were male. Since most of them were the same age and study year (66% fourth year students), and SPSS analysis showed there was no statistical significance ($p > .05$) based on these parameters, so these variables are reported descriptively and were not included in the main inferential analyses.

One of the questions in the survey dealt with the issue of time students spent online daily. More concretely, they were asked to assess the amount of time in hours ranging from “less than 1 hour” to “more than 10 hours”. Here, the highest chosen option was “between 4 and 5 hours online per day” with the frequency of 40%, while 24.2% declared that they spend “from 6 to 7 hours”, and 9.5% declared that they spend more than 10 hours online per day. This off course, includes not only time spent online for academic reasons, but for the means of communicating with their peers, pleasure, gathering news information and content creation (Zhang & Lv, 2026). No significant gender differences were observed in reported time spent online (chi-square test, $p = .480$).

When asked to report their digital literacy on a Likert scale from 1 to 5 (1 being “I need assistance”, 2 being poor, 3 being average, 4 very good, and 5 excellent), this young generation that spends so much time online reported themselves as “very good” and “excellent” (76% of students cumulatively). An independent-samples t-test was performed to analyze the differences in self-reported digital literacy scores between male and female students. The findings indicated that male students ($M = 4.15$, $SD = 0.88$) reported slightly higher digital literacy scores than female students ($M = 3.97$, $SD = 0.71$).

In regard to how often they use different online platforms and tools, ChatGPT leads the category with 43% of students answering that they use it “multiple times a day”. The most frequently reported use of ChatGPT was obtaining explanations of specific terminology (71%). This was followed by using ChatGPT as a substitute for Google (61%), brainstorming (48%), summarizing texts (41%), writing parts of texts (36%), and translation (34%), structuring papers and presentations (25%), language corrections (24%), writing entire texts (17%), image generation (17%), help with coding (14%), and help with tables (9%). To examine the association between gender

and using ChatGPT as a substitute for Google, a chi-square test of independence was conducted. The chi-square test indicated a statistically significant association between gender and using ChatGPT as a substitute for Google $p = .021$. Out of the respondents that stated that they use ChatGPT instead of Google, 81% of them were of a female gender and 19% were of a male gender. This is to show that there is a huge difference in how those of different gender search online. Hence, out of the respondents that stated they use ChatGPT for coding, 69.2% were of male gender and only 30.8% were of female gender.

Because it is generally established that ChatGPT can generate wrong or falsified citations (for example, non-existent article titles or incorrect DOI numbers), the authors asked students how frequently they check the accuracy of information gained from AI tools. The findings revealed that 40% of students checked the data occasionally, while 20% said they rarely verified the information. The following question asked students if they had previously acknowledged that they use AI tools in their papers. Nearly half (48%) reported never doing so, and 24% indicated they were not aware that they were supposed to. The fact that students are not aware of this shows that they do not fully understand the academic integrity in the context of new AI technologies. Recent studies have shown that clear rules for citing AI tools in papers are still not fully formed and are much needed (Matysik & Jaworski, 2025). When asked whether they think it is okay to use texts written by AI, 42% of the students chose a neutral answer, and 29% considered it completely acceptable, which shows that many of them have nothing against using AI in their writing and work on assignments at faculty.

A one-way ANOVA test was conducted in order to examine how acceptability ratings differed across ChatGPT use-frequency groups. The frequency of students' use of ChatGPT results in a significant difference in whether they considered the use of AI-written text in assignments acceptable. Overall, students who reported using ChatGPT more often rated ChatGPT use in writing significant sections of academic text as acceptable. Conversely, students only using it once a month obtained a mean acceptability rating ($M = 2.57$) a lower than daily users ($M=3.17$). The pattern emerged among groups with intermediate frequency use, as the students who used ChatGPT several times in a week had the greatest average ($M=3.22$).

These results may indicate the more students are exposed to AI tools the more comfortable they are with incorporating them into their academic writing. The survey results show that as many as 70% of students agree with the statement that plagiarism is wrong, but also that there is a significant lack of awareness and knowledge among students about plagiarism. Thus, 30% of students were not aware or were not sure that plagiarism is cheating, 23% do not know that there are different types of plagiarism, while one third of students do not know how to cite electronic sources, and the same percentage was in doubt whether they might be copying without realizing it. A one third of the students responded that they do not know how to cite electronic sources, and a same percentile was in doubt whether they might be copying without realizing they were doing so. Concurrently, 38% of students were unsure that their faculty effectively regulates plagiarism; more than half (54%) said they do not know whether there are penalties for plagiarism. Most importantly, 56% of student respondents are uncertain whether there is an overarching mechanism for monitoring academic honesty infringements and 57% are not sure whether there are national-level policies or information campaigns about plagiarism. With regards to ethics, the same finding is evident through the large scale and institutional and systemic deficiency of plagiarism rules, where students are confused by a lack of rules.

To gain a deeper understanding of the reasons behind why students plagiarize, a factor analysis was performed on 15 survey sub questions regarding reasons for plagiarizing. The analysis aimed to identify themes or patterns within student responses. Five different factors were found using Principal Component Analysis with Varimax rotation. These factors together explained about 69% of the total variance. These five factors correspond to distinct motivational categories underlying student plagiarism:

- Not knowing how to do research or cite sources correctly (examples of academic skill deficits).
- Not having enough time or motivation (having too many assignments or trying to save time).
- Problems with writing (not being able to get their ideas across or not being sure of their writing skills).
- Problems with the faculty (unclear assignment instructions or professors not talking about plagiarism enough).

- Deliberate intent to plagiarize (including intentionally copying to achieve better grades).

These results show that plagiarism is not caused by just one thing, but instead, it is caused by a complicated mix of personal, academic, and institutional factors. To deal with plagiarism, educators need to not only enforce the rules, but also educate on them, explain them, support, and communicate more clearly with students.

A multiple linear regression analysis was performed to examine the factors affecting students' level of acceptance of AI-generated papers. The dependent variable was the students' assessment of how appropriate it was to use AI to write large parts of papers (Q10). The model had six predictors: digital literacy (Q3), how often they use AI (Q4), whether they check the accuracy of their AI-generated content (Q7), editing AI texts (Q8), citing the use of AI (Q9), and the belief that ChatGPT-generated papers are plagiarism (or not) (Q16). The overall regression model was statistically significant, $F=8.21$, $p<.001$, which means that the group of predictors explained a significant amount of the difference in students' acceptability scores. The model explained about 36% of the difference in Q10 ($R^2 = .359$, Adjusted $R^2 = .315$), which is a medium effect size. The belief that using ChatGPT is plagiarism was the strongest and most important negative predictor ($\beta = -.431$, $p < .001$). This suggests that students who perceive the use of ChatGPT as a form of academic misconduct are considerably less inclined to deem its application acceptable in academic writing. On the other hand, the frequency of AI use (Q4) was a positive and statistically significant predictor ($\beta = .182$, $p = .049$), which means that students who use AI tools more often are more likely to agree that it is acceptable to use it for writing papers. The other variables did not have any significant effects. However, digital literacy came close to being significant ($p = .094$), which suggests that it could be a trend worth looking into in future research. These results indicate that students' moral and ethical perceptions of AI-generated texts, especially their classification of it as plagiarism, are the primary factors influencing their acceptance of it. Moreover, familiarity and regular engagement with AI tools may enhance their acceptance in academic environments.

Responses from students about how much blame they think should fall most on students who engage in plagiarism (taking place within school walls) illustrated their individual and structural views. Only 26% of students believed the students had most

of the blame, but a much larger share – 42% said society itself has a role in how the students think about authorship. Students, therefore, view cultural and structural factors as major reasons for unethical behavior in relation to academic behavior. Other interesting responses included the internet (8%), AI itself (6%) and even nobody at all (10%). Fewer than 6% of students (4%) found professors, (2%) colleagues, (1%) the university responsible. This is an interesting and critical finding, but also a revealing one because it means students do not necessarily feel they share responsibility for what they decide to do. When students take the blame of plagiarizing to others, the strategy to preventing such act may need to include something more than student behavior. An examination of this phenomenon uncovered some large divergences in students' perspectives on who to blame for plagiarism. On the contrary, Group 2 (students who attributed the blame to professors) had the highest mean acceptance of AI-generated text ($M=4.00$, $SD=1.41$), whereas Group 3 (students who blamed peers or colleagues) had the lowest average acceptance level ($M=1.50$, $SD=0.71$). In Group 1 students attributed blame on themselves ($M=2.92$) and in Group 5 students to society ($M=2.80$) respectively giving them a relatively small perspective. By using statistical significance of ($p=.038$), another interesting relationship to the effect scale was observed between students' experience of getting caught plagiarizing and their assignment of blame. The results indicated that the most common blame attribution among students that had been caught plagiarizing was the students themselves; however, students who did not get caught showed a wider range of blame attribution. Identifying these patterns indicates that students' moral reasoning and accountability might influence their attribution of blame and their views about the role of AI in academic work. The good news: over 50% of the students (52%) said they had never plagiarized, while 41% reported plagiarizing without being caught and 7% admitted they plagiarized and being caught. To explore this in more detail, the authors asked the students when using ChatGPT constitutes plagiarism, and most students (65%) said it is when text is copied without changing it and without saying that the tool was used. This shows that most students know that AI-generated content that is not credited or edited goes against academic integrity standards. A smaller group (19%) thought that using ChatGPT for ideas or to help with structure, even if you made changes, could still be considered plagiarism. Intriguingly enough, 13% respondents believe that using ChatGPT is never to be thought of as a form of plagiarism because the tool is not a traditional type of author. This paints the landscape of the current state of mind among the respondents and controversy of

using AI tools, which clarifies that there is still big moral grey area around AI authorship. Finally, 32% of students believe that whether using ChatGPT counts as cheating depends on the rules defined by the course, professor, or university ethics standards. This shows that academic institutions lack the clear, consistent and precise guides for usage of AI tools, to which 63% of students agreed.

Finally, students were asked about their use of ChatGPT in environmental courses (e.g., LCA, eco-design, circular economy, ESG). The most common uses were explaining key concepts and terminology (64%), exchanging topics and ideas for projects (56%), and summarising scientific articles or reports (52%). These responses show that properly targeting student use within a course allows students to perceive AI as a tool to support learning, especially for understanding complex content and working with literature, and not just as a writing tool.

4 Conclusion

“May not machines carry out something which ought to be described as thinking but which is very different from what a man does?”

—Alan Turing

The conducted research showed that students have a wide range of opinions and behaviors when it comes to plagiarism and the use of AI in their education. For example, more than half of the surveyed students claimed that they had never plagiarized, but a large number of them (41%) admitted that they had plagiarized, but that no one had caught them. This speaks in favor of the presence of academic dishonesty that is not registered, which shows the need to strengthen institutional monitoring and support mechanisms.

Today's time is certainly characterized by the raising of AI, which has become a powerful and easily accessible tool, but the results of the presented research clearly indicate the necessity of developing institutional frameworks and guidelines for the adequate use of AI. This “management of the use of AI” will also result in responsible AI practices that imply a culture of academic integrity.

As generative AI tools like ChatGPT are used more and more in higher education, not only regulatory or technical issues arise, but also much more sophisticated ones related to creative processes and the right of authorship in cases when AI helps in the process of creating a task, essay, or work. In other words, if the text is made by a machine, can the student call it his original author's work? And perhaps the most important of all questions, how to teach students to be honest and adhere to academic integrity when the border between AI-generated text and human-generated text is getting smaller and smaller? The results of the presented research show that the current perception of students about the use of AI in education, as well as their behavior when using AI, represent the basis for further research.

Future research should include how students perceive responsibility in their joint work with AI, and how social and institutional norms affect their personal ethical principles. To this should be added the research of possible ways in which educational systems can promote critical AI literacy, i.e. “a set of competencies that enables individuals to critically evaluate AI technologies; communicate and collaborate effectively with AI; and use AI as a tool at home and in the workplace” (Kentz, 2025) while maintaining innovation and integrity.

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LEGAL AND ETHICAL ASPECTS OF THE UNWTO'S GLOBAL CODE OF ETHICS FOR TOURISM (1999)

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The UNWTO's Global Code of Ethics for Tourism (GCET) was adopted in 1999 as an international legal act (in 10 articles), more precisely a set of ethical principles on which, as a response to all the negative impacts of tourism, modern tourism should be based in the conditions of economic, social and cultural globalization. Today, the significance of the principles of the Code for world tourism is stronger and more relevant than ever before. The Code establishes a frame of reference for the sustainable and socially responsible development of world tourism. The Code, however, does not solve all the current problems of a legal (application and implementation of the principles) and ethical (sustainable development and social responsibility in tourism) nature in a global society. The results of the work are interdisciplinary understandings of the need to strengthen the guidelines of the Code in seven different legal, economical and ethical directions.

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1 Introduction

The UNWTO's Global Code of Ethics for Tourism (GCET) was adopted by the UNWTO in 1999 (the UN adopted a resolution on the Code in 2001) as an international legal act (in 10 articles), more precisely a set of ethical principles on which, as a response to all the negative impacts of tourism, modern tourism should be based in the conditions of economic, social and cultural globalization.

More than 26 years after its adoption, the significance of the principles of the Code for world tourism is stronger and more relevant than ever. The Code establishes a **frame** of reference for the sustainable and socially responsible development of world tourism. It is a continuation of many (similar) international legal acts, principles, declarations and codes, giving them contemporary thinking (e.g. reducing the negative impacts of tourism on the environment and cultural heritage, benefits for tourist destinations in terms of local community development, environmental conservation, changing demographic trends, social well-being of citizens and improving the living standards of residents, limiting capacity in tourist-saturated areas, creating a favorable public opinion or tourist image of a country, region or place, the right to rest, freedom of movement and promoting a fair, responsible and sustainable world tourism order that will benefit all sectors of society.)

The Code, however, due to its specific nature, does not solve all the current problems of a legal (application and implementation of the principles of the Code) and ethical (sustainable development and social responsibility in tourism) nature in global society. From a legal perspective, the Code is not a legally binding but a voluntary legal act to which UNWTO members can accede if they wish/agree to do so. Ethically, the UNWTO is hesitant to consider most of the problems that could threaten the liberal development of tourism, is primarily dedicated to the promotion of tourism rather than the issue of sustainable tourism development and serves the interests of the tourism industry more than the rights of the "subordinates", so the "ethical tourism" is still more of a theoretical proposition than a practicable reality.

The paper is divided into five chapters, where, along with an introduction and conclusion, the content of the Code principles, its legal effects (application and implementation of the Code) and ethical aspects (sustainable tourism development, socially responsible tourism) are analyzed.

2 The Adoption and Content of the UNWTO's GCET

In the 1990's, awareness of the harmful impacts of tourism increased and within the UNWTO (UN Tourism)¹ an idea was proposed to adopt a code of ethics that would help reduce the negative impacts of tourism on the environment and cultural heritage while maximizing its benefits for residents in tourist destinations.² This was the result of the global understanding that tourism in a certain area, region or country, in addition to economic goals, has other goals relating to the interests of the wider community. UNWTO, as the UN's specialized agency for tourism, aims to ensure that member countries, tourist destinations and the business sector maximize the positive economic, social and cultural effects of tourism, while minimizing its negative social and environmental impacts. With this designation, UNWTO then placed itself in the central role of promoting ethical principles and finding ways to implement them in business practice, and as a central place for dialogue on these issues, which is in line with the goals of the modern economy as well as establishing relationships with various stakeholders in society.³

In response to all the negative impacts of tourism, the need for a global code of ethics was recognized and such a proposal was formally put forward in a resolution by the UNWTO General Assembly in 1997. Over the next two years, a special committee was formed to prepare the Code, and a draft document was prepared by the General Secretariat in consultation with the Business Council, the Regional Commissions and the Executive Council of the UNWTO. The UN Committee on Sustainable Development endorsed the concept of the Code and requested the UNWTO to seek further comments from the private sector, civil society organizations and workers' organizations. Written comments on the text of the Code were received from more than 70 UNWTO Member States and other bodies, which ultimately resulted in the current Code with its introductory chapters and ten articles. The Code was adopted by a unanimous adoption of resolution A/RES/406(XIII) at the session of the UNWTO General Assembly in Santiago held in October 1999.

¹ The United Nations World Tourism Organization or UN Tourism (formerly UNWTO) is a specialized agency of the UN which promotes responsible, sustainable and universally-accessible tourism and only intergovernmental organization that serves as a global forum for tourism policy issues and a practical source of tourism know-how. Its membership includes 160 Member States, 6 Associate Members, 2 Observers, and more than 500 Affiliate Members representing the private sector, education institutions, tourism associations and local tourism authorities.

² Senečić, J., Vukonić, B. (1997). *Marketing u turizmu*. Mikrorad, Zagreb, Croatia, 41.

³ Moon, C., Bonny, C., ed. (2001). *Business Ethics: Facing up to the Issues*, The Economist Books, published in: Clarke, A., Chen, W. (2007). *International Hospitality Management*. Elsevier, 305.

In 2001, ECOSOC⁴ adopted a draft resolution of the Code and called on the UN General Assembly to adopt the Code, and the official adoption of the Code by the UN was achieved on 21 December 2001 through resolution A/RES/56/212, which further encouraged the UNWTO to promote effective implementation of the Code.

The GCET represents the first serious attempt at a comprehensive codification of the basic ethical principles on which modern tourism should be based under the current conditions of globalization.⁵ In clear and concise formulations, the world's highest tourism forum has accepted the concept of sustainable tourism development and argued its social, ecological and economic dimensions. Although it differs on the opinions, interests⁶ and positions regarding the content and contribution of the Code to the ethical business of the international tourism industry, the Code is to this day actually the only legal act at the highest⁷ level of international law in tourism.

The Code's text contains ten articles of the rights and obligations of participants in the tourism process (public authorities, professional service providers, local populations and tourists themselves), and in particular emphasizes all the important functions of tourism as a factor of international peace and understanding, education, culture, national and regional development and so on: 1. Tourism's contribution to mutual understanding and respect between peoples and societies (article 1.), 2. Tourism as a vehicle for individual and collective fulfilment (article 2.), 3. Tourism, a factor of sustainable development (article 3.), 4. Tourism, a user of the cultural heritage of mankind and a contributor to its enhancement (article 4.), 5. Tourism, a beneficial activity for host countries and communities (article 5.), 6. Obligations of stakeholders in tourism development (article 6.), 7. Right to tourism (article 7.), 8. Liberty of tourist movements (article 8.), 9. Rights of the workers and entrepreneurs in the tourism industry (article 9.) and 10. Implementation of the principles of the Global Code of Ethics for Tourism (article 10.)

⁴ The United Nations Economic and Social Council.

⁵ Hitrec, T. (2001). Globalni etički kodeks za turizam, Turizam, Vol. 49, No. 1., IZT, Zagreb, 91.

⁶ Tomljenović, R., Boranić Živoder, M., Marušić, Z. (2013). Podrška interesnih skupina razvoju turizma. Acta Turistica, Vol. 25. No. 1., 73-102.

⁷ The process of "transforming" the GCET into a binding international convention has, admittedly, already been "attempted" with the adoption of the UNWTO's Framework Convention on Tourism Ethics (2020), but has not yet been ratified (10 ratifications are required yet only one has been achieved).

3 Legal aspects and effects of the GCET

Although the GCET is apparently only the act of an international organization that applies (and even optionally) only to its members, its legal significance is much broader. Analyzing the legal aspects arising from it and the effects it has on international law and national laws, three important questions arise: 1. What is the GCET source of law and what is its legal force? 2. To whom does the GCET apply? 3. What is the (direct and indirect) impact of the GCET on international law and national laws?

3.1 The GCET as a source of law

The GCET is the act of an international organization (UNWTO - UN Tourism) and as such can be considered as a source of law only for this organization and its members. The GCET, however, by its very nature, represents and establishes a frame of reference for the responsible and sustainable development of world tourism and builds on many similar declarations, conventions and codes, adding new thinking that reflects changes in contemporary society.

The preamble to the resolution on the adoption of the Code explicitly mentions it, among other things, as a frame of reference, the legal instruments of which the GCET, as a source of law in the field of tourism, is a kind of successor: 1. Universal Declaration of Human Rights (1948)⁸; 2. International Covenant on Economic, Social and Cultural Rights (1966); 3. International Covenant on Civil and Political Rights (1966); 4. Warsaw Convention on Air Transport (1929); 5. Chicago Convention on International Civil Aviation (1944), and the Tokyo, The Hague and Montreal Conventions in relation thereto; 6. Convention on Customs Facilities for Tourism (1954) and related Protocol; 7. Convention concerning the Protection of the World Cultural and Natural Heritage (1972); 8. Manila Declaration on World Tourism (1980); 9. Resolution of the Sixth General Assembly of WTO (Sofia)

⁸ For example, the right to travel and tourism is incorporated into key international documents, and the Universal Declaration of Human Rights, in article 13.2, explicitly states that "Everyone has the right to leave any country, including his own, and to return to it". In conjunction with article 24, which states: "Everyone has the right to rest and leisure, including reasonable limitation of working hours and periodic holidays with pay", this important international document is credited with placing travel and tourism within the scope of human rights. Garbutt, R. ed. (2008) *Activating Human Rights and Peace: Universal Responsibility Conference*, published in: Higgins-Desbiolles, F.; Blanchard L. (2010). *Tourism in the context of human rights, justice and peace*. Australia Southern Cross University.

adopting the Tourism Bill of Rights and Tourist Code (1985); 10. Convention on the Rights of the Child (1989); 11. Resolution of the Ninth General Assembly of WTO (Buenos Aires) concerning in particular travel facilitation and the safety and security of tourists (1991); 12. Rio Declaration on the Environment and Development (1992); 13. General Agreement on Trade in Services (1994); 14. Convention on Biodiversity (1995); 15. Resolution of the Eleventh General Assembly of WTO (Cairo) on the prevention of organized sex tourism (1995); 16. Stockholm Declaration against the Commercial Sexual Exploitation of Children (1996); 17. Manila Declaration on the Social Impact of Tourism (1997) and 18. Conventions and recommendations adopted by the International Labour Organisation in the area of collective conventions, prohibition of forced labour and child labour, defence of the rights of indigenous peoples, and equal treatment and nondiscrimination in the work place.

3.2 Legal application, implementation and dispute resolution of the GCET

Article 10. of the GCET (Implementation of the principles of the Global Code of Ethics for Tourism) states the need for the cooperation of all stakeholders in tourism development in the implementation of the principles of the code, from which follows that the provisions of the GCET are applied voluntarily if UNWTO members decide to do so (e.g. if a UNWTO member state wants to introduce the provisions of the code into national law), and the World Committee on Tourism Ethics is appointed as the body for resolving disputes and interpreting and applying the Code. Since the Code is not a legally binding document, this article foresees the possibility of a mechanism for voluntary implementation by recognizing the role of the Committee to which all stakeholders can report, on a voluntary basis, everything related to the application and interpretation of the Code.

The Protocol on the Implementation of the GCET was proposed at the UNWTO General Assembly in 2001, and Part I of the Implementation Protocol was adopted, which enabled the conditions for the establishment and framework of the Committee. Part II of the Protocol, which relates to the dispute settlement mechanism, was adopted at the General Assembly in 2005. Regarding dispute settlement, the Protocol stipulates that in the event of a dispute, the parties shall address the Committee as the competent body for dispute settlement.

At the regular session, the Committee considers and approves recommendations to the parties regarding the resolution of the case, and possibly establishes a three-member panel to draft recommendations. The Committee also decides on the deadline for fulfilling the issued recommendations. The contents of the decision on implementation and conclusions are published through a press release. Regarding the content of the Code, the Committee may issue clarifications or advisory opinions. When considering disputes, the Committee follows the guidelines for considering disputes, where the important decision is that the Committee will not consider disputes that have not been jointly submitted by all involved parties. However, it was decided that questions concerning the general application of ethical principles in tourism can be submitted unilaterally.⁹

The first session of the Committee was held in Rome in 2004. The Committee was established as an independent and impartial body composed of eminent persons. The members are elected by the UNWTO Regional Commissions and the Business and Education Council, and are confirmed by the UNWTO General Assembly. The main tasks of the Committee are to promote and disseminate the Code, to evaluate and monitor the implementation of the Code, and to mediate and conciliate in resolving differences concerning the application or interpretation of the Code.

As a priority in its activities, the Committee highlights the exploitation of people, especially children, sustainable development in tourism, freedom of movement of travelers, ensuring effective rights of travelers, fair business in the tourism industry, training of personnel and the continuous implementation of the principles of the Code as a basis for a better understanding of people and nations and a strong contribution to the idea of peace. In 2008, the Committee introduced its permanent Secretariat, which provides technical and expert support to the Committee, especially in the promotion and application of the Code. To this day, the Secretariat monitors the ethical aspects of important issues in tourism such as facilitating tourist travel, travel restrictions related to HIV or COVID, campaign on the protection of children from exploitation in tourism, a call on authorities and employers in tourism that will limit job losses, a call on states not to introduce restrictions on travel, which could threaten employment and the economy of many countries, etc.

⁹ Faure, M.G., I Made Budi, A. (2015). Settling Disputes in the Tourism Industry: The GCET and the World Committee on Tourism Ethics, Santa Clara J. Int'l L., 375-415.

3.3 The impact of the GCET on international law and national laws

The GCET, by its legal nature, is neither an international convention nor a binding act for member states, but it nevertheless represents (pioneering) principles of international law in tourism¹⁰ and has a major indirect influence (like EU recommendations, for example) when implementing the same principles into national laws. UNWTO (UN Tourism) also annually calls on all states and the tourism private sector to integrate the principles of the Code into their legislation, professional practice and codes of conduct.¹¹

In addition to the role of providing guidance to the national legislation of the member countries, the Code is also intended for membered associations, which should introduce it into internal regulations and implement it in practice. In the principles of the Code, the aspiration to introduce a different global business policy is visible, which would eventually represent a new instrument of international law, and not just ethical guidelines of desirable behavior.¹²

However, there is the impression that the legal position of the GCET in international law should be strengthened. The directions of this strengthening should be: 1) strengthen the guidelines of the Code by binding implementation (first attempt of adoption of the Framework Convention on Tourism Ethics (2020) has not provided results as yet) of the global principles of the Code into new international, EU and national acts, regulations and codes, 2) the adoption of national tourism strategies based on the principles of the Code, 3) raising the legal nature of the current or future Code to a legally binding and not only a voluntary instrument of law and 4) protecting the right to travel as a basic human right of international law.

¹⁰ Esenova, A.E., Ermukhamedov, A.B. (2025). The Role of International Organizations (UN, WTO, UNWTO) in the Formation of the Legal Regime of Tourism. *Universal Science Perspectives International Scientific Practical Journal*, Vol. 1., No. 1., 1-6.

¹¹ In the first 10 years since the adoption of the GCET (1999-2009), 49 countries have adopted the principles of the Code into their legal texts, while 48 countries have used the same principles as a basis for establishing national laws and regulations or for establishing policies and master plans towards sustainable and responsible tourism development. Today, this number exceeds 100 member countries. Most countries have included relevant regulations in contractual instruments, specific codes of conduct or professional rules. One of the most significant actions related to the dissemination of the Code is its translation into 43 national or local languages, which has facilitated its distribution among various tourism stakeholders.

¹² Hitrec, op. cit.

4 Ethical aspects of the GCET

The ethical aspects arising from the GCET can be summarized in two major parts: 1) The Code is an attempt to create a balance between economic gains from tourism and the protection of all participants (states, legal and natural persons) and non-economic goods (environment, ecology, cultural heritage) used for tourism purposes and 2) The Code attempts to address the two largest ethical aspects of modern tourism: 1. sustainable tourism development and 2. social responsibility in tourism.

In the modern tourism industry, new concepts of "sustainable tourism", "moral tourism", "tourism ethics", "visitor nature", "green tourism", "responsible tourism", "people-oriented tourism" and "parallel tourism" are used. The Code's preamble establishes as a basic premise the right to tourism and the freedom of movement of tourists, and the desire to promote a fair, responsible and sustainable world tourism order from which all sectors of society will benefit, but it is specifically noted that this is *"...in the context of an open and liberalized international economy"*. A justifiable critique is that the purpose of adopting a Code is primarily in the function of the tourism industry and not the well-being of all stakeholders involved in tourism activities. Theorists, therefore, have divided views on the ethical aspects of GCET.

First¹³ have noticed that the decisions of the UNWTO are strongly influenced by the business tourism sector and seems indecisive considering most of the problems that could threaten the liberal development of tourism, which is logical for an institution whose activity is primarily dedicated to the promotion of tourism, and from that perspective it does not appear an organization with the greatest credibility for considering the implications of sustainable tourism development. The ethics of the Code is ostensibly shown in its statements regarding the right to rest and leisure, the right to freedom of travel, the impact of tourism on local communities and social rights of workers in tourism, but there is no mention of the relationship between developed and underdeveloped countries, sharing of benefits arising from tourism, limitation of capacity in saturated areas, impact of tourism on climate change, the promotion of ecological modes of transport (e.g. the use of trains compared to airplanes) or promoting longer holidays compared to more shorter ones.

¹³ Dubois, G. (2010). Codes of conduct, charters of ethics and international declarations for a sustainable development of tourism, published on web hrlibrary.umn.edu/business/ttra.PDF, 1-23.

Second¹⁴ think that the Code in its current form is essentially a document that serves the interests of the tourism industry while ignoring the rights of the marginalized and oppressed. The Code attempts to legitimize the economic exploitation implied by the market-oriented policies of liberalization and globalization, and the solution would be to embody the ideals supported by civil society organizations. The Code has not resolved the conflicts over resources and cultural practices resulting from the increased influx of tourists to previously relatively peaceful parts of the world. Responsible and sustainable tourism is not incompatible with increasing liberalization and it is possible to reconcile the economy and ecology, openness to international trade and the protection of social and cultural identities, so it is good that the Code is a reference point for discussions on a wide range of issues related to tourism (sustainable development, justice and the protection of local cultures).

Third¹⁵ believe that the Code is a comprehensive set of principles intended to guide stakeholders in tourism development. A problem is also the process of becoming aware of the Code's existence and its implementation. There is also the question of the alternative of establishing codes of ethics by company or sector as opposed to a single global code of ethics, which could be more beneficial for the tourism industry.

Fourth¹⁶ argue that ethical tourism is in the best interests of all involved. It offers tour operators a competitive advantage and safeguards the future of the industry by ensuring the long-term sustainability of the destination. It offers tourists a rich experience, as holidays are planned according to the specific characteristics of the destination. It is also in the interests of those living or working in these destinations, as it can help combat poverty and contribute to sustainable development.

In conclusion, although the issues related to social and environmental impacts are recognized in the Code, the main problems in practice remain corruption, political problems, state intervention, customs clearance, transfer of funds and differences in business practices. Until these issues are fully articulated, the Code will not be able to eliminate many of the problems that plague the tourism industry.¹⁷

¹⁴ Sreekumar, T. T (2003). Why We Need an Alternative Code of Ethics for Tourism.. *Contours*, Vol. 13. No. 1. Hong Kong, 15-17.

¹⁵ Sheppard, A. V. (2005). *Ethics, Tourists and Environmental Practices*. Master thesis, JIBC, 41.

¹⁶ Donyadide, A. (2010). *Ethics in tourism*. *European Journal of Social Sciences*, Vol. 17. No. 3., 426-433.

¹⁷ Fennel, D. (2006). *Tourism Ethics*. Channel View Publications, 253.

4.1 Sustainable tourism development

Sustainable tourism represents the development of sensitive tourism in a region that is able to protect the social and environmental context for the next generations while achieving a long-term return on investment through tourism. However, despite new monitoring systems¹⁸, what usually occurs is a focus almost exclusively on the environment and the economy, putting the social and cultural in a subordinate role.¹⁹

GCET contains five paragraphs on sustainable tourism (article 3.): 1. safeguard the natural environment with a view to achieving sound, continuous and sustainable economic growth; 2. saving rare and precious resources, in particular water and energy and avoiding so far as possible waste production; 3. reduce the pressure of tourism activity on the environment and enhance its beneficial impact on the tourism industry and the local economy; 4. tourism infrastructure and activities designed and programmed as protection of natural heritage composed of ecosystems and biodiversity and 5. recognition of the value of nature tourism and ecotourism.

Data from UN Tourism for the year 2025²⁰ show that the number of realized tourist trips in the entire world was about 1.52 billions (4% more compared to 2024) and the total income from tourism amounted to about 1.9 trillion US\$ (5% more compared to 2024). The tourism industry has increasing financial strength, so a shift towards sustainability in conditions of general competition can only happen if the pressure comes from the sphere of tourist demand, which will be moved to those areas that care more about cultural and ecological protection and social connection. Free time and rest days in modern society are of great importance and should not be viewed exclusively as entertainment. Those forms of tourism that bring the most benefits to all participants should be developed and improved without being associated with unpleasant consequences, primarily ecological and social.²¹

¹⁸ Marković Vukadin, I., Krešić, D. (2020). Pregled i evaluacija postojećih međunarodnih sustava pokazatelja održivosti turizma. *Hrvatski geografski glasnik*, Vol. 82, No. 1, 85-110.

¹⁹ Clarke, A., Chen, W. (2007). *International Hospitality Management*. Elsevier, 298.; introducing a new hotel to the market can have a direct impact on local employment, but adopting a local procurement policy can have more far-reaching impacts as engaging local artists and artisans in the hotel, combined with offering local food and drink and promoting local music and dance performances can help develop a stronger sense of local identity. This is an added benefit for locals, but it also benefits tourists as more and more visitors seem to be looking for a "sense of place".

²⁰ UN Tourism (2026). *World Tourism Barometer*, Volume 24, Issue 1, January 2026, 3-4.

²¹ Vujić, V. (2021). *Održivi razvoj turizma*. Fakultet za turistički i hotelski menadžment, Opatija.

4.2 Social responsibility in tourism

GCET does not have a separate article on social responsibility in tourism, but the aforementioned concept emerges from almost every provision in it. The "message" of the Code is or at least should be that the tourism industry can regroup and strengthen peace and tolerance, promote development, create new jobs, stabilize society and eradicate abuses that can infiltrate society through tourism.

New concepts in tourism business have expanded from the purely economic and financial to the social and environmental sphere. Some scholars²² predict that the opportunity to create economic value by creating social value will be one of the most powerful forces driving growth and the global economy. Companies will make huge strides in environmental protection when they treat it as an incentive for productivity and not just a satisfactory response to external pressure. Others²³ point out that sustainability can be analyzed from the point of view of its three interconnected components - economic, environmental and social, but now in relation to business analysis, and not only to the ethical. Third ones²⁴ point to numerous changes in the world economy that have led many large international organizations to adopt ethical practices: they emphasize in particular that technological innovation, globalization, the importance of intangible assets, competition for talent and the growing use of economic networks are leading to changes towards the adoption of ethical practices.

Finally, although we are still far from ethical tourism on a global level (the tourism industry still creates ecological and social pressure on attractive destinations for profit), the issues that are resolved through the principles of the Code are gaining more importance in the world of tourism and no longer fall exclusively under the domain of creating a favorable image, but have their real economic basis through achieving a competitive advantage in the global market. From all presented here, the conclusion follows that the sustainability of tourism in the modern world is largely determined by the ethical prerequisites on which it currently (does not) rest.

²² Porter, M., Kramer, M. (2011). The Big Idea: Creating Shared Value. *Harvard Business Review*, Vol. 89, No. 1-2, 62-77.

²³ Smajlović, S. (2023). Budućnost turizma. *Tranzicija*, Vol. 25, N. 51, 115; Clarke, Chen, op. cit., 306.

²⁴ Moon, C., Bonny, C., ed. (2001). Business Ethics, *The Economist Books*; Buzar, S. (2015). An Analysis of the Global Code of Ethics for Tourism in the Context of Corporate Social Responsibility. *Acta Economica Et Turistica*, Vol. 1., No. 1., 41-57.

5 Conclusion

The GCET (1999) is an act of an international organization (UNWTO - UN Tourism) and as such can be considered as a voluntarily source of law only for that organization and its members (160 Member States, 6 Associate Members, 2 Observers, and more than 500 Affiliate Members representing the private sector, education institutions, tourism associations and local tourism authorities). It also represents and establishes a frame of reference with a set of international law principles for the responsible and sustainable development of world tourism and builds on many similar declarations, conventions and codes, adding new thinking that reflects changes in contemporary society.

From the standpoint of the legal aspects arising from GCET and legal effects it has on international law and national laws, three important conclusions arise: 1. that GCET is an international source of law with clear principles for implementation, 2. that GCET be applied to its members (and even then only voluntarily) but has a great indirect effect in national laws and 3. that World Committee on Tourism Ethics, appointed as the body for resolving disputes and interpreting and applying the Code, provides a certain legal "seriousness" to the code.

The ethical aspects arising from the GCET can be summarized in two major parts: 1) The Code is an attempt to create a balance between economic gains from tourism and the protection of all participants (states, legal and natural persons) and non-economic goods (environment, ecology, cultural heritage) used for tourism purposes and 2) The Code attempts to address the two largest ethical aspects of modern tourism: 1. sustainable tourism development and 2. social responsibility in tourism.

Although more than 26 years have passed since the adoption of the Code, the principles on which it is based have not yet been fully accepted and implemented by all stakeholders in international tourism. The concepts of business ethics, corporate social responsibility and, more recently, shared values are gaining more space and declarative significance, but they still do not have a widely accepted practical application. Although all business entities declare their support for the implementation of all the Codes' principles, there is widespread distrust, especially from civil society organizations, that this is an act of a formal nature only, while a true and sincere understanding and implementation of such principles is still rare.

The main results of the work are interdisciplinary understandings of the need to strengthen the guidelines of the Code by binding implementation of the global principles of the Code into new international (UNWTO's Framework Convention on Tourism Ethics from 2020 is a first timid attempt), EU and national acts, regulations and codes (1), the adoption of national tourism strategies based on the principles of the Code (2), raising the legal nature of the current or future Code to a legally binding and not only a voluntary instrument of law (3), equating the desire to achieve economic profit with the benefits that tourism brings on a social and environmental level (4), suppressing discrimination of the developed over the underdeveloped world (5), that the sustainability of tourism in the modern world must be determined by the ethical preconditions on which it currently (does not) rest (6) and that the right to travel is a basic human right of the international law (7).

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DESETA OBLETNICA eZDRAVJA NA NACIONALNEM INŠTITUTU ZA JAVNO ZDRAVJE

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Nacionalni inštitut za javno zdravje je leta 2015 prevzel v upravljanje rešitve projekta eZdravje. Od takrat se storitve eZdravja stalno nadgrajujejo in razvijajo. Obseg njihove uporabe se širi, povečujeta pa se tudi obseg dostopnih vsebin in funkcionalnosti za paciente ter zdravstvene delavce. Kljub izzivom, s katerimi se NIJZ spoprijema pri nacionalni uvedbi inovativnih rešitev, je bila uvedba rešitev uspešna, saj so storitve eZdravja danes nepogrešljiva podpora izvajalcem zdravstvene dejavnosti in omogočajo elektronski dostop do zdravstvenih podatkov za celotno populacijo. Največji dosežek slovenskega eZdravja je popolna pokritost populacije, kar je eden redkih primerov v svetu. V prispevku opisujemo značilnosti in dosežke rešitev eZdravja: eRecept, portal za paciente zVEM, zVEM+, eNaročanje, CRPP, evidence uporabnikov eZdravja, Teleradiologija in TeleKap. Prikazujemo tudi podatke o njihovi uporabi.

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TENTH ANNIVERSARY OF eHEALTH AT THE NATIONAL INSTITUTE OF PUBLIC HEALTH

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In 2015, the National Institute of Public Health of the Republic of Slovenia (NIJZ) assumed responsibility for managing the solutions of eHealth project. Since then, eHealth services have undergone continuous upgrades and enhancements. The scope of their usage has steadily expanded, along with the range of content and functionalities available to both patients and healthcare professionals. Despite the challenges NIJZ faced in introducing innovative solutions at the national level, the services have been successfully implemented. Today, these eHealth services play a crucial role in supporting healthcare providers and facilitating electronic access to health records for the entire population. The most significant achievement of the Slovenian eHealth is its full population coverage, representing one of the few rare examples worldwide. This paper describes the main characteristics and achievements of the eHealth solutions, including ePrescription, the zVEM patient portal, the zVEM+ healthcare professionals portal, eAppointment, the Central Registry of Patient Data, the eHealth Users Database, Teleradiology and TeleStroke. In addition, it presents data illustrating their usage.



University of Maribor Press

1 Uvod

Projekt eZdravje se je začel leta 2008 in je trajal do novembra 2015. Osnovan je bil na dokumentu e-Zdravje2010 – Strategija informatizacije slovenskega zdravstvenega sistema 2005–2010, ki ga je leta 2005 izdala Projektna enota Centra informatike v zdravstvu pri Ministrstvu za zdravje Republike Slovenije. Projekt eZdravje je predstavljal enega večjih projektov informatizacije javnih storitev v Sloveniji. Vodilo ga je Ministrstvo za zdravje Republike Slovenije ob sofinanciranju Evropskega socialnega sklada. Nacionalni inštitut za javno zdravje (NIJZ) je 1. decembra 2015 prevzel v upravljanje rešitve projekta eZdravje, sredstva za vzdrževanje in nadaljnji razvoj pa zagotavlja Ministrstvo za zdravje. Od takrat se storitve eZdravja stalno nadgrajujejo in razvijajo. Obseg njihove uporabe se širi, povečujeta se tudi obseg dostopnih vsebin in funkcionalnosti za paciente ter zdravstvene delavce. Vse rešitve eZdravja delujejo na nacionalni ravni, kar pomeni, da so vanje vključeni vsi izvajalci zdravstvene dejavnosti v Sloveniji. Pomembni izhodišči za uspešno delovanje sta Zakon o zbirkah podatkov s področja zdravstvenega varstva – ZZPPZ ("Zakon o zbirkah podatkov s področja zdravstvenega varstva (ZZPPZ)," 2018) in številka kartice zdravstvenega zavarovanja (KZZ številka), ki zagotavlja enolični identifikator pacientov v vseh zdravstvenih zbirkah.

Kljub izzivom, s katerimi se NIJZ spoprijema pri nacionalni uvedbi inovativnih rešitev, lahko rečemo, da je bila uvedba rešitev uspešna, saj so storitve eZdravja danes nepogrešljiva podpora izvajalcem zdravstvene dejavnosti in omogočajo elektronski dostop do zdravstvenih podatkov za celotno populacijo. Evropska komisija Slovenijo na podlagi indeksa digitalnega gospodarstva in družbe (DESI) 2024 uvršča na visoko osmo mesto pri dostopu do elektronskih zdravstvenih zapisov na ravni EU. Skupna ocena zrelosti na področju eZdravja je 88 %, medtem ko je povprečje držav članic EU 79 % (Commission et al., 2024)

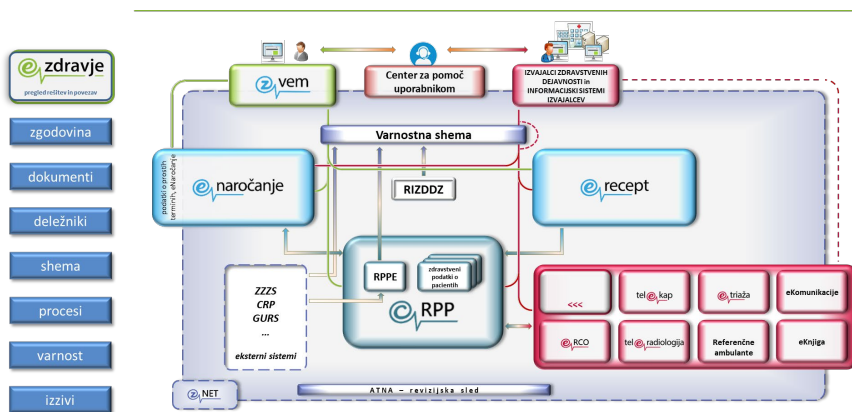
eRecept je prejel nagrado informacijska jagoda za najboljši dosežek na področju informacijske družbe leta 2017. Portal zVEM je prejel nagrado za tekoče dosežke na področju informacijske družbe za leto 2022, mobilna aplikacija zVEM pa eNagrado za leto 2022.

2 Metodologija

V prispevku predstavljamo analizo funkcionalnosti in uporabe rešitev eZdravja ob desetletnici eZdravja na NIJZ. Z raziskavo želimo odgovoriti na vprašanja, kakšne so rešitve eZdravja, raziskati njihov razvoj in uporabo skozi leta. Uporabili smo metodologijo študije primera (Kljajić Borštnar, 2022; Yin, 2018), ki je vključevala poglobljeno študijo področja in njeno analizo. Izvedli smo pregled literature s tega področja (Rant & Rant, 2018; Rant, Kosednar, et al., 2025; Rant & Stanimirović, 2019, 2020, 2021, 2024a, 2024b; Rant et al., 2021, 2022a, 2022b; Rant et al., 2017; Rant et al., 2018; Rant et al., 2019; Rant, Čančarević, et al., 2025; Stanimirović et al., 2022a, 2022b); Kosednar, 2025; Tepej Jočić, L., 2024, Janet, J., & Štupica, E., 2025; Plevnjak, N., Stanimirović, D., 2024). Pregledali smo projektno dokumentacijo, navodila uporabnikom in tehnične specifikacije rešitev. Uporabili smo metodo opazovanja in vključili izkušnje ter strokovno mnenje strokovnjakov na NIJZ, ki upravljajo rešitve eZdravja. Podatki o uporabi so dejanski statistični podatki o uporabi, prejeti iz administratorskega modula rešitve. Analiza funkcionalnosti in uporabe rešitve eRecept je bila izvedena decembra 2025 in januarja 2026. Statistični podatki iz poslovnih in administratorskih modulov so bili pridobljeni decembra 2025.

