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RESILIENCE OF INTERNATIONAL COAL ENTERPRISES TO ECONOMIC CRISES FROM A FINANCIAL PERSPECTIVE

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Purpose: With the widespread globalization and internationalization of human activities, changes – both beneficial and destructive – are shifting and escalating very rapidly. As a result, the exposure of economies, industries, and the companies operating within them to the risks and effects of the changes that have occurred is increasing. Thus, the purpose of the article is to assess the resilience of international coal enterprises to economic crises (the Covid-19 pandemic and Russia's invasion of Ukraine) from a financial perspective.
Design/methodology/approach: The analysis conducted in the article covers the years from 2010 to 2023. It includes 15 international coal companies, which, due to the scale of internationalization, and thus exposure to economic risk, were further divided into three groups. The research methodology is based on financial analysis indicators and econometric modelling of bankruptcy risk.
Findings: The results show an increase in exposure to crisis risks in companies with a higher share of exports in sales. The consequences of cyclical changes are also more severe for all coal companies with generally weak financial conditions. The economic crisis is also more intensely experienced by mining companies in the immediate vicinity of its outbreak.
Research limitations/implications: This analysis is financial in nature and does not focus on other aspects of the business, which may pose a certain research limitation. Furthermore, the relationships and reactions described are not statistically confirmed and, aside from crises, the impact of other factors on the financial condition of the companies studied is not analysed.
Practical implications: Despite similar problems, the adaptability and resilience of mining companies in different regions can differ significantly. Thus, there is a real opportunity to strengthen the resilience of coal companies by among others: planning production considering national and international economic conditions, as well as opportunities for both product and geographic diversification and optimizing the share of exports in sales.
Social implications: The role of the state in mitigating economic shocks should become apparent long before economic changes occur, as the energy market is insensitive to ad hoc and short-term decisions.
Originality/value: The contribution of the research to industrial economics is to determine the financial consequences of the impact of economic crises on the operation of coal companies and to answer the question of the extent of their crisis resilience.
Keywords: resilience; economic crisis; mining company; financial dimension of resilience.
Category of the paper: Research paper.

1. Introduction

The last fifteen years have been a period fraught with many rapid and profound changes of varying nature and origin (Gaigaliene and Jurakovaite, 2024; Vukovic et al., 2017; Kozub-Idźkowska, Proniewski, 2011). Some were positive, stimulating socio-economic develop-ment, such as the development of Industry 4.0 (Valaskova et al., 2024; Eger, Žižka, 2024), or the wider use of artificial intelligence in business and society (Yu et al., 2021; Shoufu et al., 2021; Doloreux, Turkina, 2021). Others, on the other hand, had a devastating im-pact on the environment and the economy, such as natural and climatic disasters, the Covid-19 pandemic (Ayinde et al., 2024; Zheng et al., 2023), the subprime mortgage crisis (Kao et al., 2018; Seabrooke, 2010), or armed conflicts (Merli, 2024; Kulyk, 2023).

With the widespread globalization and internationalization of human activities, changes – both beneficial and destructive – are shifting and escalating very rapidly (Armah, Amewu, 2022; Filipava, 2024). As a result, the exposure of economies, industries, and the companies operating within them to the risks and effects of the changes that have occurred is increasing. This exposure is particularly acute for the mining industry, due to its traditional nature, low level of adaptation to change, and detrimental impact on the environment and local communities (Kramarz, 2021; Andrews, Oppong, 2022).

Under such circumstances, resilience, understood as an organization's invulnerability or insensitivity to crisis factors, is a particularly desirable characteristic (Elliott, 2014). In practice, it means the avoidance of problems and difficulties and the ability to resist the negative impact of the socio-economic environment (Zabłocka-Kluczka, 2014; Tarapata, Woźniak, 2022). It allows to cope with threats and can be a driver of entrepreneurship, even during recessions (Sienkiewicz-Małyjurek, 2020). Thus, having resilience conditions the interruption of an enterprise during an economic crisis.

Given these circumstances, the purpose of the article is to assess the resilience of international coal enterprises to economic crises (the Covid-19 pandemic and Russia's invasion of Ukraine) from a financial perspective. Analyses in such a context are very rarely conducted. This is because the literature is dominated by economy-wide considerations using mainly statistical and/or econometric research tools. These are of a macroeconomic, environmental or social nature, with the result that the area of microeconomic and financial consequences of economic crises is overlooked and neglected. Meanwhile, building resilience at the meso and macro levels is not possible without developing individual resilience strategies for individual companies.

The analysis conducted in the article covers the years 2010-2023. It includes 15 international coal companies, which, due to the scale of internationalization, and thus exposure to economic risk, were further divided into three groups. The research methodology is based on financial analysis indicators, to identify the effects of the economic crisis

on individual companies and assess their resilience in financial terms. These indicators identify profitability, liquidity, quality of working capital management and debt. In addition, an econometric bankruptcy prediction model was used in the process of aggregating the obtained results.

The contribution of the research conducted to the economics of mining companies is due, according to the above argumentation, to the following circumstances:

- Considering the financial micro-perspective of the resilience of mining companies to crisis situations, which is neglected in contemporary research.
- Carrying out a diagnosis of resilience in a group of 15 mining companies, considering the scale of internationalization of their operations.
- Using financial analysis tools and an econometric bankruptcy pre-diction model to assess the economic dimension of resilience in mining companies.
- Identifying characteristics, that promote the resilience of mining companies to economic crises.
- Formulating management conclusions towards strengthening the resilience of mining companies.

In the following part of the article, literature studies are presented that provide the background for the research problem undertaken. They concern risk resilience in the mining industry and the response of mining companies to the Covid-19 pandemic and Russia's invasion of Ukraine. Based on these, a substantive and methodological research gap was identified. Then, the research approach was described, and the results of the analysis were presented. The entire discussion is closed with recommendations and a summary of the research results, that also includes research limitations and directions for further research.

2. Literature review

2.1. Risk resilience in companies and the mining industry

Considerations of corporate and extractive industry resilience are currently focused on several key issues. An overview of these is provided later in this subsection.

In contemporary research on the resilience and risk of extractive companies, a lot of attention is paid to the security of supply, which can be threatened by sudden random events and unexpected economic crises. Thus, Radebe and Chipangamate (2024) distinguish four groups of risk factors, that must be considered in the planning process of the minerals and metals supply chain. These are conditions relating to: machinery and technical systems, human resources, the environment, and general logistical circumstances. The authors also emphasize that creating effective resilience strategies requires a high level of competence in hazard

assessment and risk management. This observation demonstrates the importance of adequately preparing mining companies for economic crises, that are difficult to predict and violent.

Similar conclusions are made by Lim-Camacho et al. (2021) based on a study of Australian mining companies exposed to risks associated with sudden climatic events (e.g., cyclone). The authors believe that strengthening the resilience of the entire mineral supply chain requires a systemic approach for identifying levers, that managers and policy makers can use to facilitate discussion and decision making toward the goal of responsive, resilient and rewarding mining value chains.

Maoela et al. (2024) look at supply chain resilience from the perspective of workers in mining companies in South Africa affected by the Covid-19 pandemic. Their surveys show that the impact of the crisis has affected different occupational groups in different ways. Nevertheless, the pandemic in all cases analysed reduced the income and general well-being of workers. In strengthening industry's resilience to future crises, it is, therefore, necessary to take a proactive stance and develop a plan of countermeasures to prevent long-term negative impacts on human resources.

