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FINANCIAL PERFORMANCE ASSESSMENT AND SUSTAINABILITY CHALLENGES IN SERBIA'S MINING AND QUARRYING SECTOR: A PROCESS MANAGEMENT PERSPECTIVE

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Abstract: *The mining and quarrying sector has become one of the fastest-growing industries in Serbia, driven by increasing global demand for strategic minerals and substantial foreign investment. This study evaluates the financial performance of the mining and quarrying sector relative to the rest nine leading export sectors in Serbia using an integrated entropy–PROMETHEE multi-criteria decision-making approach. Sector rankings are based on four profitability and three indebtedness indicators calculated from sector-level financial statements for 2024 published by the Serbian Business Registers Agency. The results identify the mining and quarrying sector as the highest-ranked sector, reflecting outstanding profitability and a favorable debt profile. Despite its strong financial performance, the sector exhibits relatively limited fiscal contributions and considerable environmental pressures, while generating positive effects on employment and wages. The findings highlight the need to complement financial success with stronger fiscal and environmental policies to ensure that continued mining expansion contributes to Serbia's long-term sustainable economic and social development.*

Keywords: *Sustainable mining, export sectors, financial performance, PROMETHEE method, Serbia, entropy method.*

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1. Introduction

Metals are indispensable to modern society, underpinning technological development and economic growth worldwide. The accelerating demand for metals (driven by technological progress and the global energy transition) highlights the world's dependence on these critical resources (Ndlovu & Adewyji, 2025; Anani et al., 2025; Zhang et al., 2024). In Europe, mineral resource availability has become a political priority due to geopolitical instability, rapid socioeconomic changes, and climate policy challenges (CAEF, 2022). The variety and volume of mineral raw materials in use are expanding rapidly, with energy security remaining a central concern. Mining and quarrying (Sector B) is vital sector contributing to national modernization and energy security (Zhu & Lin, 2022) and must adapt quickly to support necessary technological advancements (Ndlovu & Adewyji, 2025).

However, mining and quarrying can cause significant environmental harm (Zhu & Lin, 2022). The tension between environmental protection and resource extraction continues to grow, presenting challenges such as escalating electricity demand, water scarcity, and broader social and environmental responsibilities (Ndlovu & Adewyji, 2025). Negative public perception and increased scrutiny regarding the sector's ecological footprint are also mounting (Seloa & Ngole-Jeme, 2022). Recognizing these pressures, mining companies are increasingly aware that profitability must be balanced with sustainable practices that preserve quality of life for current and future generations (Ndlovu & Adewyji, 2025).

In Serbia, the mining and quarrying sector has become increasingly important due to rising global demand and high market prices for key metals over the past decade. Positioned at a crossroads, the sector boosts economic growth while addressing significant environmental challenges. Serbia's rich mineral reserves offer substantial economic opportunities and the potential to meet global mineral demand (Vujović et al., 2025), but also require advanced processing capabilities, raise environmental concerns, and face geopolitical risks. The inflow of foreign direct investment (FDI), particularly in copper, gold, and lithium, has spurred rapid sector growth and boosted export earnings (Ratkaj et al., 2021), although concerns about long-term financial sustainability and broader development impacts persist (Stuehlen & Anderl, 2024).

Long-standing mining activity, especially in Eastern Serbia's copper districts, has caused serious environmental problems, notably heavy metal contamination of air and surface water (Adamović et al., 2022). Sector development is further hindered by outdated technologies, legislative barriers, and limited institutional capacity. Despite some progress in regulatory reforms, implementation challenges remain. Achieving sustainable growth and prosperity requires robust laws, strategic investments, and a careful balance between social welfare, environmental protection, and economic development (Vujović et al., 2025). While regulatory improvements are primarily the responsibility of state authorities, advancing geological exploration also depends on industry professionals and alignment with international standards (Simić et al., 2021). Streamlining procedures and adopting global best practices are essential for continued progress.