3 Rezultati in diskusija

3.1 Rešitve eZdravja



Slika 1: Rešitve eZdravja

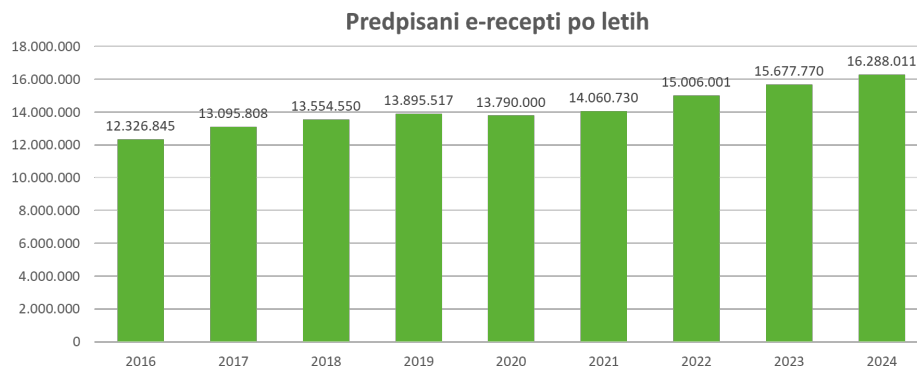
Vir: lasten

V okviru eZdravja deluje dvajset med seboj povezanih rešitev (slika 1).

3.2 eRecept

eRecept je bila prva rešitev eZdravja, ki je bila uvedena na nacionalni ravni. Novembra 2015 je bila uvedena na primarni ravni v celotni Sloveniji, na sekundarni in terciarni ravni pa februarja 2016. Dnevno se uporablja pri izvajalcih zdravstvene dejavnosti in v lekarnah, velik pomen pri dostopnosti pacientov do zdravil je imela tudi med epidemijo covid-19.

eRecept je nacionalna informacijska rešitev za varno elektronsko predpisovanje receptov in elektronsko izdajo zdravil. Elektronski recepti (e-recepti) nastanejo v lokalnih informacijskih sistemih pri izvajalcih zdravstvenih dejavnosti (IZD) in se hranijo v centralni evidenci elektronskih receptov (ERR). EER je vir informacij za lekarne, kjer na podlagi predpisanih e-receptov pacientom izdajo zdravila. Pacient lahko vse te podatke spremlja prek portala za paciente zVEM ("Portal zVEM," 2025). Vidna so predpisana zdravila, kdo in kdaj jih je predpisal, vidne so izdaje zdravil in koliko izdaj je še na voljo pri obnovljivih receptih. Pacient lahko različne izdaje istega recepta dvigne v različnih lekarnah v Sloveniji.



Slika 2: Število predpisanih e-receptov po letih

Vir: lasten

Že v prvem mesecu – december 2015 – je bilo predpisanih 772.217 e-receptov, eRecept je uporabljalo 1275 izvajalcev. Skupno število predpisanih receptov na letni ravni je do leta 2019 naraščalo, med letoma 2019 in 2021 se ni bistveno spreminjalo.

Od leta 2022 zaznavamo porast skupnega števila predpisanih receptov. Leta 2023 je bilo predpisanih že več kot 15.600.000 receptov, leta 2024 pa je število preseglo 16.000.000 (slika 2). eRecept je uporabljalo 1500 izvajalcev zdravstvene dejavnosti; e-recepte so predpisovali v 1109 organizacijah, zdravila pa je izdajalo 360 lekarn.

Cilj eRecepta je bil, da bo 90 % receptov predpisanih elektronsko. Od leta 2020 je več kot 96 % receptov predpisanih elektronsko, leta 2024 je bil ta delež 97 %.

Ravni 100 % zaradi pravil predpisovanja nikoli ne bomo dosegli, saj se papirno predpisujejo nekateri nujni recepti, recepti pri obisku na domu, osebni recepti zdravnikov za lastno uporabo in recepti za zdravila z narkotičnimi in psihotropnimi snovmi (Rant & Stanimirović, 2024a).

Rešitev eRecept je primer dobre prakse digitalizacije zdravstva v Sloveniji. Med epidemijo covid-19 je omogočala nemoten dostop do zdravil, saj je zdravnik lahko predpisal recept za zdravilo na daljavo, pacient pa ga je s svojo kartico zdravstvenega zavarovanja dvignil v kateri koli lekarni v Sloveniji. To kaže tudi uspešna uporaba te rešitve, saj je več kot 97 % receptov predpisanih elektronsko, kar nas uvršča v sam svetovni vrh.

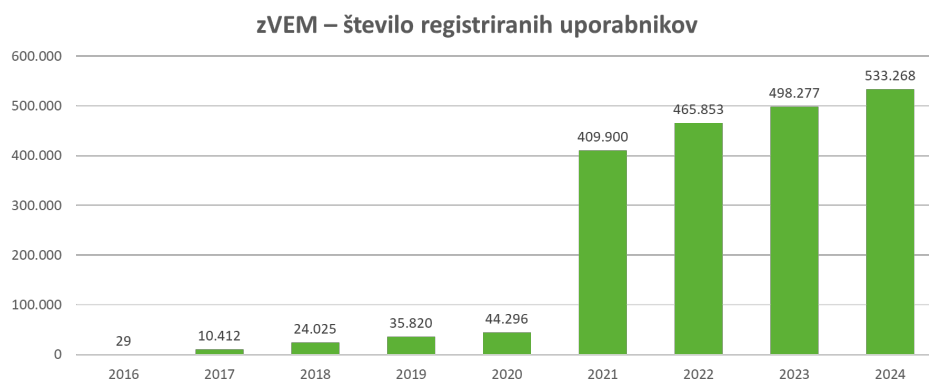
Leta 2024 smo medicinskim sestram dodali možnost vpogleda v e-recepte. Leta 2025 smo uvedli preverjanje zdravil glede prepovedanih snovi za športnike na osnovi Liste prepovedanih snovi in postopkov za športnike, za katero skrbi Slovenska antidoping organizacija (SLOADO). Načrtujemo tudi prilagoditve novim zahtevam, ki jih bodo prinesli predvsem Zakon o spremembah in dopolnitvah Zakona o zdravilih (ZZdr-2), Pravilnik o razvrščanju, predpisovanju in izdajanju zdravil za uporabo v humani medicini ter Zakon o digitalizaciji zdravstva (*Zakon o digitalizaciji zdravstva (ZDigZ)*, 2025)

Uspešna uporaba eRecepta v Sloveniji je povečala zahteve za čezmejno uporabo, kar prinaša nove pravne, uporabniške in funkcionalne zahteve. Razvoj poteka tudi v tej smeri in testna izmenjava s Hrvaško že kaže prve rezultate.

3.3 Portal za paciente zVEM

Pacientom je najbolj znana rešitev spletni portal za paciente zVEM – zdravje vse na enem mestu. Omogoča varen in zanesljiv dostop do podatkov v zbirkah eZdravja in Zavoda za zdravstveno zavarovanje Slovenije (ZZZS) prek ene vstopne točke. Z vidika pacienta je pomemben mejnik v zgodovini slovenskega zdravstva in ena večjih pridobitev v zadnjih desetletjih. Med epidemijo je prevzel pomembno vlogo obveščanja in ozaveščanja prebivalstva.

Dostop do portala zVEM je mogoč z uporabniškim računom nacionalne storitve SI-PASS, s kvalificiranim digitalnim potrdilom SIGEN-CA, mobilno identiteto smsPASS, biometrično osebno izkaznico z uporabo mobilne aplikacije eOsebna oziroma z drugo digitalno identiteto. Rešitev je bila tehnično vzpostavljena ob zaključku projekta eZdravje novembra 2015. Polna uporaba z možnostjo registracije uporabnikov je možna od začetka leta 2017. Mobilna aplikacija zVEM je bila razvita zaradi naraščanja potreb uporabnikov in je v uporabi od julija 2021. Število registriranih uporabnikov je okrog 530.000, od tega v mobilni aplikaciji 360.000. Vsak mesec je zabeleženih okrog 100.000 edinstvenih obiskov.



Slika 3: Število registriranih uporabnikov portala zVEM po letih

Vir: lasten

Portal je doživel velik razvoj med epidemijo covid-19, saj je bila takrat prek portala zVEM vzpostavljena rešitev nacionalnega naročanja na cepljenje, izdajala so se digitalna covidna potrdila in izvajal se je vnos rezultatov testov za covid-19 za

izvajalce brez svojih informacijskih sistemov. Hitrejše rast števila registriranih uporabnikov leta 2021 gre pripisati možnosti izpisa kovidnega potrdila (EU DCP) junija 2021 in nastanku aplikacije zVEM za mobilne telefone julija 2021, saj se je takrat število uporabnikov povečalo za več kot devetkrat (slika 3).

Leta 2025 se je razširil obseg funkcionalnosti in dostopnih vsebin. Omogočeno je obveščanje pacientov s potisnimi obvestili, elektronsko pošto in SMS-sporočili, omogočen je tudi vnos podatkov za stik, ki so predpogoj za obveščanje pacientov in nacionalno uvedbo elektronske komunikacije z ambulantami.

Na portalu so na voljo tudi vsebine ZZZS: potrdila o zadržanosti eBOL in ePODK, podatki o izbranih osebnih zdravnikih, obveznem zavarovanju in zgodovini zavarovanj, stroških zdravil in storitev, medicinskih pripomočkah, denarnih nadomestilih, veljavnosti evropske kartice zdravstvenega zavarovanja ter potrdilih A1.

Pacient lahko za dostop do svojih zdravstvenih podatkov in izvajanje večine storitev na portalu zVEM v svojem imenu pooblasti drugo osebo, ki je digitalno bolj vešča, s čimer se pomembno poveča dostopnost storitev eZdravja za ranljivejše skupine pacientov (Janet, J., & Štupica, E., 2025).

3.4 Nacionalna rešitev zVEM+

Nacionalna rešitev zVEM+ je bila uvedena leta 2021 in je namenjena izključno profesionalnim uporabnikom, tj. uporabnikom pri izvajalcih zdravstvene dejavnosti. Omogoča zajem podatkov in njihovo obdelavo ter oddajo raznih poročil, izvajanje poizvedb po osnovnih demografskih podatkih pacientov, zlasti med epidemijo covida-19 pa sta bili pomembni funkcionalnosti izdajanje digitalnih kovidnih potrdil in vnos rezultatov testov za covid-19 v Centralni register podatkov o pacientih (CRPP). Omogoča tudi informacijski dostop upravljavcu NIJZ za izvajanje javnozdravstvene dejavnosti, npr. tekoče pridobivanje podatkov o umrljivosti (Rant, Stanimirović, & Janet, 2022).

Med najbolj široko uporabljanimi rešitvami zVEM+ je Osebna kartica zdravil (OKZ). Gre za dokument, ki ga pripravljajo farmacevti v aplikaciji zVEM+ oziroma v lekarniških aplikacijah. Pri tem uporabljajo tudi podatke iz eRecepta. Dokument je

enotne oblike in je namenjen pacientom, ki prejemajo večje število zdravil. Vsebuje seznam pacientovih zdravil in navodila za jemanje. Pacientom je OKZ vidna v elektronski obliki na portalu zVEM. OKZ je mogoče izdelati od marca 2023, naši podatki pa kažejo, da število ustvarjenih OKZ vztrajno narašča, kar pomeni, da se rešitev med izvajalci in pacienti vse bolj uporablja (Janet, J., & Štupica, E., 2025).

Portal zVEM+ nudi tudi informacijsko podporo Registru redkih nemalighnih bolezni (RRNB), ki ga upravlja Pediatrična klinika UKC Ljubljana.

Od leta 2025 se zVEM+ uporablja tudi kot komunikacijsko vozlišče za varno elektronsko komunikacijo pacientov s svojimi ambulantami in komunikacijo o pacientu med izbranim osebnim zdravnikom in specialistom. Pacienti lahko prek portala zVEM stopijo v stik s svojim izbranim osebnim zdravnikom, zobozdravnikom, otrokovim pediatrom ali ginekologom. V prihodnje bo omogočena tudi komunikacija z drugimi zdravstvenimi timi, s katerimi je pacient povezan, kot so timi diplomiranih medicinskih sester, patronažne službe in specialistični timi za naročene paciente.

Portal zVEM+ vključuje tudi upravljanje zdravstvenih timov, kar je osnovni pogoj za uvedbo usmerjene komunikacije in drugih naprednih funkcij za člane timov, ki obravnavajo paciente.

3.5 eNaročanje

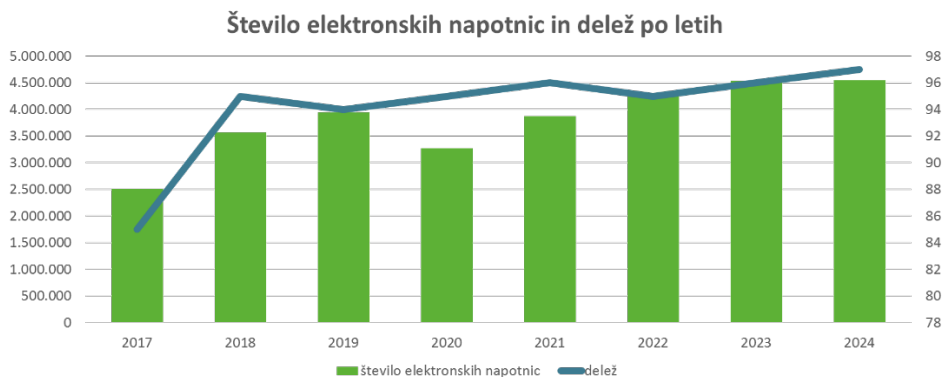
eNaročanje je nacionalni informacijski sistem za elektronsko napotitev in elektronsko naročanje na zdravstvene storitve s primarne na sekundarno in terciarno raven ter znotraj sekundarne in terciarne ravni. Namenjen je tudi spremljanju čakalnih dob in čakalnih seznamov. Rešitev eNaročanje je bila uvedena na nacionalni ravni leta 2016, Ministrstvo za zdravje (MZ) pa je 10. aprila 2017 izenačilo elektronske in papirne napotnice.

Informacijsko rešitev eNaročanje sestavljajo tri komponente: napotovanje, naročanje in čakalne vrste. Zdravnik v svojem lokalnem informacijskem sistemu za napotovanje izdela elektronski dokument e-napotna listina (ki je lahko e-napotnica ali e-delovni nalog). Elektronsko ga podpiše in s tem prenese v centralni sistem

eNaročanja. Naročanje na napoteno zdravstveno storitev se izvede na osnovi e-napotne listine.

Rešitev omogoča elektronsko naročanje prek spleta. Pacienta lahko naroči zdravnik, ki je izdal e-napotnico, medicinska sestra, ali pa ga naročijo na infotočki pri izvajalcu. Pacient se lahko naroči prek portala zVEM, prek portala za e-naročanje ali s pomočjo svetovalca v klicnem centru. Pacient še vedno lahko stopi v neposreden stik z izvajalcem zdravstvene dejavnosti, pri katerem se želi naročiti na izbrano zdravstveno storitev, tako kot je bilo mogoče pred uvedbo rešitve eNaročanje, torej po telefonu, e-pošti, navadni pošti ali osebno, tako da ga na zdravstveno storitev naroči napotni izvajalec (specialist), ki to storitev izvaja.

Rešitev eNaročanje omogoča prikaz čakalnih dob oziroma prvih prostih terminov na vrsto zdravstvenih storitev, kot so določene v šifrantu vrst zdravstvenih storitev (VZS). Čakalne dobe se poročajo za nabor zdravstvenih storitev, v šifrantu različice 18 je takih storitev 2088. Za sporočanje točnih podatkov so odgovorni izvajalci zdravstvene dejavnosti, ki te storitve izvajajo. Centralni sistem prikazuje samo tiste podatke, ki jih sporočajo posamezni izvajalci zdravstvenih dejavnosti (Rant, Kosednar, et al., 2025).



Slika 4: Število in delež e-napotnic po letih

Vir: lasten

V prikaz podatkov o čakalnih dobah je vključenih več kot 2100 vrst zdravstvenih storitev. Neposredno elektronsko naročanje je možno na več kot 700 storitev. Leta 2024 je bilo 97 % napotnih listin elektronskih. Mesečno se izda več kot 400.000 e-napotnih listin in ustvari se več kot 700.000 e-naročil. Od uvedbe sistema eNaročanje je bilo skupaj izdanih več kot 37 milijonov e-napotnih listin, vsaj eno storitev za eNaročanje pa izvaja več kot 1100 izvajalcev.

Leta 2020 in 2021 je opazen padec izdaj e-napotnic, od leta 2020 do 2024 pa število e-napotnic spet narašča in presega 4 milijone letno. Delež e-napotnic med vsemi napotnicami je od leta 2020 vsaj 95 %. Leta 2024 je bilo 97 % napotnic izdanih elektronsko (slika 4).

Ključna prednost eNaročanja je med drugim poenoten/centralni čakalni seznam, v katerega izvajalci v stvarnem času sporočajo podatke o prvih prostih terminih, izvajalci pa so odgovorni za pravilnost podatkov o naročilih. eNaročanje omogoča vpogled v ažurne podatke o prvih prostih terminih, pregled napotnih listin in naročil ter naročanje prek spleta.

Napotnice so od avgusta 2024 veljavne do zaključka zdravljenja, tako da pacient ne potrebuje dodatnih napotnih listin za diagnostiko, kontrole ali posege v okviru istega zdravstvenega stanja in iste vrste dejavnosti.

Potisna obvestila v mobilni aplikaciji zVEM omogočajo, da pacient iz eNaročanja prejema obvestila o izdanih napotnih listinah in terminih, na katere je naročen. Na ta način je pacient pravočasno obveščen o svojih zdravstvenih obravnavah na specialistični ravni, kar zmanjšuje neopravičene izostanke od termina in pomembno vpliva na ozaveščanje o dolžnostih pacienta.

Pravilnik o naročanju in upravljanju čakalnih seznamov ter najdaljših dopustnih čakalnih dobah (Pravilnik o naročanju in upravljanju čakalnih seznamov ter najdaljših dopustnih čakalnih dobah, 2024) prinaša novo definicijo nedopustno čakajočega pacienta (Kosednar, 2024), zato se je spremenila metodologija izračuna nedopustno dolgo čakajočih pacientov, kar je bilo treba implementirati v rešitvi eNaročanje.

V eNaročanju je od 1. septembra 2025 omogočena izdaja in sprejem elektronskega delovnega naloga za fizioterapijo, načrtovana je tudi uvedba delovnih nalogov za druge dejavnosti (patronaža in druge). Z elektronskim delovnim nalogom za fizioterapijo se pacient lahko sam prek spleta naroči k fizioterapevtu, poročajo se prvi prosti termini na fizioterapevtske storitve, urejen je tudi nacionalni čakalni seznam pacientov.

V sklopu eNaročanja je implementirana tudi rešitev ePosvet. To je elektronska komunikacija med zdravstvenimi delavci, natančneje med zdravnikom družinske medicine in zdravnikom specialistom, da zdravnik družinske medicine pridobi mnenje zdravnika specialista na zastavljeno klinično vprašanje. ePosvet je omogočen za vse vrste zdravstvenih dejavnosti.

3.6 Centralni register podatkov o pacientu (CRPP)

Centralni register podatkov o pacientu je enotni sistem za zbiranje in izmenjavo zdravstvenih podatkov o pacientih, ki v Republiki Sloveniji prejmejo zdravstveno oskrbo. Namen CRPP je omogočiti elektronsko izmenjavo zdravstvenih podatkov med izvajalci zdravstvene dejavnosti tako, da so podatki dostopni ob izvajanju zdravstvene obravnave.



Slika 5: Temeljni gradniki CRPP

Vir: lasten

CRPP sestavljajo trije temeljeni sistemski gradniki (slika 5). Register demografskih in statusnih podatkov pacientov vsebuje osnovne osebne podatke, kot so npr. ime, priimek, naslov, podatki o zdravstvenem zavarovanju. Dokumentni sistem vsebuje elektronsko zdravstveno dokumentacijo (npr. dokumenti v formatu pdf ali xml). Baza zdravstvenih podatkov vsebuje strukturirane zdravstvene zapise v obliki, ki je primerna za dostopnost in nadaljnjo rabo podatkov. Dostop do CRPP je omejen s tehničnimi mehanizmi, temelječimi na Pravilniku o pooblastilih za obdelavo podatkov v CRPP. (Pravilniku o pooblastilih za obdelavo podatkov v CRPP, 2025) Izvajalci zdravstvene dejavnosti do CRPP dostopajo prek svojih lokalnih zdravstvenoinformacijskih sistemov ali prek spletne rešitve zVEM+. [5] Podatki iz CRPP se prikazujejo pacientom prek portala zVEM.

Pošiljanje podatkov v CRPP je v skladu z veljavno zakonodajo [1] obvezno za vse izvajalce zdravstvene dejavnosti. Zapisi se vnašajo tekoče. V CRPP se dnevno vnese približno 200.000 novih zdravstvenih zapisov, na mesečni ravni pa približno 5 milijonov. Od začetka delovanja do 31. decembra 2025 je bilo v CRPP na voljo že več kot 330 milijonov dokumentov.

Leta 2023 je bila izvedena tehnološka prenova CRPP, ki omogoča nadaljnji razvoj naprednih digitalnih storitev. Obsežne vsebinske razširitve se obetajo s projektom eKarton, ki se izvaja v okviru Načrta za okrevanje in odpornost (NOO).

3.7 Evidenca uporabnikov eZdravja (EueZ – varnostna shema)

Evidenca uporabnikov eZdravja (EueZ) je centralna avtentikacijska in avtorizacijska storitev za rešitve eZdravja. Trenutno so z EueZ povezane rešitve eZdravja, v kratkem pa bodo povezane tudi rešitve, ki se razvijajo v okviru NOO.

Profil v EueZ ima skoraj 575.000 uporabnikov portala zVEM, celotno število uporabnikov EueZ presega 590.000, poleg tega je vpisanih več kot 2900 aktivnih izvajalcev zdravstvene dejavnosti.

Uporabniki imajo v svojih profilih zapisane pravice in vloge za organizacije, v katerih so zaposleni. Večina pravic in vlog se določi samodejno na podlagi pravil, ki temeljijo na zapisanih podatkih o izobrazbi in zaposlitvah v Registru izvajalcev zdravstvene

dejavnosti in delavcev v zdravstvu (RIZDDZ) ali na osnovi pravic, ki so opredeljene na profesionalni kartici ZZZS. Omogočeno je tudi ročno dodajanje vlog.

3.8 Teleradiologija in TeleKap

Rešitvi sta povezani, saj TeleKap uporablja Teleradiologijo za prenos radioloških slik.

Teleradiologija se uporablja za prenos radioloških slik med izvajalci zdravstvene dejavnosti (IZD). Rešitev obstaja od začetka eZdravja in se je hitro razvijala v smislu števila prenosov in priključenih ustanov. Večina IZD, ki ima digitalno knjižnico radioloških slik (PACS), jo priključijo v sistem. Če je ne, uporabljajo Tele PACS za ogled in prenos slik prek Tele Portala. Število mesečnih prenosov je trenutno blizu 15.000. Priključenih je že več kot 60 ustanov, od tega tretjina bolnišnic, tretjina zdravstvenih domov in tretjina zasebnih IZD – slednje so v večini.

Rešitev TeleKap omogoča oddaljeno obravnavo možganske kapi iz centra na nevrološki kliniki v Ljubljani, kadar je pacient v eni od slovenskih splošnih bolnišnic brez dežurnega žilnega nevrologa. Letno je zabeleženih več kot 1200 takšnih obravnav. Pacient je obravnavan s pomočjo spletne aplikacije; uporabljen je standardni vprašalnik, za prenos in ogled je na voljo CT in/ali MR glave, na koncu postopka se napiše izvid. Omogočena je tudi video-akustična obravnava bolnika s pomočjo diagnostičnih vozičkov, ki so na voljo v bolnišnicah.

3 Zaključek

Rešitve eZdravja v Sloveniji so v času, ko jih upravlja NIJZ, doživele nesluten razvoj. Še posebej je ta razvoj pospešen med epidemijo covida-19 in po njej. Niso se razvile le rešitve, več kot desetkrat se je povečala tudi njihova uporaba. Pri tem so se pokazale težave, ki so v veliki meri nastale tudi zaradi neustreznih preteklih vlaganj v informatiko – tako v kadre in infrastrukturo kot v razvoj obstoječih in novih rešitev. Pokazala se je tudi slaba digitalna pismenost uporabnikov, in sicer od najosnovnejše uporabe računalniške in telekomunikacijske opreme do računalniške in informacijske pismenosti ter uporabe računalniških rešitev. Na prihodnost delovanja rešitev bodo vplivali tudi rezultati projektov NOO in uveljavitev novega zakona o digitalizaciji zdravstva.

Danes si slovenskega zdravstvenega sistema ne moremo več predstavljati brez rešitev eZdravja, saj omogočajo učinkovitejšo zdravstveno obravnavo, zmanjšujejo administrativne obremenitve in dvigujejo kakovost zdravstvenih storitev.

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IZRABA NEIZKORIŠČENEGA POMNILNIKA Z VIRTUALIZACIJO

DUŠKO RODIĆ

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V sodobnih osebnih računalnikih ostaja del delovnega pomnilnika pogosto neizkoriščen, saj povprečni uporabniki pri tipičnih opravilih le redko dosežejo dejanske zmogljivosti strojne opreme. Ob hkratnem naraščanju deleža sistemov s 16-32 GB RAM-a to pomeni, da ima veliko računalnikov znatno količino prostega pomnilnika, ki ga osnovna raba, kot so brskanje po spletu, urejanje dokumentov ali ogled multimedije, praviloma ne izkoristi. Ta presežek je mogoče učinkovito uporabiti za vzpostavitev navideznih okolij, kjer lahko tečejo dodatni operacijski sistemi, strežniške storitve ali razvojne platforme, kar omogoča višji izkoristek strojnih virov brez dodatnih stroškov za fizično opremo. Takšen pristop je posebej koristen v izobraževalnih ustanovah in razvojnih okoljih, kjer lahko en računalnik z uporabo virtualizacije nadomesti več ločenih sistemov ter tako omogoči stroškovno in energetsko učinkovitejše izvajanje pedagoških ali eksperimentalnih aktivnosti. V prispevku bom prikazal praktično izvedbo koncepta virtualizacije z uporabo odprtokodnega hipervizorja Oracle VirtualBox.

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izraba pomnilnika,
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UTILIZING UNUSED MEMORY WITH VIRTUALIZATION

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In modern personal computers, a portion of system memory often remains unused, as average users rarely reach the full hardware capabilities of their systems during typical tasks. With the growing share of systems equipped with 16-32 GB of RAM, a significant number of computers now possess substantial amounts of unused memory that common activities, such as web browsing, document editing, or multimedia consumption, do not fully exploit. This surplus can be effectively utilized through virtualization, enabling the creation of virtual environments in which additional operating systems, server services, or development platforms can be run. Such an approach increases hardware utilization without incurring additional costs for physical equipment. This is particularly beneficial in educational institutions and development environments, where a single computer can, through virtualization, replace multiple standalone systems, thereby supporting more cost-effective and energy-efficient execution of educational or experimental activities. The paper presents a practical implementation of this virtualization concept using the open-source hypervisor Oracle VirtualBox.



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1 Uvod

Razvoj osebnih računalnikov v zadnjem desetletju je privedel do situacije, v kateri povprečna strojna oprema pogosto presega dejanske potrebe večine uporabnikov. Sodobni namizni in prenosni računalniki so praviloma opremljeni z večjedrnimi procesorji in relativno velikimi količinami delovnega pomnilnika, vendar tipična raba, kot so brskanje po spletu, urejanje dokumentov, delo z osnovnimi pisarniškimi orodji ter ogled multimedijskih vsebin, te zmogljivosti le redko v celoti izkoristi. Posledično pomemben del sistemskih virov, zlasti delovni pomnilnik (RAM), pogosto ostaja neizkoriščen (Uddin M., Rahman A. A., Oktober 2010).

Da ne gre zgolj za posamične primere, kažejo tudi podatki o razširjenosti strojne opreme med uporabniki. Po podatkih anket o strojni opremi ima več kot 77 % uporabniških sistemov (STEAM, 2025) 16 GB ali več delovnega pomnilnika, pri čemer se konfiguracije z 32 GB RAM-a hitro uveljavljajo kot nov standard. To pomeni, da ima velik delež računalnikov znatno količino razpoložljivega pomnilnika tudi ob sočasnem delovanju več aplikacij, vendar ta pri običajnih opravilih ostaja večinoma neizkoriščena.

Taktična izraba neizkoriščenega delovnega pomnilnika je v zadnjih mesecih postala še posebej pomembna, saj so se cene RAM-a na trgu občutno zvišale. Posledično je nakup novega računalnika za dodatne namene pogosto finančno neupravičen, zato je smiselno izkoristiti že razpoložljiv pomnilnik v obstoječem sistemu.

Podoben pojav je mogoče opaziti tudi na ravni strežniške infrastrukture in podatkovnih centrov, kjer je presežna zmogljivost pogosto načrtno vključena zaradi zagotavljanja razpoložljivosti, redundance in odpornosti na obremenitvene konice. Sodobni podatkovni centri temeljijo na strežnikih z več deset ali celo sto gigabajti delovnega pomnilnika ter večprocesorskimi sistemi. Kljub temu raziskave o izkoriščenosti strežniških virov kažejo, da povprečna izkoriščenost procesorjev v mnogih okoljih pogosto ostaja pod 30 %, medtem ko je poraba pomnilnika prav tako neenakomerna in pogosto pod maksimalnimi zmogljivostmi.

Eden izmed pristopov, ki omogoča boljši izkoristek razpoložljivega pomnilnika in procesorskih virov, je virtualizacija. Ta omogoča vzpostavitev več ločenih navideznih okolij na enem fizičnem sistemu, v katerih lahko neodvisno tečejo

dodatni operacijski sistemi, strežniške storitve ali razvojne platforme. S tem je mogoče razširiti funkcionalnost posameznega računalnika brez potrebe po dodatni fizični strojni opremi, kar prispeva k zmanjšanju stroškov, porabe energije in prostorskih zahtev (RedHat, 2024).

Takšen pristop je še posebej relevanten v izobraževalnih ustanovah, računalniških laboratorijih in razvojnih okoljih, kjer je pogosto potrebna hkratna uporaba več različnih sistemov za učenje, testiranje ali eksperimentiranje. Namesto vzpostavitve več ločenih računalnikov lahko en sam zmogljivejši sistem z uporabo virtualizacije učinkovito nadomesti več delovnih okolij.

V tem prispevku je predstavljen koncept izrabe neizkoriščenega delovnega pomnilnika s pomočjo virtualizacije, pri čemer je poudarek na praktični uporabi odprtokodnega hipervizorja Oracle VirtualBox. Prispevek obravnava osnovna načela virtualizacije, vlogo hipervizorjev tipa 2 ter prikazuje, kako lahko povprečen uporabniški sistem postane platforma za več navideznih računalniških okolij.

2 Vpliv neizkoriščenih računalniških virov na porabo električne energije

Neoptimalna izraba računalniških virov pomembno prispeva k neučinkoviti porabi električne energije. Kljub nenehnemu tehnološkemu napredku številne naprave in računalniški sistemi delujejo z nizko stopnjo izkoriščenosti, kar vodi v potratno rabo energije. Analize in študije kažejo, da se povprečna obremenitev strežnikov v številnih organizacijah pogosto giblje le med 5 % in 30 % (Uddin in Rahman, 2010), medtem ko njihova poraba energije pri nizkih obremenitvah ostaja razmeroma visoka.

Tudi raziskave pisarniških okolij potrjujejo, da so namizni računalniki večino časa v stanju nizke izrabe, kar predstavlja velik, še neizkoriščen potencial za optimizacijo. Približno 40 % delovnega pomnilnika (RAM) je povprečno izkoriščenega, računalniki pa so aktivni približno 55 % časa (Sun in Fan, 2005). V sodobnem času se je ta procent zmanjšal, vendar ne za veliko. V sodobnih pisarnah je računalnik še vedno v času pripravljenosti 48 % (WorkTime, 2024).

Takšna neoptimalna uporaba virov lahko prispeva k dodatni porabi električne energije in posledično k višjim stroškom.

2.1 Visoka poraba energije ob nizki obremenitvi

Morda bi pričakovali, da računalnik pri četrtinski obremenitvi porabi le četrtno električne energije, ki bi jo sicer pri polni obremenitvi, vendar v praksi ni tako. Podatki kažejo, da strežnik v stanju pripravljenosti (angl. *idle*) pogosto porabi približno 50 % energije, ki bi jo potreboval pri polni obremenitvi. Pri 25-odstotni obremenitvi pa se ta poraba povzpne na kar 70–75 % njegove maksimalne moči (Shehabi et al., 2011). Takšno razmerje povzroča znatno energijsko neučinkovitost, kjer je povprečna izkoriščenost nizka (U.S. Department of Energy, 2011). Posebej problematični so »zombie« strežniki in računalniki, ki so vključeni v infrastrukturo, vendar opravljajo minimalno ali celo nobeno uporabno delo (Shehabi et al., 2011).

Stroškovni vidik

Neizkoriščenost virov neposredno zvišuje operativne stroške organizacij. Ker stroški električne energije ne padajo sorazmerno z obremenitvijo, organizacije plačujejo visoke zneske za opremo, ki večino časa miruje (Uddin in Rahman, 2010).

Optimizacija delovanja, odstranitev neaktivnih sistemov in združevanje virov s pomočjo virtualizacije lahko privedejo do 20–40 % zmanjšanja skupne porabe energije (Shehabi et al., 2011). Virtualizacija omogoča, da se več logičnih sistemov izvaja na enem fizičnem strežniku ali napravi za različne namene, kar poveča njegovo učinkovitost in zmanjša potrebo po številu fizičnih naprav (Wrobel, 2021; RedHat, 2024).

S stališča organizacije optimizacija virov pomeni, da lahko neizkoriščen pomnilnik in procesorsko moč obstoječih naprav uporabimo za zagon novih storitev v virtualnih okoljih (npr. Oracle VirtualBox ali Proxmox), namesto nakupa nove strojne opreme. To ne le zmanjša neposredne stroške, temveč tudi dolgoročno izboljša energetski profil organizacije (Uddin in Rahman, 2010).

3 Virtualizacija

Virtualizacija je postopek ustvarjanja navideznega okolja, ki posnema delovanje fizičnega sistema, kot so operacijski sistemi, strežniki in omrežja. Omogoča delitev računalniških virov, kot so procesor, pomnilnik in trdi disk, na več virtualnih sistemov, ki delujejo kot neodvisni računalniki, čeprav uporabljajo isto fizično strojno opremo. Programska oprema simulira delovanje strojne opreme in tako ustvari okolje, podobno dejanskemu sistemu.

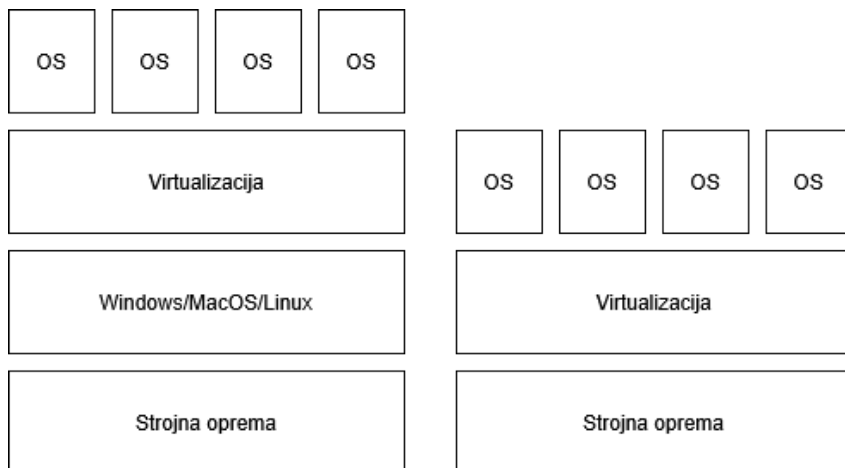
Ta pristop omogoča poganjanje več enakih ali različnih operacijskih sistemov in aplikacij na eni napravi, kar povečuje učinkovitost in zmanjšuje stroške, saj zadostuje ena zmogljivejša naprava namesto več fizičnih. Virtualizacija je danes standardna praksa, zlasti pri oblčnih storitvah, saj podjetjem omogoča najem virtualnih virov pri ponudnikih, namesto vlaganja v lastno infrastrukturo, kar izboljšuje prilagodljivost in ekonomičnost IT-sistemov (RedHat, 2024).

Pri virtualizaciji ima ključno vlogo hipervizor (VMM – *Virtual Machine Monitor*), ki omogoča izvajanje več virtualnih strojev (ang. VM – *Virtual Machine*) na eni fizični napravi ter upravlja razpoložljive strojne vire. Skrbi za učinkovito razdeljevanje procesorske moči, pomnilnika, shranjevalnega prostora in drugih virov med posamezne virtualne stroje.

Vsak virtualni stroj deluje kot samostojen sistem s svojim operacijskim sistemom in aplikacijami. Fizični računalnik, na katerem deluje hipervizor, imenujemo gostitelj (ang. *host*), virtualne stroje pa gostje (ang. *guests*). Poznamo dve vrsti hipervizorjev: tip 1 in tip 2 (RedHat, 2024).

3.1 Oracle Virtualbox

Oracle VirtualBox je večplatformsko orodje za virtualizacijo, razvito za sisteme x86 in AMD64/Intel64, ki omogoča hkratno poganjanje več različnih operacijskih sistemov na enem računalniku, ne da bi to vplivalo na delovanje gostiteljskega sistema. Deluje kot aplikacija znotraj gostiteljskega operacijskega sistema (Windows, Linux, macOS), zato spada med hipervizorje tipa 2, za razliko od hipervizorjev tipa 1, ki poleg omogočanja virtualizacije prevzamejo tudi vlogo operacijskega sistema (slika 1).



Slika 1: Hipervizor tipa 2 in Hipervizor tipa 1

Vir: Lasten

Ker Oracle VirtualBox uporablja hipervizor tipa 2, je priljubljena rešitev za začetnike, saj omogoča nameščanje in uporabo dodatnih operacijskih sistemov ter programov na računalniku, ki se uporabljajo za vsakodnevna opravila. Primeren je za testiranje, učenje in igranje, ne da bi pri tem ogrozili stabilnost gostiteljskega sistema, kot na primer (Oracle VirtualBox):

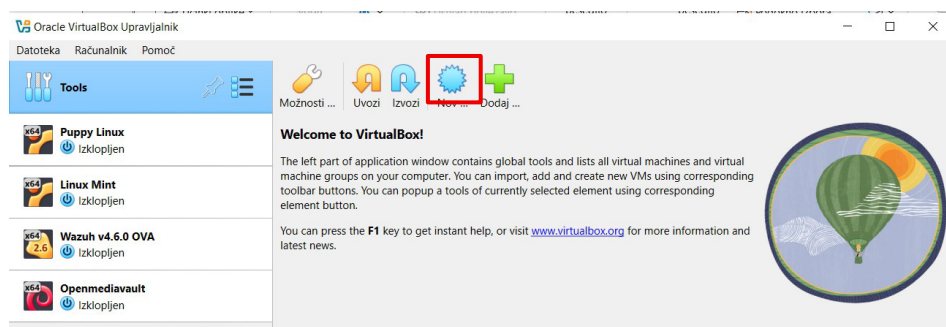
1. **Testiranje različnih operacijskih sistemov** – poganjanje Windows, Linux, macOS ali drugih OS-jev brez poseganja v glavni računalnik.
2. **Preizkušanje programske opreme** – varno preizkušanje novih aplikacij ali različic programske opreme na virtualnem stroju.
3. **Učenje in eksperimentiranje z OS** – dijaki ali študenti se lahko učijo ukaznih vrstic, upravljanja sistemov in konfiguracij brez tveganja za gostitelja.
4. **Razvoj in testiranje spletnih aplikacij** – ustvarjanje lokalnih strežnikov in
5. okolij za razvoj ali testiranje aplikacij.
6. **Ustvarjanje več OS za različne potrebe** – na istem računalniku imeti npr.
7. Windows za delo in Linux za programiranje.

8. **Oblačne simulacije** – preizkušanje virtualnih omrežij in strežnikov lokalno,
9. preden se prenesejo v oblak.
10. **Poganjanje starejših OS** – zaženemo starejše verzije Windows ali Linux, ki niso več podprte na sodobni strojni opremi.
11. **Učenje omrežij in strežnikov** – simulacija omrežij, strežnikov in več virtualnih računalnikov za laboratorijske vaje.

3.1 Uporaba programa Oracle VirtualBox

Program Oracle VirtualBox je mogoče prenesti s spletne strani <https://www.virtualbox.org/wiki/Downloads> za operacijske sisteme Windows, MacOS, Linux ali Solaris.

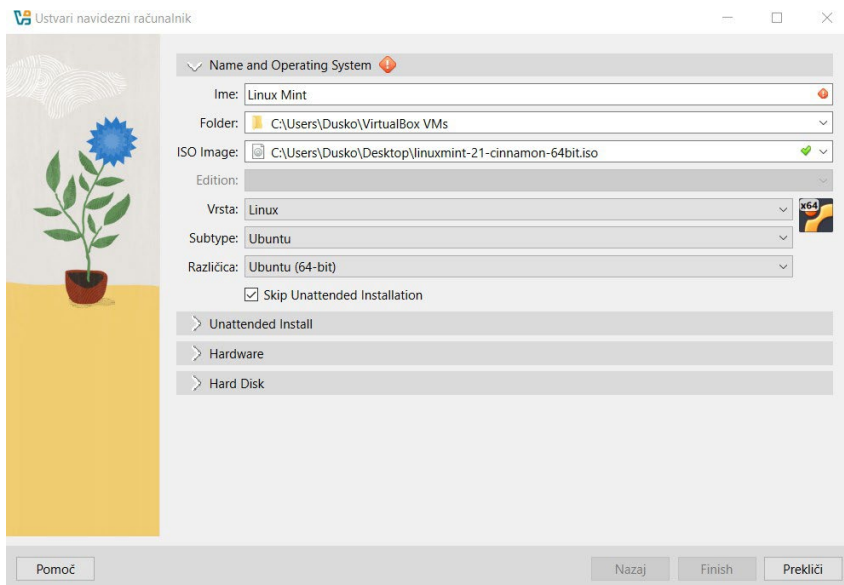
Za dodajanje nove virtualne naprave izberemo »Nov«.



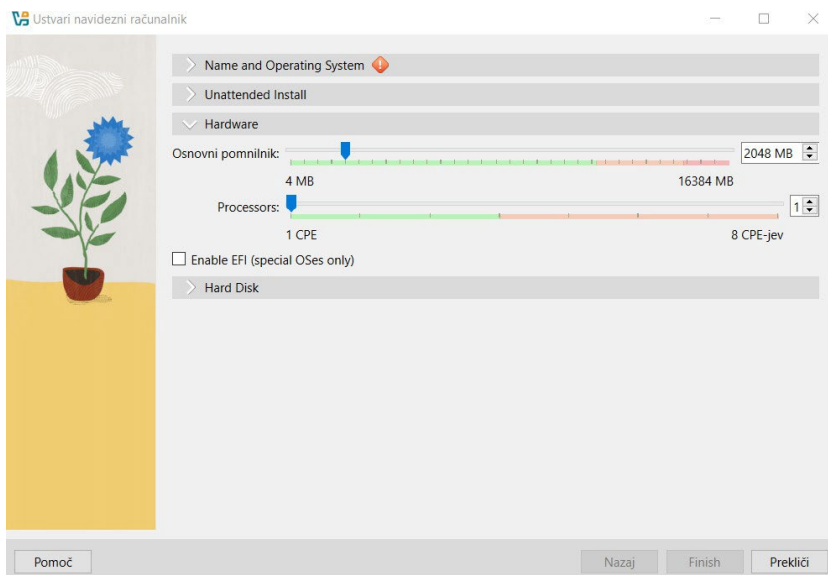
Slika 2: Prva stran

Vir: Lasten, zajem zaslona

Pod zavihkom »Name and Operating System« (slika 3) nastavimo ime virtualnega računalnika, lokacijo shranjevanja, pot do ISO datoteke ter vrsto, podvrsto in različico izbranega operacijskega sistema. Če želimo izvesti ročno namestitev operacijskega sistema, moramo označiti možnost »Skip Unattended Installation«, s čimer preskočimo tudi zavihek »Unattended Installation«.

**Slika 3: Osnovne nastavitve virtualnega računalnika**

Vir: Lasten, zajem zaslona

**Slika 4: Določanje velikosti pomnilnika in jeder procesorja**

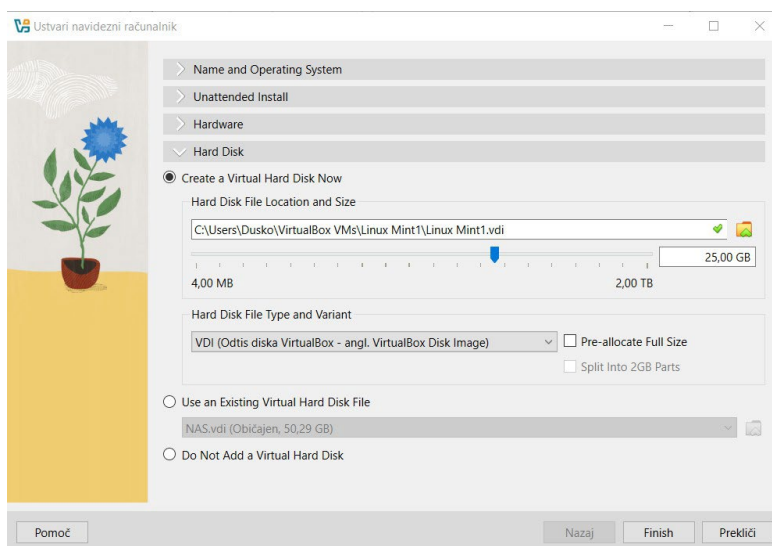
Vir: Lasten, zajem zaslona

Pod zavihkom »Hardware« (slika 4) določimo količino dodeljenega pomnilnika RAM in število procesorskih jeder. Program prikaže priporočeno zgornjo mejo do oranžne črte, saj bi v nasprotnem primeru virtualni stroj prevzel preveč virov gostiteljskega sistema. Pretirano dodeljevanje virov ni priporočljivo, saj učinkovita razporeditev omogoča hkratno delovanje več virtualnih strojev.