Given the climate risks, the issue of resilience of mining companies is also being analysed in an environmental context. Studies by Gustafsson et al. (2022), conducted in a group of multinational private mining corporations, show, that most of the surveyed companies have implemented a system for assessing the impact of climate on business operations and have integrated environmental risk management. Nevertheless, this attitude and actions are primarily the result of investor pressure. Local community opinion and legal legislation are far less important in this case, illustrating the power and importance of private capital in transforming the mining industry and shaping its resilience to changes in the socio-economic environment.

The low resilience of mining companies to environmental changes is also described by Xiao et al. (2021) using Chinese coal mines as an example. The authors note, that the main manifestation of the mining industry's ecological adaptation is the natural link between the intensity of mining and the scale of the harmful impact of mining on the environment. It is, therefore, imperative to strengthen the process of conscious and long-term planning for sustainable development of mining areas.

Many studies also expose the low resilience of the mining industry to economic shocks in very different contexts. One of these is the local and regional approach. In this thread, da Silva et al. (2021) analyse the situation of Brazilian municipalities associated with iron ore mining after the sharp drop in iron ore prices in 2013. Their findings show, that the vast majority of local communities lack economic resilience and are unable to cope with the financial and fiscal consequences of reduced demand. This illustrates the low awareness of the consequences of economic changes and the poor preparedness of local authorities to manage risks.

Low community resilience to changes related to mine operations is also described by Wasylycia-Leis et al. (2014). According to the authors, it can be strengthened mainly by effective governance, which, in practice, means cooperation between mining companies and local authorities, the development of sustainable mining development plans and ongoing communication of all stakeholders involved in the development of the mining industry.

The importance of cooperation between mining company stakeholders increases in the case of mine closures, which most often represent an economic and social shock to the local community. Preparing a region for the impact of mine closures, according to Syahrir et al. (2021), should, therefore, begin as early as the start of mining operations. In addition, it is critical to take a responsible approach to planning alternative paths for regional development, using best practices and involving both local government and the mining industry.

According to Maconachie and Conteh (2025), the mining industry is also characterized by low resilience to changes and transformations induced by the socio-economic environment, especially in less developed regions. This is most often due to financial shortcomings, as well as the habits and customs of mining communities (Jonek-Kowalska, 2024). Adaptation to change is also complicated by environmental challenges, forcing a rapid and effective energy transition (Li et al., 2024). However, as Hu and Hassik (2017) describe, despite similar issues, the adaptive capacity and resilience of mining companies in different regions can differ significantly, which accentuates the importance of proper governance in mitigating socioeconomic risks.

2.2. Mining industry responses to the Covid-19 pandemic and the Russia-Ukraine armed conflict

Given the hypersensitivity of the mining industry to change, one can conclude, that sudden and deep crises caused by unpredictable circumstances are a particular threat to mining companies. In the past five years, such crises can certainly include the Covid-19 pandemic and the Russia-Ukraine armed conflict.

In this vein, research on a group of 333 gold mining companies is conducted, among others, by Klayme et al. (2023). Their conclusions show, that the Covid-19 pandemic has exacerbated the risk aversion of capitalists and inhibited industry investment. This attitude is holding back the development of the mining sector for many years, due to the time and capital intensity of investment in mining companies.

It is interesting, however, that the mining industry's response to deep economic crises is not uniform. Studies by Zhang et al. (2023) show, in fact, that in the case of coal mining, the Covid-19 pandemic contributed to increased production and demand for thermal coal, thus reviving the sector's operation and halting decarbonization. This is primarily due to the volatility of energy prices and the uncertainty of alternative energy supplies, and the desire of countries to maintain energy security at the expense of other energy policy priorities.

Similar observations are presented by Liu et al. (2022) in the case of China's coal sector. The authors note, that the Covid-19 pandemic caused a significant increase in demand for hard coal and a marked expansion of domestic coal production. Nevertheless, as a result of the crisis, China's raw material exports declined and, as a result, mining companies focused on internationalization of mining operations suffered the most.

The changes in the international hard coal market caused by the Covid-19 pandemic are also confirmed by a study by Parra et al. (2021). Furthermore, the authors also note the increase in the use of hard coal as an energy feedstock, which poses a threat to the implementation of zero-carbon climate policy and negatively impacts the environment.

In their analysis of the energy raw materials market response to the Covid-19 pandemic, Wang et al. (2022), in turn, point to the risk transmission mechanism between the oil and thermal coal sectors. They also emphasize the role of state interventionism in mitigating raw materials market crises, although they also note its waning effectiveness over time. Their observations suggest that, in the future, volatility and risk in the energy raw materials market under the influence of economic fluctuations may increase significantly.

A factor, that has certainly increased uncertainty in the energy raw materials market, is the Russia-Ukraine armed conflict, which has resulted, among other things, in an embargo on coal and gas supplies from Russia to Europe. Under these conditions, as in the case of the Covid-19 pandemic, some regions (e.g., Poland) have begun to reconsider increasing thermal coal production and postponing the liquidation of hard coal mining (Bijańska, Wodarski, 2024; Overland, Loginova, 2023; Ślusarczyk et al., 2023).

As a result, coal is still the main energy resource in the Polish economy. Following the invasion, only the directions of its inflow to Poland changed (Jonek-Kowalska, Grebski, 2024; Carmona, Dąbkowska, 2024). Thus, the adopted policy adversely affects the energy transition and the implementation of EU environmental policy in the country.

There is also no shortage of hypotheses in the literature about the beneficial effect of reducing the supply of Russian coal and oil on the greening of the energy industry. Such a view is represented by Clegg (2024), who states, that shortages in the supply of traditional energy resources can become an impetus for accelerating the green transition and making European countries independent of non-renewable energy sources. This calls into question the sense of the Russian invasion of Ukraine and the importance of Russia's energy resources in creating economic development.

The above views are also shared by Černoch et al. (2024), who believe, that limiting the supply of Russian coal to Europe will accelerate the decommissioning of mining and force the adoption of alternative energy development paths in many other European countries.

However, the question of the feasibility of choosing pro-environmental energy policies remains open, especially in emerging and developing countries, that are clearly struggling with energy transition. After all, it is one thing to set development directions, that are otherwise clear and lucid, and quite another to implement them, which requires determination, investment,

time, and a lasting change in attitudes and views. This is clearly confirmed by the recent course in the energy policy of Germany, which was at the forefront of Europe's green transition, and is now reopening mines and investing in coal-fired power plants (Kinkartz, 2022).

The wishful thinking of rapid and effective change in energy policies seems to be confirmed by Xin and Zhang's (2024) research. Indeed, their analysis shows, that the highest energy instability, manifested, among other things, by large fluctuations in energy prices, is for countries that impose sanctions on Russia. Countries, that do not restrict trade with Russia, are characterized by higher resilience to the crisis, as is Russia itself. Further escalation of sanctions and armed conflict, according to the authors, could contribute to destabilizing the energy market in most European countries.

