Analisyis of Performance Indicators of Scientific and Tecnological Development

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Abstract In today's world of turbulent changes, it is quite clear that modern development depends on innovation and technological development. Technological entrepreneurship, as a part of entrepreneurship, achieves its goals through innovation in an environment that fosters the use and creation of new technologies. In this way, it leads to numerous significant changes in the economy and prosperity of a country. The triple helix, a concept based on the joint work of the state, universities and the economy, enables better growth of the knowledge-based economy and the overall well-being of the country. The aim of this paper is to show the importance of technological entrepreneurship, understanding the process of innovation and knowledge-based economy as conditions for national growth and development. Indicators of scientific and technological development were chosen as quantitative indicators of the position of countries in order to make a comparison, identify shortcomings and see space for future support and improvement. It is suggested to take a larger number of indicators for the needs of future research. The contribution of this work is reflected in the systematization and analysis of selected indicators for the period from 2015 to 2021, which can serve the academic community as a basis for future analyses.

Keywords: technological entrepreneurship, Triple helix concept, indicators, performance

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1 Introduction

In today's world of turbulent technological change, innovation and entrepreneurship are areas of increasing importance and study. Technology entrepreneurship, as part of entrepreneurship, helps create economic value through technology-based ideas. In the knowledge society, in addition to technology, universities also play an important role, which are increasingly facing the challenge of becoming more socially and economically relevant organizations. This means that in addition to preserving and transmitting knowledge, they should create knowledge and use it. In addition, they should work closely with industry and government for socio-economic development. That relationship is described by the Triple Helix model, and effective cooperation plays an important role for economic survival, where the crisis can be overcome by using innovative solutions.

After the introduction, the second chapter will present a review of the literature for the concepts of entrepreneurship, technological entrepreneurship and digital entrepreneurship. The third is dedicated to the Triple Helix model (TH) and a study that described the impact of the TH model on the startup ecosystem. The fourth chapter focuses on indicators of scientific and technological development to present the results of the analysis in the fifth. Due to the limited length of the paper, the fifth chapter will present the systematization of the obtained results of a broader analysis.

The aim of the paper is to present the results of an analysis which, based on randomly selected indicators, compared Serbia with neighboring countries, but in parallel, an analysis of the same indicators of developed countries - the United States of America, Sweden, Switzerland, Germany, France and Israel - was carried out as an example of successful work, in order to shortcomings were seen, as well as possibilities for future support and improvement of the entrepreneurial ecosystem.

2 Entrepreneurship - literature review

Entrepreneurship is a field that is increasingly studied and has a great influence on peoples lives. Continuous learning creates the necessary knowledge that helps technology entrepreneurs take risks, venture into new business ventures, and succeed in the global marketplace. More open thinking and fostering an

environment where every idea is welcome makes the current business successful and enables further development.

2.1 Definition and concept of entrepreneurship

According to the authors Brem & Borchardt (2013), entrepreneurship enables individuals to look for opportunities in those places where others see unsolvable problems and is reflected in the creation of new jobs, improved productivity, increased wealth and a higher quality of life. In addition, it helps to find solutions to the challenges facing the world, thinking of energy, environment, health, safety and education. Onetti et al. (2010) define entrepreneurship as „the process by which companies and the individuals who work within them explore and use opportunities, using their ability to proactively manage uncertainty".

The definition of entrepreneurship according to the authors of Acs et al., (2019) is not driven by entrepreneurship out of necessity, but by opportunity. Entrepreneurs and their businesses are tied to scalability and economic growth. They represent the link between invention and commercialization. In their opinion, the invention itself, without entrepreneurship, would remain in a university laboratory or a research and development (R&D) facility. Another aspect of their definition refers to the level of technology, that is, their definition becomes open to non-technological innovators and process innovations.

2.2 Technological entrepreneurship

The Symposium on Technological Entrepreneurship held in 1970 at Purdue University (USA) represents an event that brought together scientists to discuss this topic for the first time, which later became a global phenomenon (Bailetti, 2012).