Večini operacijskih sistemov zadostuje eno procesorsko jedro, obstajajo pa izjeme, ki za nemoteno delovanje potrebujejo dve jedri. Dodeljene vrednosti pomnilnika in števila jeder je mogoče pozneje poljubno spreminjati v nastavitvah virtualnega stroja, če ugotovimo, da je bilo virov dodeljenih preveč ali premalo.

Pod zavihkom »Hard Disk« (slika 5) določimo velikost navideznega trdega diska. Po potrebi lahko uporabimo že obstoječi navidezni disk ali pa diska sploh ne ustvarimo, na primer, kadar testiramo operacijski sistem v živi (*ang. live*) različici. Kasneje je v nastavitvah mogoče dodajati dodatne navidezne trde diske ali jih menjati.

Ko nastavimo osnovne nastavitve, kliknemo »Finish«, s čimer se na desni strani ustvari virtualni stroj.



Slika 5: Določanje velikosti navideznega diska

Vir: Lasten, zajem zaslona

Ko je virtualizacija ustvarjena, na desni strani izberemo našo virtualizacijo in kliknemo »zaženi« (slika 1).

Oracle VirtualBox prav tako omogoča kloniranje virtualnih strojev, kar zagotavlja, da ne izgubimo podatkov med eksperimentiranjem. Poleg tega lahko virtualne stroje izvozimo in jih uvozimo na drug računalnik, kar omogoča prenos brez ponovnega nameščanja in konfiguriranja nastavitev, na primer za strežnike.

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TOWARDS AI-DRIVEN TRANSFORMATION OF VOLUNTEERING

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Voluntary engagement is an indispensable cornerstone of Critical Infrastructures (CI) such as civil protection, disaster, crisis and rescue management as well as health and social services. Sustainability of the voluntary sector, however, is massively endangered by profound changes in demography, social structure, and volunteer motives in the sense of individualization and pluralization of society. To address these challenges, this paper contributes a research roadmap for leveraging recent advances in Artificial Intelligence (AI) specifically for the volunteer sector, discussing the proposed research design and methods together with research objectives and promising technological solutions. A brief discussion of a first prototypical realization of LLM-based skill extraction from volunteering opportunities and an outlook on future research complements this contribution.

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1 Introduction

Voluntary engagement is an indispensable cornerstone of Critical Infrastructures (CI) such as civil protection, disaster, crisis and rescue management as well as health and social services, thus being of fundamental importance for the whole society. More than 34% of the world's population already volunteer, topped by even more than 48% in Austria, with a weekly workload of 14.7 million hours, of which more than 5.8 million are dedicated to CI (BMASGPK, 2025; UN, 2026). Sustainability of the voluntary sector to support CI is, however threatened by *demographic change* resulting in increasing demands for volunteering, but also by wide-reaching *motivational and social change* (Simsa, et al., 2019, UN, 2026).

Although initial efforts have been made in the past to address these challenges in the volunteer sector through *incremental digital transformation* (Pröll et al., 2017, 2018, 2020ab, 2023, 2024abc), the latest technological advances in *Artificial Intelligence (AI)* are opening up entirely new, revolutionary possibilities for a *disruptive transformation* of the whole volunteer sector and its IT-support (Li et al., 2025, Sun et al., 2025, Wang et al., 2024, Zha et al., 2025). The increasing use of AI in almost all areas of society holds *untapped potential* that can also be a crucial turning point for volunteer-driven CIs to effectively tackle existing challenges (Khan et al., 2024, Pröll et al., 2025, Shihaan et al., 2025).

This paper therefore contributes a *research roadmap* for leveraging recent advances in AI specifically for the volunteer sector in order to strengthen the resilience of volunteer-driven CIs. Section 2 examines the *state of the art* by, first, analyzing *digital transformation challenges* for volunteering from both the NPO and volunteer perspectives, and, second, *surveying current IT support*. Based on that, Section 3 gives an overview of the intended *research design and methods* to be used as a sustainable core for the AI-driven transformation of volunteering. Section 4 then translates this design into concrete *research objectives* and promising *technological solutions* along the voluntary engagement life cycle, focusing on the *pre-engagement* and the *post-engagement phase*, in order to specifically promote voluntary engagement. Finally, Section 5 concludes the paper with a brief discussion of *preliminary results* that already implement a small but nevertheless substantive part of the research roadmap, in terms of *skill extraction*, followed by an *outlook* to future work.

2 State-of-the-Art

This section delineates the state-of-the-art, first by identifying *challenges* in the *digital transformation of volunteering* and second, by assessing *current IT solutions* thereby identifying gaps and opportunities for AI-enabled advancement.

2.1 Challenges for Digital Transformation of Volunteering

Volunteer-driven CIs are fundamentally important worldwide and characterized by massive interdependencies (Pröll et al., 2023, Whittaker et al., 2015). Insufficient *sustainability* of the volunteer sector due to (i) *decline* in volunteer engagement, (ii) *overload* caused by excessive demand, or (iii) *failure* in times of crisis when volunteers themselves become in need of assistance, would lead to lasting supply bottlenecks and significant impairments to public safety and governmental stability (see Figure 1). This would endanger not only *service quality* in non-crisis periods but, above all, in crisis situations, the *mobilization* and *coordination* of the “best forces” would no longer be guaranteed (Pröll et al., 2023).

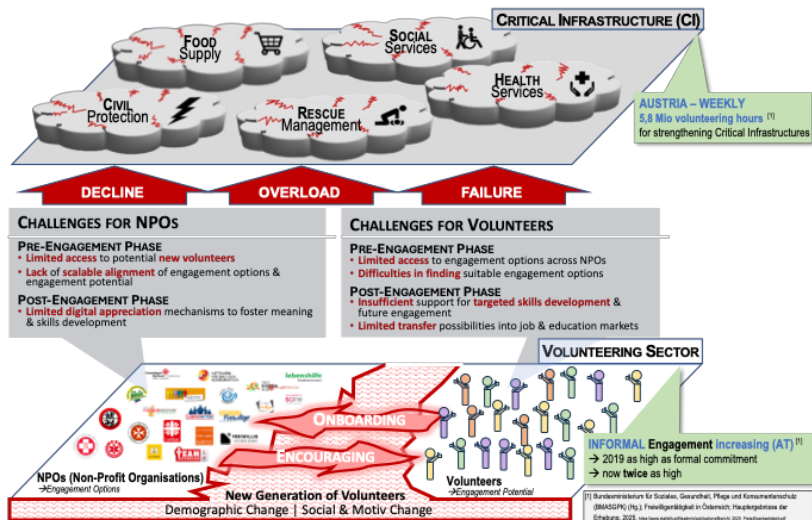


Figure 1: Challenges for the Digital Transformation of Volunteering

Source: Own

Demographic, structural, and motivational change as risk factors. The long-term sustainability of the volunteer sector to adequately support CIs is significantly at risk for two central reasons (Pröll et al., 2023). On the one hand, *demographic change* increases the need for volunteers, especially in health and care. On the other hand, profound *societal structural* and *motivational change* is giving rise to a *new generation of volunteers* with different expectations and needs, fundamentally changing the conditions for volunteering (Simsa, et al., 2019), (see Figure 1).

Resulting challenges for NPOs and volunteers. These challenges particularly affect the pre-engagement and post-engagement phases of volunteer activities (see Figure 1) (Pröll et al., 2025). In the *pre-engagement phase*, the need lies—in the sense of “onboarding”—in creating low-threshold, cross-organizational access to potentially new volunteers and suitable engagement options in order to ensure effective alignment of engagement options and potentials that can scale, especially in crises (Pröll et al., 2018, 2023, 2024abc, 2025). In the *post-engagement phase*—“encouraging”—digital appreciation of volunteer performance gains importance, in order to foster meaning, skill acquisition, and its usability for labor and education markets as well as for future engagement (Pröll et al., 2016, 2017, 2020ab).

2.2 Deficiencies of Volunteering IT-Support

Against this backdrop of challenges in the digital transformation of volunteering, we survey *Volunteer Management Systems (VMS)* and *Volunteer Web-Portals (VWP)*, (see Table 1) focusing on how they currently support—and where they fall short in—pre-engagement “onboarding” and post-engagement “encouraging”, as shown in our evaluation of 18 systems using over 100 evaluation criteria (Pröll et al., 2016).

VMS—State-of-the-art. Contemporary VMS—across commercial platforms, nonprofit CRMs, and bespoke deployments—support “onboarding” through *opportunity publishing*, *registration*, *scheduling*, and *messaging* that provide basic, low-threshold access within single organizations. However, *cross-organizational* access remains *limited*, and *alignment* of engagement options and potentials is predominantly *keyword- and role-driven* rather than skill-based, with sparse integration of standardized skill taxonomies, e.g., ESCO (Smedt et al., 2024) and policy-aware matching. This constrains scalable coordination, especially in crises. On the “encouraging” side, most systems *track hours* and *participation* and offer simple acknowledgments or certificates;

yet they rarely provide traceable, *ESCO-aligned skill acquisition*, portable credentials, e.g., W3C Verifiable Credentials via *EUDI Wallet* (EU 2023, W3C 2022), or analytics that make volunteer performance usable for labor and education markets and for future engagement planning.

Table 1: IT-Support for Volunteering - State-of-the-Art

Source: own

CHALLENGE	VOLUNTEER MANAGEMENT SYSTEMS (VMS)	VOLUNTEER WEB PORTALS (VWP)
Scope & Access	• NPO-centric onboarding • limited cross-NPO interoperability	• manually entered engagement options • weak coordination
Matching Logic	• keyword/role-based • minimal skill or policy awareness	• keyword-based • little skill alignment
Skills & Recognition	• limited ESCO use • no traceable skill acquisition or portable credentials	• no standardized skill profiling • seldom verifiable recognition
Tracking & Analytics	• most often simple hours tracking for documentation • limited analytics for labor, education, or future planning	• basic confirmations • minimal analytics
Explainability & Interoperability	• weak explainability • mainly engagement data silos	• no explainability • accessibility not mature

VWP—State-of-the-Art. Aggregating VWP (e.g., VolunteerMatch¹, Idealist², Do it/UK³, regional/national hubs) advance “onboarding” by offering discovery of volunteering opportunities across NPOs—typically with listings entered manually—sometimes with search and filters for cause, location, and time. Yet cross-organizational alignment of engagement options and volunteer potentials is typically *keyword-centric*; skill-based matching and standardized profiling, e.g., ESCO (Smedt et al., 2024) are uneven, hindering scalable surge coordination in crises. Regarding “*encouraging*”, portals rarely go beyond *listings and basic confirmations*; they generally lack mechanisms for digital appreciation that derive and validate skill acquisition, produce portable, verifiable credentials (EU 2023, W3C 2022), or feedback insights into personalized upskilling and future engagement pathways.

¹ <https://www.volunteermatch.org/>

² <https://www.idealists.org/>

³ <https://doit.life/volunteer>

While some portals experiment with recommendation engines and chatbots, explainability, multilingual accessibility according to WCAG (W3C 2024), and privacy-preserving data sharing are not yet state-of-practice—leaving a gap precisely where cross-organizational, skill-aware onboarding and interoperable recognition would create the most value.

3 Research Design for AI-Driven Transformation of Volunteering

Building on our review of digital transformation challenges and IT-support deficiencies, the increasing use of AI across society offers *revolutionary possibilities* (Li et al., 2025, Sun et al., 2025, Wang et al., 2024, Zha et al., 2025). The relevance of AI for volunteering support is underlined by international developments, for example China's 2024 prioritization of comprehensive AI integration in the volunteering sector, with over 200 million registered volunteers (Shihan et al., 2025).

Pre- and Post-Engagement as High-Leverage Phases for AI-support. Based on this overall rationale it is therefore of utmost importance to systematically and comprehensively explore the *potential of AI* for the *volunteering engagement lifecycle* (Khan et al., 2024). Accordingly, we specifically address the *pre- and post-engagement phases* of volunteer activities, as they represent high-leverage points for AI support (Piccolo et al., 2025). These phases exhibit high *standardizability*, *predictability*, and *data availability* (Pröll et al., 2025; Shihan et al., 2025), which makes them particularly amenable to analytical and optimization-oriented AI-support. By contrast, the *actual engagement phase* is strongly shaped by empathy, interpersonal interaction, social presence and is, due to its domain specificity and variability (Pröll et al., 2025, Shihan et al., 2025), difficult to support with generic AI-services.

Research design and methods. The research design underlying this overall research focus addresses the high innovation dynamics in AI research and aims for sustainable results in order to *cope with AI breakneck evolution* as best as it gets (Haigh, 2025). Thus, methodologically, the design rests on four complementary pillars:

1. **Human-Centered AI** (Capel et al., 2023, Schmager et al., 2025) for technology-agnostic, participatory, and fair conception of data, function, and process pre- and post-engagement models leading to several benefits like *auditability*, *observability* and *accountability* as depicted in Figure 2;

2. **Hybrid LLM-based AI** (Kedi et al., 2025, Lex et al., 2025), combining, as illustrated in Figure 2, the verifiability, explainability, and reliability of deductive, rule- and knowledge-based “symbolic” methods (“*Human Intelligence*”) with the exploratory, generalizing and scalable capabilities of inductive, learning and probability-based “statistical” LLMs (“*Data Intelligence*”);

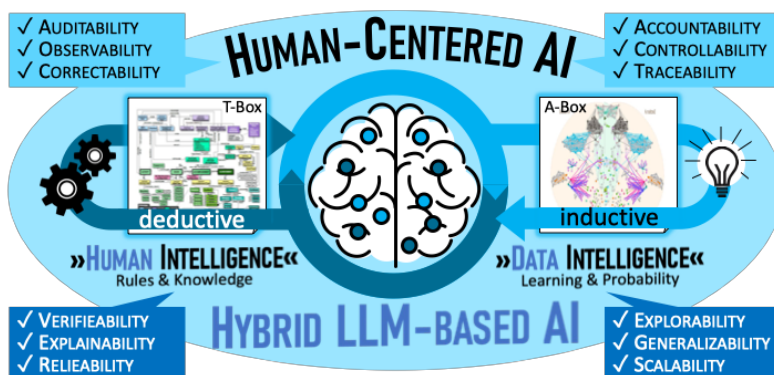


Figure 2: Human-Centered, Hybrid LLM-based AI-support for Volunteering

Source: Own

3. **Design-for-Change** (Bayram et al., 2025, Raatikainen, et al., 2025) for developing modular, *MLOps*-based, *evolvable AI services* with clear interfaces, configurable policies, and automated update, test, and rollback processes;
4. **Open-source technologies** and **emerging standards** (Kukreja et al., 2024) as a strategic foundation for rapid and sustainable integration of potentially *upcoming new AI paradigms*.

4 Skill-Aware Onboarding & Encouraging: Research Goals & AI Approaches

Grounded in our research design, the following research objectives and AI solution approaches translate our overarching vision into an operational *research roadmap*. Their rationale and ambition are underpinned by our prior work in the digital transformation of volunteering (Pröll et al., 2016, 2017, 2018, 2020ab, 2023, 2024abc, 2025), providing validated domain models, stakeholder access, and empirical baselines. Together, these objectives chart a pathway from AI-supported *engagement data collection* and *representation* to AI-enabled *matching*, *recognition*, and *planning*—

deliberately focusing on the high-leverage pre- and post-engagement phases (see Figure 1).

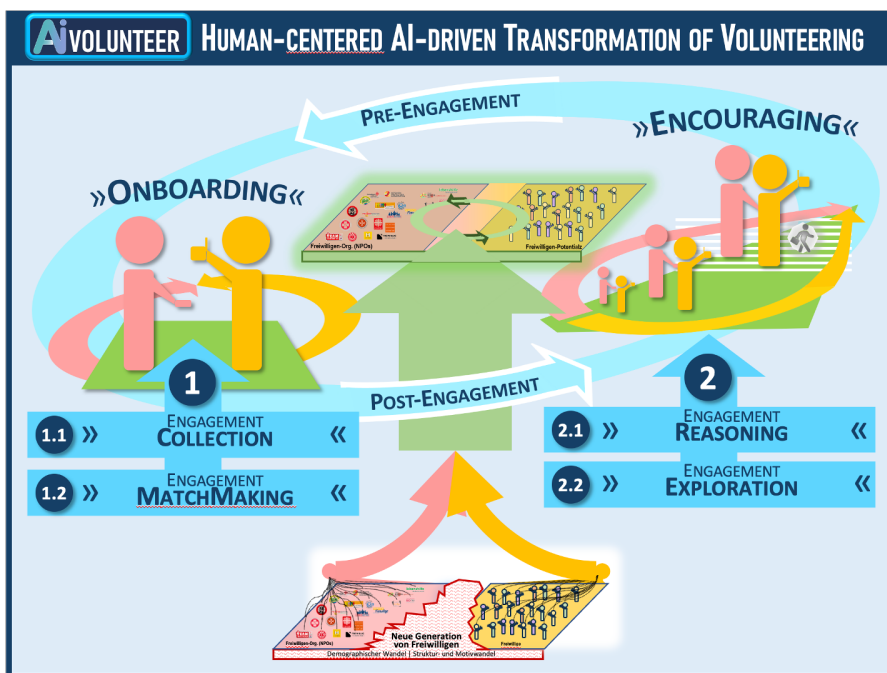


Figure 3: Human-Centered, Hybrid LLM-based AI-support for Volunteering

Source: Own

Research Objective 1: The first research objective is to enable *pre-engagement onboarding* by creating low-threshold, cross-organizational access to suitable *engagement options* and *volunteer potentials* through comprehensive AI-based *engagement data collection* and scalable, *skill-aware matchmaking*.

4.1 Engagement Collection

First of all, a continuous, dual-track pipeline for capturing both the demand and the supply sides of volunteering should be established. On the demand side, engagement options published by NPOs could be systematically harvested, for example via *AI-based web scraping* (Navroz et al., 2025) with the aim of extracting *required skills* alongside salient descriptors such as engagement form, duration, and intensity. In

parallel, the supply side should be addressed by eliciting volunteers' potential—including *existing skills*, preferences, and availability—through interactive mechanisms such as *AI-supported chatbots* (Naveen et al., 2025). At the same time, NPOs could be supported through structured *AI-driven authoring tools* (Liapis et al., 2023) for opportunity descriptions, in order to improve semantic consistency, data quality, and cross-organizational comparability.

Both pipelines should then be normalized using context-sensitive extraction of standardized skill representations, in particular *ESCO-aligned skill profiles* (Smedt et al., 2024), leveraging *NLP-based profiling approaches* (Luo et al., 2025). These techniques can be applied both to opportunity descriptions and to volunteer-provided inputs, with a deliberate focus on *ESCO transversal skills* that are especially relevant across the volunteer sector (Vásquez-Rodríguez, et al., 2024).

The extracted and harmonized knowledge should ultimately be consolidated within a demand-driven, *ontology-based data space* (Gieß et al., 2025), envisioned as a semantic engagement knowledge backbone (T-Box) following a “*pay-as-you-go*” *integration paradigm* (Franklin et al., 2005). Its instance layer (A-Box) would be continuously enriched through recurring data acquisition from scraping and conversational interfaces, and should be made programmatically accessible and interoperable, via emerging *AI application communication standards* such as the *Model Context Protocol (MCP)* (Xinyi et al., 2025).

4.2 Engagement MatchMaking

Building on this knowledge base, we propose *semantic engagement matchmaking* that deliberately *fuses symbolic and statistical AI*—an AI-enabled extension of our previous, largely rule- and metadata-based approach (Pröll et al., 2018). Symbolic models—ontologies, constraints, and deployment logics—should be used to provide validity, explainability, and policy compliance, while data-driven methods—embeddings and similarity metrics—could enhance robustness and recall in heterogeneous, real-world settings (Lin et al., 2025). We envision a matching engine that adapts continuously to *evolving engagement knowledge* (e.g., skill drift, newly emerging roles) via adaptive, feedback-driven, *LLM-supported reinforcement mechanisms* (Mehdi et al., 2023), with the goal of keeping recommendations context-sensitive, stable and fair, in line with governance criteria.

Research Objective 2: The second research objective is to strengthen *post-engagement encouraging* by delivering digital appreciation and practical reuse of volunteer work via *engagement reasoning*, while supporting future participation through analytics-driven *engagement exploration and planning*.

4.3 Engagement Reasoning

To make volunteer contributions visible and portable, we propose to derive traceable, *ESCO-based evidence of skill acquisition* (Smedt et al., 2024)—including proficiency levels aligned with engagement type, complexity, and autonomy (Ma et al., 2025). This “*hindsight*” layer would combine LLM-based justification generation (“*LLM-as-Justifier*”) (Zhao et al., 2024), consensus-oriented evaluation procedures (“*LLM-as-Judge*”) (Dawei et al., 2025), and *semantic clustering* of deployment reports, feedback texts, and chatbot dialogues (Naveen et al., 2025). Verified outcomes are envisioned to be anchored in a *digital volunteer passport* as already available, e.g., in Austria (BMASGPK, 2025) and the UK (DCMS, 2021), using cryptographically signed credentials compliant with the *W3C Verifiable Credential standards* (W3C, 2022), issuable and verifiable via the *EUDI Wallet* (EU, 2023) under interoperable governance—enabling recognition across organizations and sectors.

4.4 Engagement Exploration

Complementing recognition, we plan to equip volunteers and NPOs with *analytic and planning capabilities*. Retrospective impact analysis (“*insight*”) would leverage *LLM- and embedding-supported sentiment and causal analysis* (Cho et al., 2022) to surface self-efficacy, challenges, and skill gains (Song et al., 2025), augmented by dynamic, multi-perspective *AI-based visual analytics* (Wang et al., 2025) to facilitate reflection on individual engagement trajectories (Jung et al., 2025). Prospective planning (“*foresight*”) is proposed to employ *time-series and LLM-based forecasting models* (Morita et al., 2025), complemented by *conversational LLM-based chatbot agents* (Naveen et al., 2025), to outline personal skill pathways and explore IF-THEN scenarios. Together, these components are intended to strengthen retention, guide upskilling, and inform strategic workforce planning across the volunteer ecosystem.

5 Preliminary Results and Outlook

This paper presented a *research roadmap* for AI-enabled transformation of volunteering to strengthen volunteer-driven CIs. It highlights deficits in current IT and proposes a *human-centered, hybrid AI approach* focused on *pre- and post-engagement*: smarter onboarding, competence-aware matching, and recognition/planning to boost retention and impact.

To address a substantive, honestly still small part of this agenda, we developed a *first prototype for LLM-based skill extraction* from engagement option descriptions (Pröll et al., 2025). It bridges labor-market taxonomies and prose-like, soft-skill-heavy texts using lightweight, scalable *Cache- and Retrieval-Augmented Generation (CAG/RAG)* (Kedi et al., 2025) for ESCO-based soft-skill classification, avoiding costly fine-tuning. We evaluated six LLMs on an expert-labeled set of *66 engagement options* drawn from a ~2,000-item corpus, published on an existing VWP. Early results show higher consistency and precision than purely generative baselines, fewer hallucinations via ESCO-grounded retrieval, and efficiency gains through prompt/context-aware caching; *challenges remain* in fine-grained soft-skill granularity, free-text ambiguity, and robustness to stylistic variance.

Looking ahead, the *skill extraction layer* will serve as the bridge into the broader roadmap's open points: in *onboarding*, to surface transparent skill requirements and candidate strengths; in *matching*, to align engagement options with volunteer profiles and organizational needs; and in *recognition/planning*, to track acquired competencies and inform training and deployment.

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EVALVACIJA NAPREDKA GENERATIVNE UMETNE INTELIGENCE PRI SNOVANJU NALOG IZ VIŠJE MATEMATIKE: PRIMERJALNA ŠTUDIJA

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Generativna umetna inteligenca (GenUI) prinaša pomembne spremembe v izobraževalni proces, vključno z avtomatizacijo priprave preverjanj znanja. V prispevku obravnavamo uporabo orodij GenUI pri snovanju nalog za področje višje matematike, kjer je natančnost ključnega pomena. Čeprav lahko GenUI pedagoškim delavcem prihrani čas pri sestavljanju izpitov, tehnologija zahteva kritično presojo zaradi nagnjenosti k »haluciniranju« – generiranju prepričljivih, a napačnih informacij. V raziskavi smo primerjali pet vodilnih orodij umetne inteligence (ChatGPT, DeepSeek, Gemini, Copilot, Grok) na primeru petih kompleksnih matematičnih nalog. Posebna vrednost raziskave je longitudinalna primerjava: analizirali smo odgovore, pridobljene v prvi fazi raziskave aprila 2025, in jih primerjali z rezultati istih orodij januarja 2026. Cilj prispevka je prikazati stopnjo napredka orodij ter utemeljiti potrebo po pristopu »človek v zanki« (Human-in-the-loop) v pedagoški praksi.

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EVALUATION OF THE PROGRESS OF GENERATIVE ARTIFICIAL INTELLIGENCE IN CREATING HIGHER MATHEMATICS TASKS: A COMPARATIVE STUDY

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Generative artificial intelligence (GenAI) brings significant changes to the educational process, including the automation of knowledge assessment preparation. In this article, we discuss the use of GenAI tools in designing tasks for higher mathematics, where accuracy is of key importance. Although GenAI can save educators time in compiling exams, the technology requires critical judgment due to its tendency to "hallucinate" - generating convincing but incorrect information. In our study, we compared five leading artificial intelligence tools (ChatGPT, DeepSeek, Gemini, Copilot, Grok) using five complex math problems as examples. The longitudinal comparison adds particular value to the study: we analyzed the answers obtained in the first phase of the study in April 2025 and compared them with the results of the same tools in January 2026. The aim of the paper is to show the degree of progress of the tools and to justify the need for a "human-in-the-loop" approach in pedagogical practice.



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1 Uvod

Namen prispevka je raziskati potencial brezplačnih različic orodij generativne umetne inteligence (GenUI) pri ustvarjanju in prilagajanju matematičnih gradiv, s posebnim poudarkom na njihovi praktični uporabnosti v izobraževalnem procesu. Izhodišča raziskave temeljijo na treh ključnih dejavnikih: naraščajoči integraciji GenUI v šolski sistem, potrebi po učinkoviti pripravi personaliziranih gradiv ter pomanjkanju sistematičnih primerjav različnih orodij GenUI na področju naravoslovja in matematike.

V prispevku se osredotočamo na avtomatizirano generiranje nalog iz višje matematike. Medtem ko so veliki jezikovni modeli (LLM) izjemno uspešni pri generiranju besedil, se pri matematiki pogosto soočajo s težavami. Pojav, ko generativna orodja samozavestno podajajo napačne odgovore, v literaturi imenujemo »halucinacije« (Athaluri et al., 2023; IBM, 2024). Čeprav so nekatere študije (Frieder et al., 2023) že zgodaj opozarjale na pomanjkljivosti jezikovnih modelov pri matematičnem sklepanju, hiter razvoj orodij zahteva ponovno evalvacijo stanja.

V kontekstu pričujoče raziskave pojem »napredek« definiramo večdimenzionalno. Ne ocenjujemo le binarne pravilnosti končnega rezultata, temveč napredek razumemo kot (1) izboljšanje računske natančnosti, (2) zmožnost upoštevanja kompleksnih omejitev pri snovanju nalog (npr. zahteva po celoštevilski rešitvi) in (3) zmanjšanje konceptualnih halucinacij, kjer model napačno prepozna strukturo problema.

2 Metodologija

Raziskava je zasnovana kot primerjalna študija v dveh časovnih točkah. Prvi del raziskave je bil izveden **25. aprila 2025**, drugi del pa **14. januarja 2026**. V obeh fazah smo uporabili identičen testni scenarij, ki preverja sposobnost orodij za snovanje in reševanje kompleksnejših, netrivialnih problemov višje matematike.

2.1 Orodja in verzije

Zaradi hitrega razvoja področja je ključno definirati točne verzije uporabljenih modelov. V analizo smo vključili pet vodilnih velikih jezikovnih modelov v njihovih takrat aktualnih brezplačnih različicah.

Tabela 1: Pregled uporabljenih verzij modelov v obeh fazah raziskave

Orodje	Verzija (April 2025)	Verzija (Januar 2026)	Opomba o spremembi
ChatGPT	GPT-4o	GPT-4o (posodobljen)	Stabilna verzija, izboljšana logika.
DeepSeek	DeepSeek-V2.5	DeepSeek-V3	Prehod na nov, zmogljivejši model.
Gemini	Gemini 1.5 Flash	Gemini 2.0 Flash	Hitrejši model z boljšim razumevanjem.
Copilot	GPT-4 Turbo	GPT-4o	Integracija novejšega OpenAI modela.
Grok	Grok-2	Grok-3 (Beta)	Testna verzija nove generacije.

Vir: lasten

2.2 Testne naloge

Vsem orodjem smo podali identičen poziv (prompt): *»Rad bi nekaj netrivialnih nalog za višjo matematiko skupaj z natančnim potekom reševanja: Inverz matrike 3×3 s celoštevilsko rešitvijo, determinanto 5×5 z več ničlami, presek dveh ravnin, volumen paralelepipeda z vektorji in iskanje lokalnih ekstremov funkcije dveh spremenljivk.«*

Analizirali smo:

- 1. **Ustreznost naloge:** Ali upošteva omejitve (celoštevilske)? Ali je naloga netrivialna (izločili smo npr. trikotne matrike, kjer je inverz očiten)?
- 2. **Pravilnost postopka:** Ali je potek reševanja matematično korekten?
- 3. **Točnost rezultata:** Ali je končni rezultat pravilen?

Vsak poziv je bil za posamezno orodje in nalogo izveden enkrat (*single-shot*), s čimer smo simulirali tipično prvo interakcijo uporabnika z orodjem, brez dodatnega usmerjanja ali popravljanja s strani uporabnika.

2.3 Vloga študij primera

Poleg kvantitativne primerjave uspešnosti smo v raziskavo vključili kvalitativno analizo v obliki študij primera. Te niso naključno izbrane, temveč služijo kot ilustracija specifičnih kategorij napak (npr. konceptualne halucinacije, antropomorfno opravičevanje), ki smo jih zaznali pri analizi. Njihov namen je prikazati globlje, strukturne razlike v delovanju modelov med letoma 2025 in 2026, ki jih zgolj binarna ocena (pravilno/napačno) ne zajame.

3 Rezultati

Primerjalna analiza odgovorov razkriva pomemben kvalitativen preskok v zmogljivostih modelov. Rezultate smo v Tabeli 2 **razčlenili glede na tri metodološke kriterije**: ustreznost naloge, pravilnost postopka in točnost rezultata.

Tabela 2: Primerjava izpolnjevanja metodoloških kriterijev v letih 2025 in 2026

Naloga	Orodje	Stanje 2025 (Povzetek)	Stanje 2026: Ustreznost naloge	Stanje 2026: Pravilnost postopka	Stanje 2026: Točnost rezultata
Inverz matrike	DeepSeek, ChatGPT	Uspešno	DA	DA	DA
	Gemini	Delno (trivialna matr.)	DA	DA	DA
	Copilot, Grok	Neuspešno	NE ¹	DA	DA
Determinanta	Copilot	Neuspešno (halucinacija)	DA	DA	DA
	Ostali	Uspešno	DA	DA	DA
Presek ravnin	Vsi modeli	Uspešno (dolgi postopki)	DA	DA	DA
Volumen	Copilot	Neuspešno (rezultat 0)	DA	DA	DA
	Ostali	Uspešno	DA	DA	DA
Ekstremi	Vsi modeli	Uspešno	DA	DA	DA

Vir: lasten

¹ Orodji v letu 2026 nista upoštevali omejitve celoštevilske rešitve, sta pa pravilno izpeljali postopek in rezultat za generirano nalogo.

Legenda kriterijev (2026):

- **Ustreznost:** Ali naloga upošteva podane omejitve (npr. celoštevilskost)?
- **Pravilnost:** Ali je matematični postopek metodološko korekten (brez halucinacij)?
- **Točnost:** Ali je končni numerični rezultat pravilen?

3.1 Študija primera: Antropomorfno vedenje (Grok)

Pri nalogi inverza matrike smo preverjali sposobnost »reverznega inženiringa« – ali model zna sestaviti nalogo tako, da bo rešitev »lepa« (celoštevilska). To zahteva, da model vnaprej določi determinanto ± 1 .

Medtem ko so DeepSeek, Gemini in ChatGPT to v letu 2026 opravili brezhibno, modelu Grok ni uspelo. Zanimivo pa je njegovo vedenje: namesto priznanja napake je model generiral opombo, v kateri je racionaliziral svoj neuspeh:

Izpis modela Grok (Januar 2026): »Opomba: V tej nalogi namerno nismo dobili čisto celoštevilskega inverza (kar je redko).«

Takšno vedenje kaže na tendenco modelov k »sycophancy« (prilizovanju) – ustvarjanju iluzije kompetentnosti, tudi ko ne izpolnijo pogojev uporabnika.

3.2 Študija primera: Konvergenca učnih podatkov

Pri nalogi iskanja **lokalnih ekstremov funkcije dveh spremenljivk** smo v letu 2026 opazili zanimiv fenomen. Trije različni modeli – ChatGPT, Gemini in DeepSeek – so generirali popolnoma identično funkcijo:

$$f(x, y) = x^3 + y^3 - 3xy \dots \dots \dots (1)$$

To nakazuje, da modeli pri generiranju nalog niso »kreativni« v človeškem smislu, temveč z veliko verjetnostjo priključijo najpogostejši učbeniški primer iz svojih učnih podatkov. Za pedagoga to pomeni tveganje: če vsi študenti uporabljajo GenUI za vajo, bodo verjetno reševali iste naloge.

3.3 Odprava konceptualnih halucinacij

Leta 2025 je orodje Copilot pri nalogi determinante 5×5 naredilo hudo napako, saj je splošno matriko (z elementi izven diagonale) napačno prepoznalo kot diagonalno in preprosto zmnožilo elemente na diagonali ($1 \cdot 3 \cdot 4 \cdot 5 \cdot 7 = 420$). Leta 2026 je isto orodje nalogo rešilo pravilno. Prepoznalo je blokovno strukturo matrike in pravilno izračunalo determinanto kot produkt determinant blokov (B_1 in B_2), kar je dalo pravi rezultat -108.

4 Diskusija

Rezultati naše longitudinalne študije kažejo, da generativna umetna inteligenca na področju matematike v enem letu ni le linearno napredovala, temveč je doživela kvalitativno transformacijo. Kot razkriva razčlenitev v Tabeli 2, napredek orodij GenUI ni enakomeren na vseh ravneh. Medtem ko sta **pravilnost postopka** in **točnost rezultata** v letu 2026 dosegla skoraj 100-odstotno zanesljivost pri vseh modelih, se razlike še vedno pojavljajo pri **ustreznosti naloge** – torej pri upoštevanju specifičnih omejitev uporabnika (npr. celoštevilске rešitve pri Groku in Copilotu).

Od »računal« do »asistenta«

Orodja, kot sta npr. DeepSeek in Gemini, so postala zanesljivi »računski stroji«. Sposobnost pravilnega izvajanja algoritmičnih postopkov je sedaj na ravni, ki jo pričakujemo od dobrega študenta. To pomeni, da lahko učitelji ta orodja varneje uporabljajo za generiranje rešitev.

Nujnost pristopa »Človek v zanki« (Human-in-the-loop)

Kljub napredku pa orodja ostajajo »taktična« in ne »strateška«. Analiza kaže, da GenUI še ne more popolnoma avtonomno sestavljati uravnoteženih izpitnih pol. Zato je nujna implementacija modela **Human-in-the-loop (HITL)** (Zhai et al., 2021). V tem modelu učitelj ne prepusti celotnega procesa stroju, temveč deluje kot nadzornik, ki definira pogoje, preveri ustreznost naloge in popravi morebitne pristranskosti ali ponavljanja. Učitelj postane »urednik« in garant kakovosti.

5 Zaključek

V prispevku smo analizirali napredek orodij umetne inteligence pri generiranju nalog iz višje matematike v obdobju od aprila 2025 do januarja 2026. Ugotavljamo, da je tehnologija dosegla stopnjo zrelosti, ki omogoča njeno vključitev v pedagoški proces, vendar z določenimi omejitvami.

Ključne ugotovitve so:

1. **Računska zanesljivost:** Napake pri osnovnih operacijah so skoraj v celoti odpravljene.
2. **Pedagoška vrednost:** Modela DeepSeek in Gemini izstopata po jasnosti razlage postopkov in upoštevanju omejitev (celoštevilstkost).
3. **Vloga učitelja:** GenUI je zmogljiv pomočnik, vendar mora končna selekcija nalog ostati v domeni človeške strokovne presoje.

Opomba

Gradivo, na podlagi katerega je bila izvedena raziskava, je obsežno (več kot 50 strani). Bralec si lahko celoten nabor generiranih nalog in rešitev ogleda na naslovu: https://bit.ly/ui_2526.

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O avtorju

Uroš Sterle je profesor matematike in diplomant FMF v Ljubljani z bogatimi izkušnjami v informatiki. Poklicno pot je začel v gospodarstvu kot programer, kjer je matematična znanja uporabljal za razvoj rešitev in optimizacijo procesov. Od leta 2010 poučuje na Šolskem centru Kranj, kjer teoretične koncepte povezuje s prakso v podatkovnih bazah, spletnih aplikacijah in omrežnih storitvah.

Je avtor učnih gradiv za razvoj algoritmičnega mišljenja ter aktivno sodeluje pri projektih za krepitev digitalnih kompetenc in v visokošolskem izobraževanju. S stalnim strokovnim izpopolnjevanjem in več kot 20-letnimi izkušnjami z individualnim poučevanjem uspešno združuje poglobljeno matematično znanje z njegovo aplikativno vrednostjo v sodobni tehnologiji.

METHODS AND INSTRUMENTS FOR DETERMINING THE RELIABILITY FOR LLM AND RAG SYSTEMS IN RENEWABLE ENERGY DOMAIN

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This paper explores the evaluation of large language models (LLMs) and retrieval-augmented generation (RAG) systems within the renewable energy domain, emphasizing the need for reliable advisory tools in high-stakes technical applications. We review existing evaluation methods, identifying gaps in answer quality, source grounding, and system stability. To address these, we propose a three-dimensional evaluation framework integrating correctness, attribution accuracy, and robustness, tailored for renewable energy's technical complexity and regulatory demands. This framework supports users without deep AI expertise and fits into RAG chatbot development and operational cycles. Drawing from a literature review, we synthesize complementary evaluation approaches and highlight domain-specific adaptations, including handling specialized terminology, multi-source integration, and evolving standards. Our study underlines the importance of combining automated and human-centered evaluation to ensure trustworthy deployment of LLM/RAG systems, bridging current methodological gaps and fostering safer, more transparent AI applications in renewable energy.

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1 Introduction

The widespread adoption of artificial intelligence has led to the growing use of AI-based advisory systems in domains where precision, transparency, and regulatory compliance are critical. Such systems, commonly implemented as conversational interfaces (chatbots), combine global data sources with domain- and region-specific knowledge. One prominent high-stakes application area is renewable energy and energy efficiency, which is the focus of this paper. These systems typically support problem diagnosis and solution formulation, while final decisions remain with human users. In addition, Retrieval-Augmented Generation (RAG) systems assist professionals in tasks such as technical documentation analysis, regulatory compliance, system design, and troubleshooting, where domain-specific terminology, evolving standards, and multi-source information present significant challenges. Such systems need robust reliability assessment methods, particularly in applications where incorrect information may lead to serious operational, financial, or security consequences. Existing literature shows that current LLM and RAG evaluation approaches remain fragmented and lack comprehensive frameworks that jointly address answer quality, grounding and source attribution, domain-specific evaluation benchmarks, and system robustness, especially in renewable energy applications. Key challenges identified in the literature include trustworthiness and grounding issues (Song et.al, 2025), (Kenthapadi et.al, 2024), limitations of general LLM evaluation and hallucination detection (Chang et.al., 2023), (Niu et.al. 2024), challenges of RAG deployment in high-stakes domains (Tu et.al., 2024), (Prabhune and Berndt, 2024), RAG-specific evaluation gaps [24], unmet domain-specific evaluation needs (Tu et.al., 2024), and ethical considerations (Jiao et.al., 2025).

This paper addresses these gaps by synthesizing existing LLM and RAG evaluation methods into a unified three-dimensional reliability assessment framework tailored to renewable energy systems. The objectives are to: (1) systematically review and categorize LLM/RAG evaluation methods, (2) develop a three-dimensional evaluation approach integrating answer quality, grounding, and stability, and (3) propose domain-specific adaptations suitable for renewable energy applications. The proposed approach is designed to be easy to apply by non-AI experts, usable throughout the RAG-based chatbot development and deployment lifecycle. Existing work is organized into six evaluation categories: (1) human evaluation, (2) LLM reliability evaluation methods, (3) RAG-specific evaluation methods, (4) multi-

dimensional evaluation frameworks, (5) AI–human and AI–AI comparison methods, and (6) risk management and governance frameworks. To ensure practical applicability in high-stakes technical domains, these approaches are consolidated into a three-dimensional verification framework addressing (1) answer quality, (2) grounding and source attribution, and (3) stability and robustness.

2 Literature Review

Research on LLM/RAG evaluation methods is a very dynamic field, but relatively new, so many research papers are in the pre-print stage. However, there are also comprehensive surveys (Chang et.al., 2024) and evaluation framework taxonomies (Yu et.al., 2024). Based on preliminary research, LLM/RAG evaluation methods are organized into six complementary categories, each addressing specific aspects of system reliability. This is elaborated further on in this chapter.

2.1 Human Evaluation

Human evaluation remains the gold standard for assessing LLM outputs, requiring careful calibration and inter-rater agreement protocols to ensure reliability. The basis of this approach are inter-rater validation methods, agreement metrics and consistency measures. Research emphasize the importance of human annotation quality in evaluation datasets (Niu et. al., 2024) and human-annotated databases for model validation, for example 5,000-sample validation in Human-Calibrated Automated Testing (HCAT) is a two-stage calibration approach aligning machine evaluations with human (Sudjianto et.al., 2024). Probability calibration and conformal prediction techniques are applied. This method embeds metrics for explainable assessment and stratified sampling for automated test generation.

2.2 LLM Reliability Evaluation Methods

Systematic reliability testing across stability, consistency, hallucination and robustness is essential for ensuring widespread LLM use, and especially trustworthy deployment in high-stakes applications. It is conducted against adversarial, out-of-distribution, and varied inputs (Tu et.al., 2024). It confirms output consistency and stability across similar queries and identifies marginal, entropy-based and bivariate weaknesses (Joshi, 2025). **Hallucination detection** (self-consistency checks) is well

described in the literature, as is the phenomenon of LLM hallucinations. There are comprehensive surveys on their detection, explanation, and mitigation approaches. Methods like SelfCheckGPT use sampling-based consistency across multiple stochastic generations to detect hallucinations at sentence and passage levels without external knowledge sources (Manakul et.al., 2023). **Stability testing** is the examination of the performance of some tasks, with the aim of determining whether there is an absence of response stability across repeated runs, systematic yes-response biases, changes in conclusions, changes in numerical values, logical reversals or other inconsistent answers with identical inputs. **Calibration assessment** (knowing when it doesn't know) is the evaluation of how well an LLM's stated confidence (explicit or implicit) aligns with its actual correctness. It is carried out by using probability calibration techniques (Sudjianto et.al., 2024), comparing predicted confidence scores or probabilities against empirical accuracy using metrics such as Expected Calibration Error (ECE). Calibration metrics are part of the HELM framework (Bommasani, 2023).

2.3 RAG-Specific Evaluation Methods

RAG systems imply the reliability of the components they rely on, but require specialized evaluation approaches that assess retrieval quality and generation fidelity.

Retriever evaluation implies the application of typical metrics: (i) Retrieval relevance and quality metrics (Es et.al.,2024) - Did you miss relevant documents? (ii) Context precision / relevance metrics – How much noise was retrieved? (iii) Redundancy and coverage assessment (Birur et.al., 2024) (iv) Multi-step retrieval pipeline effectiveness (Krishna et.al., 2025) **Generator evaluation** contains evaluation of: (i) Faithfulness / roundedness' to retrieved context (Es et.al.,2024) - Are claims supported by retrieved text? (ii) Answer precision and accuracy (Birur et.al., 2024) (iii) Answer completeness and hallucination metrics (Zhu et. al.,2025). (iv) Answer relevance detection (Zhu et. al.,2025) - Does it actually answer the question? If RAG (and this also applies to LLM) provides citations, **citation-level evaluation** comprises (Song et.al., 2024): (i) Citation precision – does the quoted passage truly support the claim? (ii) Citation recall – are all major claims backed by citations? (iii) Attribution granularity – paragraph-level vs whole-document citation. **Trustworthiness and attribution** evaluation refer to: (i) Trust-Score for RAG

trustworthiness (Song et.al., 2024). (ii) Grounded attributions and learning to refuse. (iii) Citation accuracy and source verification.

The literature also describes end-to-end RAG Assessment using comprehensive ranking scores (Birur et.al., 2024) and factuality, retrieval, and reasoning measurement (Krishna et.al., 2025) and unified evaluation frameworks (FRAMES, VERA) (Krishna et.al., 2025), (Birur et.al., 2024).