Meanwhile, the increase in prices in the mining and quarrying sector as a result of Russia's invasion of Ukraine was noticeable around the world and, according to estimates by Yagi and Managi (2024), brought a global loss to the world economy of a 2.85% decline in annual GDP. This illustrates the magnitude of the military crisis, not only in relation to the mining sector, but more importantly in relation to overall economic development.

The identifiable impact of the increase in demand and prices for coal and oil caused by the Russia-Ukraine military conflict also affected the quotations of mining companies. A study by Nerlinger and Utz (2022) shows, that it contributed to an increase in the stock prices of mining companies. At the same time, the increase was more intense for North American companies than for European and Asian companies. Thus, those competing with Russian suppliers of fossil fuels were more effective, having gained the opportunity to capture new (mainly European) markets.

It is worth adding, however, that, according to Izzeldin et al. (2023), the crisis triggered by Russia's invasion of Ukraine has less impact on the global economy than the Covid-19 pandemic of 2020 or the subprime mortgage crisis of 2008. Its effects are mainly translated into raw materials markets. The stock and commodity markets are also reacting quickly to it.

2.3. Identification of research gap

From the analyses presented in the previous subsections, it is clear, that considerations of mining industry resilience are concentrated within three main threads, namely: (1) logistical resilience relating to the supply chain; (2) environmental resilience related to the adaptation of mining companies to increasing climate demands; and (3) community resilience to mining operations. The authors of most of these studies use statistical analyses, surveys or case studies. Furthermore, these analyses are conducted at the national or regional level, and less often focus on the mining companies themselves.

In contrast, the threads describing the impact of the Covid-19 pandemic and Russia's invasion of Ukraine on the coal sector largely refer to macroeconomic relations along the demand-supply price line. They are mainly conducted at the economywide level using econometric analysis.

In the context of the above observations, it can be said, that the literature lacks microeconomic analyses, concerning individual companies or groups of companies. The financial consequences of the impact of economic crises on the operation of mining companies are also not determined. Therefore, it is difficult to answer the question of the extent of the resilience of these enterprises to rapid socio-economic changes and to identify the determinants of this resilience.

Given the above research gap, the purpose of this article is to assess the resilience of international coal enterprises to economic crises (the Covid-19 pandemic and Russia's invasion of Ukraine) from a financial perspective. The results of this analysis will provide conclusions on the financial consequences of the aforementioned developments and allow us to assess the extent and distinguishing features of the resilience of the mining companies under study.

3. Research methodology

3.1. Sample and research design characteristics

As already mentioned, the study included 15 coal mining companies operating in the international raw materials market. The selection of the sample for the study was guided by the following considerations:

- the possibility of making direct comparisons, expressed by concentrating the operations of the studied companies primarily on thermal coal mining,
- maximization of the size of the research sample to identify as many responses to economic crises in coal companies as possible,
- financial data availability, which is guaranteed when coal companies are publicly traded on stock exchanges.

The features of coal companies that meet the above requirements are shown in Table 1.

Given the varied size of the share of exports in sales, the companies studied were further divided into three groups. The first included companies with a share of 0% or close to 0%. The second consisted of coal companies with an average share of exports in sales of up to 50%. The third group included companies with the highest share of exports in sales – above 50%. In this way, it was possible to conduct identification of the financial impact of economic crises in connection with the individual risk exposure of the companies studied to the international raw materials market (Arbelo et al., 2024; Domínguez Romero et al., 2024; Shen et al., 2023).

Table 1.
Characteristics of the coal companies in the research sample

Company	Stock Exchange	Coal type	Mining volume [kt]*	Mining site	Directions of sale	Share of exports in sales
China Coal Energy	HKSE*, China	thermal coal	119170	China	China	0.00%
China Shenhua Energy	HKSE, China	thermal coal	324500	China	China	0.00%
Coal India	BSE*, India	thermal coal	703000	India, Africa (Mozambique)	India	0.00%
Bumech	WSE*, Poland	thermal coal	1380	Poland	Poland	0.00%
LW Bogdanka	WSE, Poland	thermal coal	7100	Poland	Poland	0.00%
Hallador Energy	Nasdaq Capital Market, USA	thermal coal	6600	USA	USA	0.00%
NACCO INDUSTRIES	NYSE*, USA	thermal coal	22900	USA	USA	0.00%
PT Bukit Asam	IDX*, Indonesia	thermal coal	37140	Indonesia	Indonesia, India, South Korea, China, Thailand, Italy, Japan, Cambodia, Others	42.11%
Exxaro Resources Limited	JSE*, South Africa	thermal coal	42500	South Africa	South Africa, Switzerland, UK, Japan, Singapore	28.63%
Bisichi Mining	LSE*, UK	thermal coal	807	South Africa	South Africa, UK	22.48%
Alliance Res.	Nasdaq Global Select Market, USA	thermal and coking coal	34900	USA	Europe, Africa, Asia, North America, and South America	15.70%
New Hope	ASX*, Australia	thermal coal, oil	7217	Australia	Japan, China, Taiwan, Chile, Australia	91.53%
Whitehaven Coal	ASX, Australia	thermal and coking coal	15740	Australia	Japan, Korea, Taiwan, Malaysia, New Caledonia, Vietnam, Indonesia, Europe	99.10%
PT Adaro Energy	IDX, Indonesia	thermal coal	65880	Indonesia, Australia	Indonesia, China, Malaysia, India, Japan, Korea, Philippines, Hong Kong, Taiwan, Thailand	88.80%
Banpu Public Company	SET*, Thailand	thermal coal	29900	Thailand, Indonesia, Australia, Mongolia, China	Thailand, Indonesia, Australia, China, Japan, India, Bangladesh, Philippines, Malaysia	97.09%

* HKSE – Hong Kong Stock Exchange, BSE – Bombay Stock Exchange, WSE – Warsaw Stock Exchange, NYSE – New York Stock Exchange, IDX – Indonesia Stock Exchange, JSE – Johannesburg Stock Exchange, LSE – London Stock Exchange, ASX – Australian Securities Exchange, SET – Stock Exchange of Thailand

– share of exports close to 0%; – share of exports up to 50%; – share of exports above 50%; * – status at the end of 2023.

Source: Own compilation based on data from the annual reports of the companies studied.

The source data was obtained from the annual financial statements of the companies studied. The analysis period covers 2010-2023. Two economic crises were considered during the research. The first is the Covid-19 pandemic, which affected all global economies (Ayaaba et al., 2024). The other is the Russia-Ukraine armed conflict, which primarily hit the energy industry (Pata et al., 2023; Ragab, Sultan, 2024). However, its repercussions are also being felt by other branches of the world's economies.

3.2. Description of research methods

As already emphasized in the introduction, the methodology of the analyses conducted in this article is based on the tools used in corporate finance. It is adapted to the subsequent research stages involving the evaluation of the following:

- The profitability of the enterprise as an efficiency dimension of the response to the economic crisis,
- Liquidity and the level of net working capital as a reflection of the actual and potential ability to settle current obligations in the pre- and post-crisis periods,
- The regularity of the capital structure as a dimension of securing the balance between own and foreign sources of financing,
- The risk of bankruptcy as a resultant assessment of the response to the crisis aggregating the assessment of profitability, liquidity and regularity of the capital structure.

The indicators used in the framework of the above research stages are shown in Table 2.