Given these complex challenges and opportunities within Serbia's mining and quarrying sector, this study employs the entropy-based PROMETHEE method to compare the profitability and indebtedness of Serbia's mining and quarrying sector with the top ten export sectors in the country, using sector-level summary balance sheet and income statement data for 2024, provided by the Serbian Business Registers Agency in 2025. The novelty of this research lies in its integrated application of the entropy-based PROMETHEE method for sectoral financial assessment, offering a comprehensive and objective comparison that supports evidence-based policy and investment decisions in Serbia's evolving economic landscape.

2. Literature review

Resource-intensive sectors, such as mining, represent some of the most critical drivers of global economic development, but also pose significant sustainability challenges. Hence, the mining and quarrying sector has long been recognized as a cornerstone of the global economy, supplying essential raw materials for industrial production, the energy sector, and infrastructure development. Rising industrialization and urbanization have intensified the global demand for metals such as steel, copper, aluminum, and rare earth elements (Lapko et al., 2019; Liang et al., 2020). Critical minerals like cobalt, lithium, and graphite are increasingly vital for renewable energy technologies, including electric vehicles, solar panels, and wind turbines, which are key to the global clean energy transition (Baldassarre & Carrara, 2025). Consequently, the ongoing energy transition is driving increased demand for minerals used in clean energy technologies, raising concerns regarding the origin and security of critical material supplies (Vakulchuk & Overland, 2021). Nevertheless, oil, coal, and natural gas continue to account for more than half of total global energy consumption (World Bank, 2023), highlighting the ongoing dependence of modern economies on both conventional and resource-intensive sectors.

The mining and quarrying sector is increasingly examined not only through its financial performance but also through its broader economic, social, and environmental impacts. Carr-Wilson et al. (2024) highlight the growing focus on the environmental, social, and governance (ESG) aspects of critical mineral extraction. This is particularly important in the context of pressures to achieve the energy transition without compromising social and environmental standards. Economic literature often emphasizes the dual nature of mining. Mining can be characterized both as a driver of growth, employment, and exports, and as a contributor to environmental challenges and social tensions (Collier & Venables, 2010). This ambivalence has sparked intensive debate on sustainable resource management and the concept of the "resource curse," according to which resource-rich countries do not necessarily achieve stable economic development (Sachs & Warner, 1995).

Numerous studies indicate that increased mineral and ore exploitation has become a defining feature of transition economies, particularly in the context of rising global demand for raw materials. Hilson (2002) emphasizes that small and medium-scale mining activities in developing countries contribute significantly to local economic growth, while simultaneously generating a range of social and environmental challenges. Studies focusing on the African continent show that the mining boom during 2000–2010 accelerated urbanization and transformed local communities (Provenzano & Bull, 2021; Bryceson et al., 2022). Similar trends have been observed in South and Southeast Asia, where the expansion of the middle class and rapid industrialization have increased demand for metals such as copper, aluminum, and steel (Elshkaki et al., 2016; Dong et al., 2019).

Regarding transition economies, the literature highlights specific challenges associated with post-socialist transformation processes. The OECD (2019) and Vakulchuk et al. (2021) note that countries in Eastern Europe and Central Asia have intensified mineral resource exploitation in attempts to attract FDI and secure foreign exchange revenues. However, this development model is often accompanied by structural contradictions between requirements to comply with green policies (e.g., within the EU accession process) and pressures to open markets to transnational companies, which create conditions conducive to increased natural resource extraction (Vivoda & Loginova, 2025). These findings suggest that both developing and transition economies are experiencing strong growth in extractive activities while simultaneously facing complex sustainability challenges, encompassing economic benefits, social tensions, and environmental impacts.

Serbia has significant reserves of copper, coal, lead, zinc, lithium and other rare minerals. Accordingly, mining and mining-related activities were an important part of Serbia's economy through the history. The mining industry in Serbia remained predominantly state-owned from the nationalization of mineral resources in 1951 until the early 2000s, encompassing major mining complexes such as Resavica, Majdanpek, Bor, and Kostolac. Despite its economic importance, mining and quarrying accounted for only 7.6% of FDI inflows to Serbia between 2010 and 2017 (Stuehlen et al., 2024).