According to the group of authors Fowosire et al. (2017), technological entrepreneurship is „a new way of applying technical science and knowledge individually or by a group of people, who create and manage a company and take financial risk in order to achieve their goals". Brem & Borchardt (2013) explain that the goal is to create economic value through research and exploitation of new solutions based on technology. In that environment, leaders demonstrate focus, passion and an unyielding will to succeed. The authors of Fowosire et al. (2017)

explain that the goal is the commercialization of innovations carried out through patenting, licensing and the establishment of university-industry partnerships. In this regard, engineers possess high technical skills, but often insufficient skills in business and in the field of entrepreneurial thinking. Therefore, Abbas (2018) points out that continuous learning is necessary to maintain the organization together with technological entrepreneurship.

Schmitz et al. (2016) talked about how important knowledge is as a factor of production and development in today's society. The economical and social development of nations are closely related to their skill to deal with knowledge. That is why universities are gaining more and more importance and becoming a key element in innovation systems. They also highlight several academic revolutions that universities have gone through. From the mission of preserving and transmitting knowledge, it came to the point that they should create knowledge and use it. In addition, in a knowledge society, universities should work closely with industry and government for socio-economic development (Schmitz et al., 2016).

2.3 Digital entrepreneurship

Digital entrepreneurship is gaining increasing significance in the global economy and scientific community. Authors Giones & Brem (2017) emphasize that the difference between digital entrepreneurs and technology entrepreneurs is actually the fact that digital entrepreneurs are often not interested in the specific technology behind their business idea, but are preoccupied with the service that is based on it. Technology is just an input factor here while on the other hand, digital technology entrepreneurship is about technology and its products are technological.

The importance of this topic is discussed by the authors Recker & Von Briel (2019), who state that the majority of global unicorns (startup companies whose value exceeds one billion dollars) are actually digital startups, as well as that 4 of the 5 most valuable companies in the world - Apple, Google, Microsoft and Amazon - began as digital startups - new ventures that had a product or service offering enabled by information and communication technologies (ICT) at the center of their market.

According to the latest Startup Genome report, digital technologies are on the list of the main trends in innovation. Leading the way are Web 3, Industry 5.0, Supply chain 4.0, 5G and digital finance.

3 Triple helix model

According to the authors Pique et al. (2018) The Triple Helix (TH) begins when the university, industry and government enter into a reciprocal relationship with each other "in which each tries to improve the performance of the other". Authors Cai & Amaral (2021) expand the definition by adding that the TH process refers to „taking on the role of another, performing a new one but retaining one's traditional function".

The authors of Pique et al. (2018) point out that according to the TH model, innovation ecosystems consist of three types of agents: universities, industry and government and that the interaction between them is crucial to improve the conditions for innovation in a knowledge-based society by: (a) industry functioning as a center production; (b) government as a source of contractual relations that guarantee stable interaction and exchange; while (c) the university is a source of new knowledge and technology (Pique et al., 2018).

When talking about key actors, the authors Cai &Amaral (2021) state that this model focuses on university, industry and government while intermediaries, legal firms and non-governmental agencies are considered as secondary players. In each of the spheres of university, industry and government, there is a range of actors among which the following are distinguished: (a) individual and institutional innovators; (b) R&D innovators and non-R&D innovators; and (c) unisphere and multisphere (hybrid) institutions. However, the existence of TH model actors and the connections between them does not necessarily mean that the result of their interactions will be positive in terms of generating knowledge, innovation and entrepreneurship. Cai & Amaral (2021) explain that the interactions of the TH model are equivalent to cooperative relations within the network as a misunderstanding of the model and state that an important but challenging task could be to identify and develop indicators that would capture the mechanism of „taking on the role of the other".

The group of authors Flechas et al. (2022) conducted research that yielded significant results on the subject of the Triple Helix model and its impact on the startup ecosystem. They analyzed the impact of their mutual relationships on the development of a healthy startup ecosystem capable of producing, supporting and nurturing high-growth entrepreneurship. Specifically, their study examined „Is there evidence of the impact of the TH model on the quality of the startup ecosystem from a global perspective?". To find the answer, they examined data on 35 countries, including Serbia.

They put forward four hypotheses (Flechas et al., 2022):

- H1. The quality of the government positively affects the quality of the startup ecosystem;
- H2. The quality of the university has a positive effect on the quality of the startup ecosystem;
- H3. The quality of the industry positively affects the quality of the startup ecosystem;
- H4. The developed Triple Helix model has a positive effect on the quality of the startup ecosystem.