The measures used in the first three stages are among the classic indicators of financial analysis. In the article, they were used to assess their overall volatility over time and their volatility during crisis periods, that is, during the Covid-19 pandemic and after Russia's invasion of Ukraine.

In the final stage of the research, a bankruptcy prediction model was used to collectively assess the changes in profitability, liquidity and capital structure, that occurred during the aforementioned crises. This is because the changes in many indicators are most often multivariate and multidirectional, which provides important analytical conclusions, but makes them difficult to synthesize.

The best-known bankruptcy prediction model is the Altman model. This article uses the Poznań model, developed in Poland in 2004 by M. Hamrol, B. Czajka and M. Piechocki (Hamrol, 2008). According to the literature, despite the passage of time, it is rated as one of the most effective (Wojnar, 2014; Godlewska, 2010) and is based on the main commonly used financial indicators.

Table 2.
List of indicators and research methods used in each research phase

Stage	Index	Formula	Interpretation
Profitability assessment	ROA Return on Assets	$\frac{net\ profit}{total\ assets}$	Efficiency of asset exploitation
	ROE Return on Equity	$\frac{net\ profit}{equity}$	Rate of return for equity donors
	EBIT Margin on Sales	$\frac{EBIT}{sales\ revenues}$	Operating profitability of sales
Evaluation of financial liquidity and net working capital	Current Ratio	$\frac{current\ assets}{current\ liabilities}$	Ability to settle current liabilities from current assets (1.5-2.0 standard)
	Quick Ratio	$\frac{current\ assets - inventories}{current\ liabilities}$	Ability to settle current liabilities from current assets after adjusting for inventories (1.0 standard)
	Net Working Capital Level	$\frac{net\ working\ capital}{total\ assets}$	Portion of fixed capital (equity plus long-term liabilities) involved in financing current assets in relation to total assets
Assessment of the regularity of the capital structure	Total Debt Ratio	$\frac{total\ liabilities}{total\ assets}$	The degree to which a company has used debt to finance its assets (max. 67%)
	Financial Debt to Equity	$\frac{financial\ liabilities}{equity}$	Assessment of the degree, to which financial (interest-bearing) liabilities are secured in equity
	Net Debt to EBIT	$\frac{net\ debt}{EBIT}$	Assessment of the ability to repay net debt (liabilities less cash and cash equivalents) from operating profit
Bankruptcy risk assessment	Econometric bankruptcy prediction model: the Poznań variant	$Z(P) = 3.562\ X_1 + 1.58\ X_2 + 4.288\ X_3 + 6.719\ X_4 + 2.368$ X_1 – Return on Assets X_2 – Quick Liquidity X_3 – Fixed Capital to Total Assets X_4 – Gross Margin on Sales	Bankruptcy risk assessment: $Z(P) \leq 0$ high probability of bankruptcy $Z(P)>0$ no threat of bankruptcy (Hamrol et al., 2004; Kisielińska, Waszkowski, 2010)

Source: Own work based on Wędzki (2009) and Hamrol (2008).

4. Results

4.1. Assessing profitability from the perspective of exposure to international risks and economic crises

The first stage of the analyses assessed the profitability of the coal companies under study. The results of this assessment are included in Figures 1-3 and Tables 3-5.

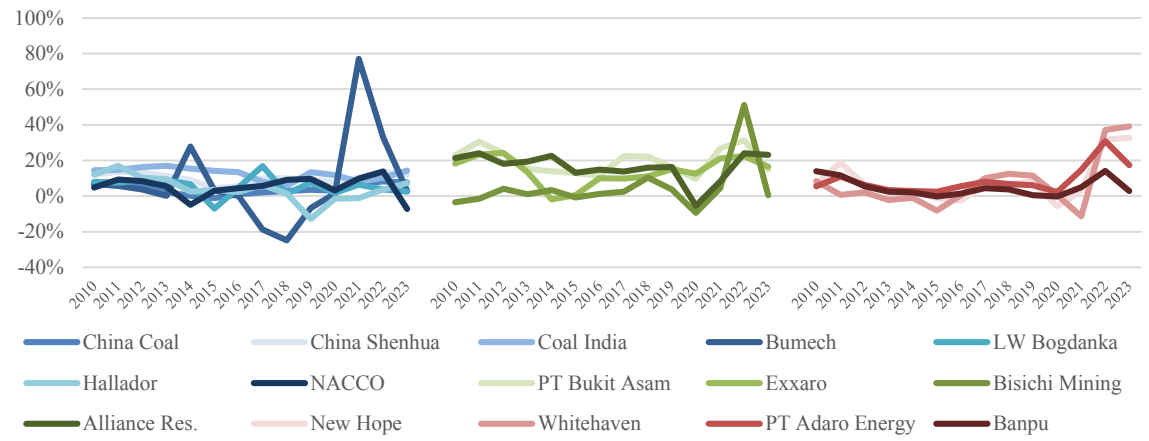

Figure 1. Return on Assets (ROA) of the coal companies studied in 2010-2023 [in %].

Source: own calculations.

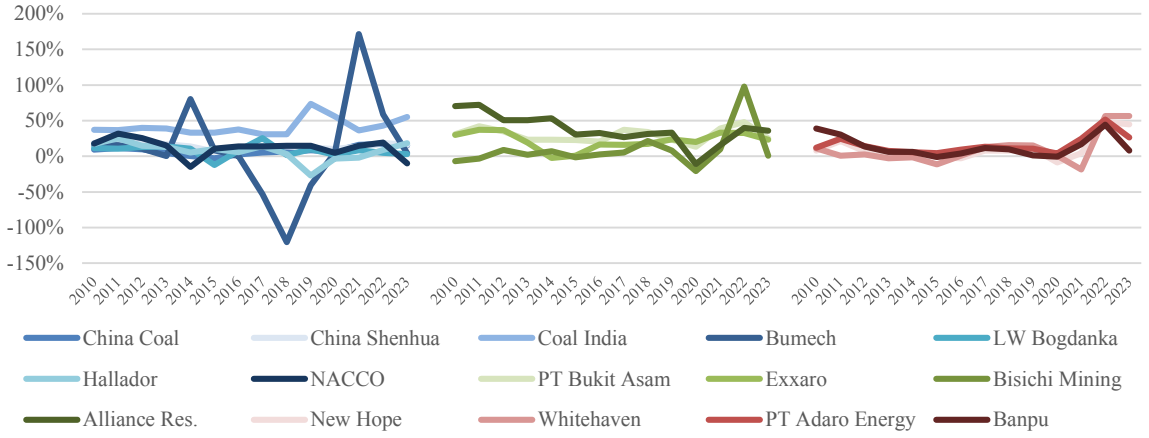

Figure 2. Return on Equity (ROE) of the coal companies studied in 2010-2023 [in %].

Source: own calculations.