2.4 Multi-Dimensional Evaluation Frameworks

Most of the commonly used benchmarks are incomplete, narrow and non-transparent. For example, SuperGLUE focuses on natural language understanding tasks, MMLU (Massive Multitask Language Understanding) tests understanding across academic subjects, and HumanEval's ability to generate correct Python code functions. Therefore, comprehensive multi-dimensional evaluation and benchmarking is necessary, by integrating quantitative and domain-specific metrics across multiple scenarios (Joshi, 2025). Such a multi-dimensional evaluation framework is HELM (Holistic Evaluation of Language Models), developed by the Stanford Center for Research on Foundation Models (CRFM). Some of the advantages of HELM are: (i) deeply evaluates each model across seven distinct dimensions (accuracy, calibration, robustness, fairness, bias, toxicity, efficiency) and provides a multifaceted profile, instead of a shallow one-dimensional answer as to whether the answer is "correct" (Bommasani, 2023). (ii) the evaluation spans 42 real-world use-case scenarios, such as question answering, multilingual dialogue, summarization, information extraction and classification, etc. which gives it diversity. (iii) enables trade-off analysis between different performance dimensions. (iv) is designed as an open, extensible ecosystem that encourages contributions from the research and industry. (v) strives for transparency and reproducibility through public release of prompts, datasets, and model access methods. There are other multi-dimensional benchmark frameworks with the focus on LLMs, e.g. COMPL-AI (Guldimann, 2024), intended for technical interpretation of the EU AI Act.

2.5 AI-Human and AI-AI Comparison Methods

LLMs as smart assessment judges bring a revolutionary change compared to solo human evaluators and their scalability limits, time and budget constraints. LLM-as-a-judge validation is an evaluation approach where an LLM is used to assess, score,

or compare the outputs of another model (or multiple models) against predefined criteria (Joshi, 2025). These methods are based on automated, scalable comparison, with human oversight and maintaining alignment with human preferences. LLM-as-judge architectures exhibit excellent capability to judge multiple quality dimensions in parallel, such as semantic and contextual correctness, conversational quality and fulfillment of user intent. Accuracy and reliability are increased through feedback loops. Today, the best practice is for prompt design in evaluation, used for validation against human judgments (e.g., 91% alignment in RAG-Check) (Mortaheb, 2025).

2.6 Risk Management and Governance Frameworks

Beyond the narrow evaluation of LLM/RAG reliability, comprehensive risk management aligned with regulatory requirements and effective governance are essential. Applying the NIST AI Risk Management Framework to LLM/RAG systems enables a structured assessment of risks across the AI lifecycle, including data quality, model behavior, security, and governance, by mapping system-specific hazards to the framework's functions for identifying, measuring, managing, and governing AI risks (Kenthapadi et.al, 2024). Similarly, applying the COMPL-AI technical interpretation of the EU AI Act allows high-level regulatory obligations to be translated into concrete, and measurable technical requirements for systematic risk evaluation and system validation (Guldimann, 2024). LLM/RAG evaluation poses distinct ethical challenges (Jiao et.al.,2025) as harms may arise from the interaction between opaque model reasoning and dynamically retrieved external content. These include bias amplification, misinformation propagation, and overreliance on unverified outputs. Such risks can be mitigated through curated and auditable retrieval sources, human-in-the-loop review for high-risk scenarios, explicit citation signals, and continuous monitoring with feedback loops. Although not part of evaluation frameworks in the strict sense, governance models for LLM/RAG deployment and use (Prabhune and Berndt, 2024) must clearly define accountability, decision rights, risk ownership, and escalation mechanisms, while ensuring regulatory compliance and secure technical architectures. In practice, these challenges can be addressed by establishing centralized AI governance structures, embedding human review into workflows, and operationalizing governance through logging, audits, training, and continuous compliance monitoring.

3 Three-Dimensional Evaluation Approach

The evaluation methods reviewed provide solid coverage of individual aspects; however, comprehensive surveys have identified notable limitations (Chang et.al, 2024), (Yu et.al., 2024), underscored domain-specific evaluation requirements (Tu et.al., 2024), and highlighted challenges related to practical deployment (Song et.al, 2024). These findings suggest significant opportunities for advancement, particularly in the development and application of integrated evaluation frameworks tailored to domain-specific contexts, alongside the provision of practical implementation guidance. In the following, a three-dimensional evaluation approach is proposed that simultaneously addresses quality, grounding/source attribution, and stability/robustness to ensure reliable LLM/RAG system deployment.

The main objectives of the proposed three-dimensional approach are: simplicity and comprehensibility and interdependencies between dimensions, comprehensive coverage of reliability concerns, alignment with existing evaluation methods and multi-method strategy, open to accepting new methods.

3.1 Definition of dimensions

The Answer Quality dimension is primarily focused on the evaluation of correctness, relevance, completeness, and coherence of generated responses. Human evaluation provides the gold standard for quality assessment (Tu et.al, 2024), (Joshi, 2025), relying on relevant metrics, such as RAGEval completeness and irrelevance metrics (Zhu et.al, 2025). Evaluation components are presented and explained in Table 1.

Dimension 2 (Grounding and Source Attribution) evaluates if generated content is properly grounded in authoritative sources with accurate attribution. Evaluation Components are explained in Table 2.

Dimension 3: Stability and Robustness is checked by evaluating system consistency, and resistance to adversarial or out-of-distribution inputs (Table 3).

Table 2: Grounding and Source Attribution dimension definition

Dimension	Metrics	Methods	Key Literature
Retrieval Quality (Effectiveness of source identification and ranking)	Retrieval precision, recall, relevance scores	Retrieval component evaluation (Es et.al., 2024), multi-step pipeline assessment (Krishna et.al., 2025)	RAGAS retrieval metrics (Es et.al., 2024); FRAMES retrieval evaluation (Krishna et.al., 2025)
Attribution Accuracy (Correctness of source citations and references)	Citation accuracy, attribution precision	Citation-level evaluation (Song et.al., 2024), grounded attribution assessment	Trust-Score framework for grounded attributions (Song et.al., 2024); RAGTruth corpus (Niu et.al., 2024)
Faithfulness (Alignment of generated content with retrieved sources)	Faithfulness scores, entailment measures	Automated faithfulness checking (Es et.al., 2024), human verification	RAGAS faithfulness metrics (Es et.al., 2024); VERA context adherence (Birur et.al., 2024)
Source Transparency (Clarity and accessibility of source information)	Source disclosure rates, transparency scores	Source tracking and verification (Birur et.al., 2024)	VERA validation framework for retrieval systems (Birur et.al., 2024)

Table 3: Stability and Robustness dimension definition

Dimension	Metrics	Methods	Key Literature
Consistency (Stability of outputs across similar queries)	Output variance, consistency scores	Repeated query testing, marginal analysis (Sudjianto et.al., 2024)	HCAT robustness testing (Sudjianto et.al., 2024); entropy-based stability (Joshi, 2025)
Calibration (Alignment of confidence estimates with actual accuracy)	Calibration error, confidence–accuracy correlation	Probability calibration (Sudjianto et.al., 2024), conformal prediction (Sudjianto et.al., 2024)	HELM calibration and robustness [2]; HCAT calibration approach (Sudjianto et.al., 2024)
Adversarial Resistance (Performance under challenging or adversarial conditions)	Adversarial robustness scores, failure rates	Adversarial testing (Sudjianto et.al., 2024), out-of-distribution evaluation	HCAT robustness testing (Sudjianto et.al., 2024); S-Eval safety evaluation (Yuan et.al., 2024)
Error Detection (Ability to identify and refuse inappropriate queries)	Refusal rates, error detection accuracy	Learning to refuse (Song et.al., 2024), uncertainty quantification	Trust-Align method (Song et.al., 2024); S-Eval safety evaluation frameworks (Yuan et.al., 2024)

3.2 Method Mapping Matrix

The three-Dimensional Approach integrates methods from all six evaluation categories to provide comprehensive reliability assessment. The mapping of evaluation methods to three dimensions is described in Table 4.

Effective implementation of the Three-Dimensional Approach and related evaluation methods requires a practical, scalable methodological framework that includes an evaluation workflow design, a description and methodological instructions for each activity, and expected inputs and deliverables. It is important to balance rigor and comprehensiveness with applicability and resource constraints.

Evaluation workflow design also includes defining criteria for different application scenarios, for example: continuous vs. periodic evaluation, sequential vs. parallel evaluation, prioritization based on application requirements.

3.3 Domain-Specific Adaptation for Renewable Energy

Renewable energy applications require specialized adaptations of the three-Dimensional Approach to address unique domain characteristics, such as:

- Technical complexity and specialized terminology
- Regulatory compliance requirements (safety, environment, grid standards)
- Multi-source information integration (e.g. research, standards,..)
- Evolving knowledge base (new technologies, updated regulations)
- High-stakes decision contexts (safety, financial, operational).

Preliminary requirements for adaptation to renewable energy are in Table 4.

Table 4: The mapping of evaluation methods to three dimensions

Evaluation Method	Answer Quality	Grounding/Sources	Stability/Robustness
Human evaluation	Human judgment as ground truth for correctness and relevance (Sudjianto et.al., 2024), (Joshi, 2025)	Human verification of source attribution accuracy (Sudjianto et.al., 2024)	Human assessment of consistency across test cases (Sudjianto et.al., 2024)
LLM reliability evaluation	Hallucination detection directly impacts correctness (Joshi, 2025), (Niu et.al., 2024)	Consistency, calibration, and adversarial resistance (Niu et.al., 2024)	Consistency, calibration, and adversarial resistance (Sudjianto et.al., 2024), (Joshi, 2025), (Yuan et.al., 2024)
RAG-specific evaluation	Completeness, correctness, and relevance of generated responses (Krishna et.al., 2025), (Es et.al., 2024), (Zhu et.al., 2025)	Retrieval quality, attribution accuracy, and citation verification (Song et.al., 2024), (Krishna et.al., 2025), (Birur et.al., 2024), (Es et.al., 2024)	Consistency across retrieval variations and adversarial contexts [L1]
Multi-Dimensional Approaches	Accuracy, completeness, and relevance metrics [2]	Accuracy, completeness, and relevance metrics [2]	Calibration, consistency, and adversarial resistance testing [2]
AI-AI comparison	Automated assessment of correctness, completeness, and relevance (Mortaheb et.al., 2025), (Joshi, 2025)	Citation verification and attribution checking (Mortaheb et.al., 2025)	Consistency testing across multiple evaluators (Joshi, 2025)
Risk management	Accuracy requirements for regulatory compliance (Guldimann, 2024), (Yuan et.al., 2024)	Verifiable accountability and source transparency (Jiao et.al, 2025)	Reliability requirements for high-stakes applications (Kenthapadi et.al, 2024), (Guldimann, 2024), (Yuan et.al., 2024)

4 Conclusion

This study underscores the critical importance of rigorous evaluation for the responsible deployment of LLMs RAG systems, particularly within high-stakes technical domains such as renewable energy. We propose a Three-Dimensional Framework for assessing LLM/RAG reliability, synthesizing insights from existing evaluation methodologies. Our literature review highlights the necessity of

comprehensive, multi-faceted evaluation approaches that integrate domain expert input. Current research trends emphasize the development of evaluation frameworks that balance automation and human oversight to ensure scalability and robustness.

We categorize LLM/RAG evaluation techniques into six methods, organized along three key dimensions: answer quality, grounding, and stability assessment. Additionally, we introduce domain-specific modifications tailored to renewable energy applications to address unique contextual requirements.

This work reflects the present capabilities and constraints of evaluation frameworks, acknowledging that the field remains rapidly evolving. Our scope is limited to text-based LLM/RAG systems, reflecting current boundaries in integrating numerical data and performing quantitative calculations. In the future research it is necessary to advance evaluation methods that accommodate these limitations and support broader, more integrated system assessments.

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DOLGOTRAJNA BOLNIŠKA ODSOTNOST PRI MIŠIČNO- SKELETNIH BOLEZNIH IN NJEN VPLIV NA DOLGOŽIVOST

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Dolgotrajna bolniška odsotnost (DBO) presega odziv na bolezen, saj pogosto izhaja iz kroničnih stanj in pomembno vpliva na dolgoživost družbe. DBO, ki traja več kot eno leto in je posledica bolezni mišično-skeletnega sistema in vezivnega tkiva, v naši raziskavi predstavlja najvišji delež odsotnosti z dela pri obeh spolih v celotnem opazovanem štiriletnem obdobju (2021–2024). Ugotovitve potrjujejo, da navedena skupina bolezni ostaja vodilni razlog delovne nezmožnosti ter predstavlja pomemben socialno-zdravstveni in družbeno-ekonomski izziv sodobne družbe. Raziskave na področju dolgoživosti poudarjajo, da ohranjanje smiselne vloge posameznika v družbi in občutka pripadnosti ter udeležba rednih strukturiranih aktivnosti pozitivno vplivata na nevroplastičnost, regulacijo stresa, presnovno zdravje in imunski sistem, ki so ključni zaščitni elementi zdravega staranja. Ukrepi, usmerjeni v preprečevanje DBO ter podporo varni in postopni reintegraciji v delovno okolje, predstavljajo pomemben dejavnik pri zmanjševanju negativnih posledic kroničnih nenalezljivih bolezni na zdravje, funkcionalno sposobnost in dolgoživost.

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LONG-TERM SICK LEAVE DUE TO MUSCULOSKELETAL DISORDERS AND ITS IMPACT ON LONGEVITY

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Long-term sickness absence extends beyond an immediate response to illness, as it frequently arises from chronic conditions and has a meaningful impact on population longevity. In our study, long-term sickness absence lasting more than one year and attributable to musculoskeletal and connective tissue disorders represents the largest share of work absence among both sexes across the entire four-year observation period (2021–2024). The findings confirm that this group of disorders remains the leading cause of work incapacity and constitutes a significant socio-health and socio-economic challenge for contemporary society. Research on longevity highlights that maintaining a meaningful social role, a sense of belonging, and regular participation in structured activities positively influences neuroplasticity, stress regulation, metabolic health, and immune function—key protective factors for healthy ageing. Measures aimed at preventing long-term sickness absence and supporting safe, gradual reintegration into the workplace play an important role in mitigating the adverse effects of chronic non-communicable diseases on health, functional capacity, and longevity.



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1 Uvod

V sodobnih raziskavah o dolgoživosti vse izraziteje prihaja v ospredje vprašanje kakovosti življenja v poznejših življenjskih obdobjih. Dolžina življenjske dobe ne predstavlja več zadostnega merila napredka. Poudarek se premika k pojmu »dodana leta zdravega življenja«, ki opredeljuje obdobje, v katerem posameznik ostaja funkcionalno zmožen, samostojen ter neobremenjen s pomembnimi omejitvami ali kronično invalidnostjo. Ta koncept odraža temeljni premik od zgolj podaljševanja življenjske dobe k izboljševanju njene kakovosti. Ocenjuje se, da je ekonomska vrednost izobraževanja za daljše in bolj zdravo življenje primerljiva ali večja od vrednosti izobraževanja za življenjske zasluge. Države, ki sistematično vlagajo v izobraževanje prebivalstva z namenom povečevanja deleža oseb z dokončano srednješolsko in univerzitetno izobrazbo, lahko pomembno prispevajo k izboljšanju zdravstvenega stanja prebivalstva, podaljšanju pričakovane življenjske dobe ter ustvarjanju znatne družbeno ekonomske koristi (Kruger, et. al., 2019). Japonska je doslej dosegla izjemne dosežke na področju zdravstvene oskrbe, kar se odraža v izboljšanih izidih zdravljenja in daljšem preživetju prebivalstva. Vendar demografske spremembe, zlasti hitro staranje prebivalstva, nakazujejo, da se bo povpraševanje po zdravstvenih storitvah v prihodnje spremenilo. Ker so bolezni v starejši populaciji pogosto kronične in neozdravljive z DBO, obstoječi modeli zdravstvene oskrbe ne zadostujejo več v celoti, zato je nujna nadgradnja zdravstvenega sistema v smeri celostne, dolgotrajne in starosti prilagojene oskrbe, primerne za potrebe starajoče se družbe (Arai, et. al., 2015). Poleg tega je ključnega pomena vzpostavitev sodelovanja med industrijo, akademsko sfero, vlado in zasebnim sektorjem, pri čemer je treba upoštevati tudi dejavnike, ki omogočajo delovno aktivno vlogo starejših v preostalem življenjskem obdobju, kot so zaposlovanje, spodbujanje medosebnih povezav ter uporaba tehnologij, ki podpirajo starejše in olajšujejo vsakodnevno delo in življenje. Med pogostimi vzroki za DBO z dela prevladujejo kronične nenalezljive bolezni, zlasti bolezni mišično-skeletnega sistema in vezivnega tkiva, neoplazme, duševne in vedenjske motnje ter bolezni obtočil, ob katerih se pojavljajo tudi druge zdravstvene težave (Šestan & Jelen, 2025). Tudi kronična bolečina ima pomemben vpliv na delovno aktivno populacijo po vsem svetu, saj prizadene približno 8 do 10 % prebivalstva. Poleg neposrednih zdravstvenih posledic je kronična bolečina povezana tudi s povečanim tveganjem za DBO, kar lahko posamezniku povzroči izgubo dohodka in hkrati poveča družbene stroške. Preprečevanje kronične bolečine je zato ključno, pri čemer je razumevanje dejavnikov tveganja za DBO prvi bistveni

korak k oblikovanju učinkovitih strategij za zmanjševanje njenega vpliva na posameznika in družbo (Larsson, et.al., 2025).

2 Pričakovana življenjska doba kot kazalnik dolgoživosti

Pričakovana življenjska doba ob rojstvu se razlikuje glede na spol, in sicer je bila leta 2021 v državah OECD v povprečju 83,0 let za ženske v primerjavi s 77,6 let za moške. Razlika v povprečju je 5,4 leta. Covid-19 je imel velik vpliv na pričakovano življenjsko dobo zaradi izjemno velikega števila smrti, ki jih je povzročila ta pandemija. Pred pandemijo se je pričakovana življenjska doba v vseh državah OECD in partnerskih državah med letoma 2010 in 2019 povečala, s povprečjem za 1,7 leta. Med letoma 2019 in 2021 se je pričakovana življenjska doba v državah OECD v povprečju skrajšala za 0,7 leta (OECD, 2024).

Te razlike v pričakovani življenjski dobi med spoloma so deloma posledica večje izpostavljenosti moških dejavnikom tveganja, zlasti večjega uživanja tobaka, prekomernega uživanja alkohola in manj zdrave prehrane. Moški pogosteje umrejo zaradi nasilnih smrti, kot so samomori in nesreče. Razlike v pričakovani življenjski dobi med spoloma so še posebej izrazite v državah srednje in vzhodne Evrope.

Tudi število zdravih let življenja pri 65 letih se med državami OECD precej razlikuje (OECD, 2024). Dolgoživost je vse bolj opazen pojav v razvitih gospodarskih družbah, kjer ljudje sistematično preživijo svojo pričakovano življenjsko dobo, tako ob rojstvu kot v poznejši starosti. Nekatere države so zabeležile opazno povečanje pričakovane življenjske dobe pri 65 letih (Ayuso, et. al., 2020).

V okviru proučevanja DBO pri mišično-skeletnih obolenjih in njenega vpliva na dolgoživost smo zasnovali osrednje raziskovalno vprašanje, ki usmerja celoten raziskovalni proces.

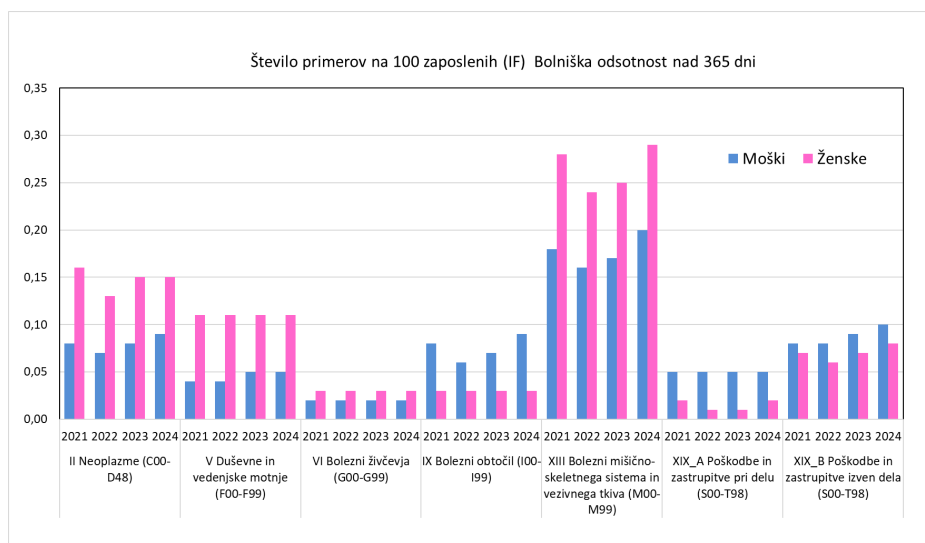
RV: Kako DBO zaradi mišično-skeletnih bolezni vpliva na dolgoživost?

3 Empirična analiza dolgotrajnega bolniškega staleža v obdobju 2021–2024

Podatke smo pridobili iz Nacionalnega inštituta za javno zdravje (NIJZ) za obdobje štirih let od leta 2021 do 2024, ki smo jih izračunali po metodologiji NIJZ:

- INDEKS FREKVENCE (IF) – število primerov odsotnosti z dela zaradi bolniškega staleža na 100 zaposlenih v 1 letu;
- ODSOTOTEK BS (% BS) – odstotek izgubljenih koledarskih dni v enem letu na enega zaposlenega delavca.

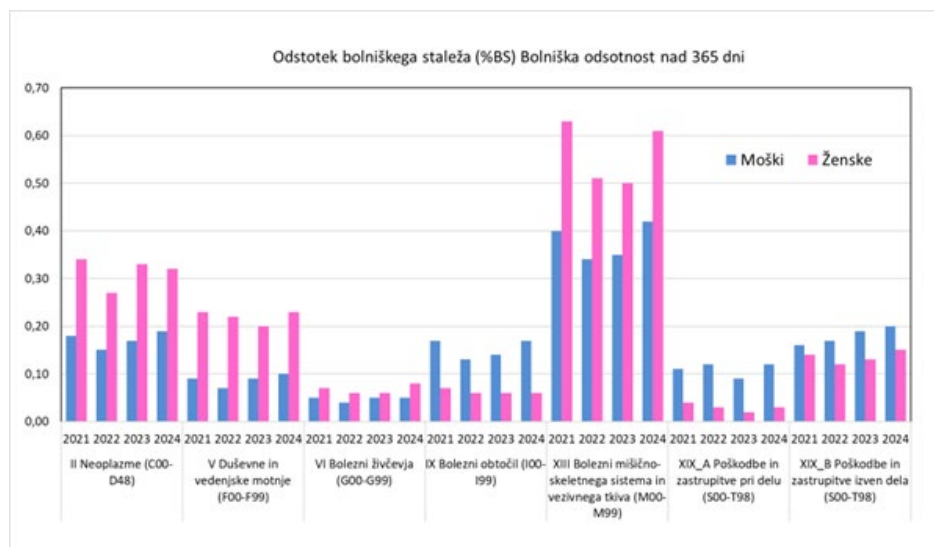
DBO so bile obravnavane glede na spol in diagnoze po MKB 10 – AM (verzija 11).



Slika 1: Število primerov DBO na 100 zaposlenih (IF) po MKB 10 – AM (verzija 11) od leta 2021 do 2024

DBO, definirana kot odsotnost, ki traja več kot eno leto, je tako pri moških kot pri ženskah najpogostejše povezana z boleznimi mišično-skeletnega sistema in vezivnega tkiva, ki predstavljajo najvišje število primerov (IF) za DBO. Pri ženskah v delovno aktivni populaciji so med pogostejšimi vzroki tudi neoplazme ter duševne in vedenjske motnje, medtem ko pri moških izstopajo poškodbe in zastrupitve izven

dela, neoplazme ter bolezni obtočil. Epidemiološki podatki kažejo, da ti vzroki ne določajo le pogostosti DBO, temveč tudi pomembno vplivajo na trajanje odsotnosti in posledično na izgubljena delovna leta ter ekonomske stroške za posameznike in družbo (slika 1).



Slika 2: Odstotek DBO po MKB 10 – AM (verzija 11), po spolu od leta 2021 do 2024

Odstotek DBO kaže podobne vzorce kot (IF). Najvišji delež DBO beležimo pri obeh spolih zaradi bolezni mišično-skeletnega sistema in vezivnega tkiva, pri čemer je delež pri ženskah višji. Prav tako je pri ženskah izražen večji delež DBO zaradi neoplazem ter duševnih in vedenjskih motenj. Pri moških so na drugem mestu poškodbe izven dela in neoplazme, pri čemer je zabeležen tudi znaten delež DBO zaradi bolezni obtočil (slika 2).

4 Razprava in zaključek

Dolgoživost kot koncept presega klasično razumevanje starajoče se družbe, ki se osredotoča predvsem na demografske trende in rast deleža starejšega prebivalstva. Dolgoživost temelji na proaktivnem preoblikovanju življenjskega poteka z namenom optimizacije podaljšanega življenjskega obdobja. Ta pristop ne obravnava staranja zgolj kot biološkega procesa, temveč kot dinamično interakcijo med

posameznikovimi zmožnostmi, družbenimi strukturami in tehnološkim napredkom. Uresničevanje družbe dolgoživosti zato zahteva sistemske prilagoditve v izobraževanju, zaposlovanju, zdravstveni oskrbi in medgeneracijskih odnosih, hkrati pa tudi preoblikovanje družbenih norm, ki določajo, kaj pomeni kakovostno in aktivno staranje v sodobnem življenjskem ciklu (Scott, 2021). Zdravo staranje, kot ga opredeljuje Svetovna zdravstvena organizacija (WHO), se osredotoča na ohranjanje notranje zmogljivosti ter telesnega, duševnega in socialnega blagostanja skozi vse življenje. Poudarja pomen preventivnega zdravstvenega varstva, pravilne prehrane in redne telesne dejavnosti pri odlašanju nastanka kroničnih bolezni in ohranjanju funkcionalne neodvisnosti (Gianfredi, et. al., 2025). Družbeno-ekonomski in tehnološki razvoj zadnjih desetletij je omogočil edinstven napredek, povezan z daljšim trajanjem življenja in boljšim zdravjem velikega dela svetovnega prebivalstva, vendar pa so v porastu tudi multimorbidnost, krhkost in invalidnost (Polidori, 2024). Z usmerjanjem na ključne mehanizme staranja bi morala biti geroterapevtika učinkovita pri zdravljenju bolnikov z multimorbidnostjo in invalidnostjo, fenotipi, ki so danes preveč pogosti med geriatričnimi bolniki. Geroznanost trdi, da temeljni biološki mehanizmi staranja prispevajo h kroničnim boleznim in invalidnostim v pozni življenjski dobi ter da je mogoče aktivno delovno dobo in dolgoživost modulirati s farmakološkimi in vedenjskimi pristopi (Ferrucci, et. al., 2024; Arai, et. al., 2015).

V naši raziskavi so mišično-skeletne bolezni eden ključnih vzrokov za DBO in obolevnost v delovno aktivni populaciji pri obeh spolih. Poleg neposrednega vpliva na delovno zmožnost te bolezni pogosto vodijo v zmanjšano produktivnost ter prezgodnje upokojevanje, kar še dodatno potrjuje pomembnost njihovega prispevka k skupnemu bremenu bolezni v populaciji v najaktivnejšem življenjskem obdobju. Tudi raziskava, ki so jo izvedli na Japonskem, kaže, da bi učinkovita odprava bolečin v križu in/ali artroz zmerno, vendar statistično pomembno podaljšala pričakovano zdravo življenjsko dobo. Ugotovitve klinično potrjujejo, da sta bolečina v križu in artroza med mišično-skeletnimi boleznimi ključna dejavnika, ki pomembno vplivata na kakovost in trajanje zdravega življenja. Mišično-skeletne bolezni in poškodbe namreč omejujejo telesno funkcionalnost posameznika ter s tem negativno vplivajo na pričakovano zdravo življenjsko dobo, hkrati pa imajo pomembne medicinske, ekonomske in socialne posledice (Ritsuno, et. al., 2021). Tudi v ZDA mišično-skeletne bolezni prizadenejo več kot 121 milijonov ljudi in predstavljajo najvišjo pojavnost bolezni, povezanih z DBO, ter invalidnostjo med vsemi skupinami

bolezni, kar poudarja potrebo po ciljno usmerjenih strategijah obravnave. Zgodnja intervencija, interdisciplinarno sodelovanje in personalizirana oskrba so bistveni za izboljšanje izidov zdravljenja, kakovosti življenja bolnikov in dolgoživosti ter za učinkovito obvladovanje naraščajočega bremena mišično-skeletnih bolezni (Nguyen, et. al., 2025). Zato intervencije, usmerjene v zmanjševanje DBO, ter krepitev trajnostne in dolgotrajne prisotnosti na delovnem mestu predstavljajo ključen javnozdravstveni in pomemben socioekonomski ukrep (Neupane, et. al., 2025).

Skratka, področje raziskav dolgoživosti hitro napreduje od intervencij na celotnem organizmu k vse bolj natančnim strategijam, specifičnim za celični tip, ki so zdaj ključne za oblikovanje učinkovitejših in personaliziranih terapij proti staranju. To bo odprlo obetavno novo poglavje v prizadevanju za odložitev staranja, podaljšanje zdravstvenega stanja in zmanjšanje bremena bolezni, povezanih s starostjo (Chen, et.al., 2025).

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THE IMPACT OF AI ON CRM - INSIGHTS FROM A BUSINESS MODEL CANVAS PERSPECTIVE

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Rapid and complex technologies development may have a disruptive effect on existing paradigms of doing business. Successful customer relationship management as one of the key levers for sales productivity, includes among others, trustworthiness in delivering expected value proposition, transparency in collaboration, truthful and safe information exchange in acquisition of new customers, optimizing customer retention, designing and maintaining proper communication channels and ensuring effective process scenarios – all of them impacting the overall customer experience, but at the same time very strongly impacted by technologies. One such impactful technology is, based on its current pace of development, Artificial Intelligence (AI). Considering its game-changing role, AI tools offer to redefine communication landscapes, introducing benefits but also risks in shaping the relationships with customers. Meanwhile, while rethinking and innovating new value creation models for customers, businesses rely on well-known frameworks and approaches in designing alternatives for customers. Business Model Canvas, being one of those structured approaches, can be a useful perspective for experimenting with AI in order to gain insights on how AI can impact customer relationship management in terms of collaboration, analytics and operations.

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1 Introduction

Digital transformation implies significant changes in the organization's business processes, resulting with a high impact on the customer relationship management (CRM) processes as well. According to Buttle and Malkan (2019) CRM aims to create and maintain profitable relationships with customers by designing and delivering high quality value. The basic framework of the customer-oriented business philosophy is given by the organization's business model, which includes the key elements of how and what the organization offers (Value), to whom (Customers) and how (Processes). Although CRM innovations are not necessarily always related to technology, contemporary innovation usually includes at least some technological improvements. This paper investigates the impact of one of the most unpredictable and disruptive technologies - artificial intelligence, and its role on changes designed in the business model of an organization while reconsidering how and what new value may be offered to customers.

Ozay et al. (2024) provided a bibliometric analysis, concluding, among other, that evolution of CRM is tracing its advancement from 1960s to 1980s as a function of information industry revolution, followed by the "Birth of Automation" via PCs in the 1990s. The rise of cloud computing and social media introduced "Social CRM", followed by the 2010s shift to SaaS and "analytical CRM" for predicting lifetime value. Today, "AI-based CRM" uses automation and predictive insights to deliver personalized customer experiences at scale, making it an essential tool for modern business strategy.

Saha (2025) states that, when compared to traditional CRM, AI powered CRMs boost conversion rates of potential customers to becoming paying buyers from 30% to 65%, by replacing manual data entry with predictive analytics and real-time audience targeting, then AI-powered personalization and sentiment analysis increase retention rates from 45% to over 80%, and AI chatbots and automated ticketing provide instant, 24/7 support, vastly outperforming the 10% response capacity within traditional CRM.

In the study of Averineni et al. (2024) a framework for using AI, and its supportive technologies, namely Machine Learning and Natural Language Processing, is presented, showing the potential to drastically transform CRM by implementing AI, starting with the strategic level of development.

CRM can benefit from using AI, but as of yet, similar to other disciplines, it lacks proper context for AI application, and therefore relying on individual preferences of AI tool users and usually without adequate context description of the case AI is used in. For contributing to this gap of scarce context taxonomy, we propose a conceptual framework based on four variables that can serve as a set of components needed to describe the context, necessary for AI content prompting related to CRM.

2 Theoretical background

Customer relationship management is the crucial tool for any organization for ensuring audience for whatever the business is delivering. It covers every phase of customer lifecycle, from customer acquisition and onboarding, over enhancing sales operations, improving customer experience, maintaining retention rates, keeping the relationship with the customer but also managing the offboarding. Supporting mechanisms for a successful CRM are data, effective processes, stakeholders ready to co-create value and operational customer channels – all of them leading the organizational culture to be more focused on innovation.

Ayaz et al. (2024) explore how AI-driven decision-making and human understanding can be enhanced in the context of ensuring more precise targeting in marketing campaigns. By applying AI techniques for exploitation of the massive volumes of data, to analyze data and gain insights for customer experience personalization, and optimization of decision-making processes, this study contributes to more transparency and interpretability of AI systems in decision-making. Alnofeli, Akter & Yanamandram (2025) propose an AI-enabled CRM capabilities framework consisting of three major dimensions (data management including data governance, data intelligence and privacy and security), multi-channel integration through content and process consistency, and tailored service offerings oriented on personalization, automation, meaningfulness and novelty. Furthermore, Alnofeli et al. after empirically testing their proposed AI-enabled CRM capabilities framework, conclude that organization can significantly enhance their organizational

performance in a sense that those dimensions and their sub-dimensions effect profitability and competitive advantage.

The adoption of AI for CRM is not limited to profit-oriented organizations. Gabay, Jonathan, & Reychav (2024) investigate AI-driven CRMs and its role in automating routines, improving segmentation and prioritization, providing virtual assistance, and guiding employees in the public sector. Also, Krishna & Vyas (2024) research the integration of advanced predictive models in the healthcare sector, emphasizing the significance of prediction models in disease prevention, allowing thereby timely intervention, but also mentioning the value of personalization and continuous patient monitoring while complying with privacy and data protection regulation. Ethical questions related to privacy and data protection pose an important issue in the study of Khneyzer, Boustany & Dagher (2024) related to implementing AI-Driven Chatbots in CRM. The authors state that in addition to beneficial economic and managerial implications, biased or incorrect results, mechanisms underlying the applied AI systems in terms of accountability, transparency and trust issues are still relevant research topics for future research.

Ledro, Nosella & Pozza (2023) investigate some challenges AI brings when integrated with CRM systems, highlighting that it requires a cultural shift towards data-driven and customer-centric approaches, so the successful implementation relies on good communication between departments involved into capturing data (like marketing and sales) as well as clear policy guidelines for data governance. Data privacy and related regulation compliance is identified and addressed by Penubelli (2024) as a challenge as well, for being an important responsibility of businesses using AI-powered CRMs.

Three basic CRM subsystems (Reynolds, 2002; Dyche, 2002) which shape interactions with customers:

- Collaborative CRM, which enables the integration of communications and information between organizational departments, stakeholders and processes. Its goal is to provide integrational mechanisms which rely on data management and analytics related to customers, but also to ensure compatibility of data from different sources, incoming and outgoing

through different channels, and appearing in different forms – from traditional to GenAI content.

- Analytical CRM is often called the “back office”, since its role is to collect, analyze, process and distribute data collected from users and design marketing strategies, based on insights gained through data analytics. At this level, the aim is to collect data through various sources on time and with enough reliability while facing the problem of the large amount of data that needs to be processed.
- Operational CRM aims to improve everyday customer communication, while being responsible for automating processes, ensuring resources, executing activities, operationalizing set goals and keeping operations focused on delivering the designed value proposition. That is why this level of CRM is considered as the CRM “front office” in delivering operations and ultimately getting the job done.

For designing and rethinking organizational business model, well-known frameworks and approaches are used. The Business Model Canvas (BMC), by Osterwalder et al. (2014), stands as the most widely adopted and used framework. It serves as a tool for defining new value creation of products and services, but also for continuous management. Its nine core components are focusing on defining and reaching the market through segments, relationships, and distribution channels, then on infrastructure through addressing the essential organizational building blocks—key partners, activities, and resources, the value propositions that center on leveraging new technologies and innovation to enhance products or services and financial viability for evaluating the cost structures and revenue streams generated by the business. Grgurević (2017) reorganizes these nine elements into the Business Model Option (BMO) matrix, consisting of The Operational Model - defined by internal structural elements, The Commercial Model - consisting of customer-facing components and The Value Proposition - focusing specifically on the core product or service offering. Although the BMO concept originates from the BMC, it differs from the original BMC by representing a simplified alternative approach, providing more focused management view on three perspectives important for easier decision making: demand (focusing on the commercial aspects), value proposition (as the answer to the demand) and supply (shaping the operational response). In our study we decided to opt for the BMO matrix instead of BMC because it can sufficiently represent the idea of business model integration in our framework by implementing

the demand-value-supply paradigm, while at the same time it enables us to focus on fewer alternatives (three instead of nine elements) of the CRM-AI context.

3 Methodology

Following the idea of gaining insights how AI tools impact CRM, the goal of this paper is to design a conceptual framework for investigating how AI tools can contribute to rethinking and redesigning the value proposition. Decision on how, when and to which extent to use AI is not simple to make, because various criteria can impact that decision. Empirically and depending on the organizational goals, the priorities of business model improvement initiatives may vary. Given the diversity of available AI tools, the level of acceptance of technological tools and trustworthiness of data, the following criteria were initially ideated primarily based on conceptual reasoning:

- Real Data Sensitivity, RDS – this criterion is linked to the required level of usage of real data in AI prompts versus organizational exploration readiness to create content without the necessity to use historical or existing data;
- Disruptive Innovation Potential, DIP – this criterion takes into account how strong the AI use depends on coupling with previous initiatives, legacy projects or systems and similar innovation limiting aspects of transformational efforts; and
- Intent Disclosure Level, IDL – this criterion explains the need for openly expressing the intention behind the usage of AI tools for CRM purposes.

These criteria are not comprehensive in terms of the opportunities and challenges that affect the application of AI in CRM, but rather represent guidelines for an acceptable and transparent application of AI. The lack of regulation when it comes implementing AI in various disciplines, results with uncertainty when it comes to understanding or it potentially leads to misinformation. The three criteria (RDS, DIP and IDL) proposed in our framework, were inspired by different perspectives on AI usage, and the lack of clear guidelines or a widely accepted consensus on AI usage as reported (unicef, Möller; Kwon 2025). Based on our understanding the three criteria form the minimum description of a context that allows positioning of any case of content prompting with AI tools and its usage for CRM. The criteria can be mapped to main theoretical concepts from the previous section: CRM goals, BMC

dimensions, CRM subsystems. Based on the literature analysis following goals (i.e. success aspects) of CRMs emerged as relevant: better targeting, innovation, personalization, transparency and trust. These goals are addressed in approaches of improving organizational business models, but due to the acceptance of BMCs in digital transformation initiatives, this method simplified in the BMO matrix (Supply, Demand and Value Proposition dimension) was selected in order to keep a clear focus on three CRM subsystems: collaborative, analytical and operational CRM. In this way, it is possible to design a conceptual framework that represents AI usage options in the context of CRM, shown in Figure 1.

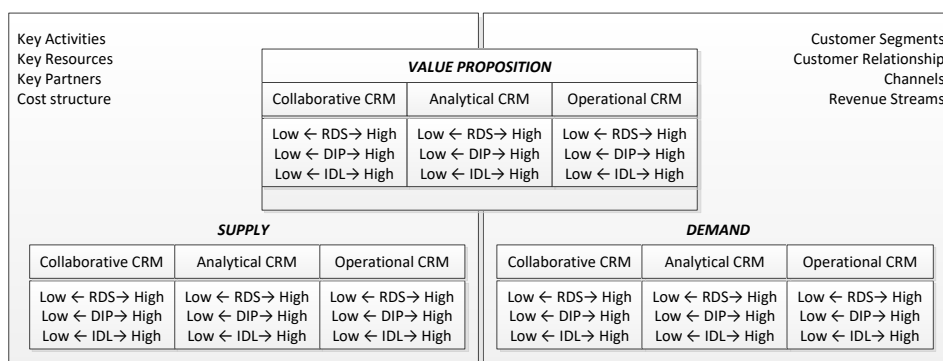


Figure 1: Conceptual framework of AI usage options in the context of CRM

Source: Own

Desired priorities of CRM goals for an organization will impact how AI usage criteria are met, so for each of the BMC dimension and CRM subsystem feasible use-cases can be defined. These use-cases, explained by examples, are presented in Table 1 in the following section.

4 Results

As discussed in the Methodology section, the decision on how to use AI in CRM depends on many criteria which can impact that decision. Our framework focuses on four variables presented in Table 1. First variable is the CRM goal, defining the scope or the desired state referenced to better targeting, innovation, personalization, transparency and trust, as identified in literature review.

Table 1: Examples of AI use-cases

CRM goal (scope)	BMC dimension (limitations)	CRM subsystem (range)	AI usage criteria (rules of engagement)	Use-case example
Case 1				
Personalization	Demand	Analytical	RDS→ High DIP→ High Low ← IDL	AI tools are used for analyzing large amount of data that needs to be processed, for creating scenarios of innovative customer experience with existing services company is offering, allowing the company to explore and select viable options.
Context Description: A company aims to introduce more customer experience options which could be perceived as more personalized. This is aligned with other CRM initiatives and contributes to designing future marketing strategies, based on data collected through various sources (analytical CRM). Existing data on customers is available and so far, credible (RDS→ High), the aimed customer segments were previously willing to try different options (DIP→ High), even if the company doesn't ask for consent in advance (Low ← IDL).				
Case 2				
Trust	Supply	Collaborative	RDS→ High Low ← DIP IDL → High	AI tools are used for analyzing existing data on business processes performance, for proposing process improvements based on case studies and best practices within the industry, creating visualizations on step-by-step introduction of new policies, providing predictions of future performance, allowing the company to explore alternatives.
Context Description: A company aims to improve customers' trust, believing this would boost perceived value of services quality and assist retaining existing market shares. This is aligned with other CRM initiatives and contributes to integration of interest of various stakeholders. Internal processes improvement depends on real data (RDS→ High), the existing stakeholders are willing to adjust or adopt new policies and changes (Low ← DIP), as long as there is a clear communication about intentions behind the initiative (IDL → High).				
Case 3				
Innovation	Value Proposition	Operational	Low ← RDS DIP→ High Low ← IDL	AI tools are used for designing a plan for a new marketing campaign, relying on trained models from AI, without the need to follow existing paradigms. Among proposed alternative scenarios for a new approach, marketers can work on initial ideas proposed by the AI tool.
Context Description: A company aims to introduce innovation at the operational level of CRM. The “front office” in delivering operations needs a strong disruptive campaign for acquiring customers for a new digital product ready to be launched (operational CRM). There is no existing data on customers since it is a new product entering a new market (Low ← RDS), there are no limitations on the execution of a marketing campaign (DIP→ High), the selected customer segment is open to any kind of approach in reach attempts (Low ← IDL).				

Source: own

The second variable is the BMC dimension from the Business Model Option (BMO) matrix, targeting the internal structural elements (the supply dimension), customer-facing components (the demand dimension) or focusing specifically on the Value proposition i.e. the core product or service offering which need to be redesigned (the value dimension). This variable is needed for understanding the existing limitations or the lack of it in the future initiatives supported by AI. The third variable is the CRM subsystem, explaining the type of work the AI initiative is scoping. Therefore, the differentiation of the collaborative, analytical or operational CRM delivers the range of the AI initiative. These three variables also provide the context for acquiring inputs by AI tools. The fourth variable is dealing with AI usage criteria: Real Data Sensitivity, RDS; Disruptive Innovation Potential, DIP; and Intent Disclosure Level, IDL. All three AI usage criteria need to be evaluated in order to round up the context for AI usage and provide the rules of engaging AI tools for gathering inputs in an AI initiative. Examples for the usage of our framework is given in Table 1.

For illustrating the use of the framework for the first case, an example of prompts with and without context is given, showing the difference of explaining the context using our proposed framework.

Prompt example without context:

"I want to create scenarios of innovative customer experience with existing services company is offering, allowing the company to explore and select viable options."

Prompt example with context:

"I want to create scenarios of innovative customer experience with existing services company is offering, allowing the company to explore and select viable options. The context is following: A company aims to introduce more customer experience options which could be perceived as more personalized. This is aligned with other CRM initiatives and contributes to designing future marketing strategies, based on data collected through various sources (analytical CRM). Existing data on customers is available and so far, credible (Real Data Sensitivity is High), the aimed customer segments were previously willing to try different options (Disruptive Innovation Potential is High), even if the company doesn't ask for consent in advance (Intent Disclosure Level is low).

Real Data Sensitivity, RDS – this criterion is linked to the required level of usage of real data in AI prompts versus organizational exploration readiness to create content without the necessity to use historical or existing data;

Disruptive Innovation Potential, DIP – this criterion takes into account how strong the AI use depends on coupling with previous initiatives, legacy projects or systems and similar innovation limiting aspects of transformational efforts; and

Intent Disclosure Level, IDL – this criterion explains the need for openly expressing the intention behind the usage of AI tools for CRM purposes."

The presented cases in Table 1 illustrate the application of our framework of implementing AI tools in CRM based on variables and activities of defining the proposer context for the usage of AI. Insights gained from this research offer to explore different use-cases impacting the business performance related to CRM.