In recent years, the discovery of new deposits of copper, gold, and particularly lithium has made Serbia increasingly attractive to transnational mining companies (Đorđević et al., 2024; Vivoda & Loginova, 2025). New opportunities to exploit resources that had previously remained outside the sector's main focus have emerged (Šajn et al., 2022). The trend has been reinforced by incentives offered by the national government with the explicit aim of attracting FDI. With ore rents ranging between five and seven percent (Official Gazette of the Republic of Serbia, 2023), Serbia has the lowest rates compared to neighboring countries. In addition, the procedures for obtaining exploration and exploitation permits have been substantially simplified. Mining activities are gradually returning to sites that were once active, albeit now facing new and more complex challenges (Sydd et al., 2022). The primary limitation lies in the insufficiently developed legal and regulatory framework, which fails to clearly and explicitly safeguard state interests, local communities, and the environment.

3. Financial analysis of mining and quarrying sector in Serbia

To evaluate the sustainability of mining and quarrying in Serbia, it is necessary to combine structural and financial indicators. The first step is to analyze the evolution of the number of enterprises and employees. This provides insight into the sector's scale and contribution to employment, which is crucial in assessing the socio-economic role of mining alongside its financial results. To take insight of operation of this sector data for 2020 (as pandemic crisis year) and last available data (for 2024) are presented in Table 1.

Table 1. Number of employees and enterprises

Year	Number of employees	Number of enterprises	Share in total number of employees	Share in total number of enterprises
2020	25,352	377	2.08	0.35
2024	29,767	386	2.25	0,34
Change (in %)	17,41	2.39	8.17	-2.86

Source: Authors

As shown in Table 1, between 2020 and 2024 the number of enterprises in the mining sector increased slightly (+2.39%), while employment grew more significantly (+17.4%). This suggests that new entrants, along with restructuring existing state enterprises, have generated additional jobs. However, the share of mining in total enterprises remained stable, while its share in total employment grew, highlighting the sector's rising importance in job creation.

To complement the analysis of enterprise dynamics, the financial position of the sector is examined. Table 2 presents aggregated balance sheet data for 2020 and 2024, which reveal changes in capital structure, assets, and liabilities.

Table 2. Balance sheet for Sector B - Mining and quarrying in Serbia in 2020 and 2024

Description	2020	2024	Change (in %)
ASSETS			
Subscribed capital unpaid	1.488.534	1.981.384	33,11
Fixed assets	491.035.197	925.889.314	88,56
Deferred tax assets	2.922.312	4.470.939	52,99
Current assets	161.529.382	364.409.841	125,60
Total assets	656.975.425	1.296.751.478	97,38
Off-balance sheet assets	136.140.569	204.402.455	50,14
EQUITY AND LIABILITIES			
Equity	362.891.105	754.600.371	107,94
Long-term provisions and liabilities	168.615.148	255.138.316	51,31
Deferred tax liabilities	601.734	1.094.557	81,90
Long-term deffered revenues and received donations	0	6.592	/
Short-term provisions and short-term liabilities	150.716.512	308.927.149	104,97
Loss above equity	25.849.074	23.015.507	-10,96
Total equity and liabilities	656.975.425	1.296.751.478	97,38
Off-balance sheet liabilities	136.140.569	204.402.455	50,14

Source: Authors

The balance sheet shows that total assets nearly doubled (+97.4%) between 2020 and 2024, with particularly strong growth in current assets (+125.6%) and fixed assets (+88.6%). Equity more than doubled (+108%), but liabilities also rose substantially, especially short-term liabilities (+105%). What is striking, however, is that these financial indicators have expanded far more rapidly than the number of enterprises (+2.39%) or employees (+17.4%). This suggests that growth in the sector was not primarily driven by a large influx of new firms, but rather by capital intensification and balance sheet expansion within existing enterprises. In other words, mining companies (especially the larger and more established ones) mobilized significant financial resources, investing heavily in fixed assets and working capital to increase production capacity.

The reduction in loss above equity (-11%) points to an improvement in solvency, indicating that enterprises have become more financially stable overall. Still, the parallel surge in both long-term and short-term liabilities shows that this expansion was financed not only by retained earnings and new equity, but also by borrowing. This pattern reflects a capital-deepening strategy where productivity gains are achieved through large-scale investments rather than broad-based growth in the number of companies. The sector's sustainability rests on the financial resilience of a relatively small number of capital-intensive enterprises, making debt management and profitability key conditions for long-term stability.

