Financial Health of Local Governments and Its Connection with ESG

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The chapter examines the relationship between ESG factors and the credit risk of Slovak municipalities. We assume that the financial profile of a municipality cannot be fully understood from its financial statements alone, and that the environment in which it operates is an equally important part of the assessment. Our dataset includes four financial indicators, namely debt, liquidity, economic margin and debt service, the unemployment rate as a social indicator and three environmental air quality indicators, namely PM10, PM2.5 and NO2. Factor analysis identifies the hidden structure of relationships among variables and extracts four components that explain 81.5% of the total variability. The first component links the concentrations of PM10 and PM2.5 particulate matter to municipalities' indebtedness, indicating a common dimension of environmental burden and financial risk. Discriminant analysis classifies municipalities into two groups: those with problem debt and those without. The key variables differentiating the groups are economic margin, liquidity and debt service. The structural matrix also shows that the environmental variables PM2.5 and NO2 exhibit a stronger direct connection with the discriminant function than most financial variables, confirming their additional information value.

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1 Introduction

Interest in non-financial factors affecting the financial stability of public administrations has grown significantly in recent years. Climate change, air pollution, demographic pressures, and the quality of governance processes are increasingly recognised as measurable factors that directly affect public entities' ability to meet their obligations. The European Banking Authority (EBA, 2025) has explicitly included environmental (E), social (S), and governance (G) risks (ESG) among the areas that must be systematically integrated into risk management. This regulatory change confirms that ESG factors are moving from a voluntary sustainability framework to a mandatory credit risk assessment tool. Most of the existing literature focuses on the relationship between ESG and credit risk at the state or corporate level.

Territorial self-government, i.e., municipalities and cities, remains relatively on the sidelines in this discussion. However, they are the ones that face climate shocks, social pressures, and investment requirements directly at the local level. Bruno and Henisz (2022) state that local governments are in a different position regarding ESG outcomes. Local governments differ in the environmental, social, and governance (ESG) outcomes they provide to their residents. Primarily, this concerns the composition of toxic emissions, the social environment, and residents' health status. These outcomes are mainly related to the quality of life of residents in a specific geographic area and go beyond standard indicators of financial health. The policies, expenditures, and revenue practices of local governments vary in the priority they assign to these ESG outcomes. It appears that municipalities' willingness to monitor and address environmental, social, and governance issues in their localities will lead people to migrate to regions with lower pollution, better schools, better health outcomes, greater safety, etc. As a result of these changes, local governments that improve their citizens' quality of life will be rewarded with increased tax revenues, which they can then use to support sustainable investments in public services. Bruno and Henisz (2024) showed that ESG characteristics of a territory are associated with lower credit risk of municipal debt. Cappiello et al. (2025) demonstrate that physical climate risks reduce credit ratings by affecting public budgets.

This chapter conceptualises ESG pillars as a framework for assessing non-financial risks with potential financial impacts. We explore the transition of these factors into credit risk, with a specific focus on the municipal context and the methodological landscape of the Slovak Republic. Our empirical approach employs factor analysis to examine the interactions among environmental, social, and financial metrics. We used discriminant analysis to confirm whether the proposed financial, environmental, and social indicators allow classification of municipalities based on their credit profiles. Finally, the chapter demonstrates why ESG integration is essential for assessing the long-term financial resilience of local governments.

2 ESG pillars

As was established by the European Commission (2023), ESG pillars serve as a framework for organising sustainability topics into three distinct domains: environmental (E), social (S), and governance (G).

The environmental pillar (E) specifically addresses the protection of the natural world, along with relevant impacts and risks. Within the framework of the European Sustainability Reporting Standards (ESRS), this area is operationalised through thematic standards covering (European Commission, 2023): climate change, pollution, water and marine resources, biodiversity and ecosystems, and the Use of resources in the transition to a circular economy.

According to the European Commission (2023), the social pillar (S) focuses on impacts on people and society, as well as issues related to the groups involved. In the social field, ESRS distinguishes four thematic standards according to which the social topics are related: own workforce, workers in the value chain, affected communities, consumers and end users.

The governance (G) pillar refers to governance and control rules, as well as to how the organisation establishes and applies governance, integrity, and oversight processes. ESRS in the field of governance use thematic standard G1 - business conduct, which covers issues of behaviour, ethics and rules that affect the integrity of decision-making and the trustworthiness of the organisation.