5 Conclusions

The evolution of CRM went through several waves is advancement from taking care of customers, through automations and social CRM to AI-supported CRM. Today, "AI-based CRM" uses all the benefits from the previous waves offering to deliver new paradigms for contemporary business strategy. In order to do this, CRM must provide a proper context for prompts used in AI tools, relying on algorithms and training models of AI tools. Based on the premise that based on inputs, equally quality-worth outputs can be expected, we propose a framework based on four variables that can serve as a set of components needed to form a context, necessary for proper use-cases.

Our research has some limitations. It is based on experience and empirical understanding of what might be achieved, when inputs are clearly stated and set. The variable related to AI usage criteria is certainly not comprehensive, opening the space of criteria for further research. On the other side, this is an attempt to bring in some systematization in the decision continuum of how the context can be defined in order to set the stage for a disclosed implementation of AI tools in CRM. Further research could therefore be oriented on describing other variables or AI usage criteria enabling a more focused case description.

Based on our initial proposition of the framework, the AI usage criteria (Real Data Sensitivity, RDS; Disruptive Innovation Potential, DIP; and Intent Disclosure Level, IDL) are setting the stage of using AI tools for CRM. The importance of Real Data Sensitivity depends not only on the organizational estimation of the significance of this criterion, but also on the transparency issues related to the trust organizations have towards AI tools in how the data will be handled. In case of using or entering real data into AI tools, the transparency of how this data will be used onwards, is an open question for many organizations. Disruptive Innovation Potential is a criterion that is related to the trust of companies to generate as many distinctive scenarios as possible, ensuring thereby a landscape of variations normally not to be expected in

brainstorming activities in traditional analytical approaches. The diversity of combinations and execution plans can be entrusted in AI tools for offering various scenarios, valuable enough to be evaluated by marketing experts. Lastly, the Intent Disclosure criterion forms the transparency playground, which either needs to be covered or can be avoided by ethical issues challenges; the demand for transparency can vary, based again on the context of a use-case AI tools that are intended to be implemented. Finally, a more in-depth exploration of these criteria reveals the need to be more honest in the beginning of what is expected from using AI tools, and on the other hand, it shows that setting the right context before using AI tools is essential for gaining useful outputs that can be valuable for CRM initiatives.

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RED BULL AND MONSTER ENERGY IN A COMPETITIVE GAME: MODELLING MARKET BEHAVIOUR THROUGH GAME THEORY

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This paper applies game theory to analyse the strategic interaction between Red Bull and Monster Energy, the two dominant firms in the global energy drink market. The main objective is to examine how their pricing, marketing, and expansion decisions can be modelled through key game-theoretic concepts. The central hypothesis posits that both companies tend to select aggressive investment strategies, leading to a stable equilibrium in which neither firm benefits from unilateral deviation. The study uses publicly available revenue and profit data to construct payoff matrices and simulate strategic outcomes under alternative competitive scenarios. A simplified two-strategy model, i.e., aggressive expansion versus conservative growth, is applied to evaluate firm behaviour and profit trajectories. The findings indicate that both companies achieve higher growth under mutually aggressive strategies, confirming the existence of a dominant-strategy equilibrium that aligns with a Nash equilibrium. The paper concludes that long-term competition between the two firms is characterised by high interdependence, strategic mirroring, and limited incentives for cooperative positioning.

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1 Introduction

Game theory is a branch of mathematical economics that examines situations where players' decisions mutually affect outcomes. In a business setting, it offers a formal framework for modeling competition, negotiation, pricing, market entry, and product development. Using game theory, one can understand how rational managers choose their best strategies in conditions of mutual dependence and identify stable equilibria, such as Nash equilibria, among competitors (Church and Ware, 2000). The energy drink market is constantly growing and very competitive. Globally, companies like Red Bull and Monster Energy hold the top spots. Red Bull, an Austrian pioneer in the industry, built a strong brand with bold, often risky marketing strategies such as sponsorships in extreme sports, event organization, and lifestyle branding. Monster Energy, an American challenger, has gained ground through aggressive business expansion and strategic partnerships, like its distribution alliance with Coca-Cola. Both companies closely observe competitors' moves and carefully adjust their prices, marketing efforts, and distribution channels, making them ideal cases for analysis through game theory. In this environment, managers face high uncertainty and pressure to anticipate rivals' reactions, highlighting the importance of strategic decision-making in a highly competitive landscape (Sharma and Tomić, 2011).

In these situations, strategic decisions like marketing investments, pricing, or expanding into new markets become “games” where the outcome for one company depends on the actions of the other. The use of game theory formalizes these decisions through models where each player (Red Bull or Monster Energy) chooses a strategy while considering the possible moves of the competitor. This approach helps understand who can achieve the best results under certain strategy combinations and assists in identifying possible dominant strategies or equilibrium points. To evaluate these competitive strategies, a simplified game model will be used, with each company choosing one of two strategies: aggressive expansion (large investments in marketing, sponsorships, and distribution expansion) or a conservative approach (careful cost control and steady growth without significant expansion). Using publicly available financial data from previous periods on revenue and net income, payoff matrices will be created to measure the profit changes for each combination of strategies. This combination of theoretical modeling and empirical analysis allows for the assessment of key variables (e.g., market share,

profitability) and the application of classical game theory concepts to a real business setting.

The aim of the paper is to examine the hypothesis that both companies, facing competitive pressures, tend to adopt aggressive strategies that result in a situation where neither can improve its outcome unilaterally – a Nash equilibrium. It is assumed that aggressive expansion is the dominant strategy for both, as initial analyses have indicated (for Red Bull and Monster, labeled as strategy “A”). In this scenario, the only Nash equilibrium is in both adopting aggressive strategies (A, A), which explains the ongoing “arms race” in the energy drink industry. Ultimately, the research will demonstrate how this dominance strategy model corresponds to the actual behavior of Red Bull and Monster and will discuss the limitations and implications of the findings.

2 Theoretical background

2.1 Game theory as a tool for decision-making

Game theory aims to help us understand situations in which decision-makers interact (Osborne, 2003). In other words, it is the analysis of strategies in interdependent situations, where participants (e.g., consumers, companies, governments) influence each other through the choices they make. When viewed strictly in a business context, game theory is used to analyse competition, negotiations, pricing, how and when to enter new markets, and product development. It allows us to understand observed behaviour, but also to predict future outcomes and prescribe optimal strategies in situations of conflict and cooperation (Holt and Roth, 2004). Rational behaviour is defined as choosing actions that maximize one’s own utility under the constraints faced by the player. Although this is a simplification of reality, it has been shown to be a useful frame of reference that works surprisingly well in many cases (Tadelis, 2013).

In game theory, we can distinguish games according to different criteria, and the key focus is on the division of games into strategic games, extensive games, games of perfect investment, and games with incomplete information, as well as the difference between cooperative and non-cooperative games. According to Osborne and Rubinstein (1994), strategy games (or the normal form of the game) are models in

which each player simultaneously chooses their strategy without knowledge of the choices of other players, that is, where the plan of action is chosen once and for all. Extensive games represent sequential decisions where the order of moves is clearly defined, and players can make decisions at different times during the game. These games are divided into games with perfect information, where all previous moves are known to all players, and games with incomplete information, in which players are partially or completely uninformed about the moves of others.

Regarding cooperative and non-cooperative games, cooperative games analyse possible coalitions of players and their joint payoffs, while non-cooperative games model the individual strategies and decisions of each player separately, without formal negotiations or coalitions (Osborne & Rubinstein, 1994). Tadelis (2013) additionally classifies games according to completeness of information (complete or incomplete information) and time dimension (static and dynamic games). Static games are those in which players make decisions simultaneously and where available information is complete, while dynamic games model situations where decisions are made in several stages and information changes during the game. Also, games can be repeated or played once, depending on the duration of the interaction (Tadelis, 2013). It is important to understand that the choice of game type depends on the nature of the interaction, the availability of information, and the time frame of decisions, all of which influence the formation of optimal strategies and the analysis of equilibria within the game (Osborne & Rubinstein, 1994; Tadelis, 2013).

2.2 Key components of the game

1. Players

Players are the decision makers in the game (Myerson, 1991). They can be individuals, firms, states, or any entity that makes strategic decisions. An economically rational player, according to Tadelis (2013), can:

- (i) Evaluate outcomes and rank them according to their contribution to their own welfare,
- (ii) Calculate paths to outcomes, recognizing which sequences of actions lead to which outcomes, and
- (iii) Choose actions that maximize the preferred outcomes.

2. Strategy

A strategy is a plan of action that determines what a player will do in each possible situation within a game (Tadelis, 2013).

- (i) *Pure strategies*: deterministic actions without elements of randomness.
- (ii) *Mixed strategies*: a probability distribution over a set of pure strategies where the player randomly chooses between multiple options according to certain probabilities (Fudenberg and Tirole, 1991).

3. Payoffs

Payoffs represent the rewards or punishments associated with each combination of strategies of all players (Tadelis, 2013). They reflect the utility or benefit that the player receives from a particular outcome.

3 Red Bull vs. Monster Energy – competitive dynamics

Monster Energy

Monster Beverage Corporation is an American energy drink company headquartered in California. Founded in 2002, it quickly gained global recognition thanks to the Monster Energy brand. The company is known for its heavy investment in sponsorships of extreme sports, music events, and the gaming scene, attracting a younger audience and creating a modern, dynamic image (Business Outreach, 2025).

Monster has seen significant revenue growth in recent years, driven by its expansion into global markets and strategic alliances, most notably its partnership with Coca-Cola. Despite its success, the company faces challenges such as market saturation and rising raw material costs, and is striving to maintain a balance between strong promotional activities and long-term profitability (Table 1).

Table 1: Monster Energy

Year	Income (in billions)	Profit margin	Net profit (in billions)	Income growth	Profit growth
2022	5,995	18,89%	1,132	28,05%	-2,68%
2023	6,569	22,83%	1,499	9,56%	24,5%
2024	6,968	20,14%	1,403	6,08%	-6,45%

Source: authors, (Macrotrends, 2025; Bloomberg, 2025)

Red Bull

Red Bull, founded in 1987 in Austria by Dietrich Mateschitz, revolutionized the energy drink industry by focusing on selling a lifestyle instead of just a product, with sales of 12.67 billion cans in 2024 (see Table 2 for deeper insight) in 178 countries (Red Bull, 2025). The company became a global leader with a 43% market share through aggressive expansion, starting in Europe in the 1990s and entering the US market in 1997, where it quickly dominated California with more than 5 million cans (Shastri, 2024). Instead of classic advertising, Red Bull invests in sponsorships of extreme sports such as Formula 1, Red Bull Air Race, and Cliff Diving, and organizes events such as Red Bull Dolomitenmann since 1988, thus building an emotional connection with the young audience from 16 to 34 years old (Perkov, 2023). Vertical integration through Red Bull Media House enables control over content, from movies and magazines to digital platforms, creating organic growth and an adventure image (Blankboard Studio, 2025; Cascade Strategy, 2024).

Table 2: Red Bull

Year	Income (in billions)	Profit margin	Net profit (in billions)	Income growth	Profit growth
2022	9,684	13,7%	1,33	7,02%	5,4%
2023	10,554	12,9%	1,36	9,0%	2,5%
2024	11,227	13,9%	1,55	6,4%	12,5%

Source: authors, (Red Bull, 2025; Statista, 2025)

4 Methodology

4.1 Mathematical game-theoretic model of strategic interaction between Red Bull and Monster Energy

Game modelling

In this competitive setting, the players are Red Bull and Monster Energy, the two dominant global firms in the energy drink market. Analytically, each player is modelled as a rational profit-maximizing agent whose objective is to increase long-run market share, brand strength, and net profitability. Practically, this reflects real-world actions: both companies operate in a highly saturated international market where aggressive marketing, expansion, and brand differentiation determine performance. Red Bull acts as the market pioneer with strong brand identity and vertically integrated media operations, while Monster Energy leverages strategic partnerships (e.g., Coca-Cola) and rapid international expansion. Both firms actively observe competitor behaviour, making them ideal subjects for strategic modelling using game theory. Let us define the framework of the game.

1. Players

The strategic interaction in the energy drink market is modelled as a two-player normal-form game: $N = \{R, M\}$, where R denotes Red Bull and M denotes Monster Energy.

2. Strategy sets

Both firms choose between two strategic options: $s_R = s_M = \{A, K\}$, where A presents 'Aggressive expansion' (high investments in marketing, sponsorships, and market penetration) and K presents 'Conservative strategy' (cost optimization and stable growth without strong expansion). Practically, Red Bull's aggressive strategy appears in its investments in Formula 1, extreme sports, digital media, and global events; tactics that enhance brand value but require significant capital. Monster Energy mirrors this through extreme sports sponsorships and heavy marketing expenditures. Conversely, conservative strategies represent periods where firms

prioritize profit margins over expansion, often during market uncertainty or rising production costs.

3. Timing of moves

The game is modelled as a simultaneous-move, one-shot game in normal form. Each firm chooses its strategy without observing the competitor's choice. Practically, this mirrors how real firms operate: pricing decisions, annual marketing budgets, and expansion plans are made independently, often based on expectations rather than direct observation. Neither firm discloses strategic plans in advance, and decisions are shaped by industry signals, historical behaviour, and predictive analytics rather than explicit coordination.

4. Payoff structure

Let $u_R(s_R, s_M)$ and $u_M(s_R, s_M)$ denote the payoff functions. Payoffs are derived from empirical growth rates of net profits for 2022-2024. Based on the data, the payoff matrix in Table 3 (Monster Energy first, Red Bull second) is:

Table 3: Payoff matrix

	R: A	R: K
M: A	(14, 8)	(16, 5)
M: K	(8, 10)	(9, 7)

Source: authors' calculations (2025).

These values represent the percentage growth of net profits under each strategic combination. The payoff functions can be expressed as:

$$u_R(A, A) = 8, \quad u_R(A, K) = 5, \quad u_R(K, A) = 10, \quad u_R(K, K) = 7$$

$$u_M(A, A) = 14, \quad u_M(A, K) = 16, \quad u_M(K, A) = 8, \quad u_M(K, K) = 9$$

Practically, these payoffs represent real financial consequences: aggressive expansion yields high growth but also greater volatility, whereas conservative strategies produce stable but lower returns. The payoff structure also captures competitive spill over effects; one firm's expansion can reduce the other's market share, altering profitability outcomes.

Game development

Dominant equilibrium

Dominant strategy equilibrium exists if both firms satisfy: $u_i(A, s_j) > u_i(K, s_j)$ for all $s_j \in \{A, K\}$. Thus, A is a strictly dominant strategy for both firms. For example, best-response analysis yields:

For Monster Energy:

- If R plays A: $14 > 8 \rightarrow A$ is better.
- If R plays K: $16 > 9 \rightarrow A$ is better.

Hence, A is Monster's dominant strategy.

For Red Bull:

- If M plays A: $8 > 5 \rightarrow A$ is better.
- If M plays K: $10 > 7 \rightarrow A$ is better.

Hence, A is Red Bull's dominant strategy. Therefore, (A, A) is a dominant-strategy equilibrium.

Analytically, both firms exhibit a strictly dominant strategy of aggressive expansion (A). This occurs because the observed historical growth patterns show that aggressive investment consistently outperforms conservative behaviour in both symmetric and asymmetric scenarios. Practically, this aligns with the competitive nature of the energy drink industry. Firms that reduce marketing intensity risk losing brand visibility and shelf presence. As a result, both Red Bull and Monster face a competitive pressure to sustain high levels of promotional activity, even when costly, because retreating allows the rival to strengthen its position at their expense.

Nash equilibrium

A profile (s_R^*, s_M^*) is a Nash equilibrium if neither player benefits from unilateral deviation. Since both players have a dominant strategy A, (A, A) is the unique Nash equilibrium. For example, at (A, A):

- Monster: deviating to K yields $8 < 14$.
- Red Bull: deviating to K yields $5 < 8$.

Analytically, the profile (A, A) is the unique Nash equilibrium. In this state, both firms pursue aggressive expansion, and neither benefits from shifting to conservative behaviour, given the other's choice. Practically, this explains the persistent marketing arms race in the energy drink sector. Both companies maintain heavy, long-term sponsorship contracts, athlete endorsements, and global event portfolios. Neither can scale back spending without risking a visible competitive disadvantage. Thus, the equilibrium reflects real-world strategic lock-in driven by mutual expectations and industry dynamics.

Assessment of Prisoner's dilemma structure

A classical Prisoner's dilemma requires: (1) A dominant strategy that leads to (D, D), (2) while (C, C) is Pareto-superior. In this case, (A, A) gives higher payoffs for both firms than (K, K). Therefore, the model does not represent a standard Prisoner's dilemma. However, the strategic tension, i.e., fear of losing market share if the rival invests aggressively, resembles an arms-race dynamic (Plous, 1993). Even if aggressive strategies are optimal in the short run, the long-term sustainability of extreme marketing expenditures can be questionable. Firms may recognize that a mutually conservative market posture would reduce industry-wide costs, but competitive pressures prevent them from adopting such behaviour. Thus, the structure resembles a "high-pressure equilibrium" rather than a cooperative optimum.

4.2 Extended model: Incorporating costs of aggressive expansion

To capture high marketing and sponsorship costs (e.g., F1, extreme sports), we introduce cost parameters: $c_R \geq 0$ for Red Bull and $c_M \geq 0$ for Monster. Net payoffs become: $u_R^c = g_R - c_R \cdot 1\{R = A\}$ and $u_M^c = g_M - c_M \cdot 1\{M = A\}$. Using reduced payoffs (as in the extended Table 4):

Table 4: Reduced payoffs

	R: A	R: K
M: A	(10, 4)	(11, 1)
M: K	(4, 6)	(5, 3)

Source: authors' calculations (2025).

Best-response analysis still suggests A is dominant for both firms, but only under moderate costs. If c_R or c_M exceed critical thresholds (e.g., for Red Bull: $8 - c_R \geq 5 \rightarrow c_R \leq 3$), the strategic ranking changes. Implications follow that with low costs, the equilibrium remains (A, A), but with high costs, the equilibrium shifts toward (K, K), reflecting a sustainability-oriented market outcome.

The following figure illustrates payoff dynamics across strategy profiles (Figure 1):



Figure 1: Payoff dynamics across strategy profiles

Source: authors' calculations (2025).

When expansion costs are introduced, the payoffs adjust downward for aggressive strategies. Analytically, this shifts the payoff matrix and may alter best responses if costs exceed critical thresholds. If the marginal cost of aggressive investment surpasses marginal gain, conservative strategies may become optimal, leading to new equilibria potentially including (K, K). Practically, rising production costs, inflation, regulatory constraints, and diminishing returns on sponsorships can force firms to reconsider expansion intensity. For example, increasing costs in logistics, sugar taxation, sponsorship inflation, or media production can reduce the profitability of aggressive campaigns. In such cases, both firms may gradually converge toward cost-efficient strategies, especially in saturated markets or economic downturns.

5 Conclusion

The analysis of the strategic competition between Red Bull and Monster Energy shows that the competition in the global market of energy drinks can be explained very effectively with the classical tools of game theory. Empirical data on revenues, profitability, and growth dynamics of both companies clearly indicate that aggressive market expansion - characterized by intensive investments in marketing, sponsorships, distribution channels, and branding - represents a strategy that systematically brings more benefits than a conservative approach. Accordingly, the modelled outcome in the form of a dominant strategy confirms the existence of a Nash equilibrium in which both firms choose an aggressive approach because neither has an incentive to unilaterally deviate from it (Osborne, 2003; Tadelis, 2013). Although such an outcome ensures high growth rates and strengthens the global visibility of the brand, it simultaneously generates a strong market race in which both parties must continuously increase investments in order to maintain their position. This dynamic resembles an “arms-race” situation, as recognized in earlier research on competitive dilemmas (Plous, 1993), because reducing the intensity of one party’s investments almost automatically creates space for the other to strengthen.

However, the extended model presented in the paper, which includes the cost structure of aggressive strategies, reveals an important nuance: if the costs of aggressive expansion exceed a certain threshold, the relative benefits of such a strategy begin to decline. In this case, there may be a shift in the equilibrium towards more conservative, cost-sustainable behaviour, which reduces competitive pressure and allows for the creation of a more stable market environment in the long run. In

such a scenario, although cooperation in the formal sense is not possible due to the non-cooperative nature of the market, both companies could find themselves in a kind of "quasi-cooperative" state in which neither has reason for extreme, costly competition, and the emphasis shifts to profitability and sustainability. This conclusion is consistent with the additional empirical assertion that both firms have strong incentives for aggressive strategies, but that after the inclusion of cost factors, the competitive balance can shift towards more conservative behaviour, thus opening up possibilities for long-term stability similar to cooperative outcomes. This confirms that the strategic decisions of Red Bull and Monster Energy are not only the result of short-term market pressures, but also structural factors such as costs, market saturation, and profitability limits.

Overall, the research indicates that the long-term behaviour of leading energy drink manufacturers is shaped by a complex combination of mutual dependence, constant adaptation to competition, and rational risk management. In this context, game theory is confirmed as an extremely useful analytical framework that enables the understanding of not only current strategic decisions, but also potential changes in future market dynamics.

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READINESS OF SLOVENIAN STUDENTS FOR AGE AND CULTURAL DIVERSITY IN THE WORKPLACE: ANALYSIS OF ATTITUDES TOWARD OLDER MIGRANTS

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In the context of demographic crisis and increasing net migration, the involvement of older migrants in active labour activity is an important task for emerging “longevity society.” The study presented in this article is aimed at identifying latent contradictions in the attitudes of Slovenian students toward cooperating with older migrants, as future recruitment specialists, managers and employees working in multicultural teams. The results obtained demonstrate that students’ attitudes toward older migrants in the workplace do not represent coherent attitudinal constructs ranging from negative to positive, but rather a space of semantic tension in which declared norms of inclusivity conflict with persistent stereotypes about them. The study contributes to the discussion on managing age and cultural diversity under conditions of demographic change and proposes a non-standard methodological tool for the in-depth analysis of latent social attitudes.

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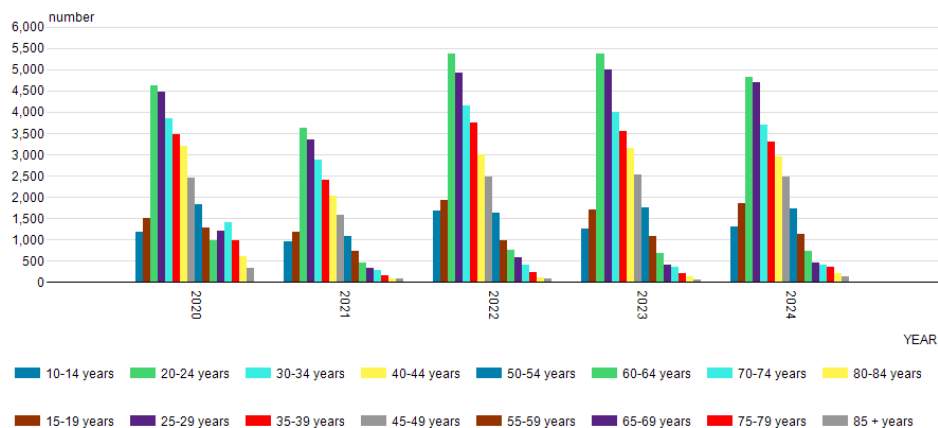
older migrants,
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1 Introduction

International migration by AGE GROUPS and YEAR. Immigrants from abroad, Sex - TOTAL.



Source: Statistical Office of the Republic of Slovenia

Figure 1: migration data in Slovenia

Source: Statistical Office of the Republic of Slovenia. (n.d.). SiStat Data Portal – Table 05N1004S

From a theoretical perspective, attitudes toward older migrants in professional activities largely depend on age-related and migration-related stereotypes. The research demonstrates the dual nature of stereotypes on the basis of which attitudes toward older workers are formed. As a rule, they combine positive qualities (experience, loyalty) with negative traits (conservatism, low learning ability) (Chiu et al., 2001; Rothermund & Couto, 2024), stigmatizing and fostering ageism in society (Zakharova, Korobko & Sotnikov, 2022). At the same time, the perception of older working migrants is often burdened by a sense of cultural distance (Britvina & Shumilova, 2018). As a result, attitudes toward older migrants are determined by the superimposition of these two positions, which contributes to the formation of double discrimination (Lee & Piper, 2013). As a basis for the formation of such a situation, complex and internally contradictory attitudes of the host population can be identified, which are the subject of this study.

The prevailing conditions create long-term structural tensions that require businesses and public institutions to rethink principles of social responsibility and human resource management strategies. This study focuses on the figure of an older migrant, whose position in the labour market serves as an indicator of the maturity of inclusive practices in still emerging “longevity society.” From the perspective of crisis management, the stability of the national economy and social sustainability depends on the ability to utilize maximally the potential of all working-age groups. It should be noted that the human capital of older migrants is a significant advantage in labour activity. However, the attitudes of work teams and decision-makers involved in hiring may become a substantial barrier for such employees. Therefore, students’ attitudes toward hiring older migrants become a predictor of future corporate norms, as they will act as future managers, HR specialists, and rank-and-file employees. Hence, it is important to study youth attitudes in this area in order to identify latent stereotypes and determine contradictions in respondents’ attitudes toward age diversity and older migrants.

2 Method and Methodology

The operationalization of key concepts is based on contemporary approaches and reduced to the following terms: a longevity society, student attitudes and stereotypes, an older migrant.

A longevity society is understood here in a broad sense as a socio-economic and organizational system aimed at creating conditions for productive, healthy and inclusive life at all stages of age. This includes restructuring labour market institutions, social security and corporate governance in order to unlock the potential of age diversity (Naegele & Walker, 2006; Principi et al., 2016).

The attitudes are understood as a stable set of beliefs, feelings and behavioural tendencies toward a social object or a subject (Eagly & Chaiken, 1993). Stereotypes are a cognitive component of attitudes representing simplified and generalized beliefs about the characteristics of an object or a subject. For example, studies show that as age increases, a worker’s attractiveness to an employer changes (Chiu et al., 2001), and in the case of migrants, perception is burdened by ideas about cultural distance.

An older migrant is an ambiguous concept, as there is no single age threshold for inclusion in the category of “older migrants.” At the same time, the age of 50 is widely used in studies devoted to the labour market, health and integration, since it often marks the onset of increased risks of age discrimination and specific problems with access to employment (Ciobanu et al., 2017). Therefore, the questionnaire includes the following definition: “An older migrant is a person aged 50 and over who was born and/or lived for a long time in another country and is now living and working (or seeking work) in Slovenia.”

A mixed qualitative–quantitative approach with a focus on an interpretative method was used to evaluate young people's opinions toward older migrants in order to determine their attitudes and stereotypes. The goal of the study is to understand the semantic structures and contradictions in respondents’ consciousness. Therefore, primary quantitative data were subjected to secondary qualitative analysis. The online questionnaire using Google Forms (N = 30) was used as a primary tool. It consisted of thematic blocks reflecting the following content: assessment of general attitudes toward age and cultural diversity in organizations; perceptions of specific competencies and characteristics of older migrant workers; a block assessing comfort levels in specific professional situations to identify latent attitudes; and a demographic block. Respondents were offered statements revealing the content of the thematic blocks, which were evaluated using a Likert scale from 1 to 5. For an in-depth analysis of the structure of respondents’ attitudes, a qualitative content analysis approach was applied (Kuckartz & Rädiker, 2025). Based on identified stable sets of responses to standardized statements, holistic “statements” about each respondent’s attitude toward older migrants were reconstructed and expressed in numerical form, further combined into a single semantic construct. Personal experience of interaction with migrants was used as a contextual parameter. For example, a set of evaluative responses from a respondent looks like the following: “1.1 = 4, 1.2 = 4, 1.3 = 5, 2.1 = 5, 2.2 = 4, ... 5.5 = They were my co-workers...” Accordingly, in the form of a single “statement” these responses read as: “I generally agree that diverse teams work better (4) and foster innovation (4), and that today leaders must know how to manage teams with age and cultural diversity (5). I believe that older migrants are rather loyal and reliable (5), but they may have difficulties with digital technologies (4). At the same time, based on my personal experience of interacting with migrants as co-workers and friends...” etc.

Thus, applying the logic of qualitative content analysis to the assessment of questionnaire statements makes it possible to study latent features of attitudes toward older migrants that remain hidden under standard statistical processing.

The results of the analysis with the identified main categories of contradictions are presented below. The following contradictions were identified and interpreted: a value–hierarchical gap between abstract recognition of the usefulness of diversity and personal comfort in status-unequal situations; heterogeneity of perceptions of older migrants; misalignment between positive images of migrants and respondents' readiness for concrete actions influencing their integration.

3 Results

The following procedure, which is an adaption of the traditional scheme of qualitative content analysis, was used for the secondary analysis.

Each questionnaire was considered as a holistic text, which made it possible to form understanding of the range of respondents' attitudes toward older migrants and identify points of potential semantic conflict.

Next, these “statements” were compared with each other to identify recurring sets of responses and evaluations. In the course of this comparison, recurring configurations of numerical responses were identified. For example, several respondents demonstrated a configuration of high scores for the statement “Today's leaders need to know how to manage teams with age and cultural differences” (4–5 points) combined with significantly lower scores for the statement “How comfortable would you feel if an older migrant were your direct manager?” (2–3 points). Thus, three variants of recurring patterns were identified. They were coded and described as follows:

“Value/Power”: A configuration characterizing a gap between recognition of value of diversity in the workplace and feeling of personal comfort in a situation where a migrant has power over a respondent.

“Image/Action”: A configuration indicating dissonance between a positive assessment of migrants’ work qualities (“They are loyal and reliable,” “They are motivated and appreciate their job”) and unwillingness to hire them (“How likely are you to support hiring a qualified older migrant into your team?”).

Table 1: Summary Table of Identified Contradictions in Students’ Attitudes Toward Older Migrants

Configuration	Meaning	“Statement” Example
Value/Power	Shows the gradient of comfort when interacting with a migrant in a work environment, expressed through contradictions between accepting an abstract norm and being personally ready to accept its consequences. Several types of attitudes appear: a coherent positive attitude, a coherent negative attitude, and a contradictory type where responses “argue” with each other. The recurrence of contradictions indicates a stable pattern.	“I completely agree that diversity in teams increases creativity and helps avoid group thinking... But to be honest, I would feel very uncomfortable if my direct supervisor were a person over 50, especially if he or she were an immigrant. There would be too many misunderstandings in communication and work approaches.” (Respondent No. 14, experience with migrants: “neutral”)
Image/Action	Contradictions between positive generalized beliefs about older migrants and readiness for real personal interaction. Respondents often show <i>symbolic tolerance</i> (positive evaluations of the group in general) but <i>real distance</i> (reluctance to work closely with them). Two directions of semantic rupture show how the migrant image is used to justify distance.	“I think older migrants are often very responsible and loyal workers... However, if I had to make a hiring decision for my work group, I would probably choose a younger candidate, possibly a local one... The risk of conflict due to differences in habits or work pace would be lower.” (Respondent No. 08, experience: “migrant friends”)
Evaluative Contradiction	Internal inconsistency of stereotypical images of older migrants: respondents combine logically incompatible evaluations. Stereotypes appear as unrelated labels whose relevance depends on personal experience with migrants.	“On the one hand, these are people with enormous life experience... On the other hand, digitalization is everywhere today, and they often have problems mastering new programs... They are simultaneously valuable and, in some ways, helpless in the face of new technologies.” (Respondent No. 23, experience: “migrant co-workers”)

Source: own

“Evaluative Contradiction”: A configuration showing internal inconsistency and illogicality of the stereotype of an older migrant (cognitive eclecticism of stereotypes). This is expressed in simultaneous agreement with mutually

contradictory statements such as “They can mentor younger co-workers” and “They may find it hard to learn new digital technologies.”

All questionnaires with their response configurations were assigned codes in accordance with their interpretative meaning in the context of the respondent’s holistic “statement.” Codes were assigned providing that the gap between dissonant responses was at least 2 points (both values were in the strong response zone, i.e., 1–2 or 4–5 points). A gap of 1 point was coded only if it was semantically significant in a specific context (for example, 5 points versus 4 points on key questions against generally positive background). Thus, the assigned codes made it possible to compare responses with each other at the level of a general system of categories and produce generalizations at the level of these categories rather than individual numbers.

4 Conclusions and Discussion

The main conclusions of the presented analysis can be summarized as follows.

Among students, attitudes toward older migrants characterized by internal inconsistency and complexity were identified. Cognitive, emotional, and behavioral components of attitudes were found to have stable configurations of semantic contradictions.

The most pronounced contradiction lies at the intersection of recognizing the value of age and cultural diversity in the workplace and personal discomfort with a situation in which an older migrant holds power over a respondent (“Value/Power”). This indicates that acceptance of inclusivity is restricted to specific status dispositions.

Another significant discrepancy was recorded between declared positive image of older migrants and unwillingness to engage in practical interactions for their labour integration (“Image/Action”). This indicates a gap between symbolic and real tolerance in students’ attitudes.

Eclecticism and lack of internal coherent logic were found in the stereotype of older migrants (“Evaluative Contradiction”). Respondents simultaneously assign them an ability to serve as mentors and an inability to learn new technology. This reflects superimposition of two independent sets of stereotypes such as age-related and migration-related stereotypes.

The results obtained are consistent with the theory of social stigmatization of older people (ageism) and studies of multiple discrimination. Older migrants become a projection of attitudinal conflicts based on the discrepancy between modern corporate norms of inclusivity and persistent stereotypes toward them.

Youth attitudes toward older migrants in the context of a longevity society represent not a coherent set of representations from negative to positive evaluations, but a space of tension and internal logical ruptures. They reflect the state of contemporary consciousness, in which norms of inclusivity and values of diversity are superimposed on persistent stereotypes and forms of group thinking. Older migrants find themselves at the intersection of two lines of “otherness” — age-related and cultural — which makes them a figure in relation to whom cognitive dissonances manifest with particular force. Nevertheless, under the conditions of the values of a longevity society and shrinking population, this topic will become increasingly salient, and the study of attitudes of future employees and managers may become a basis for education and work with youth regarding inclusivity and perception of age and cultural diversity.

Despite being an experimental approach, the application of qualitative content analysis procedures to standardized quantitative data allowed for the semantic deconstruction of numerical responses and the analysis of their meaning in order to find contradictions in students' attitudes toward older migrants. While qualitative approach permits analytical conclusions about the structure of the studied social phenomena, the quantitative sample restricts the potential for statistical generalizations to the total Slovenian student population. Survey methods capture verbally expressed attitudes, which may differ from actual behaviour. Nevertheless, the identified internal contradiction within respondents' attitudes themselves represent significant scientific interest. This approach corresponds to the goal of the study, which was to understand complex and often ambivalent nature of attitudes toward older migrants in the context of a longevity society.

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ANALIZA RAZISKOVALNIH TRENDOV UPORABNIŠKE IZKUŠNJE V E- IZOBRAŽEVANJU

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Uporabniška izkušnja ima ključno vlogo pri uspešnosti in učinkovitosti e-izobraževalnih okolij. Kljub naraščajočemu številu raziskav na tem področju pa še vedno primanjkuje ažurnih in celovitih analiz, ki bi sistematično prikazale razvoj in trende raziskav uporabniške izkušnje v e-izobraževanju. Namen članka je analizirati raziskovalne smernice ter prepoznati teme in tehnologije povezane z uporabniško izkušnjo v e-izobraževalnem kontekstu. Študija temelji na bibliometrični analizi znanstvenih objav, zbranih iz baze podatkov Web of Science, pri čemer je bila za vizualizacijo in identifikacijo tematskih grozdov uporabljena programska oprema VOSviewer. Rezultati kažejo, da se med pomembnejše raziskovalne teme na področju uporabniške izkušnje v e-izobraževanju uvrščajo uporabniška izkušnja v e-izobraževanju, dojemanje uporabniške izkušnje, podatkovno podprti e-izobraževalni sistemi, interaktivna učna okolja, razširjena resničnost, oblikovanje uporabniških vmesnikov, mobilno učenje ter izzivi uporabniške izkušnje v e-izobraževanju. Identificirali smo tudi tehnologije, ki se v kontekstu uporabniške izkušnje in e-izobraževanja najpogosteje pojavljajo. Raziskava prispeva k boljšemu razumevanju področja uporabniške izkušnje v e-izobraževanju ter podaja celovito sliko omenjenega področja, ki lahko služi kot izhodišče za prihodnje raziskave.

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USER EXPERIENCE IN E-LEARNING RESEARCH TREND ANALYSIS

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User experience plays a key role in the success and efficiency of e-learning environments. Despite the growing number of studies in this area, there is still a lack of up-to-date, comprehensive analyses that systematically show the development and trends of user experience research in e-learning. The purpose of the paper is to analyze research directions and identify topics and technologies related to user experience in the e-learning context. The study is based on a bibliometric analysis of scientific publications collected from the Web of Science database using VOSviewer software to visualize and identify thematic clusters. The results show that the most important research topics in the field of user experience in e-learning include user experience in e-learning, perception of user experience, data-supported e-learning systems, interactive learning environments, augmented reality, user interface design, mobile learning, and challenges of user experience in e-learning. We also identified the technologies that most frequently appear in the context of user experience and e-learning. The research contributes to a better understanding of user experience and e-learning and provides a comprehensive picture of these fields, which can serve as a starting point for future research.



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1 Uvod

E-izobraževanje postaja vse bolj razširjen in privlačen način pridobivanja znanja. E-izobraževanje nudi številne prednosti pred klasičnim oziroma tradicionalnim izobraževanjem, kot so velika časovna in krajevna prilagodljivost, možnost personalizacije, interaktivnost, omogočanje izobraževanja v lastnem tempu in drugo. K še večji razširjenosti in prepoznavnosti e-izobraževanja je dodatno pripomogla pandemija COVID-19. V času pandemije se je velika večina izobraževalnih ustanov morala v zelo kratkem času prilagoditi novim okoliščinam izobraževanja. Na uspešno izvedbo ter zadovoljstvo uporabnikov z e-izobraževanjem vpliva več dejavnikov. Eden pomembnejših dejavnikov je uporabniška izkušnja (Ang. UX – User Experience), ki vpliva na motivacijo, zadovoljstvo, zavzetost in učinkovitost izobraževanja (Maslov et al. 2021; Zardari et al., 2021; Rohles et al., 2022). Uporabniška izkušnja se nanaša na vidike doživljanja, vključno z uporabnikovimi čustvi in stimulacijo, ki se dogaja med interakcijo s produktom (Nakamura et al., 2017). Na področju e-izobraževanja ima uporabniška izkušnja ključno vlogo pri zagotavljanju zanimivosti in zavzetosti uporabnikov, glavni cilj pa je ustvarjanje izobraževalnega okolja, ki usmerja pozornost uporabnikov na nalogo (Wong et al., 2024).

Uporabniška izkušnja zajema odzive uporabnikov pri uporabi določenega produkta, sistema ali storitve (Sheikh et al., 2021; Gordillo et al., 2014) in je opredeljena kot subjektivno videnje in občutenje posameznika, ki nastane kot rezultat treh integriranih dejavnikov: začetnega čustvenega stanja uporabnika, uporabniškega vmesnika (vključno z njegovim oblikovanjem, uporabnostjo in funkcionalnostjo) ter konteksta, v katerem poteka interakcija (Raban et al., 2018).

Ključni elementi uporabniške izkušnje vključujejo enostavnost uporabe in kakovost informacij, ki statistično pomembno vplivajo na vedenje uporabnikov v e-izobraževanju (Zardari et al., 2021). Sodobna tehnologija in ustrezno oblikovane naloge zagotavljajo, da e-izobraževanje podpira uporabniške zahteve med izobraževalnimi dejavnostmi, medtem ko raznolikost večpredstavne vsebine, pravično ocenjevanje in možnost interakcije prispeva k pozitivnemu doživetju izobraževanja (McCarthy et al., 2021). Stopnja zanimivosti in kakovost uporabniškega vmesnika določata angažiranost študentov pri uporabi izobraževalnih sistemov, saj zapleteni uporabniški vmesniki odvrčajo uporabnike od procesa

izobraževanja (Malang et al., 2020). Uporabniški vmesniki naj bodo preprosti in intuitivni za uporabo, kar olajša razumevanje in navigacijo (Christanto et al., 2023).

V kontekstu e-izobraževanja je izredno pomembno, kako se uporabnik počuti med procesom izobraževanja. Prijetna uporabniška izkušnja pozitivno vpliva na angažiranost in motivacijo uporabnikov, zato morajo oblikovalci in razvijalci izobraževalnih okolij ustvariti učna okolja, ki krepijo občutek uporabnosti, zaupanja in užitka (Erlangga et al., 2023). V številnih raziskavah ugotavljajo, da je uporabniška izkušnja v izobraževalnih platformah pomembna za uspeh izobraževanja (Dave, 2023; Rasmus et al., 2020). Zato je pomembno poznati smeri razvoja, trende in ključne elemente uporabniške izkušnje na področju e-izobraževanja. S pomočjo bibliometrične analize lahko dobimo širši vpogled v trende objav in raziskovalne teme (Gao et al., 2021) na osnovi analize avtorstva, navajanj in ključnih besed (Chen & Xiao, 2016). Da bi raziskali vlogo uporabniške izkušnje v e-izobraževanju, smo si zastavili tri raziskovalna vprašanja, na katera bomo poskušali odgovoriti s pomočjo bibliometrične analize, in sicer:

- RV1: Kateri pojmi so v ospredju raziskav uporabniške izkušnje in e-izobraževanja?
- RV2: Kateri tematski sklopi se pojavljajo v raziskavah uporabniške izkušnje in e-izobraževanja?
- RV3: Katere tehnologije se uporabljajo v raziskavah uporabniške izkušnje in e-izobraževanja?

V nadaljevanju članka so predstavljena teoretična izhodišča, vezana na področje e-izobraževanja, uporabniške izkušnje in uporabniške izkušnje v e-izobraževanju. Sledijo poglavja o metodah dela, rezultatih ter diskusija. Predstavljene so omejitve raziskave, predlogi za nadaljnje raziskave ter zaključek.

2 Teoretična izhodišča

2.1 E-izobraževanje

Izraz e-izobraževanje se je pojavil sredi devetdesetih let prejšnjega stoletja, s pojavom interneta. Kot navajajo Aulakh et al. (2023), je prva dokumentirana uporaba e-izobraževanja zabeležena v letu 1998. E-izobraževanje lahko opredelimo kot

računalniško podprto izobraževalno orodje ali sistem, ki omogoča izobraževanje kjer koli in kadar koli (Daramola et al., 2017).

E-izobraževanje vključuje različne medije, katerih namen je zagotavljanje besedil, zvoka, slike, animacije in videoposnetkov prek različnih kanalov, kot so avdio, video, satelitska televizija in drugi (Pavel et al., 2015; Karnatak et al., 2014). E-izobraževanje se izvaja na dva načina, sinhrono in asinhrono (Ajmera et al., 2014). Sinhrono e-izobraževanje vključuje internetno povezavo in neposredno komunikacijo, medtem ko asinhrono e-izobraževanje omogoča visokošolskim učiteljem in sodelavcem, da s študenti komunicirajo po potrebi in ne v realnem času (npr. forum, e-pošta) (Daramola et al., 2017).

V okviru e-izobraževanja so med najbolj poznanimi oblikami in formati spletni tečaji (ang. online courses), kombinirano izobraževanje (ang. blended learning), množični odprti spletni tečaji (ang. Massive Open Online Courses – MOOCs), mobilno izobraževanje (ang. mobile learning). Spletne tečaje lahko opredelimo kot strukturirane izobraževalne programe, ki se izvajajo prek sistemov za upravljanje učenja in ponujajo sinhrono ali asinhrono izvedbo (Zhao, 2023). Kombinirano izobraževanje predstavlja hibridni pristop, ki vključuje klasično oziroma tradicionalno izobraževanje, dopolnjeno z internetno izvedbo (Karnatak et al., 2014). Množični odprti spletni tečaji, znani tudi kot MOOC, ponujajo obsežne izobraževalne vsebine, ki so dostopne širokemu krogu ljudi (Zhao, 2023). Mobilno izobraževanje omogoča dostop do izobraževanja preko pametnih telefonov, tablic, specializiranih izobraževalnih aplikacij in platform (Danish et al., 2020).

Na področju e-izobraževanja so izredno pomembni tako imenovani sistemi za upravljanje učenja (ang. learning management system – LMS), ki služijo kot središče za uporabnike, visokošolske učitelje in sodelavce ter ostale udeležence, na njih pa se nahajajo gradiva različnih oblik, forumi, testi in drugo (My et al., 2022). Med bolj poznane in razširjene sisteme za upravljanje učenja sodijo Moodle, Blackboard, Canvas, Google Classroom, TalentLMS. Za uporabnike omenjenih sistemov je pomembno, da so ustrezno motivirani, angažirani in se pri delu dobro počutijo, kar pa lahko zagotovimo z ustrezno uporabniško izkušnjo.

2.2 Uporabniška izkušnja

Izraz uporabniška izkušnja (ang. User Experience) se je kot koncept pojavil v devetdesetih letih prejšnjega stoletja in se nanaša na interakcijo med človekom in računalnikom (Nielsen et al., 2022; Liu et al., 2025). Področje uporabniške izkušnje obravnava interakcijo med človekom in računalnikom ter se pogosto obravnava kot disciplina, ki se osredotoča na izboljšanje učinkovitosti interakcije med ljudmi in računalniki (Tanaksaranond, 2018).