One of the most significant results was the confirmation of expectations. There the authors Flechas et al. (2022) highlighted the opinions of authors such as Champenois and Etzkovitz (2018) who argued that government, industry and university must necessarily overlap to promote innovation. After separate analysis of independent latent variables, they did not find statistical significance of the impact on the startup ecosystem. However, when these variables were analyzed together, influence had a significant coefficient of determination, consistent with previous literature. In this regard, their results highlight the importance of policies and multilateral agreements that enable the joint development of innovation and the creation, support and nurturing of high-growth entrepreneurial initiatives. There they give the example of America, as a country with a healthy ecosystem, which constantly develops policies and laws that directly or indirectly favor the ecosystem.

4 Indicators of scientific and technological development

Scientific and technological activities and capabilities are recognized as increasing drivers of economic growth and well-being, so it is increasingly common for

countries, especially developing countries, to give priority to development programs in higher education, science and entrepreneurship that are based precisely on science and technology. In order to monitor success, numerous indicators have been introduced that help in understanding, but it must be remembered that in all these data there must be a careful selection and design of indicators, because only such selected and designed indicators can translate data from statistics into useful knowledge.

The authors Tijssen & Hollanders (2006) state the definition of science and technology indicators according to which the OECD (Organization for Economic Cooperation and Development) explains them as „analytical tools, i.e. a series of data designed to answer questions about the science and technology system, its internal structure, its relationship with the economy and society and the degree to which it fulfills the objectives of those who manage it, work in it or are otherwise affected by its influences" (Tijssen & Hollanders, 2006). In addition, they point out that the availability of scientific and technological statistics as well as indicators and the choice of the most appropriate indicators largely depends on the stage of economic development of the country and the availability of facilities for collecting reliable comparative statistics.

Iizuka & Hollanders (2017) explain in their paper that three types of innovation indicators are currently used: science and technology (S&T) indicators, innovation research indicators and composite innovation indicators that combine different indicators. Each indicator has its own characteristics, data collection methods and data sources and shows different aspects of the innovation process.

5 Systematization of performance indicators of scientific and technological development

The indicators included in the analysis are:

- Global Entrepreneurship Index (GEI)
  GEI consists of three sub-indices in order to show entrepreneurial attitudes, entrepreneurial abilities and entrepreneurial aspirations of a country (Acs et al., 2017);

- Global Innovation Index (GII) - contains about 80 indicators in order to show the most complete picture of innovation including measures of the political environment, education, infrastructure and knowledge creation for each economy[1];
- Bloomberg Innovation Index (BII) - ranks the top 50 most innovative countries globally based on six equally weighted metrics including R&D spending, manufacturing focused on the pharmaceutical, automotive or computer industries, high-tech public enterprises, education, researchers and patents;
- Gross domestic expenditure on R&D as a percentage of gross domestic product (GERD) - represents the total expenditure on R&D carried out on the national territory during a given period. Includes R&D carried out domestically and those financed from abroad, but excludes expenditure on R&D carried out abroad;
- Global Competitiveness Index (GCI) - includes micro and macro economic bases of national competitiveness;
- Human Development Index (HDI) - provides a unique index measure that includes three key dimensions of human development: long and healthy life, access to knowledge and a decent standard of living[2];
- ICT Development Index (IDI) - is a composite index that combines 11 indicators into one reference measure that can be used to monitor and compare ICT development between countries and over time[3];
- Risk capital (VC)[4] and private equity index - the index measures the attractiveness of countries for investors in the classes of venture capital (VC) and private equity (PE). It provides the most up-to-date aggregated information on the quality of the investment environment and assessment of the ease of doing business in 125 countries[5];

Each index was shown as a country's rank, and in that case a higher rank carried a less favorable position, except for the GERD index and the Human Development Index, which were shown as a value. In that case, a higher value meant a better position.