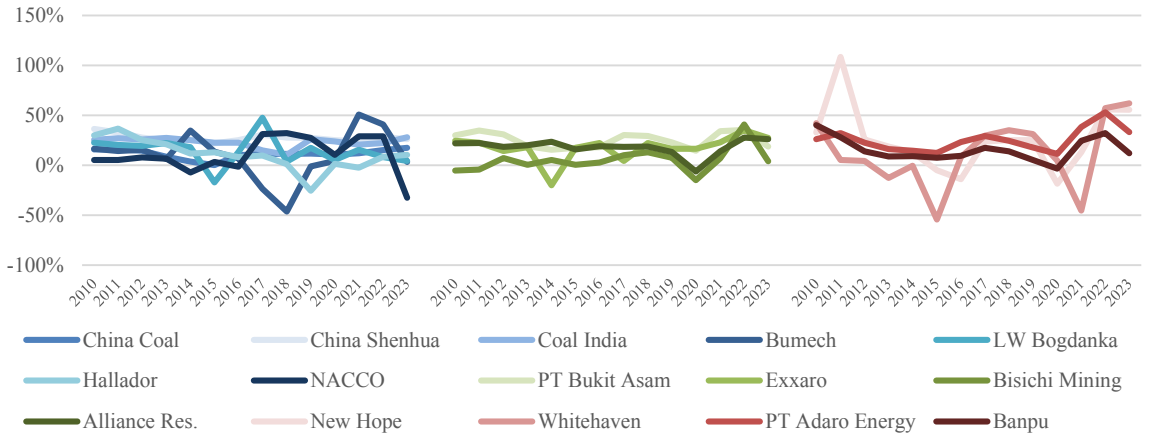

Figure 3. EBIT Margin on Sales of the coal companies studied in 2010-2023 [in %].

Source: own calculations.

Table 3.
ROA volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	9.31%	4.05%	3.04%	0.7495
China Shenhua Energy	9.32%	10.19%	2.80%	0.2752
Coal India	11.34%	12.66%	3.40%	0.2682
Bumech	101.78%	7.98%	24.86%	3.1160
LW Bogdanka	23.77%	5.56%	5.33%	0.9582
Hallador Energy	29.81%	4.34%	7.16%	1.6518
NACCO INDUSTRIES	20.94%	5.36%	5.68%	1.0601
PT Bukit Asam	21.77%	19.59%	7.07%	0.3611
Exxaro Resources Limited	26.14%	14.06%	7.93%	0.5639
Bisichi Mining	60.70%	4.82%	14.10%	2.9234
Alliance Res.	29.52%	16.40%	7.84%	0.4780
New Hope	38.47%	8.36%	11.60%	1.3880
Whitehaven Coal	50.46%	7.16%	14.82%	2.0703
PT Adaro Energy	28.49%	8.79%	7.78%	0.8850
Banpu Public Company	14.44%	4.81%	4.93%	1.0249

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Table 4.
ROE volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	20.39%	7.99%	5.89%	0.7368
China Shenhua Energy	14.09%	14.70%	4.25%	0.2892
Coal India	42.68%	41.71%	12.05%	0.2889
Bumech	291.91%	11.30%	66.37%	5.8719
LW Bogdanka	37.76%	8.05%	8.38%	1.0414
Hallador Energy	51.71%	7.49%	12.65%	1.6882
NACCO INDUSTRIES	46.59%	12.29%	12.21%	0.9934
PT Bukit Asam	34.45%	29.87%	9.73%	0.3257
Exxaro Resources Limited	39.83%	21.83%	12.15%	0.5566
Bisichi Mining	118.43%	9.38%	27.18%	2.8968
Alliance Res.	83.17%	37.99%	21.40%	0.5633
New Hope	56.90%	11.07%	16.62%	1.5017
Whitehaven Coal	74.70%	9.97%	21.86%	2.1915
PT Adaro Energy	47.55%	15.73%	12.69%	0.8069
Banpu Public Company	45.24%	13.61%	14.40%	1.0580

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Table 5.
EBIT margin on Sales volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	17.29%	11.28%	4.81%	0.4262
China Shenhua Energy	14.68%	27.46%	3.80%	0.1382
Coal India	17.51%	23.04%	4.95%	0.2150
Bumech	97.20%	9.68%	24.59%	2.5403
LW Bogdanka	64.89%	14.31%	14.31%	0.9999

Cont. table 5.

Hallador Energy	62.29%	10.61%	15.29%	1.4417
NACCO INDUSTRIES	64.88%	10.43%	18.25%	1.7486
PT Bukit Asam	20.96%	25.12%	7.70%	0.3067
Exxaro Resources Limited	55.05%	17.41%	12.87%	0.7391
Bisichi Mining	56.05%	5.26%	12.53%	2.3841
Alliance Res.	33.82%	18.06%	8.14%	0.4508
New Hope	126.93%	25.77%	32.28%	1.2528
Whitehaven Coal	116.35%	11.92%	34.32%	2.8790
PT Adaro Energy	41.93%	25.35%	11.42%	0.4504
Banpu Public Company	43.76%	15.71%	11.78%	0.7500

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Thus, the average return on total assets of companies with the lowest share of exports ranges from 4% to almost 13% (Table 3), and Figure 1 additionally shows, that the amplitude of its fluctuations over time in the analyzed group is the smallest. The standard deviations of ROA (with the exception of Bumech and Hallador Energy) are the lowest among the surveyed companies and do not exceed 6%. Nevertheless, only China Shenhua Energy and Coal India (high ROA, low coefficient of variation) can be considered outstanding in terms of the level and volatility of return on assets. US and Polish companies show lower return on assets and significantly higher risk associated with its realization, despite a very low share of exports and exposure to international risk.

In the group of companies with a higher share of exports (up to 50%), the profitability of total assets is higher. In 3 of the 4 companies, its average value exceeds 14%. Standard deviations are also higher. Nevertheless, given the rather moderate levels of the coefficient of variation, it is difficult to say unequivocally, that the risk exposure of this group of companies is higher. Undoubtedly, South Africa's Bisichi Mining, with its low average profitability and high volatility over time, is the worst performer on the list.

Among companies with the highest share of exports (above 50%), ROA ranges from 4% to almost 9%, and the standard deviation from almost 5% to over 11%. Average profitability with high volatility negatively affects the final level of risk expressed by the coefficient of variation – in all companies in the group its value exceeds 0.80.

Referring to the impact of the Covid-19 pandemic, it can be noted, that the decline in ROA in 2019 and 2020 primarily affected companies in groups 2 and 3. Thus, it more severely affected the companies with greater exposure to the international coal market than those serving the domestic market.

On the other hand, Russia's invasion of Ukraine resulted in a significant increase in ROA for companies in group 2 and 3, meaning, that they benefited from the imbalance in the energy raw materials market and became – in terms of profits – a beneficiary of this economic crisis. In group 1, Bumech also benefited from this economic turnaround. It’s worth adding, however, that the described growth was incidental in most companies, as ROA dropped significantly in 2023, reaching levels close to precrisis ones. Still, this was not the case for 2 Australian

companies (New Hope and Whitehaven Coal) and 1 US company (Alliance Resource Partners), which is most likely due to their raw material diversification (in addition to thermal coal, they also offer coking coal or oil).

As the share of exports increases, the ROE increases in group 2, with moderate volatility, and thus risk (Figure 2 and Table 4). The exception, as in the ROA assessment, is the Indian company Bisichi Mining, with the lowest group profitability and the highest tendency for it to change over time.

ROE, on the other hand, is declining in the last analysed group, characterized by the highest share of exports. The volatility of this indicator is also increasing, and thus its unpredictability and associated risks. This suggests an optimal volume of exports, not exceeding 50% of sales, which makes it possible to maximize profitability, while minimizing its volatility over time. It applies to the Indonesian, South African and American companies. The first two mine only hard coal, while the third also produces coking coal.