Uporabniška izkušnja obravnava čustva, prepričanja, preference, zaznave, fizične in psihološke odzive ter vedenja, ki se pojavijo pred, med in po uporabi nekega izdelka, storitve ali sistema (Bachmann et al., 2018). Najpogostejše je prepoznana kot interdisciplinarno področje, ki se kaže skozi različne komponente in dimenzije (Kaasinen et al., 2012). Z modelom CUE (ang. Components of User Experience) so opredeljeni trije glavni vidiki uporabniške izkušnje: zaznavanje kakovosti oziroma uporabnosti, čustvene reakcije, ki jih sproži aplikacija, ter zaznavanje neinstrumentalne kakovosti, kot je vizualna estetika (Lim et al., 2023).

Dejavniki, pomembni za praktično delo in posledično pri dojemanju izkušnje, vključujejo informacijsko arhitekturo, uporabo in vizualno podobo (Putri et al., 2022). Drugi dejavniki, ki so pomembni pri uporabniški izkušnji, so še zaželenost, dostopnost, verodostojnost in vrednost, ki jo nudi (Albeedan et al., 2024). Sun et al. (2025) navajajo, da na uporabniško izkušnjo vplivajo tri temeljne kategorije: notranje stanje uporabnika, značilnosti sistema in kontekst interakcije.

Za vrednotenje in merjenje uporabniške izkušnje sta se oblikovali dve skupini pristopov, kvantitativni in kvalitativni. Kvantitativni pristopi vključujejo vprašalnike o uporabniški izkušnji za merjenje uporabniške izkušnje z izdelki ali storitvami (Hinderks et al., 2019). Ti vprašalniki so namenjeni merjenju uporabniške izkušnje, vključno s klasičnimi merili uporabnosti ali pragmatičnimi lastnostmi, kot so učinkovitost, obvladljivost in učljivost, ter hedonističnimi merili kakovosti, kot so stimulacija, zabava uporabe, novost, čustva in estetika (Hinderks et al., 2019). Kvalitativni pristopi pa se osredotočajo predvsem na opazovanje uporabnikov med delom, postavljanje vprašanj glede procesa dela ali neposredno spraševanje uporabnikov o njihovih pogledih in občutkih (Novak et al., 2023). V praksi se

kvantitativni in kvalitativni pristopi kombinirajo glede na različne faze življenjskega cikla storitve, produkta ali sistema (Novak et al., 2023).

2.3 Uporabniška izkušnja v e-izobraževanju

Pomen uporabniške izkušnje se je znatno povečal s pojavom spletnih strani in pametnih telefonov (Hidayat et al., 2021). Uporabniška izkušnja je pomemben dejavnik za ustvarjanje navdušenja uporabnika med izobraževanjem. Rezultat dobre uporabniške izkušnje je lahko dolgotrajna uporaba izobraževanja (Hidayat et al., 2021), vodi pa tudi do boljše zavzetosti in zadovoljstva uporabnikov, kar poveča verjetnost, da bodo študenti dosegli svoje cilje (Alghabban et al., 2021), ter neposredno vpliva na učne izide in rezultate (Rohles et al., 2022). Slaba uporabniška izkušnja e-izobraževanja pa vodi do nezadovoljstva uporabnikov, zaradi česar se večja verjetnost, da bodo uporabniki opustili izobraževanje ali pa ga končali s slabšim uspehom (Rahayu et al., 2023).

Sistemi e-izobraževanja morajo biti zasnovani tako, da upoštevajo značilnosti uporabnikov glede predhodnega znanja in izkušenj ter nudijo podporo administraciji, študentom ter visokošolskim učiteljem in sodelavcem (Maslov et al., 2021). Alshaykha (2022) poroča, da imajo vizualni elementi pomembno vlogo pri dvigu učinkovitosti e-izobraževanja, saj neposredno vplivajo na zadovoljstvo uporabnikov in njihovo vztrajnost. Učinkovitost in zadovoljstvo uporabnikov lahko še dodatno povečamo z uporabo interaktivnih komponent, kot so kvizi, forumi, testi in skupinsko delo, ki prispevajo k temu, da se uporabniki bolje povežejo z vrstniki. Večpredstavni elementi, kot so videoposnetki, animacije in slike, naredijo izobraževalno izkušnjo bolj privlačno in izboljšajo razumevanje (Suhadi et al., 2023).

Raziskava, ki je bila izvedena s strani priznanega svetovalnega podjetja za upravljanje McKinsey & Company in je vključevala več kot 7000 študentov iz Severne in Južne Amerike, Evrope, Azije in Bližnjega vzhoda, omenja osem ključnih kazalnikov, ki vplivajo na izobraževalno izkušnjo študentov v visokem šolstvu: jasna navodila, preprosta digitalna izkušnja, uravnoteženi učni formati, privlačna izvedba vsebin, praktično in prilagodljivo učenje ter pravočasna podpora (Child et al., 2023).

Na spletnem portalu LMS (LMS Portals, b. d.) med ključnimi komponentami uporabniške izkušnje v e-izobraževanju izpostavijo uporabnost, dostopnost, vizualno zasnovo, interakcijo in angažiranost ter prilagajanje. Sharma (2025) predstavlja priporočila in dobre prakse za ustvarjanje dobre uporabniške izkušnje v e-izobraževanju, med katerimi izpostavi intuitivno navigacijo, prilagojenost učnega okolja za mobilne naprave, dostopnost, personalizacijo izobraževalne izkušnje, kratek čas nalaganja spletne strani, dobro podporo uporabnikom, ter redno testiranje in posodobitve okolja.

Nekateri sistemi za upravljanje učenja omogočajo personalizacijo učnega okolja in povratne informacije, kar udeležencem pomaga prilagoditi okolje svojim željam in potrebam; kombinacija uporabniku prijaznih vmesnikov, interaktivnosti in personalizacije pa ustvarja temelje za učinkovito in kakovostno uporabniško izkušnjo (Suhadi et al., 2023).

3 Metodologija

Raziskava je bila razdeljena na dva dela. V prvem delu smo izbrali relevantne publikacije s področja uporabniške izkušnje in e-izobraževanja. V drugem delu pa smo izvedli bibliometrično analizo z orodjem VOSviewer.

Podatke za analizo obstoječe literature na temo uporabniške izkušnje v e-izobraževanju, smo pridobili v bazi Web of Science. Web of Science je baza podatkov in storitev indeksiranja citiranosti, namenjena predvsem raziskovalcem, ki zajema širok nabor literature z različnih znanstvenih področij (Ruiz-Perez et al., 2023). Je ena najpogostejše uporabljenih podatkovnih baz, ki jih raziskovalci uporabljajo za bibliometrične analize, znana po tem, da vključuje najkakovostnejše publikacije (Bircan & Salah, 2022), ter služi kot raziskovalno orodje pri izvajanju na podatkih temelječih raziskav (Li et al., 2017).

Za raziskovalno metodo smo izbrali bibliometrično analizo. Omenjena metoda postaja zaradi vedno večje digitalizacije publikacij in dostopa do bibliografskih podatkov vse zanimivejša za izvajanje tovrstnih raziskav (Gao et al., 2021). Z bibliometrično analizo lahko raziskujemo trende v znanosti ter preglede in prikaze stanja nekega področja (Mirawati et al., 2024). Za vizualizacijo in podrobnejšo analizo bibliometričnih podatkov izbranih publikacij smo uporabili programski

paket VOSviewer, ki omogoča prikaz vizualizacije in raziskovanje bibliometričnih podatkov (Eck & Waltman, 2011).

Identifikacija in izbor publikacij je bil opravljen po smernicah PRISMA (ang. Preferred Reporting Items for Systematic Reviews and Meta-Analyses). Postopek identifikacije in izbora je potekal v štirih delih. V prvem delu smo v bazi Web of Science identificirali publikacije s področja e-izobraževanja in uporabniške izkušnje. Kot iskalni niz (ang. topic search) smo uporabili:

TS = ("e-learning" OR "elearning" OR "online learning" OR "digital learning" OR "distance learning" OR "blended learning") AND ("user experience" OR "UX" OR "usability").
Rezultat iskanja je vrnil 2197 publikacij.

Izbrane so bile publikacije, ki so bile objavljene v zadnjih desetih letih (od 2016 do 2025). Iskanje je bilo omejeno na objave tipa Science Citation Index Expanded, Social Sciences Citation Index in Emerging Sources Citation Index. Po upoštevanju kriterijev iskanja je v fazi identifikacije ostalo 874 publikacij. V fazi pregleda so bili pregledani ključni elementi publikacij. Pri tem smo izključili 13 publikacij, ki niso bile v angleškem jeziku. V fazi vključitve je bilo dokončno izbranih 861 publikacij, ki so bile vključene v raziskavo; podatki so bili pridobljeni dne 8. 1. 2026.

4 Rezultati

Rezultati analize pokažejo, da se število publikacij od leta 2016 do leta 2022 konstantno povečuje. Po letu 2022 pa ostaja relativno konstantno. Število objavljenih publikacij po letih in njihov delež v odstotkih sta prikazana v Tabeli 1.

Tabela 1: Pregled števila objavljenih publikacij po letih ter njihov delež v odstotkih v celotnem številu publikacij

Leto objave	Število objav v letu	Odstotek (%) od 861 objavljenih publikacij
2016	28	3,252 %
2017	31	3,600 %
2018	24	2,787 %
2019	36	4,181 %
2020	57	6,620 %
2021	115	13,357 %
2022	154	17,886 %
2023	120	13,937 %
2024	151	17,538 %
2025	145	16,841 %

Vir: Lasten

najpogostejše pojavljajo v analiziranih publikacijah, je: e-izobraževanje (ang. e-learning) (171 pojavljanj), uporabnost (ang. usability) (164 pojavljanj), izobraževanje (ang. learning) (141 pojavljanj), spletno učenje (ang. online learning) (94 pojavljanj), študenti (ang. students) (76 pojavljanj), uporabniška izkušnja (ang. user experience) (72 pojavljanj), oblikovanje (ang. design) (68 pojavljanj), tehnologija (ang. technology) (64 pojavljanj), model (ang. model) (62 pojavljanj) in zadovoljstvo (ang. satisfaction) (55 pojavljanj).

Drugo raziskovalno vprašanje je bilo: »Kateri tematski sklopi se pojavljajo v raziskavah uporabniške izkušnje in e-izobraževanja?« Odgovor na zastavljeno vprašanje smo dobili z analizo ključnih besed v tematskih grozdih (Slika 1) in programom VOSviewer. V nadaljevanju so navedeni tematski grozdi (osem) s ključnimi besedami:

- Tematski grozd 1: **Uporabniška izkušnja v e-izobraževanju** (rdeča barva, 63 ključnih besed).
- Tematski grozd 2: **Dojemanje uporabniške izkušnje** (zelena barva, 44 ključnih besed).
- Tematski grozd 3: **Podatkovno podprti e-izobraževalni sistemi** (temno modra barva, 41 ključnih besed).
- Tematski grozd 4: **Interaktivna učna okolja** (rumena barva, 27 ključnih besed).
- Tematski grozd 5: **Razširjena resničnost** (vijoličasta barva, 22 ključnih besed).
- Tematski grozd 6: **Oblikovanje uporabniških vmesnikov** (svetlomodra barva, 22 ključnih besed).
- Tematski grozd 7: **Mobilno učenje** (oranžna barva, 11 ključnih besed).
- Tematski grozd 8: **Izzivi uporabniške izkušnje v e-izobraževanju** (rjava barva, 8 ključnih besed).

Kot primer navajamo ključne besede tematskega grozd 4: active learning, adaptation, avatars, behavior, classroom, collaboration, collaborative learning, computer-aided instruction, constructionism, disabilities, education, environments, game-based learning, games, gamification, metaverse, pandemics, pedagogy, reality, rehabilitation, support, time, tool, videos, virtual reality (VR) in voices. Opazimo

lahko, da so pomembni pristopi kot so igrifikacija (ang. gamification), virtualna resničnost, sodelovanje in drugo. Poudarja se pomen sodelovanja in angažiranosti, ki je lahko pri e-izobraževanju problematična, kar sovпада z ugotovitvami drugih avtorjev (Aziz et al., 2020).

V skladu s tretjim raziskovalnim vprašanjem »Katere tehnologije se uporabljajo v raziskavah uporabniške izkušnje in e-izobraževanja?«, smo na osnovi vizualizacije omrežja ključnih besed na področju uporabniške izkušnje in e-izobraževanja ter ključnih besed v osmih tematskih grozdih pripravili klasifikacijo tehnologij, ki se pojavljajo v izbranih publikacijah. Tehnologije lahko razdelimo v enajst kategorij: IKT in informacijski sistemi, E-izobraževanje in izobraževalne tehnologije, sistemi za upravljanje učenja, mobilne in spletne tehnologije, umetna inteligenca in tehnologije za delo s podatki, razširjena in navidezna resničnost, igrifikacija, tehnologije, povezane z zdravstvom, uporabniška izkušnja in večpredstavnost.

5 Diskusija

Raziskava se osredotoča na prikaz intelektualne strukture raziskav objavljenih publikacij s področja uporabniške izkušnje in e-izobraževanja ter identifikacijo ključnih elementov omenjenega področja. Publikacije so bile pridobljene iz baze publikacij Web of Science. Po opravljenem pregledu in selekciji publikacij smo v končni analizi uporabili 861 znanstvenih publikacij, na podlagi katerih smo identificirali 3774 ključnih besed. Kot metodologija raziskovanja je bila uporabljena tehnika bibliometrične analize, za prikaz in vizualizacijo podatkov pa programsko orodje VOSviewer. Pregled rezultatov raziskave pokaže, da je omenjeno področje interdisciplinarne narave, saj se v njem prepletajo tehnologija, izobraževanje, psihologija, motivacija in drugi dejavniki.

Na podlagi rezultatov glede objavljenih publikacij zaznamo konstantno rast števila objavljenih publikacij od leta 2016 do leta 2022. Od leta 2022 do leta 2025 pa je število objavljenih publikacij dokaj konstantno. Rast števila objavljenih publikacij lahko pripišemo digitalizaciji in pospešenemu uvajanju digitalnih tehnologij v e-izobraževanje ter posledično izboljševanju uporabniške izkušnje. Številni sistemi za podporo učenju (LMS) so se z leti izboljševali z vidika uporabniške izkušnje z dodajanjem (npr. elementov igrifikacije) ali odvzemanjem (npr. minimalizmom vmesnika) določenih elementov. K rasti števila objavljenih publikacij je vsekakor

pripomogla pandemija COVID-19, ki je večino izobraževalnih ustanov in njihovih uporabnikov prisilila k uvedbi in uporabi e-izobraževanja ter posledično k izboljševanju uporabniške izkušnje. Predvidevamo, da bo v prihodnosti število objav z omenjenih področij ostalo dokaj konstantno z rahlim pozitivnim trendom, saj tehnologije, kot je umetna inteligenca, omogočajo nadaljnji razvoj številnih izobraževalnih poslovnih modelov ter uporabo uporabniške izkušnje na področju e-izobraževanja.

Odgovor na prvo raziskovalno vprašanje, ki se glasi »RV1: Kateri pojmi so v ospredju raziskav uporabniške izkušnje in e-izobraževanja?«, smo dobili s pomočjo programskega orodja VOSviewer. Vizualizacija omrežja ključnih besed na področju uporabniške izkušnje in e-izobraževanja pokaže kompleksno strukturo področja. Identificiranih je bilo osem tematskih grozdov, ki so medsebojno vsebinsko barvno ločeni, a hkrati pomensko povezani. Vsebina tematskih grozdov se nanaša na različne elemente e-izobraževanja in uporabniške izkušnje. Opazimo lahko, da se posamezni grozdi nanašajo na uporabniško izkušnjo v e-izobraževanju, dojemanje uporabniške izkušnje, podatkovno podprte e-izobraževalne sisteme, interaktivna učna okolja, razširjeno resničnost, oblikovanje vmesnikov, mobilno učenje, izzive uporabniške izkušnje v e-izobraževanju in druge sorodne tematike.

Odgovor na drugo raziskovalno vprašanje, ki se glasi »RV2: Kateri tematski sklopi se pojavljajo v raziskavah uporabniške izkušnje in e-izobraževanja?«, smo dobili s pomočjo programa VOSviewer in vizualizacije omrežja ključnih besed. Deset ključnih besed, ki se najpogosteje pojavljajo v analiziranih publikacijah, so: e-izobraževanje, uporabnost, izobraževanje, spletno učenje, študenti, uporabniška izkušnja, oblikovanje, tehnologija, model in zadovoljstvo. Iz prikazanega lahko ugotovimo, da se ključni elementi uporabniške izkušnje v e-izobraževanju nanašajo na sklope, povezane z načinom prilagajanja, oblikovanja in krepitev uporabnosti uporabniške izkušnje, ter tehnološko in pedagoško podporo, ki sta povezani z zadovoljstvom uporabnika.

V skladu s tretjim raziskovalnim vprašanjem »RV3: Katere tehnologije se uporabljajo v raziskavah uporabniške izkušnje in e-izobraževanja?«, je bila na osnovi analize ključnih besed in vizualizacije omrežja ključnih besed na področju uporabniške izkušnje in e-izobraževanja izdelana tudi klasifikacija tehnologij, ki se delijo na: IKT in informacijske sisteme, e-izobraževanje in izobraževalne tehnologije, sisteme za

upravljanje učenja, mobilne in spletne tehnologije, umetno inteligenco in tehnologije za delo s podatki, razširjeno in navidezno resničnost, igrifikacijo, zdravstvene tehnologije, uporabniško izkušnjo, večpredstavnost ter programe za analizo, evalvacijo in validacijo.

Iz rezultatov lahko ugotovimo, da sta področji uporabniške izkušnje in e-izobraževanja dokaj kompleksni glede uporabe različnih tehnologij. To pomeni, da je treba dobro poznati tehnologije, ki jih posamezna organizacija uporablja, in na osnovi tega prilagajati uporabniško izkušnjo z namenom povečanja zadovoljstva, motivacije, angažiranosti in drugih želenih učinkov, ki so vezani na uporabnike e-izobraževanja.

6 Zaključek

E-izobraževanje je imelo od nekdanj številne prednosti pred klasičnim izobraževanjem, ki so postale še očitnejše v času pandemije COVID-19. Učinkovitost, zavzetost in zadovoljstvo uporabnikov e-izobraževanja lahko bistveno izboljšamo z ustrezno uporabniško izkušnjo.

Članek ima svoje omejitve. V raziskavo so bile vključene samo publikacije iz baze podatkov Web of Science. Omeniti je treba, da obstajajo tudi druge baze publikacij, kot so Scopus, Dimensions, Lens, PubMed, OpenAlex in druge. Vključitev tudi drugih baz podatkov bi lahko vplivalo na rezultate. Čeprav je baza Web of Science ena večjih in najbolj priznanih baz publikacij, bi priporočali, da se v prihodnje raziskave izvedejo tudi na osnovi publikacij, ki so objavljene v drugih bazah. V raziskavi smo uporabili samo publikacije, kot so Science Citation Index Expanded, Social Sciences Citation Index in Emerging Sources Citation Index. Izbiro omenjenih vrst publikacij pa argumentiramo z njihovo kakovostjo in težo objav.

V prihodnosti bi bilo smiselno izvajati redne periodične raziskave na omenjenem področju, saj se razvoj uporabniške izkušnje v e-izobraževanju izjemno hitro odvija. Prav tako bi bilo smiselno izvesti poglobljene raziskave določenih ključnih elementov, ki smo jih identificirali v članku. Zanimivo bi bilo analizirati tudi elemente, ki so manj zastopani kot so kulturne razlike uporabnikov, etične in pravne vidike. Razumevanje in boljše poznavanje ključnih elementov je bistvenega pomena za implementacijo in prilagajanje uporabniške izkušnje v e-izobraževanju.

Ugotovitve lahko pomagajo razvijalcem in administratorjem učnih okolij pri oblikovanju izobraževalnih okolij in pri izbiri pristopov in orodij. Prav tako si z ugotovitvami pomagamo pri strateškem načrtovanju in odločanju povezanim z e-izobraževanjem. Predstavljeni rezultati pa nudijo izhodišča za nadaljnje strokovne in znanstvene raziskave posameznih dejavnikov.

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DIVERZIFIKACIJA KMETIJSKE DEJAVNOSTI: PODJETNIŠKA STRATEGIJA IN TRŽNI VIDIKI

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Strateško načrtovanje dopolnilne dejavnosti na kmetiji zahteva preverjanje razvojnih pogojev, analizo trga ter razumevanje konkurenčnega okolja. Primer obravnavane kmetije z dolgoletno tradicijo prikazuje podjetniški pristop k diverzifikaciji z uvedbo predelave sadja v marmelade, sokove in sirupe, kar omogoča ustvarjanje dodatnega dohodka in širitev zaposlitvenih možnosti. S SWOT analizo ter oceno tržnih priložnosti in tveganj so opredeljene ključne prednosti, izzivi in konkurenčne prednosti nove dejavnosti. Strateški poslovni načrt vključuje programe, finančne projekcije in kazalnike uspešnosti, ki potrjujejo, da je diverzifikacija izvedljiva, ekonomsko sprejemljiva in tržno privlačna, ob pogoju inovativnosti, kakovosti izdelkov in prilagajanja potrebam kupcev.

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DIVERSIFICATION OF AGRICULTURAL ACTIVITIES: ENTREPRENEURIAL STRATEGY AND MARKET ASPECTS

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entrepreneurship,
diversification
complementary,
farm activities,
fruit processing,
business planning

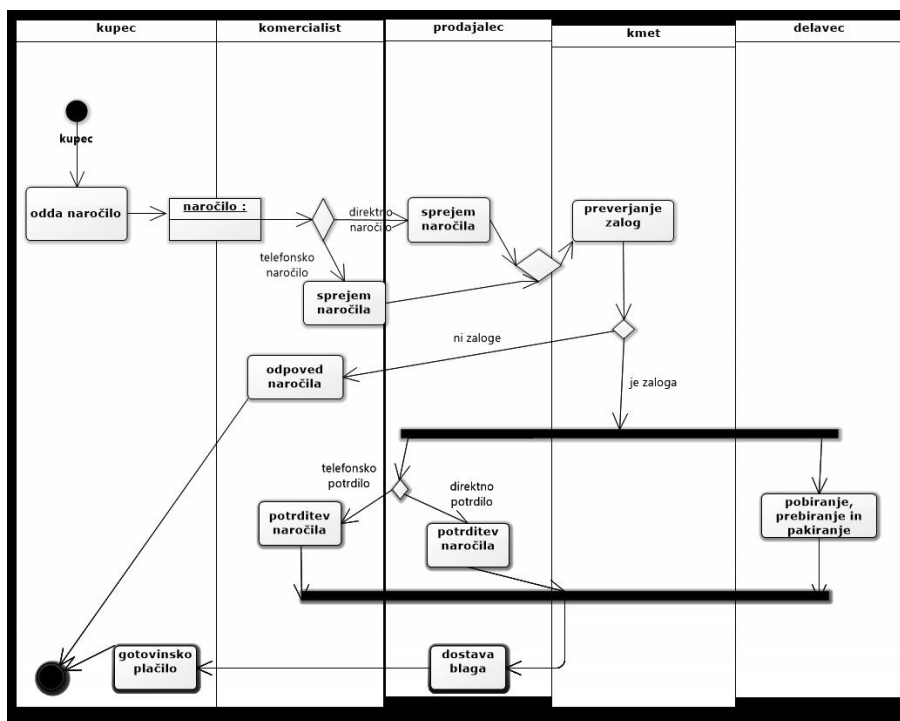
Strategic planning of complementary farm activities requires an assessment of development conditions, market analysis and an understanding of the competitive environment. The case study farm, with a long-standing tradition and loyal customers, applies an entrepreneurial approach by diversifying into fruit processing, producing jams, juices and syrups to generate additional income and employment opportunities. A SWOT analysis and an evaluation of market opportunities and risks highlight the key strengths, challenges and competitive advantages of the new activity. The strategic business plan includes product programmes, financial projections and performance indicators, demonstrating that diversification is feasible, economically sustainable and market-attractive, provided the emphasis remains on innovation, product quality and meeting customer needs.



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1 Uvod

Dopolnilna dejavnost na kmetiji je dejavnost, ki jo lahko opravlja nosilec kmetije ali član kmetije, ki dobi dovoljenje nosilca kmetijskega gospodarstva. Izvaja jo lahko le fizična oseba kmetijskega gospodinjstva. Dopolnilna dejavnost omogoča kmetiji večjo delavno moč, dodatni dohodek in boljšo rabo proizvodnih zmogljivosti kmetije (GOV.SI, 2025).



Slika 1: Diagram aktivnosti

Vir: Miklavčič (2019)

Cilj je razširiti dejavnost na donosne dejavnosti. Možnosti so pri sadjarstvu in vinogradništvu, kar bomo preverili s skrbnim načrtovanjem in usmeritvijo doseči večjo dodano vrednost. S strateškim načrtom bomo opredelili razširjeno dejavnost, ki nudi redno zaposlitev. Bohak in sod. (2010) pišejo, da je na družinski kmetiji pomembno imeti naslednika, ki bo vodil kmetijo naprej. Dobro je tudi, da ima naslednik (ki je v več kot 80 % moški - po njihovi raziskavi), kmetijsko izobrazbo in

po možnosti čim višjo. Tako bo pametno in inovativno nadaljeval kmečko tradicijo družine. Višja izobrazba po njihovem mnenju pomeni možnost zaposlitve ob vodenju kmetije.

Dopolnilno dejavnost na kmetiji lahko prištevamo tudi k družinskim podjetjem, saj so poleg nosilca dopolnilne dejavnosti vključeni še ostali člani družine, ki pomagajo pri proizvodnji, predelavi, marketingu, nabavi dodatnega materiala in prodaji izdelkov in/ali storitev (Kostanjevec in G. Omerzelj, 2013).

Na sliki 1 je prikazana pot od želje kupca do prodaje izdelka. Črna pika na sliki predstavlja začetek poti, kvadratki predstavljajo aktivnosti v samem procesu, puščice kažejo smer poteka procesa. Zadnja postaja, torej prevzem blaga in zadovoljstvo kupca kaže druga črna pika z obrobo. Romb predstavlja odločanje možnosti med procesom, debelejša črna črta pa kaže, kako lahko ena aktivnost vpliva na več dejavnikov. Na vrhu v izhodišču je opredeljen izvajalec dejavnosti.

2 Opis problema z obravnavano tematiko

Želja vsakega podjetnika je, da odpre dejavnost v kateri bo užival, poleg tega pa mu bo prinesla dobiček. Cilj je torej s čim manj sredstvi in stroški voditi dejavnost in imeti čim več prometa in posledično dobička. Potrebno je pravilno ovrednotiti ali se v tem primeru kmetije bolj splača prodati sveže sadje, izdelke iz viška tega sadja (prezrelo sadje, poškodovano sadje, sadje neprilučnega izgleda) ali izdelke iz lepega, primerno zrelega sadja. Kot vsak projekt ima tudi ta veliko število opcij in tveganj, glavno tveganje je le v majhni meri okolje (vreme, škodljivci in hranilna vrednost tal) (Pažek, 2010), cene sadja so bolj pogojene verigam supermarketov in mednarodnim prodajnim kanalom na drobno. Poleg tega na ceno negativno vplivajo tudi plače delavcem, cena energetikov, komunalne storitve in ostali inputi v kmetijstvu (Gričar S., 2010). Prav zato je potreben dober strateški načrt, ki nam omogoča večjo transparentnost procesa vrednotenja in ocenjevanja projekta in nam olajša odločitve pri odločitvi za odprtje dopolnilne dejavnosti na kmetiji. Če pa se v odprtje dejavnosti spuščamo prvič, brez resnih izkušenj je dobro, da dobro pretehtamo dobre in slabe strani, pregledamo statistične podatke o izdelkih, ki jih želimo tržiti, pregledati konkurenčnost trga, ki nam onemogoča monopol nad proizvodi. Dobro je premisliti ali bodo izdelki dostopni širši javnosti ali se posvetimo določenim kupcem – torej preverimo trg prodaje. Poleg tega moramo upoštevati še davke in

dajatve, ki jih plačamo državi in ti višajo lastno ceno izdelkov, katera potem lahko ne bo konkurenčna večjim pridelovalcem in ponudnikom.

Za izvajanje dopolnilne dejavnosti na kmetiji mora nosilec izpolnjevati zakonsko določene pogoje, ki opredeljujejo minimalne površine osnovnih kultur, uporabo pretežno lastnih surovin ter ustrezno kmetijsko ali sorodno izobrazbo. Dopolnilna dejavnost se lahko izvaja na lokaciji kmetije ali nosilca kmetijskega gospodarstva, pri čemer zakon dopušča prodajo lastnih izdelkov ter omejen delež dokupljenih surovin. Predpisani so tudi osnovni higijenski, tehnični in prostorski standardi ter obveznost vodenja ustreznega knjigovodstva. Navajamo le najpomembnejše:

- Uredba o dopolnilnih dejavnostih na kmetiji, Uradni list RS, št. 57/15
- Zakon o dohodnini (ZDoh-2), Uradni list RS, št. 117/06
- Pravilnik o skupinah kmetijskih pridelkov, Uradni list RS, št. 4/16
- Pravilnik o minimalnih tehničnih pogojih in o obsegu storitev za opravljanje gostinske dejavnosti, Uradni list RS, št. 35/17.

Ti zakonski okvirji določajo osnovne pogoje za predelavo sadja ter predstavljajo regulativno izhodišče za načrtovanje diverzifikacije kmetijske dejavnosti.

3 Refleksija na tematiko

Strateški načrt dopolnilne dejavnosti na kmetiji je zelo uporabno orodje pri projektu, saj bomo z njim dobili vpogled v zahtevnost začetka delovanja in tudi možne zaplete. Analize in samo načrtovanje projekta bo pomagalo pri odločitvi ali odpreti dopolnilno dejavnost na kmetiji ali ne. S strateškim načrtom želimo podati objektivno oceno projekta za lažje odločanje. Ker pa nekaj podatkov o sami prodajni ceni izdelkov ne bo znanih, jih bomo uporabili iz vsakdanjega življenja. Menimo, da je strokovnega gradiva dovolj s katerim lahko dobimo vsaj delno predstav o uspešnosti odprtja omenjene dejavnosti.

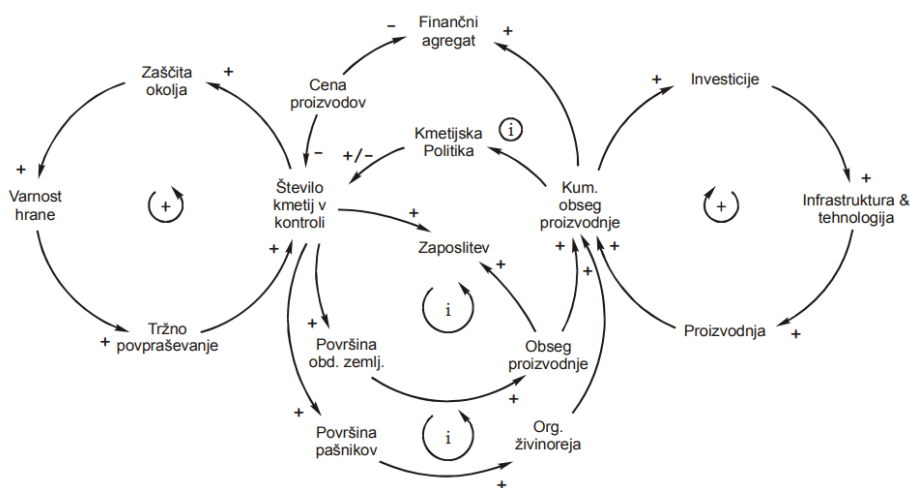
Glede na dosedanje znanje in vedenje sklepamo o načelni uspešnosti projekta; zanima pa nas pomembnost specializacije na ožji trg z bolj specifičnimi in posebnimi izdelki. Podjetja namreč delujejo v okolju, ki je zelo spremenljivo, dinamično in negotovo. Zato se s strateškim načrtovanjem bolje pripravimo na možne dogodke in se jim prilagodimo. Tako na dolgi rok posluujemo z dobičkom (Veršič, 2018).

Prilagodimo se najenostavneje z inovacijami: na primer namesto navadne marelične marmelade pripravimo marelično marmelado s sivko in jo ponudimo restavraciji, ki jo lahko ponudimo kot sladico oziroma polivko na goveji biftek. Inovativno je izbrati sestavine in jih združevati tako, da bodo zanimive za kupca. Ena od teh možnosti je na primer sirup iz rožmarina ali sok iz kakija. Čeprav si s tem povečamo tveganje za manjšo prodajo, nam inovacije lahko zmanjšajo konkurenčnost trga, saj je običajnih sokov, sirupov in marmelad na trgu veliko. Inovativnih izdelkov pa je na trgu zelo malo. Z rednimi degustacijami in reklamami nas ljudje lahko spoznajo kot inovativno kmetijsko gospodarstvo. S tem postanemo znani in drugačni, to pa je tudi naša želja.

4 Raziskovalni načrt

Metodologija

Pri strateškemu načrtovanju smo uporabili podatke iz Statističnega urada RS (SURS), iz realnega življenja (cene predelanih izdelkov) in iz znanstvenih in strokovnih člankov in ostalih besedil. Tabelni prikazi so uporabljeni iz gradiva Strateškega vodenja podjetja (Papler, 2025).



Slika 2: Vzročno-posledični diagram kmetijstva

Vir: Škraba in sod. (2008)

Kmetijstvo teži k trajnostnemu razvoju. Prav o tem pišejo Kljajić in sod. (2010), v njihovem članku omenjajo metodologijo systemske dinamike in systemsko dobo (Ackoff, 1998), ki pravi, da je vsak sistem del družbenega sistema in ta del ekološkega sistema. Torej cilj dopolnilne dejavnosti ni le zaslužek, ampak tudi zadovoljiti družben in ekološki sistem ne le same kmetije, ampak tudi okolja. Te povratne zanke sistema so prikazane na Sliki 2. Smer puščice kaže smer od vzroka do posledice. + znak pove, da imata vzrok in posledica isto smer, znak – pa da imata nasprotno smer.

5 Strateške rešitve – načrt podjetja

Izhodišča (interes udeležencev, vizije)

Cilj strateškega načrta je odprtje dopolnilne dejavnosti na kmetiji, naša želja je kot v vsakem manjšem in večjem podjetju s čim manj vložki (inputi) dobiti čim več izlozkov (outputov) in s tem doseči čim večji dobiček. Pri tem je pomembna dobra kvaliteta izdelkov in zvestoba kupcev. Zato vztrajamo, da so naši izdelki čim bolj naravni in s čim manj dodanimi sladkorji in ostalimi sladili (Tabela 1). Prav o tem pišeta tudi Hribar in Bojnec (2010). Kupci živil dajejo vedno večji pomen ne le ceni, ampak tudi zdravim živilom, dobremu okusu, vonju in izgledu živil, s čim več naravnimi sestavinami v živilih. Kupci raje kupijo preverjena, že poznana živila, ki dobro vplivajo na razpoloženje.

Za začetek želimo predelati sadje v marmelade, sokove in sirupe (Tabela 2) višek sadja, ki ga ne moremo svežega prodati (prezrelo sadje, poškodovano sadje); če pa bi se promet povečal, načrtujemo dokup dela sadja od poznanih kmetovalcev. V začetku se bo z dopolnilno dejavnostjo intenzivneje ukvarjala ena oseba, v primeru večjega povpraševanja pa dve.

Tabela 1: Smotri, merila uspešnosti in standardi uspešnosti

Št.	Smoter	Merilo uspešnosti	Rang	Standardi uspešnosti po letih				
				Leto 1	Leto 2	Leto 3	Leto 4	Leto 5
1	Inovativni izdelki	Število novih in drugačnih izdelkov na tržišču	6	3 novi izdelki	5 novih izdelkov	5 novih izdelkov	5 novih izdelkov	7 novih izdelkov
2	Čim manj dodatnih sladil	Procent izdelkov z nič ali minimalnimi vrednostmi dodatnih sladkorjev	4	največ 80%, z največ 20 % sladkorja	največ 70%, z največ 20 % sladkorja	največ 60%, z največ 20 % sladkorja	največ 50%, z največ 20 % sladkorja	največ 40%, z največ 20 % sladkorja
3	Kakovost	Zadovoljstvo kupcev in velika kupna moč	3	100 zadovoljnih kupcev	200 zadovoljnih kupcev	300 zadovoljnih kupcev	350 zadovoljnih kupcev	400 zadovoljnih kupcev
4	Bližina trga	Čim več prodanih izdelkov doma in na bližnji tržnici	1	30% izdelkov prodanih doma in na bližnji tržnici	40% izdelkov prodanih doma in na bližnji tržnici	45% izdelkov prodanih doma in na bližnji tržnici	50% izdelkov prodanih doma in na bližnji tržnici	55% izdelkov prodanih doma in na bližnji tržnici
5	Cenovno dostopni izdelki	Cene primerljive s konkurenčnimi cenami	2	med 1-2€ razlik cene od konkurenčnega sadja	med 1-2€ razlik cene od konkurenčnega sadja	med 1-2€ razlik cene od konkurenčnega sadja	med 0,5-1€ razlik cene od konkurenčnega sadja	med 0,5-1€ razlik cene od konkurenčnega sadja
6	Domače sveže sadje	Procent predelanega domačega in svežega sadja	5	predelava 90% domačega sadja	predelava 90% domačega sadja	predelava 80% domačega sadja	predelava 80% domačega sadja	predelava 70% domačega sadja, ostalih 30% od ostalih pridelovalcev (zaradi večje proizvodnje)

Vir: lastni

Tabela 2: Programi organizacije

Št.	Program	Enota	Značilnosti programa	Pričakovana vrednost letno				
	Proizvod za odjemalce	Nosilec		Leto 1	Leto 2	Leto 3	Leto 4	Leto 5
1	Marmelada brez sladkorja	NM	Naravna sveža marmelada brez dodatnih sladkorjev in konzervansov (tridilo agar ali nič)	400	500	700	900	1000
2	Marmelada z 20 % sladkorja	NM	Naravna sveža marmelada z do 20 % dodatnih sladkorjev in brez konzervansov (tridilo agar ali nič)	600	700	900	1100	1200
3	Sirup	NM	domač sirup s 50 % sladkorja in 50 % v vodi namočenih zelišč	200	300	500	700	800
4	Sok brez sladkorja	NM	naravni stisnjen sok brez dodatnih sladkorjev in konzervansov	200	300	500	700	800
5	Sok z do 20 % sladkorja	NM	naravni stisnjen sok z do 20 % dodatnih sladkorjev in konzervansov	400	500	700	900	1000

Vir: lastni

Naša vizija je, da bi v roku petih let od dopolnilne dejavnosti lahko živele dve odrasli osebi. Torej, da bi mesečni prihodek zadostoval dvema minimalnima plačama v Sloveniji. Ta je bila v letu 2019 bruto 886,63 EUR na osebo, v letu 2020 pa je bila 940,58 EUR bruto na osebo (GOV.SI, 2019). Poleg tega je naša vizija biti prepoznaven ne le v ožjem okolišju, ampak tudi širše. Cilj je prodaja blaga na domu in na tržnici. Želja je, da se udeležujemo raznih sejmov in dogodkov, saj s tem naredimo dodatno reklamo. Vsaj dvakrat letno nadaljujemo tradicijo organiziranja Dneva odprtih vrat (25. april) in Tržnega dneva (15. maj), kjer obiskovalci poskusijo naše izdelke, ki jih v vsakdanjem življenju velikokrat prezremo. Imajo pa močan potencial, zaradi novosti v ponudbi in inovativnosti. Prav ti dve lastnosti pripomoreta k uspešnosti in učinkovitosti podjetja v današnjem času (Kaluža in Bojnec, 2018).

Podana imamo sredstva. 2 ha intenzivnih in ekstenzivnih sadovnjakov, 0,5 ha oljčnikov in 0,05 ha vrta z zelišči. Poleg tega razpolagamo z obstoječo hladilnico površine 10 m² in sušilno omaro s 5 m² sušilnih površin. Dejavna je kuhinja z uporabo izdelkov pri pripravi malic za dijake, študente in za zaposlene. S prenovljeno

spletno stranjo pospešujemo spletno prodajo. Za te namene imamo na razpolagi 10.000 EUR. V primeru Pomoči mladih prevzemnikov (Bohak in sod., 2010), pa kmetiji za razvoj pripada še dodatnih 45.000 EUR, za kar je potrebno izpolnjevati določene pogoje (Ministrstvo, 2019).

Tabela 3: Interes udeležencev in vizija organizacije

Št.	UDELEŽENCI	INTERESI UDELEŽENCEV ORGANIZACIJE	Rang
	Kdo ima vpliv na organizacijo?	Kaj predvsem hočemo?	
1	Nosilec kmetije	prodati čim več sadja bodisi svežega, bodisi predelanega v marmelado, sok ali sirup.	2
2	Nosilec dopolnilne dejavnosti	prodati čim več predelanih izdelkov	4
3	Konkurenca	po čim nižji ceni prodati svoje izdelke, kar lahko manjša dobiček našim izdelkom	3
4	Kupci	hočejo po čim nižji ceni dobiti čim kvalitetnejše izdelke	5
5	Država	pobiranje davkov in inšpekcijski pregledi primernosti prostorov in izdelkov	1

Vir: lastni

Analiza priložnosti, tveganja in privlačnosti trga

Tabela 4: Analiza priložnosti in težav

PRILOŽNOSTI		TEŽAVE	
Prednosti organizacije za program	Rang	Slabosti organizacije za program	Rang
Lastna pridelava sadja	4	Časovna stiska v vrhuncu sezone za predelavo	3
Obstoječi trg s prodajo svežega sadja	3	Že obstoječi trgi prodaje v kraju	2
Turističen kraj bivanja za večjo možnost prodaje v turistični sezoni	2	Neznana letna količina surovin (sadja)	1
Izkušnje s kuhanjem marmelad in sokov	1		
PRILOŽNOSTI V OKOLJU ZA PROGRAM	Rang	NEVARNOSTI VOKOLJU ZA PROGRAM	Rang
Turističen kraj	4	Izpad pridelka zaradi vremenskih sprememb	3
Bližina Italije za tuji trg	3	Prihod večjega pridelovalca z nižjimi cenami izdelkov	2
Kmetijsko razvit kraj	1	Sprememba zakona o prodaji na drobno	1
Primerna klima kraja	2		

Vir: lastni

Pri strateškem načrtu se je potrebno posvetiti tudi prednostim in slabostim organizacije za program, upoštevati pluse in minuse v okolju za program, torej za odprte dopolnilne dejavnosti na kmetiji. Analiza priložnosti in težav je prikazana v Tabeli 4.

Tabela 5 kažeta opis dejavnika konkurenčnosti (prednosti), Tabela 6 pa opis dejavnika konkurenčnosti (slabosti) proti ostalim pridelovalcem. Dejavnike smo ovrednotili z utežmi.

Tabela 5: Skupni dejavniki uspešnosti, prednosti

Št.	Opis dejavnika uspešnosti – konkurenčnosti (prednosti)	Utež
K1	Inovativnost: manj konkurenčnosti	0,2
K2	Obstoječi trg: s svežim sadjem	0,2
K3	Turizem: turističen kraj	0,1
K4	Bližina tujega trga (Italija): želja po domačem sadju in domačih izdelkih	0,1
K5	Čas pridelave: čim hitrejša pot iz drevesa do porabnika	0,2
K6	Domače sadje: ni stroškov nakupa sadja; kakovost je preverjena	0,2
		1,0

Vir: lastni

Tabela 6: Skupni dejavniki uspešnosti, slabosti

Št.	Opis dejavnika uspešnosti – konkurenčnosti (slabosti)	Utež
K1	Inovativnost: manjše število kupcev zaradi nepoznavanja novih okusov in izdelkov	0,2
K2	Obstoječi trg: z marmeladami in sokovi v kraju	0,2
K3	Turizem: le sezonski (pozna pomlad, poletje, zgodnja jesen)	0,1
K4	Bližina tujega trga (Italija): italijanska deklaracija in želja po ugodnih izdelkih	0,1
K5	Čas pridelave: časovna stiska na vrhuncu sezone	0,2
K6	Domače sadje: neznane količine sadja za predelavo pogojene vremenu in letini	0,2
		1,0

Vir: lastni

Položaj in strategija na tržišču (kupci, konkurenti, SWOT analiza)

Zaradi bližine trga in turističnega kraja bivanja je njihova prioriteta prodati pridelke čim bližje domu. Torej na domačem naslovu in na bližnji tržnici, ki je blizu mejnega prehoda z Italijo. S tem se pridobi tudi tuj trg. Poleg tega bi izdelke prodajali preko interneta, a na začetku le v manjši meri, saj je pošiljanje izdelkov v stekleni embalaži

lahko nevarno. Ker pa kupci že 40 let hodijo tudi na mestno tržnico, bi tudi tam ponudili njihove izdelke in si s tem razširili tržišče tudi na ostali del Slovenije (Tabela 7).