[1] WIPO, 2021 (https://www.globalinnovationindex.org/analysis-indicator)
[2] HDI, https://hdr.undp.org/data-center/human-development-index#/indicies/HDI
[3] IDI, 2015 (https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2015/MISR2015-w5.pdf)
[4] Risk capital (VC)is a form of private equity that invests in companies with high growth potential in exchange for an equity stake
[5] VC and PE index (https://www.forbes.com/sites/iese/2021/07/08/these-are-the-most-attractive-countries-to-investors-post-covid/?sh=2339d4e72698

Based on the performed review of the indicators, the observed results were classified into the following table:

Table 1: Evaluation of the analyzed indicators

Index	The result
GEI	For the observed period, Serbia has the highest rank every year except for 2017, when Bulgaria was a couple of ranks below Serbia
GII	For the observed period, Serbia has the highest rank every year
BII	For the observed period, Serbia has the highest rank every year
GERD	For the observed period, each year, Serbia has the smallest investments in relation to Slovenia and Hungary, and the largest in relation to Romania. Bulgaria had a higher score than Serbia only in 2017. From 2015 to 2017, we were in step with Croatia, only to be overtaken by Croatia in the following years. Slovenia singles out the largest investments, which is double or more than Serbia
GCI	For the observed period, Serbia has the highest rank every year
HDI	For the observed period, Serbia has the highest rank every year
IDI	For the observed period, Serbia has the highest rank every year in relation to all countries except Romania
VC & PE	For the observed period, Serbia has the highest rank in 2018 and 2021, while only Croatia in 2016 was in a more unenviable position

In the observed period, the following was observed for the group of developed countries:

- America ranks best when looking at GEI and VC and PE;
- Switzerland ranks best when looking at the GII;
- Switzerland, Sweden and Germany lead in BII and HDI;
- Switzerland and Sweden lead in terms of FDI;
- Switzerland and America take the best place in the GCI.

The data arranged in this way indicated the unenviable position of Serbia in relation to the countries of the region. And as all the countries in the region lag behind the observed developed countries, it was noticed that there are many fields that need to be worked on in order to try to take a better place and make progress.

6 Conclusion

As the use of technology is an inevitable feature of modern and future society, smart ways of using it must be found. The world is facing increasing challenges, but it is necessary to nurture and encourage technological entrepreneurship as a way to overcome problems and bring prosperity. The country's economy should be based on knowledge, so universities get a new function. The knowledge created in their laboratories or R&D centers should be linked to industry. Here, Serbia is characterized by excellent engineers who lack business knowledge, which is connected to the fact that our educational system lacks more programs that study entrepreneurship.

The state should choose good ways of connecting with the university and the economy, as well as mechanisms for listening to their needs. The described study „How the Triple Helix affects the quality of the startup ecosystem" showed the synergistic effect of these actors, which is far greater than the individual impact. One of the limitations of the described study was that they could not include in the analysis those regions that traditionally do not report information in databases. Based on this, this paper relies on the opinions of the authors of the study, because in order for countries to be compared, they must measure the same data.

There are data that show us that Serbia has started to move in the right direction. So, for example, in the last few years, a noticeable increase in the number of startups, but also an increase in their visibility in the domestic economy and education system. The educational system is becoming more interested in implementing programs in areas that are important for the startup ecosystem, and the number of informal gatherings and trainings is also increasing. Good progress is also reflected in the adopted first national strategy for the development of the startup ecosystem for the period from 2021 to 2025, and startups and angel investors are recognized for the first time in domestic legislation. In addition to the formation of the first domestic entrepreneurial capital fund, an increasing number of foreign funds are present in

Serbia, investing and monitoring the work of domestic companies. Good progress is also reflected in the Strategy for Scientific and Technological Development of Serbia for the period from 2021 to 2025, the general goal of which is to accelerate the development of the Republic of Serbia through improving the quality and efficiency of science, technological development and innovation and further integration into the European Research Area. The goal is for the institutions of science and technological development to become strengthened to the level of being internationally recognizable, capable of independently solving problems and responding to social challenges. From here we conclude that there are movements, but that the actual figures show us that it is still not enough.

If we want to develop, we must work strategically in these fields, and the three main pillars on that path should be the government, the economy and universities. Bad indicators results mean insufficiently good relations between the actors of the Triple Helix, so one of the suggestions for further progress is to start from there and to use new methods to nurture the connection between institutions, innovations and the creation and transfer of knowledge. In addition, it is suggested that in future research, a precise classification of indicators should be included in measuring both the quality of a country's startup ecosystem and its scientific and technological development. A proposal is made to include a larger number of indicators in that model, but with a note that a larger number of data requires a more careful analysis. There is a constant need to improve the system of recording methods and analysis of development indicators.

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