The pillars defined in this way are also associated in the literature and standards with a financially significant perspective, i.e., the fact that sustainable risks and opportunities can affect the entity's economic functioning. According to the standard S1 of the International Financial Reporting Standards (IFRS) (IFRS Foundation, 2023, p. 6), issued by the IFRS Foundation, formulates this link explicitly: "the standard requires that the entity, including municipalities, disclose information about all sustainable risks and opportunities that can reasonably be expected to affect the entity's cash flows, its access to financing or the cost of capital over various time horizons".

The ESG concept provides a systematic framework for integrating environmental, social, and governance factors into municipal financial decision-making, risk management, and reporting transparency. ESG has evolved into a cornerstone of the capital market's information infrastructure, with investors increasingly relying on sustainability data to evaluate local government stability. As noted by Christensen, Serafeim, and Sikochi (2021), integrating ESG metrics into investment decisions serves as a critical tool for identifying risks and opportunities in municipal financing. Consequently, lenders now utilise this information to determine the creditworthiness and long-term viability of municipal entities.

ESG is also linked to organisations' risk management and internal governance processes. In a risk-averse regulatory environment, ESG is recognised as an essential component that local governments must address alongside traditional risk management functions. To ensure consistency, the European Banking Authority (EBA, 2025) has established reference methodologies for identifying, measuring, and monitoring ESG risks. For municipalities, adopting these standards means embedding sustainability into the core of their administrative oversight and long-term financial planning.

According to the European Commission (2023), ESG is also related to transparency and reporting, as it is materialised in practice through standardised disclosure frameworks. In the European ESRS environment, these structures enable long-term comparability and consistency of information across the public sector. For local authorities, this framework serves as a formal communication channel. By adhering to these disclosure standards, municipalities can provide reliable information to

institutional lenders and stakeholders, ensuring that sustainability efforts are documented in a globally recognised and verifiable format.

Despite the growing use of ESG in practice, the literature emphasises the need to distinguish between the concept of ESG itself and the specific products of providers, especially ESG ratings. Christensen, Serafeim, and Sikochi (2021, p. 6) note the empirically observed discrepancy between ratings from different providers. For municipalities, this means that increased transparency does not inherently lead to a consensus on their sustainability standing. Instead, divergent methodological choices and interpretive frameworks among providers can result in varying assessments of a local government's creditworthiness and ESG performance.

A significant part of this methodological ambiguity stems from the fact that ESG ratings lack a single "subject" of assessment, as we know it for credit ratings. The authors Berg, Kölbel and Rigobon (2022, p. 1335) subsequently explain that the differences between ESG rating providers can be analytically decomposed into differences in the scope of the assessed topics (scope), in the way the same attributes are measured (measurement) and in the weighting of individual categories (weight). In their empirical results, measurement dominates on average, contributing 56%, scope 38%, and weights 6%. It means that the differences in ratings are not only a question of which areas are monitored, but also of how the same areas are quantified.

The discrepancy in ESG ratings also has market implications for public entities. Gibson, Krueger, and Schmidt (2021, p. 8) report that their analysis shows a positive association between the discrepancy in ESG ratings and returns. Therefore, the risk premium of a company with a higher discrepancy in ESG ratings is higher. In addition, Christensen, Serafeim and Sikochi (2021, p. 35) found, when testing market implications, that the discrepancy is positively associated with return volatility and absolute price movements. They also document a connection with a lower probability of obtaining external financing. For municipalities, these findings support the conclusion that methodological transparency is essential when working with ESG ratings. Therefore, in empirical applications, it is appropriate to directly state the source of the rating used, the method of construction and the limitations of its interpretative comparability.

2.1 ESG factors as sources of non-financial risk

In the literature on public finance risks, environmental, social, and governance factors are increasingly recognised as non-financial sources of shocks that can impact budgetary stability and an entity's ability to meet its obligations. According to the Organisation for Economic Co-operation and Development (OECD) (2024, p. 3), fiscal risks in public budgets, including local government budgets, manifest as deviations in revenue and expenditure from the plan and arise not only from macroeconomic fluctuations but also from institutional weaknesses and unforeseen liabilities. As the OECD states in its publication Managing rising subnational fiscal risks: "Risks can also arise from weaknesses in budgetary institutions and processes or from the materialisation of contingent liabilities that were not included in the budget." In the same text, the OECD emphasises that frequent or large materialisations of risks can "threaten fiscal sustainability as well as the efficient provision of essential public goods and services to the population." This framework applies to municipalities because their financial stability is tied to the continuity of public services (operations, maintenance, and investments). At the same time, they are exposed to local shocks of environmental, social, or governance origin.