Tabela 7: Odjemalci in vrednost poslovanja

Rang	Odjemalec		Kupci na domu	Strategija podjetja do odjemalca	Vrednost poslov				
	Naziv	Značilnosti			Leto 1	Leto 2	Leto 3	Leto 4	Leto 5
1	Kupci na domu	Kupec, ki pozna izdelek ga pride kupit na domač naslov	Cenovno dostopno, kakovostno, zdravo	Degustacije in ogled proizvodnje	400	500	900	1100	1300
2	Kupci na tržnici	Znani in novi kupci poskusijo in kupijo izdelke	Cenovno dostopno, kakovostno, zdravo	Degustacija	800	800	900	900	1000
3	Kupci na tržnici v Kranju	Novi in obstoječi kupci kupijo izdelke	Cenovno dostopno, kakovostno, zdravo	Degustacija	400	700	800	800	800
4	Kupci prek internetne prodaje	Novi in obstoječi kupci kupijo izdelke	Cenovno dostopno, kakovostno, zdravo	Dober slikovni material in reklama	200	700	700	1500	1700
Skupaj					1800	2300	3300	4300	4800

Vir: lastni

Tabela 8: Konkurenti

Rang	Konkurenti za program		Konkurenčnost program		Strategija do konkurenta za program
	Naziv	Opis	Prednost programa	Slabost programa	
1	Supermarketi	Tuji izdelki z nizko ceno in majhnim sadnim deležem	Nizka cena, že obstoječi trg	Majhen sadni delež, veliko sladkorjev, slab sadni okus in aroma	Domače sadjem malo ali nič sladkorjev, veliko sadne arome
2	Večji pridelovalci	Delno domači, delno dokupljeni izdelki srednjega cenovnega razreda s srednjim sadnim deležem	Spodnja cena, že obstoječi trg	Srednji sadni delež in manjša sadna aroma	Domače sadjem, malo ali nič sladkorjev, veliko sadne arome
3	Manjši pridelovalci	Domači izdelki s srednjim in nizkim sadnim deležem	Že obstoječi trg	In inovativnosti	Inovativni izdelki po konkurenčni ceni

Vir: lastni

Poleg tega morajo pregledati konkurente na trgu, ki jih lahko ogrožajo oziroma znižujejo cene in naše prihodke. Na konkurenčnost vplivajo: dobavitelji, odjemalci, konkurenti z enakimi izdelki in konkurenti z dopolnjujočimi izdelki (Kavčič, 2009).

Tem se morajo zaperstaviti in postati nekoliko drugačni in privlačni. Le-tako bodo pridobili kupce, ki so do sedaj izdelke kupovali drugje, odslej pa bi z zamenjavo dobavitelja pridobili posel (Tabela 8). Za njih so največji konkurenti velike trgovske verige s poceni izdelki, nato sledijo večji pridelovalci in nazadnje manjši pridelovalci.

Za dober strateški načrt je pomembno izdelati SWOT (poslovenjeno SPIN) analizo, ki je najpomembnejša analiza v poslovanju. Opazujemo štiri aspekte: prednosti, slabosti v notranjosti procesa in nato še priložnosti in nevarnosti pri zunanjem aspektu na program.

Portfolio prikaz programov podjetja

Portfolio prikaz vsebuje izdelke glede na oceno in uteži. S tem dejansko vidimo ali so izdelki dovolj kakovostni, inovativni, konkurenčni in zadovoljivi za kupce. Tavčar (2006) poudarja, da je potrebno organizacijo obravnavati kot skupnost interesov notranjih in zunanjih udeležencev. Torej tako članov kmetije, ki se trudijo prodati izdelke in kupcem, ki želijo kupiti kakovostne, sveže in cenovno primerne izdelke.

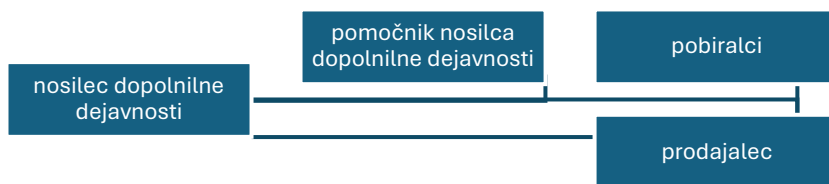
Tabela 9: Ocenjevanje konkurenčnosti za vse programe

Št.	Program	T1	Utež	T2	Utež	T3	Utež	T4	Utež	T5	Utež	Ocena	Rang
	Naziv	ocena	z utež	ocena	z utež	ocena	z utež	utež	z utež	utež	z utež		
1	Marmelada brez sladil	4	0,2	3	0,2	4	0,2	4	0,1	3	0,1	4	4
2	Marmelada z največ 20 % sladil	2	0,2	1	0,2	5	0,2	4	0,1	3	0,1	3	1
3	Sirup	5	0,2	5	0,2	3	0,2	3	0,1	5	0,1	4	5
4	Sok brez sladil	4	0,2	3	0,2	4	0,2	3	0,1	3	0,1	4	2
5	Sok z največ 20 % sladil	2	0,2	4	0,2	5	0,2	4	0,1	3	0,1	4	3

Vir: lastni

V Portfolio matriki vrišemo ocene programov. Ocena 1 pomeni zelo slabo, ocena 5 pa zelo dobro. Merila za konkurenčnost smo uporabili iz Tabele 5 in Tabele 6, pri merila privlačnosti za kupce pa iz Tabele 1. Nato smo določili skupno oceno vsakega programa glede vseh meril in izrisali Sliko 3.

Kako poteka pot od naročila kupca do dostave izdelka lahko vidimo na Sliki 1, kjer je izrisan diagram aktivnosti.



Slika 4: Organigram urejenosti organizacije

Vir: lastni

Izvajanje programov podjetja

Kljub vsem analizam, ki so bile predhodno opravljene, je potrebno za dobro poslovanje in uspeh pri dopolnilni dejavnosti na kmetiji, narediti tudi načrt dejavnosti, uspešnost programa po standardih, ki smo jih določili, finančne izračune glede bilance uspešnosti in bilance stanj. Pregledati je potrebno tudi naložbe sredstev v programu. Če se tudi ta del pozitivno izide, nam to pokaže, da je projekt smiseln in se vanj lahko podamo samozavestno in resno.

Načrt strateške dejavnosti za program (navzven in navznoter)

Tabela 11 in Tabela 12 prikazujeta dejavnosti nosilca in ostalih delavcev navznoter in navzven. To je naš načrt, kako bomo delati v prihodnjih letih.

Tabela 11: Načrt strateških dejavnosti navznoter

Leto	Dejavnosti nosilca programa	Dejavnosti drugih za program
1. leto	Prvo leto nosilec urediti spletno stran in začeti posredovati izdelke na trg.	Pomoč pri reklami novih izdelkov na trgu. Izvajanje degustacij in promocija na sejmihi.
Ostala leta	Redno na trg uvajati nove izdelke in jih primerno reklamirati na spletni strani in na sejmihi.	Inovativno proizvodnjo novih izdelkov, prisotnost na sejmihi, degustacije na domu in na tržnicah.

Vir: lastni

Tabela 12: Načrt strateških dejavnosti navzven

Leto	Dejavnosti nosilca programa	Dejavnosti drugih za program
1. leto	Priprava novega prostora za proizvodnjo in sestavi 5-letni načrt dela. Začetek proizvodnje.	Priprava začetnih izdelkov za prodajo. Sodelovanje z nosilcem glede načrta za delo.
Ostala leta	Vzdrževanje urejenosti prostora, dokup strojev za lajšanje dela (razkoščevalac, preša, sterilizator). Vodenje knjigovodstva, Vzdrževanje odnosa med delavci.	Vzdrževanje urejenosti prostorov in kvalitete izdelkov. Inovativne ideje glede novih izdelkov. Dobri odnosi v kolektivu.

Vir: lastni

Uspešnost programov po standardih uspešnosti

V tabeli 1 zgoraj, smo si zadali merila uspešnosti in standarde, ki jih želimo uresničiti. Cilj se je čimbolj približati našim ciljem, je pa pri nekaterih (količina domačega sadja) težava zaradi neznanih vremenskih razmer, ki nam lahko pokvarijo pridelek. Naš cilj je vsaj 80 % upoštevati naš program uspešnosti.

Finančne projekcije (bilanca uspešnosti in bilanca stanja)

Tabela 13: Bilanca uspeha dopolnilne dejavnosti na kmetiji

Postavke bilance uspeha		Vrednost po letih				
Izberemo primerno podrobnost		Leto 1	Leto 2	Leto 3	Leto 4	Leto 5
A. Čisti prihodki od prodaje		250	675	1475	2125	2500
B. Sprememba vrednosti zalog proizvodov in nedokončane proizvodnje		0	0	0	0	0
C. Vrednost usredstvenih (aktiviranih) lastnih proizvodov in storitev		1800	2300	3300	4500	4500
Č. Drugi prihodki od poslovanja		0	100	150	150	150
D. Kosmati donos od poslovanja						
E. Stroški blaga, materiala in storitev						
1. Nabavna vrednost prodanega blaga (2.+3.)		450	575	825	1075	1200
2. stroški materiala		337,5	451,25	618,75	806,25	500
3. Stroški storitev		112,5	341,25	618,75	25	500
F. Stroški dela (1.+2.)						
1. Stroški plač		800	8000	800	800	800
2. Stroški socialnega in pokojninskega zavarovanja		150	150	150	150	150
G. Amortizacija neopredmetenih dolgoročnih sredstev in opredmetenih osn. sredstev		50	50	50	50	50
H. Odpisi osnovnih sredstev		0	0	0	0	0
I. Drugi odhodki poslovanja		100	50	0	0	0
J. Dobiček ali izguba iz poslovanja						
K. Prihodki od deležev iz dobička podjetij v tujini		0	0	0	0	0
L. Prihodki od deležev dobička drugih		0	0	0	0	0
M. Prihodki od obresti in drugi prihodki od financiranja		0	1	5	10	15
N. Odpisi dolgoročnih in kratkoročnih finančnih naložb		0	0	0	0	0
O. Stroški obresti in drugi odhodki financiranja		0	0	0	0	0
P. Dobiček ali izguba rednega poslovanja						
R. Izredni prihodki (tudi prihodki za poravnavo izgube prejšnjih let)		0	0	0	0	0
S. Izredni odhodki (tudi odhodki za poravnavo izgube prejšnjih let)		0	0	0	0	0
T. Celotni dobiček ali izguba		250	676	1480	2135	2515
U. Davki iz dobička		0	0	0	0	0
V. Drugi davki		5	13,52	29,6	42,7	50,3
Z. Čisti dobiček ali čista izguba poslovnega leta		245	662,48	1460,4	2092,3	2454,7

Vir: lastni

Pomembna elementa strateškega načrta sta bilanca uspeha podjetja (Tabela 13) in bilanca stanja (Tabela 14). Dajeta dejanski vpogled v številke, torej prihodke in odhodke, iz katerih lahko izračunamo ali bomo s poslovanjem imeli dobiček ali izgubo. Prva leta smo logično načrtovali, da bodo donosi manjši, saj se na trgu šele vzpenjamo in imamo zaradi začetka delovanja tudi nekaj več stroškov nakupa strojev in izgradnjo prostorov. Po nekaj letih je dobro, da se nam dobički večajo, saj to pomeni več prometa in ustalitev na trgu. Da imamo dobre dejanske možnosti poslovanja vidimo na Tabeli 13 pod črko Z, ki pomeni čisti dobiček iz poslovanja.

Tabela 14: Bilanca stanja dopolnilne dejavnosti na kmetiji

Sredstva	Leto 1	Leto 2	Leto 3	Leto 4	Leto 5	Obveznosti do virov sredstev	Leto 1	Leto 2	Leto 3	Leto 4	Leto 5
A. Stalna sredstva						A. Kapital					
I. Neopredmetena dolg. sredstva	0	0	0	0	0	I. Osnovni kapital	48.000	47400	46400	45500	45000
II. Opredmetena osn. Sredstva	7.000	7600	8600	9500	10.000	II. Vplačani presežek kapitala	0	0	0	0	0
III. Dolgoroč. finančne naložbe						III. Rezerve					
1. Delnice in deleži	0	0	0	0	0	IV. Presež. čisti dob. ali izg. prejš. let	0	245	662,48	1450	2092
2. Dolgoročno dana posojila	0	0	0	0	0	V. Revalorizacijski popravki kapitala	0	0	0	0	0
3. Dolgoročni depoziti	0	0	0	0	0	VI. Nerazd. čisti dob. ali izg. Prej. let	0	0	0	0	0
IV. Popravek kapitala						B. Dolgoročne rezervacije					
1. Odkupljene lastne delnice	0	0	0	0	0	C. Dolgoročne obveznosti iz financiranja					
2. Neplačani vpisani kapital	0	0	0	0	0	1. Dolgor. dobljena pos. pri bankah 2	0	0	0	0	0
B. Gibljiva sredstva						2. Dolgor. pridobljena druga posojila	0	0	0	0	0
I. Zaloge						Č. Dolgoročne obveznosti iz poslovanja	0	0	0	0	0
1. Material	500	500	600	600	700	1. Dolgoročni krediti pri bankah 2	0	0	0	0	0
2. Nedokončana proizvodnja	0	0	0	0	0	2. Dolgoročni krediti pri drugih	0	0	0	0	0
3. Proizvodi	1800	2300	3400	4300	4800	D. Kratkoročne obveznosti					
4. Trgovsko blago	0	0	0	0	0	1. Kratkoročna posojila pri bankah 2	0	0	0	0	0
5. Predujmi za zaloge	0	0	0	0	0	2. Kratkoročna posojila pri drugih	0	0	0	0	0
II. Dolgor. terjatve iz poslovanja	0	0	0	0	0	3. Kratkor. izdani vrednostni papirji E.	0	0	0	0	0
III. Kratkor. terjatve iz poslovanja	0	0	0	0	0	E. Kratkoročne obveznosti iz poslovanja					
IV. Kratkoročne finančne naložbe	0	0	0	0	0	1. Kratkor. Obv. do drugih dobav.	0	0	0	0	0
V. Denarna sredstva	48.000	47.400	46.400	45.500	45.000	2. Druge kratkoročne obveznosti	0	0	0	0	0
VI. Aktivne časovne razmejitve	0	0	0	0	0	F. Pasivne časovne razmejitve					

Vir: lastni

Naložbe finančnih sredstev v programe

Del naložbe dopolnilne dejavnosti kmetije je usmerjena v kuhinjo in stroje (Tabela 14), ki se bodo odplačevali obročno brez obresti. Ostale naložbe pa so nakup materialov za proizvodnjo (Tabela 15).

6 Rezultati, ugotovitve ter priporočila podjetju

V Tabeli 14 o bilanci podjetja smo za dopolnilno dejavnost namenili 10.000 EUR (kuhinja, stroji). Sredstva za embalažo in reklamo se krijejo z dobičkom prejšnjih let. Ves denar, ki ga lahko dobimo kot mladi prevzemniki kmetije, zato lahko vložimo v obnovo sadovnjakov, v modernejšie stroje (ki niso bili prvotni namen nakupa) in v boljšo reklamo. Za lajšanje dela zaradi časovne stiske v višku sezone lahko tako najamemo še 2 dodatna delavca. Višek denarja pa je priporočeno vložiti tudi v inovacije, ne le novih izdelkov, ampak tudi v razvoj in širitev proizvodnje. Tako pridobimo na strateški pomembnosti, ugotavlja Verčič (2018) v svojem članku o Strateškem pomenu podjetja v procesu uresničevanja strategij.

Poleg tega se mlademu prevzemniku priporoča, da dobro izbere ime blagovne znamke, ki bo v celoto povezala inovativne izdelke. V strateškem načrtu izpostavljajo inovativnost in kakovost kot ključni smernici za uspešno poslovanje. Tako lahko uspe manjši pridelovalec, da povečuje trg in izpolni svoje želje – biti zaposlen na lastni kmetiji in biti sam svoj vodja.

7 Sklepna misel

Z novimi načini organizacije in prilagajanja na spremembe v okolju dosežemo želene cilje in tako povečamo konkurenčnost drugim pridelovalcem in predelovalcem (Papler in Bojnec, 2006).

Strateški načrt dopolnilne dejavnosti na kmetiji je pokazal, da lahko ob pravi taktiki in na pravem kraju solidno poslujmo tudi ob konkurenci večjih in enakih proizvajalcih. Potrebno je imeti željo, sredstva, talent in okolje, ki to omogočajo. Kmetija s 50-letno tradicijo in ustaljenimi kupci je dober začetek za predelavo sadja, ki ni 1. kategorije. Tako imajo ne le manj odpadnega sadja, ampak te »odpadke« predelajo v druge izdelke, ki jim prinašajo dodatni prihodek za kmetijo in možnost zaposlitve več ljudi. Ob nosilcu dopolnilne dejavnosti se poveča zaposlitev za dva delavca za pomoč pri pobiranju sadja in proizvodnji marmelad, sokov in sirupov.

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Bibliografija: COBISS izpis obsega več kot 950 enot. Raziskovalni interesi: Hotelsko upravljanje; zadovoljstvo gostov; turizem; načrtovanje destinacije; napitnina; vodenje projektov; inovativnost v turizmu; turizem za osebe s posebnimi potrebami.

Drago Papler izobrazba: Ima interdisciplinarna znanja: doktor znanosti, magister gospodarski inženir, univerzitetni diplomirani ekonomist, diplomirani gospodarski inženir, inženir elektroenergetike in inženir kmetijstva in krajine. Zaposlitve: V Elektru Gorenjska je 20 let deloval na področju priprave dela in tehnične komercialne investicij. Po odprtju trga z električno energijo se je ukvarjal z marketingom in prodajo. Od leta 2006 je bil vodja Službe za investicije in razvoj v družbi Gorenjske elektrarne, od leta 2011 do 2014 vodja organizacijske enote Investicije, razvoj in projektiranje, od leta 2015 je bil svetovalec direktorja za raziskave in razvoj. Od leta 2014 do 2021 je bil predstavnik vodstva za sisteme vodenja kakovosti, upravljanje z energijo ter obvladovanje tveganj. Od leta 2021 kot predstojnik vodi Medpodjetniški izobraževalni center na Biotehniškem centru Naklo. Pedagoško delo: Docent za področje ekonomije in managementa, predavatelj ekonomije, energetike in managementa na višješolskih, univerzitetnih in magistrskih programih. Raziskovalno delo: Višji strokovno raziskovalni sodelavec, interdisciplinarne raziskave s področja agroekonomije, managementa, podjetništva, kakovosti, energetike, turizma, izobraževanja. Sodeluje kot recenzent publikacij, urednik revij, organizator dogodkov in projektov. Je znanstveno raziskovalni sodelavec revije EGE Zagreb in zaslužni član Združenja elektroenergetikov CIGRE-CIRED. Bibliografija: COBISS-izpis obsega 1650 enot, od tega 52 izvirnih znanstvenih člankov, 8 znanstvenih monografij.

Nejka Mikavčič je zaključila magistrski študij programa Gospodarski inženiring, 2. bolonjske stopnje, na Poslovno-tehniški fakulteti, Univerze v Novi Gorici in pridobila naziv magister gospodarski inženir.

ARTIFICIAL INTELLIGENCE INTEGRATION FOR THE OLDER WORKFORCE

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The article addresses the challenges and opportunities of the older workforce when implementing artificial intelligence (AI). Rapid technological advancements are changing the workplace, requiring new competencies and adaptability. The older workforce faces various challenges, such as technological anxiety, complex user interfaces, decreased trust in AI, and fear of job loss. Additionally, social and organisational factors, including technological ageism and insufficient inclusion of the older workforce, further complicate the situation. Successful AI implementation requires a comprehensive and inclusive approach, including technology adjustment, training programs, and fostering psychological safety and open communication. Principles of lifelong learning, intergenerational mentorship, and ethically designed AI systems can significantly reduce resistance to new technology and improve attitudes toward AI. This new technology should not be seen as a threat but rather as a tool to complement existing knowledge and productivity within the organisation.

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1 Introduction

This article aims to synthesize the existing studies on barriers and enablers of AI use among the older workforce and to propose the necessary steps organizations can apply to implement or strengthen the use of AI.

Artificial intelligence is rapidly evolving, and the changes it brings to workplace operations are becoming increasingly crucial for all generations, especially older workers (Novak et al., 2023). This demographic group possesses extensive work experience and institutional knowledge but did not grow up alongside the rise of AI. As a result, they face challenges adapting to new technologies, hindering their ability to enhance productivity and remain competitive in a dynamic corporate environment (Casas & Román, 2024).

The percentage of the older workforce is increasing, making it imperative to empower and enable training and development to acquire new skills essential to maintaining productivity and competitiveness in the labor market (Vasilyeva & Vasileva, 2022). The global population aged 65 and older is projected to double from 703 million in 2019 to 1.5 billion by 2025, signaling a significant transformation in the labor force's demographic structure (United Nations, 2019).

Special attention is needed to address the challenges older generations face in accepting AI, including technological complexity, user interface issues, technological anxiety, and declining knowledge retention (Joshi, 2025). Understanding the attitudes of the older workforce towards AI and their concerns regarding innovative workplace approaches is crucial for developing effective training strategies and implementing AI itself (Reigas & Sukiene, 2025).

Furthermore, it is essential to focus on the resistance and hesitation of the older workforce towards engaging with AI, stemming from the contradictions between their experiences and new technologies (Golgeci et al., 2025).

In accordance with the issues and trends outlined above, the following research questions will be addressed:

RQ1: What individual barriers shape attitudes toward AI among the older workforce?

RQ2: What organizational factors shape attitudes toward AI among the older workforce?

RQ3: Which steps are most recommended to improve AI acceptance among the older workforce?

2 Methodology

To analyze the use of artificial intelligence among the older workforce, a qualitative methodology was employed, as it enables a deeper understanding of individuals' complex perceptions and connections (Novak et al., 2023). This approach was chosen for its ability to uncover contextual factors influencing older workers' interactions with AI. Gathering quantitative data alone would not suffice. A literature review, including qualitative case studies, was conducted to examine the challenges and solutions of implementing and using AI.

A structured search was conducted in major academic databases: Scopus, Web of Science and ScienceDirect. We used combination of keywords such as: Artificial Intelligence, the older workforce, trust in AI, digital skills and change management. Studies were included if they (1) addressed AI in workplace, (2) included older workers or the older workforce, (3) focused on attitude towards AI (acceptance or resistance related constructs).

We have considered both qualitative and quantitative research as well as literature reviews. More recent publications were prioritized to reflect latest developments in AI adoption. Conceptual integration and actionable guidance over exhaustive coverage of all publications were prioritized due to the nature of the article (as an article used in a conference). Included studies were synthesized using a thematic analysis, group findings into AI characteristics and implications, (2) individual concerns and organizational interventions. We used those findings in Discussion chapter to propose the phased implementation framework.

3 Results

The synthesis resulted in three main parts: (1) AI characteristics and implications, (2) individual concerns and limitations affecting the older workforce and (3) organizational interventions. To frame these parts, AI is defined as the ability of computers and machines to mimic human behavior and execute tasks autonomously (Morandin-Ahuerma, 2022). The origins of AI can be traced back to 1956 when the term was introduced in discussions about machines performing tasks previously executed by humans, utilizing their cognitive abilities (Buaka & Moid, 2024). Since then, the field has progressed through developments in machine learning and neural network methodologies (Wiberg, 2020), further advanced by the emergence of extensive digital datasets, enabling contemporary forms of AI capable of generating abstract interpretations and judgments (Dwivedi et al., 2023). Such rapid development is relevant as it amplifies the pace of workplace change, which can cause anxiety and trust concerns among the older workforce.

Today, AI can be conceptualized in various ways. Morandin-Ahuerma offers valuable insights by classifying AI along two dimensions: the level of cognitive capability and the degree of autonomy exhibited by the system (Morandin-Ahuerma, 2022).

Artificial intelligence classification	
LEVEL OF COGNITIVE ABILITY	LEVEL OF AUTONOMOUS DECISION MAKING
LIMITED AI Inability to adapt to new environments	REACTIVE AI Autonomous execution of tasks without prior memory
STRONG AI Ability to adapt to new environments	DELIBERATIVE AI Ability to plan and decide based on data
SUPER AI Ability to perform highly complex tasks	COGNITIVE AI Imitation of human behaviour
	AUTONOMOUS AI Ability to autonomously interact

Figure 1: Artificial Intelligence Classification

Source: Morandin-Ahuerma, 2022

The implementation of AI and attitudes towards it have been extensively studied. Reid concludes that AI initially negatively affects workers' feelings, especially when personal data is gathered and analyzed. Additionally, the use of AI in companies impacts workforce trust towards leaders and managers. Transparency and worker inclusion in such decisions are crucial for building confidence in new technology (Reid, 2024).

Significant differences in AI usage exist among various age groups. Two studies indicate that age bias in AI development is a major concern, leading to misperceptions in the utilization of digital tools (Doargajudhur & Baboo, 2024; Wissemann et al., 2022). Golgeci et al. confirm these claims, noting that only 16% of individuals aged 55 and over have used AI tools, compared with 56% of the working population aged 18 to 24 (Golgeci et al., 2025).

The limited use of AI among older individuals raises a pertinent question: why do they not utilize it as much as their younger counterparts, given its potential benefits in the workplace? First, there is a general resistance to change among the older workforce. Some older workers refuse to accept new technology and prioritize maintaining professional autonomy (Reigas & Šukienė, 2025). Chu et al. argue that AI tools were developed without considering the needs, experiences, or preferences of older users, making acceptance and efficient use more difficult (Chu et al., 2022). Older workers often experience technological anxiety exacerbated by complex user interfaces, which also reduces AI usage (Wolfe et al., 2025). If the results of using AI tools fail to meet the expectations of the older workforce, it can lead to a lack of trust in the benefits of such systems (Shandilya & Fan, 2024).

A significant factor influencing the use of AI is the fear of job loss. The assumption, although not entirely clear, is that the further development of AI will render current positions obsolete. Rapid implementation of AI in the workplace heightens concerns about job security; if AI is perceived as a threat, acceptance of new technology will be low (Wolfe et al., 2025).

However, it is not solely the resistance and fear of the older workforce that can limit AI adoption. Social and institutional factors must also be considered. Prejudice against this group can lead to social bias, known as ageism in AI, which may result in discriminatory practices and guidelines that inadvertently reinforce it (Chu et al.,

2022). This can lead to the exclusion of older workers as relevant stakeholders in discussions about AI implementation (Stypinska, 2023). Conversely, Rashid warns against paternalistic help or compassionate ageism. There have been instances where organisations have attempted to protect older workers from digitalization, potentially resulting in negative outcomes, despite known positive effects associated with digitalization (Voinea et al., 2024).

All these factors diminish the potential for successfully implementing and utilizing AI to its fullest extent. Therefore, a robust training and learning plan must be established to mitigate these limitations. This plan needs to address the barriers: technological anxiety, interface complexity, and knowledge retention, while also being tailored specifically for the older workforce. Studies indicate that an effective training program can significantly reduce barriers and enhance the older workforce's sense of competence and autonomy in the digital age (Komp et al., 2022). The content should extend beyond technical instructions to include psychological support and adaptable user interfaces, creating a more inclusive and supportive work environment (Nedeljko et al., 2023).

Although the younger workforce tends to benefit more from using artificial intelligence (Haslberger et al., 2023), other research indicates that core principles of artificial intelligence adoption, such as motivation, self-reliance and social interaction are not age dependent, which means implementation done right can also be effective with the older workforce (Capinding & Dumayas, 2024). It makes sense that understanding how attitudes towards artificial intelligence, the most pressing concerns, and the psychological appraisals of the older workforce influence their use of digital technology (Chiu et al., 2021). Personalized training programs that focus on employees' technical skills and wellbeing have been shown to reduce resistance to artificial intelligence and increase its use and engagement (Sadeghi, 2024).

Kronberger et al. concluded that ongoing training and development will be crucial to equip the workforce with the necessary skills for the effective use of artificial intelligence (Kronberger et al., 2024).

4 Discussion

The strategy for implementing artificial intelligence should commence with a strong commitment to lifelong learning within the organisation. This commitment is a crucial part of organisational culture, empowering the older workforce to embrace new technologies and enhancing their adaptability to AI (Çolak, 2023).

4.1 Phase 1: Preparation and Review

It is essential to assess and eliminate age-biased algorithms in AI systems. This involves thorough analyses by AI ethics experts collaborating closely with IT specialists. Jung et al. highlight the issue of AI systems that prioritize speed over experience, necessitating reconfiguration to account for long-term know-how and thus avoid age discrimination (Jung et al., 2025).

Once age discrimination is addressed, it is crucial to analyze the attitudes of the older workforce toward AI. Such an analysis will assess the levels of technological anxiety and the current complexity of AI systems in place (Wolfe et al., 2025). A small focus group consisting of the older workforce members can be organized to identify potential fears associated with using AI (Joshi, 2025). The goal of these steps is to pinpoint individual and group obstacles, as well as the expectations of the older workforce.

To initiate actual implementation, a project working group must be established. This group should include representatives from HR, IT, psychology, health and safety, and, most importantly, the older workforce representatives (Fenwick et al., 2024).

4.2 Phase 2: Design and Pilot Runs

The project group should participate in designing user interfaces tailored for the older workforce. Prototype methods can be used to test user acceptance and streamline workflows (Chan et al., 2024). The objective of this step is to reduce the number of steps required to complete tasks (fewer clicks), automate frequently used operations (e.g., automated report generation), and adjust font and icon sizes.

A clear curriculum must be developed to facilitate effective training for the older workforce. The training program should incorporate micro-learning, practical examples, and real-life scenarios. It is imperative to offer courses that emphasise

how AI complements the roles of the older workforce rather than replacing them (Chetty, 2023). The ultimate goal is to enhance AI proficiency while alleviating older workers' fears of job loss.

4.3 Phase 3: Implementation and Adjustment

This phase is the most critical and time-consuming. It should begin with a pilot execution within a smaller group. Each participant should have a mentor (typically a younger person skilled in AI) available to assist and resolve issues in real-time, which can help reduce technological anxiety (Berger et al., 2024). Establishing intergenerational mentorship is also advisable, allowing the older workforce members to share their experiences while younger colleagues help them master AI tools (Dhiman et al., 2023; Sarioguz & Miser, 2024).

Effective communication is vital during this transition. Regular AI town halls are recommended, during which company leadership provides updates on implementation, explains the purpose, progress, and its impact on the workforce (Sadeghi, 2024).

For successful implementation, inclusion and engagement are essential. This can be achieved by organizing regular workshops and forums where the older workforce members can offer feedback on AI. The aim is to provide them with an opportunity to co-create how new technologies will shape the future workplace (Altepost et al., 2024). This involvement enhances their sense of control and ownership while also reducing resistance to change.

Despite these efforts, some workforce members may still struggle psychologically and technologically. Continuous and efficient psychological and IT support during the transition is crucial (Nkomo & Kalisz, 2025; Kaaria, 2024).

4.4 Phase 4: Assessment and Optimization

After the implementation and training phases, the effectiveness of the AI system must be assessed by establishing key performance indicators: attitudes toward AI (e.g., the ATAI questionnaire), productivity (measured by the time taken to complete

tasks using AI), and user satisfaction (measured through surveys at predetermined intervals).

5 Conclusion

We conclude that the implementation of artificial intelligence is a change that affects not only processes and productivity but also people. Literature analysis indicates that the older workforce often occupies less favorable positions, not necessarily due to a lack of motivation or capability, but rather due to a combination of structural, psychological, and organisational factors. Technological complexity, unsuitable user interfaces, and fears of job loss significantly impact their willingness and confidence to use AI.

Nevertheless, the findings suggest that these obstacles can be addressed through a well-thought-out and inclusive onboarding plan. The key lies in the organization's commitment to lifelong learning, which provides the older workforce with technical knowledge, psychological support, and a sense of safety. An effective approach includes establishing a multidisciplinary project group, developing user-friendly interfaces, providing mentorship, and implementing a step-by-step rollout.

Artificial intelligence should not be viewed as a tool that will replace people. Instead, it is a technology that can complement human knowledge and experience, especially among the older workforce. The implementation of AI is not merely a technical challenge but primarily an organisational and human-focused project that requires leadership, open communication, and active engagement from relevant stakeholders. While strategy is crucial, it is just one part of the solution. Most companies recognize the potential of AI, but hasty implementation can lead to issues that do not justify the associated costs. Therefore, we recommend treating AI use as a top priority, reflected in the company's overall strategy and objectives—both at the individual and group levels.

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VPLIV KOMUNIKACIJE V ORGANIZACIJI NA IZGORELOST ZAPOSLENIH V JAVNI ZDRAVSTVENI USTANOVI

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Komunikacija v organizaciji pomembno vpliva na organizacijsko klimo in psihofizično počutje zaposlenih, zlasti v delovno obremenjujočih okoljih, kot je javni zdravstveni sektor. Namen prispevka je bil preučiti zaznave zaposlenih o organizacijski komunikaciji, raven izgorelosti ter povezanost med organizacijsko komunikacijo in izgorelostjo v javni zdravstveni ustanovi v Sloveniji. Raziskava temelji na analizi zaznav zaposlenih o ključnih vidikih organizacijske komunikacije ter njihovega psihofizičnega počutja. Ugotovitve nakazujejo relativno stabilnost organizacijske klime, hkrati pa opozarjajo na izzive na področju spoštljive komunikacije in vključevanja zaposlenih v procese odločanja. Pri zaposlenih je zaznana zmeren raven izgorelosti. Prispevek predstavlja izhodišče za nadaljnje raziskave ter poudarja pomen izboljšanja komunikacijskih praks kot pomembnega preventivnega dejavnika v javnem zdravstvenem sektorju.

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THE IMPACT OF ORGANIZATIONAL COMMUNICATION ON EMPLOYEE BURNOUT IN A PUBLIC HEALTH INSTITUTION

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Internal communication plays an important role in shaping organizational climate and employee well-being, particularly in highly demanding work environments such as the public healthcare sector. The aim of this paper is to examine employees' perceptions of organizational communication, the level of burnout, and the relationship between organizational communication and burnout in a public healthcare institution in Slovenia. The study is based on an analysis of employees' perceptions of key aspects of organizational communication and their psychosocial well-being. The findings indicate a relatively stable organizational climate, while also highlighting challenges related to respectful communication and employee involvement in decision-making processes. A moderate level of burnout among employees was identified. The paper provides a starting point for further researches and emphasizes the importance of improving communication practices as a preventive factor in the public healthcare sector.



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1 Uvod

Sodobne organizacije delujejo v pogojih povečanih delovnih obremenitev in visokih zahtev glede učinkovitosti, kar pomembno vpliva na psihosocialno počutje zaposlenih. Organizacijsko okolje ima pri tem ključno vlogo, saj lahko bodisi spodbuja delovno zavzetost in dobro počutje bodisi prispeva k razvoju negativnih psihosocialnih izidov, med katerimi je izgorelost eden osrednjih izzivov sodobnih delovnih okolij.

Izgorelost je kompleksen psihološki pojav, ki se razvija kot posledica dolgotrajne izpostavljenosti kroničnim delovnim stresorjem in neugodnim organizacijskim razmeram. Opredeljena je kot sindrom čustvene izčrpanosti, depersonalizacije in zmanjšanega občutka osebne učinkovitosti (Maslach, Schaufeli, Leiter, 2001). Gre za postopni proces, ki pomembno vpliva na delovno uspešnost, zadovoljstvo z delom ter kakovost delovnih odnosov, pri čemer je še posebej izrazit v delovno intenzivnih sektorjih.

Takšen kontekst je značilen tudi za javni zdravstveni sektor, kjer zaposleni delujejo pod izrazitimi časovnimi pritiski, v čustveno zahtevnih situacijah ter ob omejenih kadrovske in organizacijske virih. Raziskave kažejo, da so ravni izgorelosti v zdravstvenih poklicih višje kot v številnih drugih dejavnostih, kar predstavlja pomemben izziv za delovanje zdravstvenih organizacij in kakovost oskrbe pacientov (Dall'Ora et al., 2020).

Pomembno vlogo pri razvoju izgorelosti imajo organizacijski dejavniki, med katerimi izstopa notranja komunikacija. Ta pomembno vpliva na organizacijsko klimo, kakovost medosebnih odnosov ter zaznavo podpore in vključenosti zaposlenih. Jasna in spoštljiva komunikacija omogoča boljše razumevanje pričakovanj in učinkovitejše obvladovanje delovnih nalog, medtem ko pomanjkljiva komunikacija povečuje negotovost, stres in nezadovoljstvo z delom (Laschinger, Leiter, 2006).

Kljub obsežnim raziskavam izgorelosti v zdravstvenem sektorju je empiričnih študij, ki bi neposredno preučevale povezavo med zaznavami organizacijske komunikacije in ravni izgorelosti zaposlenih, zlasti v slovenskem javnem zdravstvenem prostoru, še vedno razmeroma malo. Namen tega prispevka je zato preučiti zaznave

zaposlenih o organizacijski komunikaciji, raven iz gorelosti ter povezanost med organizacijsko komunikacijo in iz gorelostjo v javni zdravstveni ustanovi v Sloveniji.

2 Komunikacija v organizaciji

Organizacijska komunikacija je v sodobni znanstveni literaturi opredeljena kot osrednji organizacijski proces, ki omogoča usklajevanje dela, prenos informacij ter oblikovanje in vzdrževanje odnosov med zaposlenimi. Raziskave poudarjajo, da notranja komunikacija pomembno vpliva na zaznave zaposlenih o delovnem okolju, organizacijski klimi in kakovosti delovnih odnosov, saj ne opravlja zgolj informacijske funkcije, temveč pomembno prispeva tudi k oblikovanju vsakodnevnih delovnih izkušenj zaposlenih (Curilla, Morales, Poma, Vicente-Ramos, 2023).

Pomen notranje komunikacije se še posebej izrazito kaže v delovno obremenjujočih okoljih, kot je javni zdravstveni sektor. Zaposleni se soočajo s kompleksnimi delovnimi nalogami, časovnimi pritiski in nepredvidljivimi delovnimi situacijami, zato so jasne in pravočasne informacije ključnega pomena za učinkovito delovanje. Empirične raziskave kažejo, da zaznana jasnost informacij pomembno prispeva k boljšemu razumevanju delovnih nalog ter zmanjšuje negotovost pri delu (Motsamai, Onyenankeya, 2025).

V tem kontekstu predstavlja pomemben vidik organizacijske komunikacije obveščenost zaposlenih, ki se nanaša na zaznavo, ali imajo zaposleni na voljo zadostne informacije za razumevanje pričakovanj in ustrezno odločanje v delovnih situacijah. Pomanjkanje informacij je povezano z nejasnostjo vlog in slabšim doživljanjem delovnega okolja, medtem ko jasna in dosledna komunikacija prispeva k večji učinkovitosti ter boljšemu sodelovanju med zaposlenimi (Curilla et al., 2023).

Poleg obveščenosti ima pomembno vlogo tudi vključenost zaposlenih v komunikacijske procese, ki se nanaša na zaznano možnost izražanja mnenj ter občutek, da so ta v organizaciji slišana in upoštevana. Sodobni pregledi literature poudarjajo, da vključujoča komunikacija, ki omogoča dvosmerni dialog, pozitivno vpliva na organizacijsko klimo in zaznano podporo zaposlenim, pri čemer ne gre nujno za formalno sodelovanje zaposlenih v procesih odločanja (Nadales-Gallego, Galindo-Reyes, F., Garrido-More, 2025).

Tretji pomemben vidik organizacijske komunikacije je spoštljiva komunikacija, ki se nanaša na kakovost medosebnega sporazumevanja v organizaciji. Profesionalen in spoštljiv komunikacijski slog prispeva k boljšim delovnim odnosom, večjemu zaupanju ter stabilnejši organizacijski klimi, medtem ko nespoštljiva komunikacija povečuje verjetnost konfliktov in negativnih zaznav delovnega okolja (Curilla et al., 2023).

Poseben, vendar tesno povezan vidik organizacijske komunikacije predstavlja tudi razumevanje neformalnih pravil in načinov vključevanja v kolektiv. Jasno komunicirana pričakovanja in norme olajšajo socialno integracijo posameznikov v delovno skupino ter prispevajo k večjemu občutku pripadnosti organizaciji (Motsamai, Onyenankeya, 2025).

Na podlagi navedenih teoretičnih izhodišč je organizacijska komunikacija v raziskavi opredeljena skozi dimenzije obveščenosti, vključenosti zaposlenih v komunikacijske procese, spoštljive komunikacije in jasnosti socialnih pričakovanj. Takšen pristop omogoča teoretično utemeljeno analizo zaznav zaposlenih o komunikaciji v organizaciji ter njihovo povezavo z izgorelostjo.

3 Izgorelost

Izgorelost predstavlja pomemben psihosocialni pojav sodobnih delovnih okolij in je povezana z dolgotrajno izpostavljenostjo delovnim obremenitvam ter neugodnim organizacijskim dejavnikom. V literaturi je izgorelost najpogosteje opredeljena kot sindrom, ki se razvija kot posledica kroničnega stresa na delovnem mestu in se kaže v čustveni izčrpanosti, odtujenem ali ciničnem odnosu do dela ter zmanjšanem občutku osebne učinkovitosti (Maslach, Schaufeli, Leiter, 2001). Gre za proces, ki se razvija postopoma in ima lahko pomembne posledice tako za posameznika kot za organizacijo.

Sodobna razumevanja izgorelosti poudarjajo, da ne gre zgolj za individualni problem, temveč za pojav, ki je tesno povezan z značilnostmi delovnega okolja. Organizacijski dejavniki, kot so delovna obremenitev, nejasna pričakovanja, pomanjkanje podpore in slaba kakovost delovnih odnosov, pomembno prispevajo k razvoju izgorelosti. Svetovna zdravstvena organizacija (WHO) je izgorelost v Mednarodni klasifikaciji bolezni (ICD-11) opredelila kot poklicni pojav, ki izhaja iz

kroničnega stresa na delovnem mestu, s čimer je dodatno poudarila vlogo delovnega okolja pri njenem nastanku (World Health Organization, 2019).

Izgorelost ima številne negativne posledice, med katerimi so zmanjšana delovna učinkovitost, nižje zadovoljstvo z delom, pogostejša odsotnost z dela ter povečano tveganje za težave na področju duševnega in telesnega zdravja (Maslach et al., 2001; Salvagioni, Melanda, Mesas, González, Gabani, Andrade, 2017). Na organizacijski ravni se lahko kaže v slabši kakovosti dela, večji fluktuaciji zaposlenih in slabših medosebnih odnosih (Schaufeli, Taris, 2014). Zaradi teh posledic je izgorelost vse pogostejše obravnavana kot pomemben izziv organizacij in sistemov dela (World Health Organization, 2019).

Zdravstveni sektor sodi med delovna okolja z večjim tveganjem za pojav izgorelosti zaradi visokih delovnih obremenitev, časovnih pritiskov in čustveno zahtevnega dela. Zaposleni v zdravstvenih ustanovah so pogosto izpostavljeni odgovornosti za zdravje in življenje drugih ter omejenim organizacijskim in kadrovskim virom, kar povečuje zaznano delovno obremenitev. Raziskave kažejo, da je izgorelost v zdravstvenih poklicih razširjen pojav in pomemben izziv za delovanje zdravstvenih organizacij (Dall'Ora et al., 2020).

Izgorelost zaposlenih v zdravstvenih ustanovah ne vpliva le na njihovo psihofizično počutje, temveč tudi na kakovost dela, varnost pacientov in organizacijsko klimo (Dall'Ora et al., 2020; Salvagioni et al., 2017). Zato se vse pogostejše poudarja pomen organizacijskih dejavnikov, kot so podpora, način vodenja in kakovost notranje komunikacije, ki lahko pomembno prispevajo k preprečevanju ali zmanjševanju izgorelosti v zdravstvenem okolju (West, Dyrbye, Shanafelt, 2018).

4 Raziskava

Na podlagi analize literature in predhodnih raziskav smo se odločili preveriti, kako zaposleni v javni zdravstveni ustanovi zaznavajo organizacijsko komunikacijo, kakšna je raven izgorelosti ter ali med zaznano kakovostjo organizacijske komunikacije in izgorelostjo obstaja povezanost. Namen raziskave, ki je bila izvedena septembra 2025, je prispevati k boljšemu razumevanju vloge komunikacije v organizaciji kot pomembnega dejavnika delovnega okolja ter njenega potencialnega vpliva na pojav izgorelosti zaposlenih.

Za namen raziskave smo si postavili naslednja raziskovalna vprašanja:

RV1: Ali zaposleni v javni zdravstveni ustanovi zaznavajo organizacijsko komunikacijo kot učinkovito z vidika obveščenosti, spoštljive komunikacije, vključenosti v komunikacijske procese in jasnosti socialnih pričakovanj?

RV2: Kakšna je raven izgorelosti zaposlenih v javni zdravstveni ustanovi?

RV3: Ali obstaja povezanost med zaznano kakovostjo organizacijske komunikacije in ravniyo izgorelosti zaposlenih v javni zdravstveni ustanovi?

4.1 Instrument in spremenljivke

Odgovore na raziskovalna vprašanja smo pridobili s kvantitativnimi metodami, kar pomeni, da smo z anketnim vprašalnikom pridobili primarne podatke, ki smo jih potem obdelali z različnimi statističnimi metodami v programu SPSS.

V splošnem delu vprašalnika smo pridobili demografske podatke o anketirancu, kot so spol, starost, dosežena izobrazba in delovno mesto. Naslednji sklop vprašanj je meril organizacijsko komunikacijo z vidika obveščenosti, spoštljive komunikacije, vključenosti v komunikacijske procese in jasnosti socialnih pričakovanj. Zajemal je 5 trditev, na katere so anketiranci odgovarjali s 5 stopenjsko Likertovo lestvico strinjanja. Zadnji sklop vprašanj je meril stopnjo izgorelosti. Z zadnjim sklopom vprašanj smo merili stopnjo izgorelosti zaposlenih, pri čemer smo pri opredelitvi posameznih faz in pripadajočih spremenljivk sledili priporočilom avtorice Bončina (2019). Izgorelost je bila obravnavana kot proces v treh fazah: izčrpanost, utrujenost ter izgorelost. Tako oblikovan merski pristop je omogočil celovito obravnavo izgorelosti kot postopnega procesa.

4.2 Rezultati

V raziskavo je bilo vključenih 58 žensk (87 %) in 9 moških (13 %), skupaj 67 anketirancev. Največ anketirancev je bilo v starostni skupini od 40 do 49 let (36 %), sledili so zaposleni, stari 50 let in več (27 %). V starostni skupini od 30 do 39 let je bilo 24 % anketirancev, medtem ko je bilo najmanj zaposlenih v starostni skupini od 20 do 29 let (13 %). Prevladujejo anketiranci z višjo, visoko ali univerzitetno

izobrazbo (64 %), sledijo tisti z magisterijem (15 %) in s srednjo šolo (13 %), najmanj jih je z doktoratom znanosti (8 %). V vzorcu ni bilo zaposlenih na poslovnih položajih (0 %). Največ anketirancev je bilo zaposlenih kot medicinske sestre in strokovni delavci (po 25 %), sledijo zdravstveni delavci ali sodelavci (24 %) ter zdravniki (12 %). Manjši delež predstavljajo administrativni delavci (8 %), raziskovalci (3 %), farmacevtski in tehnični delavci (po 1,5 %).