While the balance sheet shows the sector's resources and obligations, the income statement provides insight into performance and efficiency. To complement balance sheet information, the income statement for Sector B - mining and quarrying is presented in Table 3.

Table 3. Income statement for Sector B - Mining and quarrying in Serbia in 2020 and 2024

Description	2020	2024	Change (in %)
Operating income	294.832.616	913.186.144	209,73
Operating expenses	292.350.777	704.927.521	141,12
Operating profit	19.261.390	218.669.185	1035,27
Operating loss	16.779.551	10.410.562	-37,96
Financial income	10.382.445	8.928.334	-14,01
Financial expenses	7.429.594	27.082.166	264,52
Profit from financing	5.082.308	439.079	-91,36
Loss from financing	2.129.457	18.592.911	773,13
Income on value adjustment of financial assets	1.016.061	471.257	-53,62
Expenses on value adjustment of financial assets	5.818.693	1.149.158	-80,25
Other income	4.736.680	7.361.582	55,42
Other expenses	3.392.223	5.136.485	51,42
Total income	311.092.775	929.947.317	198,93
Total expenses	309.125.756	738.295.330	138,83
Profit from regular business operations before tax	20.341.152	203.882.132	902,31
Loss from regular business operations before tax	18.364.637	12.230.145	-33,40
Positive net effect on results from discontinued operations	124.973	27.984	-77,61
Negative net effect on result from discontinued operations	134.469	147.904	9,99
Profit before tax	20.332.375	203.752.918	902,11
Loss before tax	18.365.356	12.220.851	-33,46
Tax on profit	802.019	23.923.321	2.882,89
Personal indemnities paid to employer	1.074	23.874.498	2.222.851 ,40
Net profit	17.815.967	160.196.054	799,17
Net loss	16.652.041	12.196.565	-26,76
Positive net result	1.163.926	143.734.248	12.249,09

Source: Authors

The income statement confirms that the mining and quarrying sector in Serbia underwent a profound transformation between 2020 and 2024. Operating income more than tripled (+209.73%), while operating expenses grew much more slowly (+141.12%). It resulted in increase of operating profit increased more than tenfold (+1,035.27%), The rapid rise in financial expenses (+264.52%), and modest decrease in financial income (-14.01%) resulted in financing losses (+773%), revealing that part of profitability growth was underpinned by increased reliance on debt financing. This aligns with balance sheet data, which shows sharp increases in liabilities. While debt-supported expansion has allowed enterprises to modernize and scale up production, it also introduces greater financial risk if market conditions (before all, commodity prices and interest rates) become unfavorable. Finally, net profit rose nearly eightfold (+799.17%), which indicates significant improvements in profitability at the sector level. These profitability results are far out of proportion to the relatively modest increase in employment and the small rise in the number of enterprises, indicating that the bulk of financial

improvements stemmed from productivity gains and efficiency improvements within existing enterprises, rather than broad-based sectoral expansion.

4. Data and methodology

Based of balance sheet and income statement analysis in is evident that analyzing profitability and indebtedness ratios of mining quarrying sector in comparison to other leading export sectors in Serbia is crucial for shaping evidence-based policies that support sustainable mining. Profitability indicators reveal whether mining enterprises generate sufficient internal resources to finance modernization, environmental protection, and community investments. Indebtedness measures indicate the sector's ability to balance external financing with long-term liabilities, which is essential for undertaking costly remediation projects and improving safety standards. According to the balance sheet and income statment data appropriate profitability and indebtenes ratios are calculated.

In this case, the following profitability ratios are used: operating profit margin (PF1), net profit margin (PF2), Return on Assets (PF3), and Return on Equity (PF4). On the other hand, indebteness indicators used in this analysis are: inndebtness ratio (DB1), leverage (DB2), and share of long term debt in total equity and liabilities (DB3).The NACE classification of economy sectors are used.