The most visible group of non-financial risks is physical environmental risks, i.e., the impacts of extreme events and long-term climate trends on people, infrastructure, and public services. The UN Intergovernmental Panel on Climate Change (IPCC, 2022, p. 8) points out in its summary for policymakers that we are already observing extensive negative impacts and losses due to climate change, and that the growth of extremes is pushing systems beyond the limits of adaptation. At the local level, this typically means a higher risk of costs for interventions, repairs, and the restoration of municipal assets, such as local roads, bridges, and public buildings, as well as pressure on services, such as crisis management, social assistance, and temporary accommodation. The OECD (2024, p. 6) directly notes the trend of increasing disaster intensity and frequency. As a result of climate change, there has been a significant increase in weather-related natural disasters, including droughts, floods, hurricanes, and fires. Regarding the division of competences, the OECD adds that supranational governments are, in practice, involved in immediate assistance, the restoration of basic public services, and the reconstruction of affected infrastructure. These mechanisms represent typical channels through which an environmental shock becomes a budgetary shock, mainly through one-off expenditures and a shift

in investment priorities. However, environmental risk is not only about disasters; chronic environmental pressures that impact the health of the population and the quality of life also play a significant role. In European conditions, air quality, characterised by the indicators PM10, PM2.5, and NO2, is most often discussed. The European Environment Agency, hereinafter referred to as EEA (2024, p. 1), states in its review Europe's air quality status 2024 that "96% of the EU urban population is exposed to hazardous concentrations of fine dust particles (PM2.5). In the context of local air quality policy, these findings can be interpreted as potential pressure on preventive and investment measures.

Social risks are often described in the public finance literature as sources of expenditure pressure, revenue shortfalls and the risk of rising liabilities. In the same document, OECD (2024) also includes public health and demographic trends among the growing fiscal risks, noting that health and long-term care spending are increasing and that budgets are under pressure, even as revenue changes. The OECD states that public health budgets may also face pressure because population ageing reduces the share of workers and, in turn, the tax base, particularly in systems linked to contributions and taxes. At the same time, the OECD directly links health risks to environmental degradation and climate change, including the risk of zoonotic diseases, thereby strengthening the argument that social and environmental factors intersect in practice. Governance risks in the context of public finance are described mainly through the quality of budgetary processes, control mechanisms and the ability to anticipate and cover contingent liabilities. OECD (2024, p. 3), therefore, includes weaknesses in budgetary institutions and processes, as well as the materialisation of contingent liabilities, as sources of fiscal risk. For municipalities, this channel can be practically visible, for example, in overvalued investment projects, in weak financial planning, in postponing maintenance, which increases future capital expenditures, or in the incorrect setting of contractual obligations, which subsequently turn into unexpected expenses. The financing aspect is also important, since a significant part of the supranational debt is in the form of bank loans and short-term instruments, which increases sensitivity to interest rate risk. Although the specific parameters vary by country, the logic is general: the combination of weaker processes and a riskier financing structure increases the likelihood of budgetary deviations and the accumulation of liabilities.

2.2 Linking non-financial risks to credit risk

In recent years, the nexus between non-financial risks and the credit profiles of public entities has gained prominence, particularly in the context of climate change. Cappiello et al. (2025) demonstrate that temperature anomalies and frequent natural disasters correlate with lower credit ratings, driven by a clear transmission mechanism: both physical and transition risks necessitate increased public spending on subsidies and disaster relief, which escalates municipal debt and erodes creditworthiness.

According to the EEA (2024), these risks manifest in municipalities as multifaceted pressures: expenditure shocks from reconstruction (sudden costs for emergency repairs and social assistance), investment pressures for climate adaptation (required funding for infrastructure adaptation and air quality improvement), revenue risks (potential erosion of the tax base due to shifts in the local economy or migration), and governance risks related to debt structures or exposure from contingent liabilities and sub-optimal debt management. Consequently, monitoring environmental data (e.g., PM10, PM2.5, NO2), social indicators (e.g., unemployment), and fiscal metrics is a vital methodological approach for quantifying how non-financial factors jeopardise a municipality's financial stability.