Given the high correlation of the above-described profitability, the Covid-19 pandemic also caused a significant reduction in ROE in the companies in groups 2 and 3. On the other hand, the Russia-Ukraine armed conflict contributed to a periodic increase in ROE in these companies in 2022.

Looking at the profitability of the surveyed companies only from the perspective of operating profit before taxes (EBIT) – Table 5, Figure 3, it can be seen, that in all groups the leading companies are Chinese, Indian, Indonesian or Australian, which are characterized by a high EBIT Margin on Sales and its lowest volatility. Polish and US companies do not perform as well in any of the assessed dimensions. This suggests greater resilience of the Asian market to general economic changes.

Nevertheless, susceptibility to deeper economic crises is already affecting all of the companies surveyed, which, as in the case of the profitability indicators surveyed earlier, is expressed in the reduction of the EBIT Margin on Sales during the Covid-19 pandemic and its marked increase after the outbreak of the Russian – Ukrainian war. Notably, severe economic fluctuations expose the weakness of the weakest. Indeed, the biggest fluctuations in EBIT Margin on Sales concern Bumech, Bisichi Mining and Whitehaven Coal – companies with the worst average performance in their groups.

4.2. Assessing liquidity and working capital from the perspective of exposure to international risks and economic crises

In the second stage of the diagnosis, the effects of economic crises on liquidity and working capital in the surveyed coal companies were assessed. The data used in this analysis are included in Figures 4-6 and Tables 6-8.

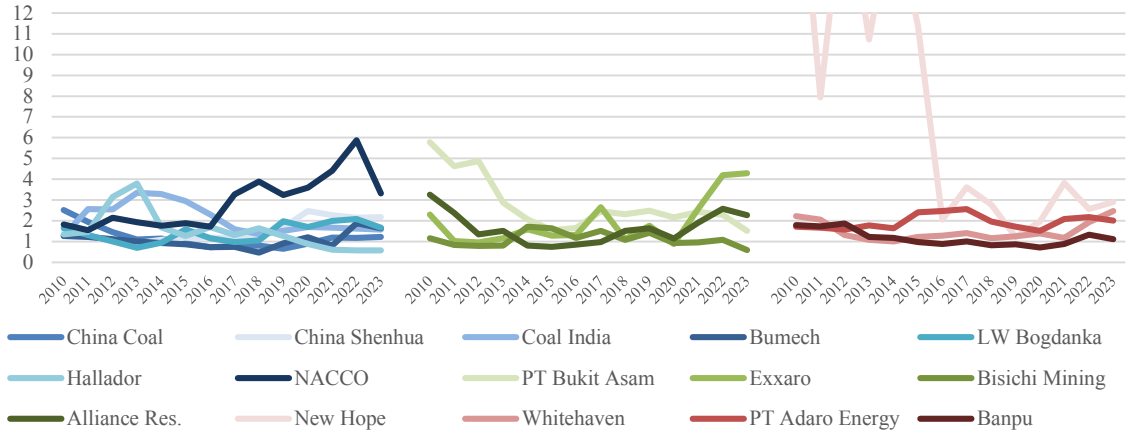

Figure 4. Current Ratio of the coal companies studied in 2010-2023.

Source: own calculations.

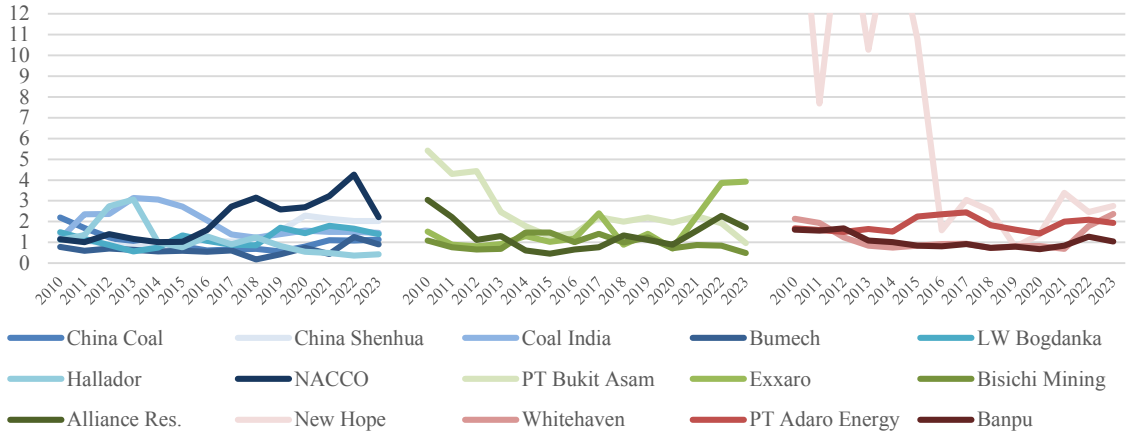

Figure 5. Quick Ratio of the coal companies studied in 2010-2023.

Source: own calculations.

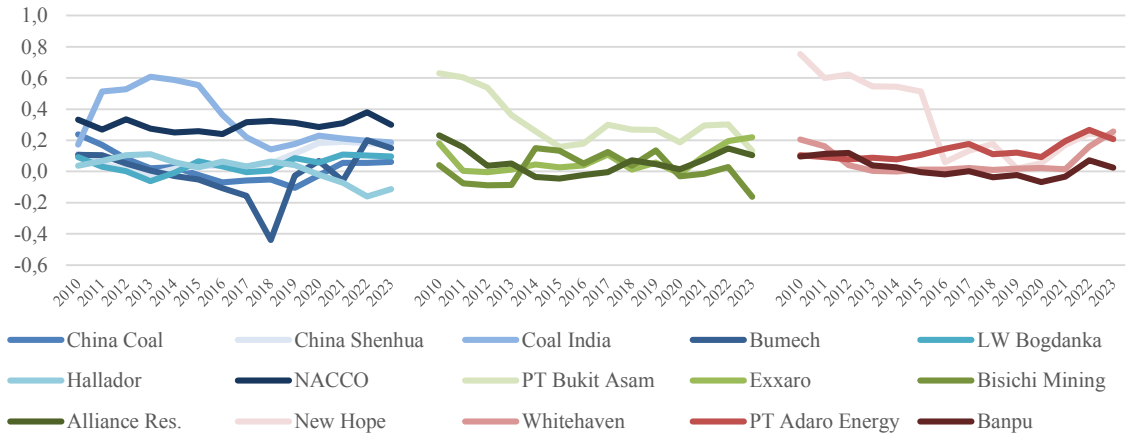

Figure 6. Net Working Capital Level of the coal companies studied in 2010-2023.

Source: own calculations.