To perform comparative analysis the entropy-based PROMETHEE II method is used. The PROMETHEE II method, part of the PROMETHEE family of outranking methods developed by Brans (1982) and further extended by Brans & Vincke (1985), Brans et al. (1986), and Brans & Mareschal (1995), is applied in this study to rank ten sectors with highest share in exports. This method ranks a set of alternatives by calculating a preference value for each of them, based on multiple criteria that are to be either maximized or minimized. Each alternative is evaluated through positive and negative preference flows. The net preference flow is computed as the difference between mentioned two preference flows and based on it final ranking in performed. To implement PROMETHEE II, it is necessary to specify for each criterion the direction of preference (minimization or maximization), weights indicating importance of each criterion, a suitable preference function (linear, usual, U-shape, V-shape, level, or Gaussian), and relevant thresholds for selected function (Brans & Vincke, 1985).

As it is already stated, assigning appropriate weight to each indicator in the analysis is essential for effective multi-criteria decision-making. An appropriate approach for determining the weights of selected indicators is essential for solving MCDM problems. The most widely recognized method for generating objective weights is the entropy method (Hwang & Yoon, 1981; Zeleny, 1982; Zou et al., 2006). Information entropy measures the degree of disorder within a system (Meng, 1989), indicating the amount of useful information each criterion provides. When the variation among alternatives on the same indicator is large (and entropy is low), that indicator carries more useful information and is assigned to gain a higher weight. Conversely, indicators with less variation (and higher entropy) are considered less informative and receive lower weights (Qiu, 2002). This ensures that the weight assignment process is data-driven and objective, leading to a more robust analysis.

Table 4 present evaluation matrix used for ranking of sectors taking into account all obsered indicators together usin PROMETHEE method. Weights are calculated using entropy method. V-shape function is used with preference flo set at level of standard deviation, in order to asign highest value of preference to better alternative when difference between two alternatives exceedes standard deviation.

Table 4. Evaluation matrix

Criteria	PF1	PF2	PF3	PF4	DB1	DB2	DB3
min/max	max	max	max	max	min	min	min
weight	0,16	0,14	0,14	0,13	0,13	0,15	0,13
preference function	V-shape	V-shape	V-shape	V-shape	V-shape	V-shape	V-shape
thresholds	absolute	absolute	absolute	absolute	absolute	absolute	absolute
p	5,25	3,78	5,77	4,38	16,38	0,52	8,91
B - Mining and quarrying	22,81	15,74	16,06	19,10	41,35	0,71	17,63
C - Manufacturing	5,42	3,59	4,90	7,15	19,44	0,43	15,00
N - Administrative and support service activities	7,28	2,44	3,02	1,85	38,58	0,71	16,41
J – Information and communication	7,05	5,43	3,90	8,54	66,23	1,89	13,59
E - Water supply; sewerage; waste managment and remediation activities	4,47	3,35	6,65	12,19	64,50	1,58	13,77
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	4,99	2,77	3,43	4,35	45,32	1,03	21,38
F - Construction	6,49	4,46	4,23	6,82	64,34	1,51	23,65
H - Transporting and storage	10,82	6,09	6,93	10,04	61,44	1,58	30,21
I - Accommodation and food service activities	4,28	1,86	2,37	2,79	76,80	2,08	0,25
M - Professional, scientific and technical activities	6,38	4,63	6,24	11,11	62,64	1,53	0,27

Source: Authors

The weights calculated by the entropy method presented in Table 4 indicate that the highest weight is assigned to the operating profit margin - PF1 (0.16), showing that this indicator most strongly differentiates sectoral performance. By contrast, the lowest weights are attached to net return on equity - PF4, the indebtedness ratio - DB1, and the share of long-term debt in total equity and liabilities - DB3 (0.13), suggesting that cross-sectoral differences for these indicators are less pronounced. Another important conclusion is that the mining and quarrying sector demonstrates outstanding results in all four profitability indicators. Its operating profit margin - PF1 (22.81) is substantially higher than that of manufacturing (5.42), transport and storage (10.82), or information and communication (7.05). Net profit margin - PF2 (15.74) is also significantly above most other sectors. In terms of return on assets - PF3 (16.06) and return on equity - PF4 (19.10), mining again leads, significantly outperforming traditional export-oriented sectors, like manufacturing. This indicates that the capital invested in mining generates much higher returns than in other leading export sectors.