3 Credit risk and municipalities

Credit risk presents a fundamental challenge in the financial landscape, particularly regarding a debtor's–such as a municipal entity's–ability to fulfil financial commitments. As stated by the ECB (2026), the risk is that a counterparty fails to settle a loan in full at the scheduled maturity. This definition highlights that for local governments, credit risk encompasses both the ultimate default and the specific timing of performance. From a management perspective, municipalities can address this by using metrics such as probability of default (PD) and expected loss (EL), aligning qualitative assessments of fiscal health with quantitative risk and credit valuation.

The link between asset quality and institutional stability makes credit risk a permanent priority for municipal financial oversight. While the European Court of Auditors (2023) focuses on banks, the principle remains identical for local

authorities: failure to service Debt leads to a loss of viability. A municipal loan or guarantee is generally considered non-performing if the obligations are more than 90 days past due. In line with EBA (2020) guidelines, municipalities should establish robust policies for identifying, assessing, and mitigating credit risk within their internal procedures. We can say that it is necessary to ensure that credit risk is not only considered as a pressure on the budget (interest margins) but also as a solvency risk (capital adequacy and loss coverage), which requires disciplined monitoring of signals of non-compliance to avoid sharp financial losses.

Regulation plays a crucial role in municipal credit risk assessment, aiming not only to measure risk but to ensure it is managed within statutory debt limits and supported by adequate fiscal reserves. Following the logic of the European Court of Auditors (2023), municipal oversight functions similarly to the Supervisory Review and Evaluation Process (SREP), verifying that sufficient budgetary buffers cover a local government's risks. Within this framework, credit risk is a key component of fiscal stability. As per the ECB's (2023) methodology, assessing a municipality's credit risk combines a quantitative analysis of debt levels–such as debt-to-revenue ratios–with a qualitative evaluation of governance. Consequently, risk is conceptualised as a combination of the municipality's current financial obligations and the effectiveness of the administrative processes governing them.

The significance of credit risk for the public sector is reflected in the need for comparability and consistency in the models used to assess municipal fiscal health. Drawing on EBA (2025) principles, oversight bodies should benchmark local governments to identify significant deviations from peer institutions. If a municipality's internal risk assessment leads to an underestimation of debt-related risks that its underlying economic conditions cannot justify, corrective measures must be taken. Methodological transparency is essential, as credit risk is a fundamental input in determining credit terms, risk premiums, and the overall availability of financing for local authorities.

3.1 Methods of assessing the financial health and credit risk of Slovak municipalities

The Council for Budget Responsibility (RRZ, 2025) describes the assessment of municipalities' financial health in Slovakia. The Council for Budget Responsibility (RRZ, 2025) has established procedures to determine whether a municipality can meet its long-term obligations, finance public services, and maintain budgetary stability without excessive debt and past-due liabilities.

From the perspective of a creditor, such as a bank or investor, the core of the assessment is credit risk, i.e. the probability that the municipality will not be able to repay its obligations properly and on time. In practice, Slovak municipalities mainly apply approaches based on regulatory limits and supervision, a set of financial indicators from accounting and budget statements, synthetic indices or scoring models that aggregate multiple indicators into a single result.

A very important group consists of the rules and limits embedded in the local government's fiscal framework. These limits serve as thresholds that enable rapid identification of municipalities with an increased risk of excessive indebtedness or excessive debt service. In Slovakia, the Council for Budget Responsibility (RRZ, 2025) defined the threshold at 60% of the previous year's current revenues. Failure to comply with it will result in fines being imposed on local governments. The significance of regulatory limits is not only punitive; they also serve a preventive role by setting a maximum debt limit relative to the local government's current revenue capacity. The Council for Budget Responsibility also explains the logic of linking rules to current revenues so that local governments can realistically cover their liabilities with their current operations. For financial health research, it is therefore natural to work with indicators of debt, debt service, liabilities, and the revenue base, as these quantities serve as the basis for the formal assessment of municipal fiscal discipline.

Another key approach to assessing financial health uses financial health indicators derived from financial statements and budget management. It is a method that does not provide a simple "meet/fail" result, as with limits, but allows for more nuanced diagnostics, for example, capturing a combination of growing past-due liabilities, low liquidity and a deteriorating operating balance, which may signal future problems

even before legal thresholds are exceeded. In the academic literature, the financial performance and financial situation of municipalities are often evaluated using multiple indicators, and municipalities are then classified into relatively homogeneous groups. The authors Lukáč et al. (2021) use a set of financial indicators to assess local governments and employ multidimensional approaches to distinguish groups of municipalities with different financial situations, emphasising that the indicators can capture differences between local governments even within a single region. According to the Institute for Economic and Social Reforms, hereinafter referred to as INEKO (2024, p. 31), in connection with the practice of Slovak local governments and the availability of data, the most used diagnostic indicators include:

- total debt and its relationship to current income,
- debt service (principal and interest payments) in relation to income,
- current account balance (continuous management), as an indicator of the ability to finance operations without pressure on Debt,
- past-due liabilities, as a signal of payment discipline,
- Liquidity, such as cash, is a short-term ability to pay liabilities.