Table 6.
Current Ratio volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	1.85	1.18	0.51	0.4322
China Shenhua Energy	1.56	1.52	0.53	0.3463
Coal India	2.08	2.09	0.72	0.3458
Bumech	1.42	1.06	0.37	0.3518
LW Bogdanka	1.38	1.42	0.45	0.3166
Hallador Energy	3.22	1.52	0.93	0.6082
NACCO INDUSTRIES	4.34	2.89	1.28	0.4431
PT Bukit Asam	4.27	2.79	1.33	0.4753
Exxaro Resources Limited	3.41	1.94	1.14	0.5870
Bisichi Mining	1.12	1.12	0.34	0.3033
Alliance Res.	2.51	1.64	0.76	0.4617
New Hope	19.85	7.68	6.89	0.8963
Whitehaven Coal	1.45	1.50	0.47	0.3113
PT Adaro Energy	1.05	1.95	0.35	0.1785
Banpu Public Company	1.15	1.17	0.38	0.3232

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Table 7.
Quick Ratio volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	1.63	1.03	0.45	0.4350
China Shenhua Energy	1.51	1.39	0.52	0.3723
Coal India	1.97	1.92	0.69	0.3575
Bumech	1.08	0.64	0.25	0.3851
LW Bogdanka	1.23	1.22	0.39	0.3183
Hallador Energy	2.70	1.15	0.81	0.7026
NACCO INDUSTRIES	3.26	2.09	1.04	0.4994
PT Bukit Asam	4.45	2.47	1.30	0.5263
Exxaro Resources Limited	3.22	1.65	1.08	0.6534
Bisichi Mining	0.98	0.98	0.32	0.3256
Alliance Res.	2.59	1.36	0.74	0.5441
New Hope	19.84	7.24	6.79	0.9382
Whitehaven Coal	1.67	1.20	0.59	0.4900
PT Adaro Energy	1.03	1.85	0.34	0.1821
Banpu Public Company	1.01	1.06	0.34	0.3201

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Table 8.
Net Working Capital Level volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	0.34	0.03	0.09	3.4812
China Shenhua Energy	0.21	0.08	0.07	0.8788
Coal India	0.47	0.33	0.18	0.5398
Bumech	0.64	-0.01	0.16	-11.9779
LW Bogdanka	0.17	0.04	0.05	1.1976

Cont. table 8.

Hallador Energy	0.27	0.02	0.08	4.6355
NACCO INDUSTRIES	0.14	0.30	0.04	0.1292
PT Bukit Asam	0.50	0.32	0.16	0.5014
Exxaro Resources Limited	0.24	0.07	0.08	1.1239
Bisichi Mining	0.31	0.02	0.10	5.6507
Alliance Res.	0.28	0.06	0.08	1.3477
New Hope	0.74	0.33	0.25	0.7532
Whitehaven Coal	0.26	0.07	0.09	1.2994
PT Adaro Energy	0.19	0.13	0.06	0.4319
Banpu Public Company	0.19	0.02	0.06	2.6789

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Thus, if values from 1.5 to 2.0 are taken as the optimal level of current liquidity, it can be seen, that in group 1 only 2 companies (American NACCO INDUSTRIES and Indian Coal India) maintain current liquidity throughout the analysis period. In contrast, Bumech, China Coal Energy and LW Bogdanka have the highest number of periods of lack of current liquidity (Figure 4). This is reflected in the averaged ratio, which is below the required standard for the aforementioned companies.

It should be added, however, that the quick liquidity ratio (for which the norm is around 1.00) in all the studied companies of group 1 performs better and allows confirmation of the ability to settle current liabilities in most of the analysed periods. The infamous exception in this regard is only Bumech, for which the averaged value of the quick liquidity ratio remains below the norm (the company meets the requirements only in 2022).

The volatility of the current and quick liquidity ratios does not exceed 0.45, which allows it to be described as moderate. Nevertheless, it should be borne in mind, that periodic or long-term inability to settle current liabilities (occurring in 5 out of 7 companies in this group) nevertheless indicates an increased liquidity risk (Table 6).

Referring to the impact of the Covid-19 pandemic on liquidity, it can be said that in group 1 it was minor. In 2019, current liquidity declined, and there was an aggravation of the inability to pay current obligations only at China Coal Energy. In the case of quick liquidity, this occurred at China Coal Energy and Hallador Energy.

The Russia-Ukraine conflict also did not affect significantly the changes in current and quick liquidity at group 1 companies. Only Bumech lost quick liquidity (while maintaining current liquidity). Furthermore, the previous inability to service current debt was maintained by Hallador Energy, so the low values of quick and current liquidity ratios can hardly be attributed to the described economic crisis in this case.

In group 2, with a greater extent of internationalization, current and quick ratios are characterized by higher variability over time (Table 7). In the companies studied, there are periods, when it is below the accepted norms (Figure 5). There are also periods of excess liquidity. The only company, that maintains the correct ability to settle current liabilities is PT Bukit Asam. On the other hand, the largest number of periods of lack of liquidity occur

at South Africa's Bisichi Mining, which ultimately translates into low, nonnormative averaged values of liquidity ratios.

In the second group, the companies' more intense liquidity responses to the Covid-19 pandemic can also be observed. In all the companies, the current and quick liquidity then noticeably decrease, including a loss of liquidity in 3 out of 4. Thus, it can be concluded, that stronger exposure to international risks exacerbates crisis risks.

For the Russia-Ukraine conflict, the reactions of the surveyed companies are no longer so clearcut. South Africa's Exxaro Resources Limited and the US-based Alliance Resource Partners maintain both current and quick liquidity, with a tendency toward over-liquidity. On the other hand, Indonesia's PT Bukit Asam and South Africa's Bisichi Mining are losing their ability to settle current liabilities for both indicators analyzed. Thus, the observed correlations may be the result of the production strategies and management goals chosen, rather than the market changes that have occurred.

In group 3, the majority (3 out of 4) of the analysed coal companies have the ability to regulate short-term liabilities throughout the period under study. They very often have excess liquidity, hence the high values of the averaged liquidity ratios. The Asian Banpu Public Company has the worst liquidity problems in this group.

During the Covid-19 pandemic, current and quick liquidity in 3 out of the 4 companies studied declined sharply, compared to previous periods, which indicates the severity of this economic crisis. The only exception in this regard is US-based New Hope, where liquidity improved in 2020 compared to 2019. Finally, 2 of the 4 companies surveyed in the Covid-19 pandemic did not retain the ability to pay current obligations.

The Russia-Ukraine conflict, as in the group 2 companies, did not significantly affect the level of liquidity of companies with a share of exports in sales above 50%. All the companies studied retained the ability to settle current liabilities. Two of them displayed an increase in liquidity ratios.

At this research stage, reference was also made to the level of net working capital of the coal companies studied (Table 8 and Figure 6). It represents that part of fixed capital, that finances current assets, and is a reserve, that can be used to meet the demand for funds necessary for current liquidity. Its amount (in the article analysed in relation to the size of total assets) is decided by the managers of the company. Nevertheless, the value of this capital should not be negative and should enable the liquidity objective indicated above to be met.

In group 1, only 2 (NACCO INDUSTRIES and Coal India) of the 7 coal companies studied have positive net working capital throughout the period under review (Figure 6). It also assumes the highest level in these companies, which positively affects its averaged values (Table 8). The worst management of net working capital is in the Polish company Bumech, Chinese company China Coal Energy and US company Hallador Energy, which is also consistent with the low evaluation of liquidity in these companies.

During both the Covid-19 pandemic and the Russia-Ukraine military crisis, no uniform trends can be identified in terms of changes in net working capital, which may indicate the insensitivity of this parameter to the described economic changes. Interestingly, however, in 4 of the 7 companies surveyed, net working capital has a low level, and its value in relation to total assets does not exceed 5%. This implies a weak liquidity buffer and a rather high exposure to the associated risks.