Pri prvem raziskovalnem vprašanju nas je zanimalo ali zaposleni v javni zdravstveni ustanovi zaznavajo organizacijsko komunikacijo kot učinkovito z vidika obveščenosti, spoštljive komunikacije, vključenosti v komunikacijske procese in jasnosti socialnih pričakovanj.

Rezultati (Tabela 1) kažejo, da zaposleni organizacijsko komunikacijo v povprečju zaznavajo kot zmerno učinkovito ($M = 3,59$; $SD = 0,844$). Najvišjo povprečno vrednost dosega trditev »Natančno vem, kako moram delovati, da se vključim v kolektiv« ($M = 4,21$), kar kaže na visoko stopnjo jasnosti socialnih pričakovanj in dobrega razumevanja vključevanja v delovno okolje. Relativno pozitivno je ocenjena tudi obveščenost o delovnih nalogah ($M = 3,70$), kar nakazuje, da zaposleni večinoma prejemajo jasne informacije o tem, kaj se od njih pričakuje. Nižje povprečne vrednosti so zaznane pri trditvah, ki se nanašajo na razpoložljivost informacij za samostojno odločanje ($M = 3,45$) ter upoštevanje mnenj zaposlenih ($M = 3,40$), kar kaže na omejeno zaznavo vključenosti v komunikacijske procese. Najnižje je ocenjena trditev »V organizaciji obstaja spoštljiva komunikacija« ($M = 3,19$), pri čemer višji standardni odklon nakazuje večjo razpršenost zaznav med zaposlenimi.

Tabela 1: Povprečne vrednosti za zaznavanje organizacijske komunikacije

	POVPREČJE	STD.OD
Natančno vem, kako moram delovati, da se vključim v kolektiv.	4,21	0,978
Vedno dobim jasne informacije, kaj se od mene na delovnem mestu	3,70	1,155
Vedno imam dovolj informacij, da se lahko odločim, kako naj ravnam	3,45	1,077
Mnenje, ki ga izrazim, se upošteva.	3,40	1,129
V organizaciji obstaja spoštljiva komunikacija.	3,19	1,246
Organizacijska komunikacija skupaj	3,59	0,844

Kot odgovor na prvo raziskovalno vprašanje lahko zapišemo, da zaposleni organizacijsko komunikacijo zaznavajo kot delno učinkovito, pri čemer so zaznave najbolj pozitivne na področju jasnosti socialnih pričakovanj, medtem ko se več izzivov kaže na področju spoštljive komunikacije in vključevanja zaposlenih v komunikacijske procese.

Pri drugem raziskovalnem vprašanju, ki se nanaša na raven izgorelosti zaposlenih v javni zdravstveni ustanovi, rezultati kažejo, da je skupna raven izgorelosti zmerna ($M = 2,79$; $SD = 1,300$). Med posameznimi dimenzijami je najvišje izražena izčrpanost ($M = 3,25$), kar nakazuje na prisotnost dolgotrajne obremenjenosti zaposlenih. Nižje povprečne vrednosti dosegata utrujenost ($M = 2,54$) in izgorelost ($M = 2,58$), kar kaže, da so izrazitejše oblike izgorelosti pri zaposlenih manj pogoste. Standardni odkloni pri vseh dimenzijah so razmeroma visoki, kar kaže na precejšnjo razpršenost zaznav med zaposlenimi (Tabela 2).

Tabela 2: Povprečne vrednosti za stopnje izgorelosti

	POVPREČJE	STD.ODKL
Izčrpanost	3,25	1,191
Utrujenost	2,54	1,368
Izgorelost	2,58	1,340
SKUPAJ	2,79	1,300

Na podlagi rezultatov lahko ugotovimo, da zaposleni v javni zdravstveni ustanovi poročajo o zmerni ravni izgorelosti, pri čemer je izčrpanost najbolj izrazita dimenzija.

Pri tretjem raziskovalnem vprašanju nas je zanimalo, ali obstaja povezanost med zaznano kakovostjo organizacijske komunikacije in ravnijo izgorelosti zaposlenih v javni zdravstveni ustanovi. Rezultati Pearsonove korelacijske analize kažejo na statistično značilno zmerno negativno povezanost med organizacijsko komunikacijo in izgorelostjo ($r = -0,451$; $p < 0,001$). Negativna vrednost korelacijskega koeficienta pomeni, da je višja zaznana kakovost organizacijske komunikacije povezana z nižjo ravnijo izgorelosti zaposlenih. Povezanost je statistično značilna na ravni 0,01, kar potrjuje, da ugotovljena povezava ni naključna.

Na podlagi rezultatov lahko podamo odgovor na tretje raziskovalno vprašanje in sicer lahko trdimo, da ima zaznana kakovost organizacijske komunikacije pomembno vlogo pri doživljanju izgorelosti zaposlenih v javni zdravstveni ustanovi, pri čemer boljša komunikacija sovpada z nižjo ravniyo izgorelosti.

5 Diskusija in zaključek

Namen raziskave je bil preučiti zaznave zaposlenih o organizacijski komunikaciji, raven izgorelosti ter povezanost med organizacijsko komunikacijo in izgorelostjo v javni zdravstveni ustanovi. Rezultati raziskave kažejo, da zaposleni organizacijsko komunikacijo zaznavajo kot zmerno učinkovito. Najbolj pozitivno je ocenjena jasnost socialnih pričakovanj, kar pomeni, da zaposleni večinoma razumejo, kako delovati in se vključevati v delovni kolektiv. Podobno ugotavljajo tudi predhodne raziskave, ki poudarjajo pomen jasnih informacij, vlog in pričakovanj za pozitivno organizacijsko klimo ter učinkovito delovanje organizacij (Curilla et al., 2023). Manj ugodne zaznave so prisotne na področju spoštljive komunikacije in vključenosti zaposlenih v komunikacijske procese, kar nakazuje na izzive v kakovosti notranje komunikacije.

Pri preučevanju ravni izgorelosti je bila ugotovljena zmerna raven izgorelosti zaposlenih, pri čemer je najbolj izrazita izčrpanost. Takšne ugotovitve so skladne z raziskavami v zdravstvenem sektorju, ki izčrpanost prepoznavajo kot zgodnjo in pogosto prisotno fazo izgorelosti pri zdravstvenih delavcih (Dall'Ora et al., 2020). Raziskave poudarjajo, da dolgotrajna izpostavljenost delovnim obremenitvam brez ustreznih podpornih mehanizmov povečuje tveganje za nadaljnji razvoj izgorelosti (Maslach et al., 2001).

Najpomembnejša ugotovitev raziskave je statistično značilna zmerna negativna povezanost med zaznano kakovostjo organizacijske komunikacije in ravniyo izgorelosti. Rezultati potrjujejo, da zaposleni, ki zaznavajo boljšo komunikacijo v organizaciji, poročajo o nižji ravni izgorelosti. Takšna povezanost je skladna s predhodnimi raziskavami, ki poudarjajo, da organizacijski dejavniki, kot so jasna komunikacija, zaznana podpora in vključevanje zaposlenih, pomembno prispevajo k zmanjševanju psihosocialnih obremenitev in izgorelosti (West et al., 2018; Salvagioni et al., 2017).

Rezultati raziskave imajo pomembne praktične implikacije za javne zdravstvene ustanove. Izboljšanje jasnosti informacij, spodbujanje spoštljive in vključujoče komunikacije ter večja odzivnost na mnenja zaposlenih lahko prispevajo k boljši organizacijski klimi in nižji ravni izgorelosti zaposlenih, kar potrjujejo tudi empirične študije v zdravstvenem okolju (Dall’Ora et al., 2020). Kljub temu je treba rezultate interpretirati ob upoštevanju omejitev raziskave, predvsem velikosti vzorca in osredotočenosti na eno ustanovo.

Raziskava predstavlja pomembno izhodišče za nadaljnje raziskovanje povezav med organizacijsko komunikacijo in izgorelostjo v zdravstvenem sektorju ter poudarja pomen sistematičnega vlaganja v razvoj kakovostnih komunikacijskih praks kot dela strategij za ohranjanje dobrega počutja zaposlenih.

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VPLIV RABE UMETNE INTELIGENCE V PROIZVODNEM OKOLJU NA EKOLOŠKE SLEDI

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Tehnologija umetne inteligence (UI) postaja orodje za izboljšanje energetske učinkovitosti in zmanjševanje ekološkega odtisa (EF). V raziskavi analiziramo vpliv uporabe UI v opazovanem sistemu na spremembe EF. Rezultati kažejo, da razvoj in implementacija UI prispevata k zmanjšanju EF predvsem zaradi učinkovitejše rabe energije. Ko energetska učinkovitost sistema preseže določen prag, lahko nadaljnja uporaba UI dodatno zmanjšuje okoljske obremenitve. Avtomatizacija in robotizacija industrijskih procesov povečujeta učinkovitost rabe virov, zmanjšujeta emisije ter posledično znižujeta EF, hkrati pa izboljšujeta kakovost industrijskega in delovnega okolja. Čeprav gospodarska rast praviloma povečuje okoljske pritiske, lahko širša uporaba UI pomembno prispeva k njihovem zmanjševanju. V Sloveniji raba UI narašča, vendar se pojavljajo izzivi, kot so nezadostno financiranje temeljnih raziskav, potreba po ustrezni regulaciji ter večjih vlaganjih v človeški kapital in prilagoditev izobraževalnega sistema. Raziskava vključuje tudi primerjalno analizo Slovenije z državami Evropske unije ter poudarja pomen premišljenega oblikovanja razvojnih strategij in okoljskih politik za podporo trajnostnemu razvoju.

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THE IMPACT OF THE USE ARTIFICIAL INTELLIGENCE IN THE PRODUCTION ENVIRONMENT ON THE ECOLOGICAL FOOTPRINT

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Artificial intelligence (AI) is increasingly recognized as an important tool for improving energy efficiency and reducing the ecological footprint (EF). This study analyzes the impact of AI implementation within the observed system on changes in EF. Results indicate that the development and application of AI can reduce EF primarily through more efficient energy use. Once system energy efficiency exceeds a certain threshold, further AI use can additionally decrease environmental pressures. Automation and robotization of industrial processes improve resource efficiency, reduce emissions, and lower the ecological footprint, while also enhancing industrial and workplace environments. Although economic growth often increases environmental pressures, wider AI adoption can help mitigate these impacts. In Slovenia, AI use is growing, but challenges remain, including limited funding for fundamental research, the need for appropriate regulation and greater investment in human capital and education. The study also compares Slovenia with EU countries and highlights the importance of policies.



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1 Uvod

Naraščajoči negativni vplivi na okolje ovirajo doseganje ciljev trajnostnega razvoja (SDG). V obdobju razvoja umetne inteligence (UI) tehnološke spremembe spodbujajo industrijske preobrazbe in vplivajo na spremembe v sistemu globalnega upravljanja. Razvoj digitalnih tehnologij UI ponuja nove priložnosti za trajnosten razvoj (Francisco, 2023) in omogoča učinkovitejši pristop za doseganje ciljev trajnostnega razvoja.

Hiter razvoj in uporaba UI prinašata tudi vrsto etičnih, socialnih in okoljskih vprašanj. Na okoljskem področju razvoj in uporaba tehnologije UI zahtevata rabo energije in virov, kar lahko poslabša vplive na okolje (Coeckelbergh, 2021). Glede na poročilo, ki ga je objavila Mednarodna agencija za energijo (IEA, 2024) bi se lahko svetovna poraba električne energije v podatkovnih centrih, industriji UI in kriptovalutah podvojila, kar bi v naslednjih treh letih preseglo svetovno letno stopnjo rasti povpraševanja po električni energiji v višini 3,4 %. Podatkovni centri pomembno prispevajo (to lahko povzroča ekološki primanjkljaj na lokalnem nivoju) k povečanju rabe električne energije, njihova skupna poraba energije pa bi lahko do leta 2026 presegla 1000 TWh (IEA, 2024). Postopek odločanja o tehnologijah UI ni pregleden (Wang, 2024), kar lahko vodi do podcenjevanja okoljskih tveganj.

Metoda merjenja trajnostnega razvoja z ekološkimi sledmi (EF), upošteva vplive ekonomskih, političnih, socialnih in delno tudi tehnoloških dejavnikov (Nketiah, 2024).

Večja produktivnost običajno izboljša učinkovitost izrabe virov, trend izboljšanja zaostaja za gospodarsko rastjo. Uporaba tehnologij UI lahko zaradi optimizacija proizvodnje in optimizacija rabe virov učinkovito zmanjša pritiske na okolje (Liu, 2024). Z uporabo digitalnih tehnologij (Big data, UI, blockchain) je mogoče podatke o trajnostnem razvoju učinkovito integrirati in analizirati, kar omogoča spremljanje in napovedovanje okoljskih sprememb v realnem času, s čimer se izboljša tudi možnost odločanja (Bibri, 2024).

Pri opredelitvi rabe umetne inteligence smo upoštevali podjetja z desetimi ali več zaposlenimi, pri čemer smo se zaradi obsežnega nabora možnih kazalcev omejili na izbrane (dostopne) kazalce uporabe UI.



Slika 1: Vloga digitalizacije pri obravnavanju trajnosti z različnih vidikov (Mondejar, 2021);

- povezava med hrano, vodo in energijo, blaginjo proizvodnega sektorja in državljanov ter, podnebnimi spremembami in varstvom biotske raznovrstnosti.

Upoštevajo se tudi celostni, trajnostni učinki, ki izhajajo iz povezanih koristi vseh teh ukrepov

Namen prispevka je empirično analizirati vpliv rabe umetne inteligence (UI) na velikost ekoloških sledi v Sloveniji. Prispevek presega deskriptivni prikaz stanja ter primerjalne analize z drugimi državami članicami EU, saj se osredotoča na kvantitativno preučevanje vzročno-posledičnih povezav med rabo UI, gospodarsko rastjo, energetske učinkovitostjo in obsegom ekoloških sledi Slovenije. Posebna pozornost je namenjena identifikaciji morebitnih asimetričnih učinkov navedenih dejavnikov na okoljsko obremenitev.

Izvirni znanstveni doprinos prispevka je večplasten, kot nam je znano, gre za prvo empirično raziskavo v slovenskem prostoru, ki sistematično preučuje povezavo med rabo umetne inteligence in ekološkimi sledmi na makroekonomski ravni. Raziskava metodološko nadgrajuje obstoječe študije z vključitvijo asimetričnega analitičnega pristopa, ki omogoča diferenciacijo med pozitivnimi in negativnimi spremembami obravnavanih dejavnikov ter njihovimi potencialno različno intenzivnimi vplivi na okoljsko trajnost. Uporaba koncepta ekoloških sledi kot celostnega in integriranega kazalnika omogoča širšo in bolj uravnoteženo presojo vplivov digitalne transformacije na trajnostni razvoj, v nasprotju s parcialnimi pristopi, ki se osredotočajo zgolj na posamezne emisijske ali energetske kazalnike. Prispevek tako zapolnjuje identificirano raziskovalno vrzel na presečišču digitalizacije in okoljske trajnosti ter zagotavlja empirično podprte ugotovitve, ki imajo pomembne implikacije za oblikovanje razvojnih, tehnoloških in okoljskih politik v Sloveniji.

2 Metodološka izhodišča

2.1 Ekološke sledi kot kazalec trajnostnega razvoja

EF opazovanega sistema predstavlja skupno površino bioproduktivnih površin in vodnih virov, potrebnih za zadovoljevanje njihovih potreb po porabi virov in absorpcijo nastalih odpadkov. Cilj metode EF je oceniti trajnost preučevanega opazovanega sistema s pretvorbo energijskih virov in snovnih tokov, glede na porabo, v šest glavnih kategorij ekološko produktivnih zemljišč: pozidane površine, energijske površine, kmetijske površine, vodne površine, gozda in jih primerjati z razpoložljivo bioproduktivno površino opazovanega sistema (Tabela 1, 2, Slika 2). Metoda EF se uporablja v raziskavah trajnostnega razvoja kot kazalnik trajnostnega razvoja opazovanega sistema.

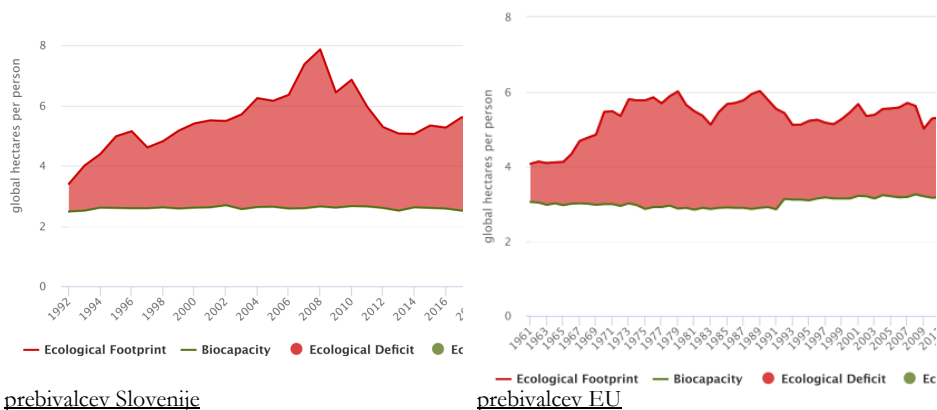
Tabela 1: Ekološke sledi in biokapaciteta prebivalcev Evrope (GFN, 2025, lasten)

leto	površine	pozidane	energijske	kmetijske	vodne	gozda	pašnikov	skupaj
		gha/preb						
2021	Biocap/preb	0,14	0	0,86	0,42	1,57	0,2	3,19
2021	EF/preb	0,14	2,75	0,9	0,19	0,62	0,2	4,8
2023	Biocap/preb	0,13	0	0,85	0,42	1,56	0,2	3,16
2023	EF/preb	0,13	2,64	0,92	0,18	0,62	0,2	4,69
2024	Biocap/preb	0,13	0	0,85	0,42	1,56	0,2	3,16
2024	EF/preb	0,13	2,64	0,92	0,18	0,62	0,2	4,69

Tabela 2: Ekološke sledi in biokapaciteta prebivalcev Slovenije (Global Footprint Network, 2025, lasten)

leto	površine	pozidane	energijske	kmetijske	vodne	gozda	pašnikov	skupaj
		gha/preb						
2021	Biocap/preb	0,08	0	0,40	0,01	1,85	0,16	2,5
2021	EF/preb	0,08	2,51	1,45	0,20	0,61	0,20	5,05
2023	Biocap/preb	0,07	0	0,39	0,01	1,81	0,16	2,44
2023	EF/preb	0,08	2,61	1,49	0,20	0,68	0,20	5,26
2024	Biocap/preb	0,07	0	0,39	0,01	1,81	0,16	2,44
2024	EF/preb	0,08	2,60	1,49	0,20	0,68	0,20	5,25

Ekološke sledi porabe vode določimo na osnovi porabljene energije za črpanje in oskrbo. Za potrebno površino za ohranjanje biotske raznolikosti se v literaturi najpogosteje uporablja vrednost 12% (Chambers, 2014). Ta površina zmanjšuje površino prostora, ki jo za svoje potrebe lahko izkoriščajo ljudje.



Slika 1:Ekološke sledi in biokapaciteta prebivalcev Evrope in Slovenije (Global Footprint Network)

Ekološke sledi populacije v opazovanem sistemu so lahko večje ali manjše od bioproduktivne površine tega sistema (ekološki primanjkljaj ali presežek). Glede na to ali primerjamo ekološke sledi sistema z lastno bioproduktivno površino ali pa z bioproduktivno površino celotnega planeta, lahko opredelimo lokalno ali globalno uravnoteženost ekoloških sledi (Slika 2, Tabela 1 in 2).

2.2 Raba UI v slovenskem gospodarstvu

UI lahko podjetja vključujejo v delovne procese na različne načine: pri prepoznavanju slik, generiranju naravnega jezika, prepoznavanju govora, besedilnem rudarjenju in pri avtomatizaciji procesov. Še vedno 77 % podjetij v vseh gospodarskih dejavnostih skupaj ne uporablja UI. Trenutno stanje v Sloveniji kaže naraščajoč trend uporabe UI, pri čemer je največje povečanje pri tehnologijah za generiranje naravnega jezika. Slovenija sooča z izzivi, kot je premajhno financiranje temeljnih raziskav in potreba po regulaciji UI, zato je za nadaljnji razvoj ključnega pomena vlaganje v raziskave, izobraževanje in sodelovanje med deležniki (Bandur, 2025).

Pri analizi kazalcev UI je uporabljena opisna in komparativna metoda, analizo kazalcev UI na ravni gospodarskih dejavnosti smo opravili za zadnje razpoložljiva časovna obdobja. V analizi smo upoštevali podjetja z desetimi ali več zaposlenimi, pri čemer smo se zaradi obsežnega nabora možnih kazalcev omejili na izbrane (dostopne) kazalce uporabe UI. Omejitve se nanašajo na leta 2021, 2023 in 2024, saj ni na voljo

dovolj podatkov za analizo časovnih serij. Proučevali smo kazalce za Slovenijo in povprečje EU. Podatke smo analizirali po kvalifikaciji Nace Rev. 2 (*delitev gospodarskih dejavnosti po Nace Rev. 2. je (Braunsberger, 2010): C – predelovalna dejavnost, E – oskrba z vodo; ravnanje z odpadki in odpadki; saniranje okolja, F – gradbeništvo, G – trgovina; vzdrževanje in popravila motornih vozil, H – promet in skladiščenje, I – gostinstvo, J – informacijske in komunikacijske dejavnosti, M – strokovne, znanstvene in tehnične dejavnosti, N – druge raznovrstne poslovne dejavnosti*) na ravni gospodarskih dejavnosti. Podatke za primerjavo kazalcev UI po gospodarskih dejavnostih smo pridobili v podatkovni bazi Eurostat (Eurostat, 2025), predstavljamo jih v Tabeli 3.

UI je pomemben del širšega procesa digitalizacije in koncepta Industrija 4.0, ki predstavljata gonilni sili gospodarske rasti in konkurenčnosti ter s tem doseganje ciljev trajnostnega razvoja. Uporaba UI prinaša prednosti, obstajajo tudi izzivi, kot so tehnološka infrastruktura, usposobljenost kadra in varnost podatkov.

V Tabeli 3 prikazujemo primerjavo podatkov uporabe tehnologij UI v Sloveniji in EU in kako se razlikujejo deleži podjetij, ki te tehnologije UI uporabljajo. Slovenija ima večje deleže od EU pri treh kazalcih in sicer pri uporabi avtonomnih robotov, samovozečih vozil in avtonomnih dronov ter pri prepoznavanju slik, obdelavi slik in generiranju naravnega jezika. Največjo razliko lahko opazimo pri uporabi tehnologije UI za prepoznavanje in obdelavo slik, pri kateri ima Slovenija za 8,8 odstotne točke večji delež podjetij, ki implementirajo to tehnologijo UI. Slovenija najbolj zaostaja za EU pri uporabi tehnologij UI za besedilno rudarjenje, in sicer za 2,3 odstotne točke od povprečja EU. V Sloveniji največ podjetij uporablja UI za prepoznavanje in obdelavo slik.

Analiza kazalcev UI v Sloveniji za leto 2023 in 2024 kaže na naraščajoč trend uporabe večine tehnologij UI, še posebej tehnologije za generiranje naravnega jezika. Gospodarska dejavnost J (informacijske in komunikacijske dejavnosti) izstopa po največjem deležu podjetij, ki uporabljajo različne tehnologije UI, kot so prepoznavanje govora, programska robotska avtomatizacija procesov, uporaba računalništva v oblaku in analitika podatkov ter strojno učenje (Bandur, 2025).

Z razvojem UI se odpirajo delovna mesta, povezana z njenim razvojem, implementacijo in vzdrževanjem, kar zahteva nova znanja, to je pozitiven vpliv na socialno okolje trajnostnega razvoja. UI ne vpliva le na manj zahtevna dela, ampak lahko znatno vpliva tudi na bolj plačana in visoko izobražena delovna mesta, saj je učinkovita pri analizi podatkov in reševanju kompleksnih problemov.

Tabela 3: Podatke za primerjavo kazalcev UI po gospodarskih dejavnostih, za podjetja z več kot 10 zaposlenimi

	Podjetja, ki uporabljajo tehnologije UI za analizo pisanega jezika (rudarjenje besedil)			Podjetja, ki uporabljajo tehnologije UI ki ustvarjajo pisni ali govorni jezik ali programske kode (generiranje naravnega jezika, sinteza govora)			Podjetja, ki uporabljajo strojno učenje (npr. globoko učenje) za analizo podatkov			Podjetja, ki uporabljajo tehnologije UI, identificirajo predmete ali osebe na podlagi slik (prepoznavanje slik, obdelava slik)		
leto 20xx	21	23	24	21	23	24	21	23	24	21	23	24
EU - 27	2,5	2,9	6,9	1,3	2,1	5,4	2,4	2,6	4,2	2,1	2,8	3,2
Belgija	4,5	6,1	15,1	2,1	4,0	12,7	4,4	4,8	8,1	3,5	4,5	6,2
Bolgarija	1,3	1,3	3,9	0,4	1,2	2,1	0,9	0,9	2,1	0,9	0,8	1,8
Češka	1,7	3,1	6,7	0,8	0,7	5,9	1,4	2,3	4,5	1,6	1,7	2,0
Danska	8,2	6,0	16,7	5,2	5,0	18,5	8,8	7,1	10,7	4,0	3,6	5,5
Nemčija	2,9	3,5	9,6	1,6	3,0	6,6	2,9	3,0	5,3	2,7	2,7	4,7
Estonija	0,9	2,0	7,8	0,6	1,2	5,8	1,1	1,6	3,5	1,2	1,5	4,2
Irska	2,7	2,7	6,4	1,1	2,2	7,3	3,5	3,0	5,5	2,0	1,4	3,1
Grčija	0,4	1,2	3,7	0,1	0,8	3,2	1,7	1,0	4,0	0,4	1,1	1,7
Šonija	2,3	3,1	5,1	1,5	2,3	4,3	2,3	3,0	3,9	3,1	3,3	3,5
Francija	2,1	2,3	4,4	1,1	1,1	3,2	2,4	2,7	4,0	1,1	1,5	2,2
Hrvaška	3,3	3,9	7,7	2,1	2,5	4,0	2,5	2,2	4,1	2,2	1,5	2,7
Italija	2,3	2,0	4,5	1,1	1,5	3,7	1,5	1,5	2,6	1,8	1,5	2,1
Ciper	0,8	1,2	3,2	0,5	1,2	3,1	1,4	2,1	5,3	1,0	1,9	1,53
Latvija	1,8	2,3	5,8	0,8	0,7	2,2	1,1	1,1	2,0	1,7	1,4	2,70
Litva	1,6	2,3	6,3	0,9	1,3	3,6	1,2	1,3	2,8	1,5	1,4	2,6
Luksemburg	8,5	9,4	17,6	2,6	3,5	8,7	3,5	3,9	6,3	2,9	3,2	4,6
Madžarska	1,0	1,2	3,3	0,4	1,0	2,7	0,7	1,0	1,8	1,0	1,1	2,3
Malta	3,1	4,5	6,6	2,1	3,4	3,7	4,5	4,7	6,5	4,1	4,6	5,8
Nizozemska	3,9	5,5	14,1	2,6	4,3	12,6	6,1	5,8	6,5	3,8	3,8	4,6
Avstrija	5,0	5,9	13,1	1,0	2,5	8,2	3,7	4,6	7,0	2,1	2,5	3,4
Poljska	0,8	0,5	1,49	0,3	0,9	2,4	0,7	1,0	1,6	0,7	0,9	1,7
Portugalska	2,5	2,8	4,2	1,0	1,4	3,1	2,0	2,1	2,9	2,4	3,5	3,1
Romunija	0,9	1,1	1,86	0,3	0,8	1,5	0,5	0,6	1,3	0,5	0,5	0,9
Slovenija	0,8	0,9	4,5	3,5	4,8	11,6	3,2	2,9	4,2	7,6	6,4	12,0
Slovaška	2,2	3,9	6,0	0,7	1,6	3,9	0,9	1,9	2,1	1,8	2,1	2,5
Finska	5,3	6,55	15,4	2,5	4,3	13,0	6,1	6,5	9,7	4,3	3,4	5,5
Švedska	3,49	4,4	15,6	2,3	3,8	12,0	4,4	4,0	8,1	2,1	2,5	5,1

Vir Eurostat, 2025, Data extracted on 18/12/2025 16:54:23 from [ESTAT] , Dataset: Artificial intelligence by size class of enterprise [isoc_eb_ai_custom_15887300], Last updated: 11/12/2025 11:00, Size classes in number of persons employed: 10 persons employed or more, Statistical classification of economic activities in the European Community (NACE Rev. 2)

UI lahko prispeva k trajnostni proizvodnji z optimizacijo dobavnih verig in transporta ter natančnejšim napovedovanjem potreb. Napovedi kažejo na široko implementacijo UI v prihodnosti z ocenami, da bo do leta 2030 okoli 70 % podjetij uporabljalo UI, kar bi

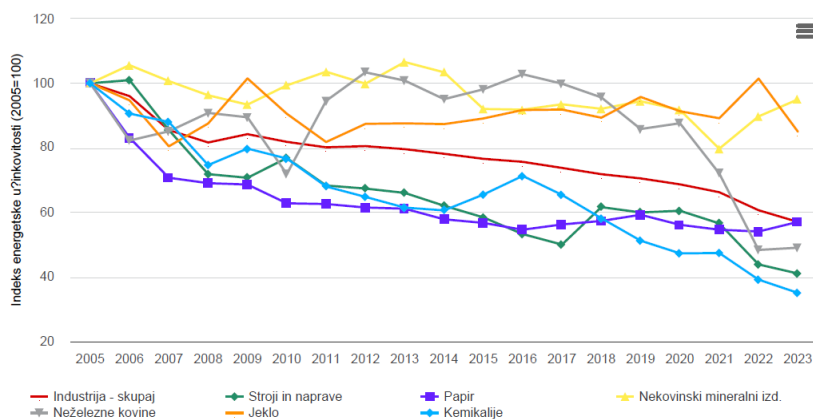
lahko svetovni BDP povečalo za 26 % (Knez, 2025). Za učinkovito izkoriščanje teh priložnosti je potrebno investirati v človeški kapital (socialno okolje), prilagoditi izobraževalne sisteme, obvladovati morebitne negativne vplive na trg dela ter zmanjšati neenakosti pri dostopu do tehnologije in njenih prednosti.

2.3 Energetska učinkovitost

Energetska učinkovitost je pomemben dejavnik trajnostnega razvoja, saj neposredno vpliva na učinkovitost rabe virov (Khan, 2022). To kaže, da uporaba UI prispeva k zmanjšanju EF.

Energetska učinkovitost v slovenski industriji se je v obdobju 2005–2023 opazno izboljšala, saj je bila leta 2023 za 43 % višja kot leta 2005. Največ so k izboljšanju prispevale panoge kemična industrija, proizvodnja strojev in naprav, neželezne kovine, proizvodnja papirja, najmanj pa jekla in nekovinskih mineralnih izdelkov. Energetska učinkovitost v industriji se mora povečevati, kar pomeni, da se mora indeks energetske učinkovitosti zmanjševati (Slika 3). Kvantitativni cilj za ta kazalnik ni bil določen. Kazalnik energetska učinkovitost v industriji prikazuje gibanje indeksa učinkovitosti rabe energije v industriji, ki je izračunan na podlagi analize intenzivnosti rabe energije po panogah izračunane kot kvocient rabe energije in gibanja indeksa proizvodnje ter strukture rabe energije v industriji. Uporabljena je bila metodologija razvita v sklopu EU (Kazalci okolja v Sloveniji, 2025).

V industriji se v Sloveniji največ energije porabi pri proizvodnji kovin. Leta 2023 je njen delež v celotni rabi energije v industriji znašal 18 %. Dodatno lahko ta sektor razdelimo na proizvodnjo jekla, na katero je odpadlo slabi dve tretjini rabe sektorja in proizvodnjo neželeznih kovin. Raba energije v tej panogi se je v letih 2022 in 2023 znatno znižala, kot posledica opustitve proizvodnje primarnega aluminija. Po rabi energije je leta 2023 sledila proizvodnja nekovinskih mineralnih izdelkov (cement, apno) s 17 %. Proizvodnja strojev in naprav je predstavljala 14 %, kemična industrija 13 %, papirna industrija pa 11 % rabe energije. Naštete panoge so leta 2023 skupaj predstavljale slabe tri četrtine rabe energije v industriji. Ostale panoge so živilska industrija, tekstilna industrija, proizvodnja prevoznih sredstev, lesna industrija, ostala industrija, pridobivanje rud in kamnin ter gradbeništvo.



Slika 3: Gibanje indeksa energetske učinkovitosti za celotno industrijo ter panoge, ki porabijo največ energije

Vir: Kazalci okolja v Sloveniji, 2025

Učinkovitost rabe energije v industriji se je v obdobju 2005–2023 izboljšala, kar pomeni, da se je raba energije na enoto industrijske proizvodnje zmanjšala. Od leta 2009 do leta 2023 se zaradi počasnega gospodarskega okrevanja in s tem naraščanja industrijske proizvodnje, strukturnih sprememb ter izboljšanja učinkovitosti procesov, učinkovitost povečuje. Leta 2023 se je nadaljevalo počasno izboljšanje energetske učinkovitosti. Leta 2023 je bila energetska učinkovitost rabe energije v industriji glede na leto 2005 višja za 43 % (Kazalci okolja v Sloveniji, 2025).

3 Empirični rezultati medsebojnih povezav med rabo umetne inteligence, energetske učinkovitostjo in ekološkimi sledmi

Ugotovimo, da raba UI in energetska učinkovitost prispeva k zmanjšanju EF. Na primeru opazovanega sistema Slovenije je to zmanjšanje manjše od pričakovanega (Tabela 4).

Predhodne raziskave objavljene v literaturi predstavljajo večji vpliv UI (Liu, 2024). Raba UI zaradi optimizacije proizvodnih procesov, uporabe pametnih tehnologij za upravljanje z električno energijo in spremljanje okolja poveča učinkovitost proizvodnje, s čimer zmanjša količino odpadkov in porabo energije (Huang, 2022), kar ima za posledico zmanjšanje EF. Pričakujemo pomembno vlogo rabe UI na zmanjšanje EF.

Tabela 4: Primerjava energetske učinkovitosti, rabe UI in EF v Sloveniji

leto	energijska učinkovitost	UI	EF
		Podjetja, ki uporabljajo tehnologije UI, ki ustvarjajo pisni ali govorni jezik ali programske kode	
2005	1	/	6,16 gha/preb
2023	0,57	4,83 %	5,26 gha/preb
2024	pričakovano izboljšanje	11,61 %	5,26 gha/preb

Vir: Lasten

Napredek tehnologij UI odpira nove možnosti za doseganje ciljev trajnostnega razvoja. Večji vpliv v rabe UI v začetni fazi pričakujemo pri večji energetske učinkovitosti, pričakovano pa se bodo v časovnem obdobju ko energetska učinkovitost doseže določen prag zmanjšale tudi EF. Ugotovitve razkrivajo regionalne razlike v tem kako razvoj UI vpliva na EF.

4 Zaključek in razprava

Glede na rezultate raziskave so predlagana naslednja priporočila za povečanje pozitivnega vpliva UI na doseganje ciljev trajnostnega razvoja:

- Rabo UI usmeriti v spremljanje parametrov pritiskov na okolje, upravljanju virov ter zmanjševanju porabe energije in zmanjšanju emisij. Raba UI lahko analizira velike količine podatkov in z uporabo simulacij lahko spodbudi razvoj zaznavanja pritiskov na okolje (zgodnje opozarjanje, zmanjševanje odpadkov, raba virov) v realnem času.
- V začetnem obdobju se je potrebno osredotočiti na izboljšanje energetske učinkovitosti in spodbujati zeleni prehod.
- Načrtno izvajati strategijo usposabljanja kadrov v industriji UI ter vzpostaviti mehanizme sodelovanja s tehnološkimi podjetji.

Še vedno obstajajo omejitve, ki so posledica kratkega časovnega intervala (raba UI) baza podatkov se izboljšuje, zato bi prihodnje raziskave lahko uporabile podatke z daljšim časovnim razponom in bi bili trendi bolj poudarjeni ob uporabi dinamičnih modelov

Teorija okoljske Kuznetsove krivulje trdi, da obstaja obrnjena povezava med gospodarsko rastjo in poslabšanjem okolja (Grossman, 1995), kar pomeni, da najprej povečana gospodarska rast vodi do povečanja EF, s pomočjo rabe UI lahko te učinke obvladujemo. Integracija industrijskih robotov (IR) v proizvodne procese poveča učinkovitost (Yu, 2023), zmanjša porabo energije in emisije CO₂. Potrebno je upoštevati povratni učinek, pričakovati je, da večja učinkovitost rabe virov vodi do splošnega povečanja porabe virov.

Ta koncept je ključnega pomena za razumevanje nenamernih ekoloških vplivov uvajanja IR v razviti industrijskih državah z UI. Povratni učinek nakazuje, da lahko raba IR poveča učinkovitost in zmanjša neposredne EF, vendar se lahko splošno povpraševanje in poraba povečata, s čimer se lahko povečajo skupne EF. V obdobju gospodarske rasti so podjetja bolj naklonjena k vlaganju v posodabljanje industrijske proizvodnje, vključno z IR. To pa lahko povzroči negativno korelacijo z rastjo EF. Opazovana industrijska okolja morajo celostno zasledovati doseganje SDG, kar združuje tehnološki napredek, gospodarsko rast in okoljsko trajnost za doseganje dolgoročne blaginje celotne družbe.

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Sinergija med človekom in umetno inteligenco

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Sinergija med človekom in umetno inteligenco (UI) predstavlja novo obliko sodelovanja, v kateri se človeška ustvarjalnost, kontekstualno razmišljanje in etična presoja združijo z računalniško hitrostjo, analitično močjo in sposobnostjo obdelave velikih količin podatkov. Takšno partnerstvo ne temelji na nadomeščanju človeka, temveč na dopolnjevanju njegovih zmožnosti. Človek prispeva razumevanje vrednot, domišljijo ter družbeni kontekst, medtem ko UI omogoča avtomatizacijo, generiranje idej, analizo vzorcev in podporo pri reševanju kompleksnih problemov. Učinkovita sinergija zahteva jasno razumevanje omejitev in prednosti obeh strani ter odgovorno, etično uporabo tehnologije. To vključuje preverjanje podatkov, transparentnost odločitev in stalno človeško presojo. Ključna elementa sodelovanja sta sposobnost oblikovanja kakovostnih navodil (promptov) ter iterativni proces, v katerem se človek in UI izmenično dopolnjujeta: človek postavlja cilje, UI predlaga možnosti, človek izbere in izboljša, UI pa optimizira rešitev. Takšno sodelovanje omogoča večjo produktivnost, hitrejšo učenje, boljše reševanje problemov in več

prostora za človeško ustvarjalnost. Sinergija med človekom in umetno inteligenco zato ni le tehnološki trend, temveč temeljna spretnost prihodnosti, ki od posameznika zahteva digitalno pismenost, kritično mišljenje in odgovorno delovanje.

Ključne besede: človek, umetna inteligenca, medsebojno sodelovanje, sinergija, etična presoja

Synergy Between Humans and Artificial Intelligence

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The synergy between humans and artificial intelligence (AI) represents a new form of collaboration in which human creativity, contextual thinking, and ethical judgement are combined with computer speed, analytical power, and the ability to process large amounts of data. Such a partnership is not based on replacing humans, but on complementing their capabilities. Humans contribute an understanding values, imagination and social context, while AI enables automation, idea generation, pattern analysis, and support in solving complex problems. Effective synergy requires a clear understanding of the limitations and advantages of both sides, as well as the responsible, ethical use of technology. This includes data verification, transparency of decisions, and constant human judgement. The key elements of collaboration are the ability to design quality prompts and an iterative process in which the human and the AI complement each other alternately: the human sets goals, the AI suggests options, the human selects and improves, and the AI

optimizes the solution. Such collaboration enables higher productivity, faster learning, better problem-solving, and more room for human creativity. The synergy between humans and AI is therefore not just a technological trend, but a fundamental skill of the future that requires digital literacy, critical thinking, and responsible action from the individual.

Keywords: human being, artificial intelligence, mutual collaboration, synergy, ethical judgment

Soft Lean Practices and Industry 4.0: Trends and Insights From a Systematic Literature Review

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Many organizations aim for continuous improvement and enhanced performance, yet achieving these goals is rarely straightforward. Lean (also known as lean management, production, methodology, thinking, or philosophy) is widely acknowledged to be one of the most effective approaches for improvement of organizational competitiveness and performance. Even so, numerous lean initiatives fail or are not sustained over time. A common reason is that organizations tend to treat the soft (human, social, and organizational) practices of lean separately from the hard (technical) elements. At the same time, organizations are improving their processes with technologies associated with the Industry 4.0 (I4.0) paradigm. These

technologies are advanced tools that can reinforce existing lean efforts. Although integrating lean principles with I4.0 technologies has clear potential, recent findings indicate that the success of digital transformation is strongly tied to the adoption of human-centered strategies. This perspective is consistent with the European Commission's research priorities, which emphasize people-oriented technological development and exploration of how such approaches can be included in modern manufacturing environments. Therefore, emphasizing soft practices is necessary for realizing the full potential of I4.0 and moving further toward the human-centered goals set by Industry 5.0. Nevertheless, there is a lack of understanding of how soft lean practices, including employee engagement and involvement, HRM practices, leadership, and organizational culture, enable or constrain lean and I4.0 integration. This systematic literature review offers a synthesis of the emerging body of research on lean and I4.0, with particular focus on the role of soft lean practices for I4.0 and lean successful integration. Accordingly, the identified starting point for successful integration is active employee engagement in problem-solving and decision-making to create a sense of ownership. On the other hand, barriers for lean and I4.0 integration are primarily the gaps in skills, the resistance to change, and fears of technological replacement. In this context, the emphasis should be on collaborative approaches and active employee participation in teamwork for the assurance of sustainable lean and I4.0 integration. HRM and employee involvement practices, such as learning initiatives, training, and job rotation, are also of high relevance, since comprehensive learning, upskilling, and empowerment initiatives that foster psychological safety are fundamental for employee engagement. Similarly, effective leadership that integrates operational management with continuous improvement and coaching is of importance to align lean and I4.0 initiatives, develop communication and collaboration, and make sure that employees' efforts are oriented by a shared strategic vision and evidence-based decision-making. Moreover, a people-centered, continuous improvement-oriented culture supports the integration of lean-I4.0 as an enabler of adaptability, collaboration, and innovation throughout the organization. This paper fills the existing gap by identifying, through a systematic literature review, the soft lean practices that are most relevant to the successful integration of lean and I4.0. The research contributes to the socio-technical system theory by highlighting that the soft lean practices foster the integration between lean and I4.0 and that, for sustainable performance, there has to be an alignment of the social and technical subsystems. Therefore, the study demonstrates that the integration of lean and I4.0 is not purely a technical but rather

a socio-technical process. Furthermore, these identified soft lean practices are interconnected and can be thought of as a system of people-centered enablers working harmoniously to facilitate effective lean and I4.0 integration. For organizations seeking sustainable digital transformation, their road toward long-term operational excellence calls for strengthening these practices.

Keywords: lean, soft practices, fourth industrial revolution, Industry 4.0, Lean 4.0

JEL classification

L20, M10, M21

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45TH INTERNATIONAL CONFERENCE ON ORGANIZATIONAL SCIENCE DEVELOPMENT: ORGANIZATION AND THE LONGEVITY SOCIETY

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Changes in the demographic structure of the population, social and economic development, and changes in society in general lead to changed circumstances for individuals and society, including in organizational sciences. In all organisations, monitoring the internal and external environment to track opportunities and threats is a necessity and practically part of everyday life. Adjustments in organisations dictated by changes in the age structure of society require a comprehensive approach to the challenges in many aspects of organisational functioning. The 45th International Scientific Conference on the Development of Organizational Sciences in the Context of a Long-Lived Society aims to raise awareness among organizations and individuals that awareness and information about new developments are a necessity for all of us. People and organizations will always be intertwined, so changes should be aimed at addressing challenges and creating social good.

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45. MEDNARODNA KONFERENCA O RAZVOJU ORGANIZACIJSKIH ZNANOSTI: ORGANIZACIJA IN DOLGOŽIVA DRUŽBA

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Spremembe v demografski strukturi prebivalstva, družbeni in gospodarski razvoj ter spremembe v družbi nasploh vodijo v spremenjene okoliščine delovanja posameznika in družbe tudi v organizacijskih vedah. V vseh organizacijah je spremljanje notranjega in zunanjega okolja za sledenje priložnosti in nevarnosti nujna in praktična delovna vsakdana. Prilagoditve v organizacijah, ki jih narekujejo spremembe starostne strukture družbe, zahtevajo celovito soočanje z izzivi na številnih aspektih delovanja organizacij. 45. mednarodna znanstvena konferenca o razvoju organizacijskih znanosti v kontekstu dolgožive družbe, gre za ustvarjanje zavedanja organizacij in posameznikov, da je osveščenost ter informiranost o novostih nujna vseh nas. Človek in organizacija bosta namreč prepletena ves čas, zato naj bodo spremembe usmerjene v soočanje z izzivi ter ustvarjanje družbenega dobrega.



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