The third important approach is synthetic indices and scoring methodologies, which convert multiple indicators into a single composite score. Their benefit is clarity and comparability between municipalities, while the disadvantage may be sensitivity to the chosen methodology. In the Slovak environment, a well-usable example is the financial health methodology published in the analytical outputs of the hospodarenieobci.sk portal, which transparently describes what the resulting score consists of. The resulting overall score describing the financial health of cities is a weighted average of the 5 partial scores obtained using weights of 30%, 10%, 30%, 15% and 15%, respectively, for total debt, debt service, current account balance, past due liabilities and liabilities more than 60 days past due.

Radebe, Nomlala, and Matenda (2025) state that there are also models aimed at early identification of financial distress, or "early warning," using indicators and composite indices. These approaches are often constructed as classification models that, based on a combination of financial ratios and thresholds, classify entities into "safe-grey-risk" zones. A systematic review of the literature states that several types

of models are used in local governments, including discriminatory approaches, logistic models and scoring frameworks, while in practice, threshold rules are often applied to interpret the result. At the same time, it should be noted that local governments have their own specificities. Their goal is to provide services; they have a different income and expenditure structure, and political factors influence them. Piermarini et al. (2023) state that it is methodologically appropriate to adapt the scoring or Z-score to the available data. At the same time, the Z-score should be interpreted with caution as an indicator of relative risk rather than an exact prediction of failure.

4 Linking ESG factors and credit risk

The link between ESG factors and credit risk is based on the thesis that environmental, social, and governance factors, particularly in the form of shocks, trends, and weaknesses in public administration, are reflected in traditional financial risks over time and can ultimately affect the borrower's ability to meet its obligations. EBA (2025) formulates this relationship as: "ESG risks can affect all traditional categories of financial risks to which institutions are exposed." In the same document, the EBA emphasises that ESG risks should be understood "as potential causes of all traditional categories of financial risks, including credit risk." In the local government environment, the link between ESG and credit risk primarily manifests through public finances. ESG factors affect the likelihood of deviations of revenues and expenditures from planned levels, and thus the stability of the budgetary position. Authors de Mello and Ter-Minassian (2024, p. 2) define fiscal risks as "events whose realisation leads to significant deviations of revenues and expenditures from budgeted amounts." The document states that sources of increasing fiscal risks include structural changes, such as those driven by climate change. From a credit risk perspective, it is crucial that the materialisation of these risks can "threaten fiscal sustainability, as well as the efficient provision of basic public goods and services." For Slovak municipalities, this framework is applicable as a theoretical justification for why it is legitimate to examine ESG variables such as air quality, social situation, or elements of governance and transparency in conjunction with indicators of financial health and indebtedness, the risk channel leading through budgetary resilience and the ability to absorb shocks without worsening payment discipline.

Regulatory frameworks increasingly emphasise that credit risk is a natural target for integration with environmental and climate factors, particularly. The Basel Committee on Banking Supervision (BCBS, 2021) states in its principles for managing climate-related financial risks that banks should understand the impact of climate-related risk factors on their credit risk profile and ensure that credit risk management systems and processes take significant climate-related financial risks into account. In this sense, when a local government seeks financing, lenders must identify and measure how climate factors influence the municipality's credit exposure.

It follows from the above that the connection between ESG and credit risk extends beyond physical risks. The governance pillar, i.e. the quality of decision-making and control mechanisms and their anchoring in risk management, also has a significant role. The European Central Bank (2022), in its compendium of good practices for managing climate and environmental risks, emphasises that the assessed institutions should build and align risk management strategies and processes to meet expectations. The document thus emphasises the logic of the connection between ESG and credit risk and shows how non-financial risks are incorporated into management processes. If the governance pillar is weak, for example, there is a lack of systematic risk identification, internal control mechanisms, planning and monitoring, the likelihood that ESG shocks and trends will be reflected in financial indicators faster and with higher losses increases. In the municipal environment, this argument is transferable in principle; the quality of financial management and control processes determines how quickly and accurately a local government can recognise and mitigate the budgetary consequences of environmental and social stimuli.