However, indebtedness indicators reveal the other side of this dynamic. The indebtedness ratio for mining - DB1 (41.35) is well above manufacturing (19.44) and administrative and support service activities (38.58), but far below information and communication (66.23) or accommodation and food service activities (76.80). Similarly, leverage in mining - DB2 (0.71) is higher than manufacturing (0.43), but still lower than information and communication (1.89) or accommodation and food service activities (2.08). The share of long-term debt in total equity and liabilities - DB3 (17.63) is somewhat higher, but less critical than in sectors such as transport and storage (30.21) or construction (23.65).

Generally observed, the evaluation matrix shows that mining and quarrying sector outperforms other sectors on profitability indicators but exhibits higher indebtedness ratios.

This duality indicates strong internal capacity to generate profit but also a financing structure dependent on debt, which creates long-term risks.

5. Results and discussion

Using the PROMETHEE method, the final ranking of sectors based on profitability and indebtedness indicators is obtained. Table 5 presents these results.

Table 5. Ranking results

Rank	Alternative	Phi	Phi+	Phi-
1	B - Mining and quarrying	0.7437	0.8185	0.0748
2	C - Manufacturing	0.1867	0.4020	0.2153
3	N - Administrative and support service activities	0.1203	0.3513	0.2310
4	J - Information and communication	0.0539	0.3864	0.3325
5	E - Water supply; sewerage; waste managment and remediation activities	-0.0451	0.2930	0.3381
6	G - Wholesale and retail trade; repair of motor vehicles and motorcycles	-0.0650	0.2524	0.3174
7	F - Construction	-0.1138	0.2292	0.3430
8	H - Transporting and storage	-0.1697	0.2339	0.4036
9	I - Accommodation and food service activities	-0.2252	0.1638	0.3890
10	M - Professional, scientific and technical activities	-0.4858	0.1182	0.6040

Source: Authors

The PROMETHEE ranking results presented in Table 5 provide a comprehensive overview of the relative standing of Serbia's key export sectors when profitability and indebtedness indicators are considered together. Mining and quarrying ranks first with a very high net preference flow (0.7437), indicating that its strong profitability clearly outweighs its indebtedness vulnerabilities when compared with other sectors. This confirms its leading position in terms of sustainability potential, provided that financial gains are strategically reinvested. These results correspond with global findings that mining remains a cornerstone of industrial development and is especially attractive in the era of clean energy transition, where demand for critical raw materials is accelerating (Lapko et al., 2019; Baldassarre & Carrara, 2025). Serbia's strong ranking in mining is consistent with recent discoveries of copper, gold, and lithium deposits, which have drawn international investors (Đorđević et al., 2024; Vivoda & Loginova, 2025). However, as literature on transition economies stresses (OECD, 2019; Vakulchuk et al., 2021), reliance on foreign capital and resource exploitation often brings structural vulnerabilities, reflected here in the relatively high indebtedness ratios despite strong profitability.

Manufacturing occupies second place (0.1867), demonstrating that although less profitable than mining, it maintains a balanced performance with manageable indebtedness, making it a stable and competitive sector. Administrative and support service activities follow in third (0.1203), and information and communication take fourth place (0.0539). Importantly, these first four sectors all have positive net preference flows, which means that their advantages relative

to other sectors outweigh their disadvantages. In other words, when compared with the rest of the economy, these sectors demonstrate stronger overall financial sustainability profiles.

By contrast, all remaining sectors show negative net preference flows, indicating that their disadvantages outweigh their advantages. Water supply and waste management ranks fifth (-0.0451), still relatively close to balance, followed by wholesale and retail trade (-0.065) and construction (-0.1138). Transport and storage (-0.1697) and accommodation and food services (-0.2252) rank lower, reflecting their weaker profitability and higher indebtedness. Professional, scientific, and technical activities record the weakest performance (-0.4858), suggesting that in this sector disadvantages strongly dominate advantages.

The ranking results not only demonstrates the relative financial superiority of mining in Serbia but also underscores the broader contradictions outlined in the literature: mining is both a driver of competitiveness and a source of sustainability challenges. Policymakers must therefore ensure that the sector's profitability is effectively channeled into long-term investments in environmental safeguards, community development, and regulatory oversight.