Empirical support for a direct link between ESG characteristics of a territory and credit risk is provided by the work of Bruno and Henisz (2024) from the field of municipal finance. The authors state that collective improvements in community ESG factors are associated with a reduction in the credit risk of municipal financial instruments over time. They also present the result in terms of the price of risk. They state that more aggregated ESG results are associated with lower credit returns for municipal financial securities. ESG is not evaluated solely as a company feature, but as a set of results and characteristics of the territory, which are subsequently associated with the credit risk of a public issuer or borrower. This concept is

conceptually compatible with the empirical part for municipalities, where environmental and social indicators, such as air quality and unemployment, represent measurable characteristics of the territory, and the municipality's financial statements allow for approximating credit quality through financial health models.

5 Analysis of ESG and financial indicators of the Slovak municipalities

The empirical analysis focuses on Slovak municipalities, and cities/villages are viewed from two perspectives. As economic units, their financial health depends on budgetary stability, indebtedness, liquidity, and payment discipline, all of which are measurable through public financial statements. At the same time, territorial units, where each municipality operates in a geographical and socio-economic environment with different air quality and unemployment rates. This dual perspective provides the basis for integrating both financial and environmental-social variables into a single analytical framework, an approach consistent with Bruno and Henisz (2024), who view ESG as a set of measurable characteristics of the territory rather than an attribute of the organisation itself.

Slovak municipalities are anchored in the fiscal framework set out in the Act on Budgetary Responsibility. The Council for Budget Responsibility (RRZ, 2025) defines the legal debt limit as 60% of the previous year's current income. This regulatory framework defines when a municipality can be considered risky from a formal perspective and is therefore part of the institutional context of credit risk assessment.

We have used publicly available data from three independent institutional sources. In comparison, the analytical set consisted of 34 municipalities with complete records for the reference year 2024. Financial data come from the Finstat database (2026). The source is the balance sheets and income and expenditure statements for the financial year 2024. Four ratio indicators were calculated from the items of these statements in accordance with the diagnostic recommendations of INEKO (2024) and RRZ (2025):

- Indebtedness (Indebtedness) - the ratio of total liabilities to the total value of assets.
- Liquidity (Cash) - the ratio of available cash to total assets.

- Economic margin (Margin) - the ratio of the difference between income and expenses to total income.
- Debt service (Debt Service) - the ratio of financial expenses to total income.

Environmental data are from measurements of the Slovak Hydrometeorological Institute (SHMÚ, 2026) for 45 Slovak municipalities. The average annual values for 2024 were used for PM10, PM2.5 and NO2. In municipalities with multiple measuring stations, the average of the stations was calculated. The management pillar (G) is not represented in the analysis due to the unavailability of quantitative management indicators at the municipal level in the Slovak public sources for the monitored period. Social data and the unemployment rate are from the website of the Central Office of Labour, Social Affairs and Family provider (UPSVaR, 2026). For each municipality, the annual average was calculated from the monthly values for the year 2024.

The average debt of the municipalities in the sample is 13.4%, which is significantly below the legal limit of 60% of current revenues (RRZ, 2025) (see Table 1). However, the 9.1% standard deviation indicates significant heterogeneity, suggesting that debt levels differ substantially across municipalities. The liquidity indicator is generally low, averaging 6.9%, consistent with common values in public administration, where excess cash is not a strategic goal. The economic margin is only 2.2%, indicating very tight operating management in most of the monitored municipalities. Debt servicing is on average 1.9%, but the standard deviation of 4.3% indicates that some municipalities pay a significantly higher share of income on instalments. The unemployment rate fluctuates significantly across the sample, reflecting regional differences in job availability and municipal tax capacity. Among the environmental indicators, PM2.5 is noteworthy, with an average value of 14.3 $\mu g/m^3$ significantly exceeding the WHO guideline value (5 $\mu g/m^3$), which is in line with the EEA (2024) findings for most European cities. The significant standard deviation of NO2 (6.6 $\mu g/m^3$) suggests that this indicator is more heterogeneous in the sample than the PM fractions. The different traffic and industrial conditions at individual locations cause it.

Table 1: Descriptive Statistics

	Indeb-tedness	Cash	Margin	Debt Servis	Unemp-loyment	PM10	PM2.5	NO2
Mean	0.134	0.069	0.022	0.019	0.037	20.588	14.265	12.71
Std. Dev	0.091	0.047	0.056	0.043	0.02	3.627	3.028	6.599

Source: own

Based on the Kaiser criterion, four components were extracted, explaining together 81.5% of the total variability. Details are given in Table 2. Before rotation, the first component captures 36.5% of the variability. After Varimax rotation, the loadings are more evenly distributed, and the components capture 26.7%, 22.4%, 18.3%, and 14.1% of the variance. The total share of 81.5% is preserved, and the rotation only facilitates substantive interpretation by ensuring that each component corresponds to a single analytical dimension.

Table 2: Variability of the extracted components

Component	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	2.924	36.544	36.544	2.134	26.677	26.677
2	1.868	23.354	59.898	1.789	22.362	49.039
3	0.936	11.706	71.604	1.467	18.338	67.377
4	0.793	9.913	81.517	1.131	14.140	81.517

Source: own

Table 3 shows the results of the factor analysis. Environmental burden and Debt represent the first component. PM10 (0.846) and PM2.5 (0.833) clearly dominate in the first component. Their strong mutual correlation is physically predictable; PM2.5 is a subset of PM10. More remarkable is the debt result (0.714), which is included in the same dimension as the environmental variables. This pattern suggests that municipalities with a higher particulate matter burden also show higher debt levels, which can be interpreted through the mechanism described by OECD (2024): environmental shocks (floods, infrastructure rehabilitation) generate one-off expenditure pressures that municipalities address through Debt.

Component 2 includes financial performance. Liquidity (0.834) and economic margin (0.686) define a group of municipalities with good operating performance and, therefore, those that can cover their obligations from their own operating activities. Debt service shows a negative value (-0.470), which is consistent with economic logic: the more a municipality pays in instalments, the less it has left for operations. Component 3 represents debt and social burden. The unemployment rate (0.898) and debt service (0.733) form a combination capturing financial vulnerability conditioned by the socio-economic environment. Municipalities with higher unemployment have a lower tax base, which increases the relative burden of instalments, not only because of the amount of Debt but also because of a weaker revenue position. This mechanism, as described by OECD (2024), is one of the main channels through which social risks are transmitted to local governments' financial results. NO2 was separated into a distinct component (0.955), confirming that its source structure differs from that of the PM fractions. NO2 primarily originates from road transport, not from heating or industry, and different local factors govern its distribution in the sample. Including NO2 in the same index as PM without further consideration would therefore lead to methodological bias.

Table 3: Rotated Component Matrix

	Component				Communalities
	1	2	3	4	Extraction
Indebtedness	0.714	0.394	0.143	0.234	0.74
Cash	-0.072	0.834	-0.233	-0.039	0.755
Margin	-0.417	0.686	-0.148	0.232	0.721
Debt Servis	0.03	-0.47	0.733	0.024	0.759
Unemployment	0.09	-0.046	0.898	-0.183	0.85
PM10	0.846	-0.299	0.065	0.253	0.874
PM2.5	0.833	-0.388	-0.013	-0.109	0.856
NO2	0.166	0.065	-0.152	0.955	0.966

Source: own

The last column reports the communalities, or the shares of variance of each variable explained by the four components together. All values exceed 0.72, confirming that the model captures each input variable well and that none are marginalised. The highest communality belongs to NO2 (0.966), a consequence of its almost exclusive binding to the fourth component. The lowest communality of the economic margin (0.721) is still sufficient and does not require any model correction.

The Discriminant analysis used the dependent variable Debt - municipalities without problem (No, n = 29) and municipalities with problematic Debt (Yes, n = 5) and eight predictive variables. The canonical correlation of 0.520 corresponds to a moderately strong association between the discriminant function and group assignment. A Wilks' Lambda of 0.729 means that 72.9% of the variability in the discriminant score is not due to group affiliation. The chi-square test ($\chi^2 = 8.843$, df = 8) yields p = 0.356. The model is not statistically significant. With five cases in the smaller group and eight predictor variables, the ratio is 8:5, which exceeds the recommended rate by a significant margin (Piermarini et al., 2023). The model should be seen as an orienting tool for identifying patterns, rather than as statistically strong evidence.