6. Policy implications

Serbia possesses significant reserves of copper, gold, lithium, and borates, which could play a vital role in strengthening long-term economic growth (Ignjatović et al., 2025). Yet, recent controversies surrounding large mining projects demonstrate that weak environmental and social safeguards can undermine public trust and create long-term ecological risks. Despite being one of the most profitable sectors, mining in Serbia is also responsible for more than 95% of the country's hazardous waste, while its CO_2 emissions remain significant at 264.2 kilotons in 2023. These facts illustrate the ambivalence of the sector: it is both a driver of competitiveness and a source of environmental challenges.

The fiscal regime for mining relies on royalties, corporate income tax, and concession agreements, but it faces persistent weaknesses. Environmental tax revenues average 4% of GDP across all sectors (Statistical Office of the Republic of Serbia, 2008–2025), yet funds collected through these instruments are rarely reinvested in environmental protection (Radovanović & Stojmenović, 2019). Moreover, royalties remain low at around 5% of income, and ecological penalties are insufficient to stimulate companies to reduce their environmental footprint (Official Gazette of the Republic of Serbia, 2023; Sydd et al., 2022). This reflects a broader policy dilemma identified in the "resource curse" literature (Sachs & Warner, 1995; Collier & Venables, 2010): while high profitability creates fiscal space for reinvestment, weak governance and low rent capture limit the transformation of resource wealth into sustainable development.

Based on the results of this study, policymakers should adopt a more balanced and robust framework for capturing and redistributing mining rents. Introducing a sliding-scale royalty system linked to mineral prices and profitability would enable the state to benefit more during commodity booms, while differentiated rates for strategic minerals such as lithium would reflect their growing importance in the global energy transition. Strengthening ecological penalties and ensuring that environmental tax revenues are earmarked for remediation and green investments would help align Serbia's policies with EU accession requirements and international sustainability standards (Carr-Wilson et al., 2024).

In parallel, direct support should be provided to encourage sustainable mining practices. Profitable firms should be encouraged to reinvest earnings into cleaner technologies, renewable energy, and circular-economy solutions. State aid should be carefully targeted toward vulnerable but strategically important enterprises, with strict conditions tied to sustainability performance. Given that profitability in the sector is supported by debt-financed expansion, policymakers must also monitor trends indebted to avoid financial instability. By integrating fiscal, environmental, and industrial policies, Serbia can position its mining industry not only as

a pillar of export competitiveness but also as a responsible supplier of critical minerals aligned with national development goals and EU climate commitments.

7. Conclusion

This study, by applying the entropy-based PROMETHEE method to sector-level financial data, provides a comprehensive comparison of the profitability and indebtedness of Serbia's mining and quarrying sector with the country's top ten export sectors. The ranking results reveal that mining and quarrying stands out as the leading sector overall, with its strong profitability decisively outweighing its indebtedness vulnerabilities. Importantly, only a few sectors demonstrate similarly positive financial sustainability, while most exhibit weaknesses either in profitability, indebtedness, or both. Although mining sector contributes positively to economic growth, export, employment and wages, it faces significant challenges in terms of environmental impact and limited tax contributions. The analysis of profitability ratios confirms whether mining firms can internally finance crucial sustainability investments, while indebtedness ratios reveal the extent to which additional borrowing would be required (which potentially increases fiscal risk).

The Serbian mining sector remains economically significant, but structural weaknesses persist, particularly among public mining companies reliant on state support due to low exploitation rents and inadequate ecological penalties. In contrast, privatized mining enterprises generally display greater financial resilience and a higher capacity to internalize environmental and social costs. To ensure that mining expansion delivers sustainable and inclusive growth, Serbia must align financial performance with environmental and social responsibility. This necessitates updating fiscal frameworks, enhancing environmental regulation, and embedding sustainability across the mining value chain, from exploration and licensing to extraction, processing, and land rehabilitation. By adopting EU-aligned standards, ensuring transparent revenue management, and promoting community engagement, Serbia can minimize the sector's negative externalities and maximize its contribution to national development.

In addition, these targeted policy actions will enable Serbia to transform its mineral wealth into a catalyst for long-term economic prosperity while reinforcing its role as a responsible and reliable partner in Europe's green transition and the global supply of critical minerals.

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