Table 4: Standardised Canonical Discriminant Function Coefficient and

Standardized Canonical Discriminant Function Coefficient	
Indebtedness	0.377
Cash	-0.484
Margin	0.902
Debt Servis	0.281
Unemployment	0.078
PM10	-1.083
PM2.5	1.625
NO2	-0.447

Structure matrix	
PM2.5	0.492
NO2	-0.445
Unemployment	0.370
Cash	-0.280
PM10	0.151
Debt Servis	0.142
Margin	-0.052
Indebtedness	0.022

Source: own

The main variable, according to the standardised coefficients, is the economic margin (0.902), and a higher operating surplus is associated with belonging to the problem-free group. Liquidity follows (−0.484) with a negative coefficient, which at first glance appears negative. A possible explanation is that municipalities close to insolvency deliberately maintain higher cash reserves as a line of defence, or that the effect arises from mutual correlation between the variables. The third in order is debt service (0.281). The structure matrix shows a different ordering than the standardised coefficients. The strongest direct correlations with the discriminant function are shown by PM2.5 (+0.492), NO2 (-0.445), and the unemployment rate (+0.370). The economic margin, dominant according to the coefficients, drops to seventh place (-0.052). The conclusion is methodologically important because the ES factors carry real discriminant information, but stronger financial predictor

variables partially obscure it. Based on the unstandardized coefficients, the discriminant function can be written:

$$Z = 14.708\ \text{Margin} - 8.792\text{Cash} + 6.067\text{Debt Service} - 0.234\text{PM10} + 0.531\text{PM2.5} - 0.068\text{NO2} - 1.738$$

Municipalities with a Z value above the dividing point are included in the debt-free group, and municipalities with a lower value in the risk group. The centroids confirm the direction: problem-free villages have an average function value of +0.245, while risky villages have a value of -1.424. We used a cross-tabulation to compare the actual and model-predicted classifications of municipalities in the original data and in leave-one-out cross-validation. On the original data, the model correctly classifies 82.4% of cases. Of the 29 problem-free municipalities, 24 (82.8%) were correctly classified, and of the 5 risky municipalities, 4 (80.0%) were correctly identified. Cross-validation reduces overall accuracy to 70.6%, and among the 5 risky municipalities, the model correctly identified only 3. The 12 percentage-point decrease reflects the model's adaptation to the data, an expected phenomenon in a smaller group with n = 5.

From the point of view of practical use, the more serious type I error is the classification of a risky municipality among the problem-free ones. In this way, 2 out of 5 risky municipalities (i.e., 40%) are overlooked in the cross-validation. For an early warning system, such a proportion would be unacceptable, and the classification threshold would need to be set in favour of sensitivity. To improve the model, we recommend increasing the sample size.

6 Conclusion

Factor analysis showed that financial variables are divided into two latent dimensions: the first, liquidity and economic margin (component 2); the second, debt service in combination with unemployment (component 3). Together, these two dimensions account for 40.7% of the variability in the set. Interestingly, indebtedness is grouped with environmental variables, indicating its link to external shocks rather than to systemic management errors. This finding aligns with the INEKO diagnostic framework (2024), which identifies liquidity, current account balance, and debt service as key signal variables for municipalities' financial health. In total, the analysis extracted four components, which explained 81.5% of the variability. Component 1 links the environmental burdens of PM10 and PM2.5 to

indebtedness; component 2 captures financial performance; component 3 captures debt and social burden; and component 4 captures isolated NO2 concentrations. The very combination of environmental and financial variables within a single component empirically supports the thesis that environmental risks are transferred to municipalities' financial condition, as formulated by OECD (2024) and Cappiello et al. (2025).

The discriminant analysis confirmed that the decisive factor between the groups is the economic margin, followed by liquidity and debt service. The result aligns with Lukáč et al. (2021) and the regulatory logic of the RRZ (2025), which bases the rules of financial responsibility on revenue capacity and liabilities. The model achieves 82.4% accuracy on the original data and 70.6% in cross-validation. However, the difference is not statistically significant ($p = 0.356$), due to the critically small number of risky municipalities in the sample ($n = 5$). The results should be seen as indicative. The structural matrix also revealed that PM2.5 and NO2 have a stronger direct correlation with the discriminant function than most financial variables, and their discriminant potential is therefore real, only partially overshadowed by stronger financial variables. Bruno and Henisz (2024) document that ESG characteristics of the territory are associated with lower credit risk, and their results suggest this direction, although a larger, more representative sample would be necessary for definitive confirmation. Our work contributes to the discussion on the inclusion of the ESG perspective in the assessment of the financial health of Slovak local governments. It shows that environmental and social factors represent a meaningful complement to traditional financial analysis.

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