In this context, it is also important to note the very high volatility of the analysed indicator, indicating an inconsistent approach to net working capital management and, most likely, the realization of its random values (Table 8). The exceptions in this regard are NACCO INDUSTRIES and Coal India, which also systematically maintain the highest and positive level of net working capital in relation to total assets.

In group 2 of the studied companies, only Indonesian company PT Bukit Asam maintains a positive level of net working capital throughout the research period. In the remaining 3 companies, the fixed capital involved in financing current assets periodically tends to be negative, and its average value is very low and strongly fluctuates over time.

Unlike in group 1, in all companies with higher export involvement, net working capital decreases, and in 2 of them it changes its value from positive to negative. Similarly, this parameter reacts to the Russia-Ukraine armed conflict (it deteriorates in 3 of the 4 companies analysed). Thus, companies with increased international activity are characterized by greater sensitivity of net working capital to economic crises.

The above conclusion is also supported, in part, by the observations of group 3 of the studied companies. In 3 of the 4, both during the Covid-19 pandemic and after Russia's invasion of Ukraine, the value of net working capital decreases.

Interestingly, among the companies with the highest share of exports in sales, only 1 coal company periodically has negative net working capital (Banpu Public Company). At Whitehaven Coal, it takes on very low values but remains positive. In the other two companies, its value is quite stable over time and at a medium to high level in relation to total assets.

4.3. Debt from the perspective of exposure to international risks and economic crises

In the final stage of the analysis, reference was made to capital changes caused by the economic crises under study. The underlying data are compacted in Tables 9-11 and Figures 7-9.

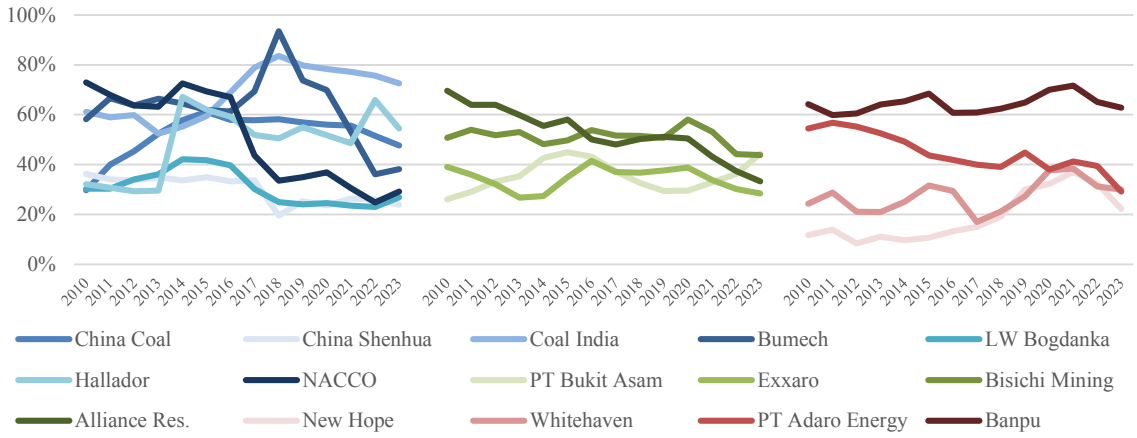

Figure 7. Total Debt Ratio of the coal companies studied in 2010-2023.

Source: own calculations.

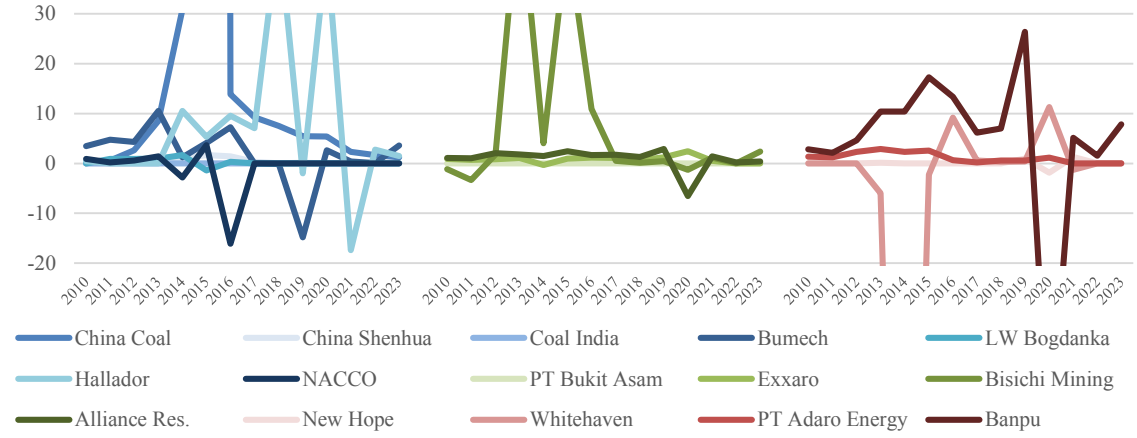

Figure 8. Net Debt to EBIT of the coal companies studied in 2010-2023.

Source: own calculations.

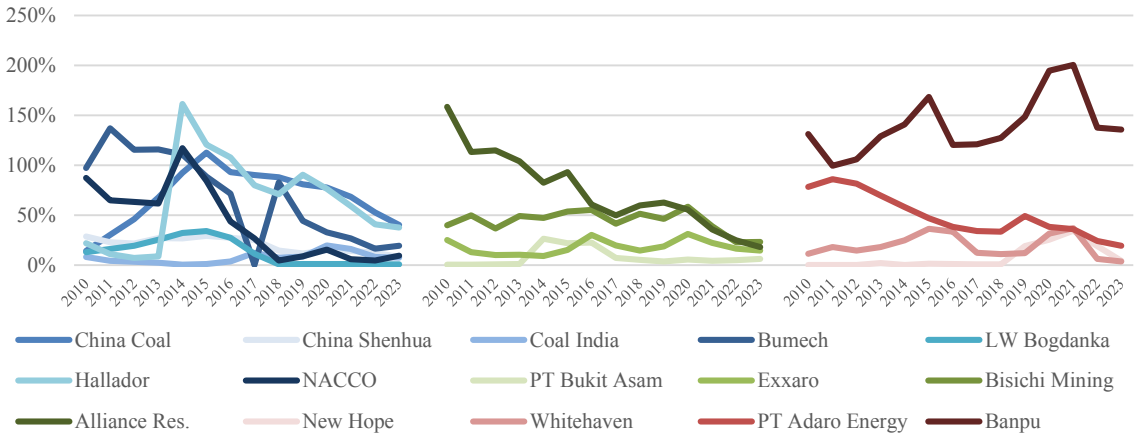

Figure 9. Financial Debt to Equity of the coal companies studied in 2010-2023.

Source: own calculations.

Table 9.
Total Debt Ratio volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	31.37%	52.02%	8.68%	0.1669
China Shenhua Energy	16.64%	29.95%	5.47%	0.1828
Coal India	31.27%	68.72%	10.53%	0.1532
Bumech	57.38%	62.64%	14.19%	0.2266
LW Bogdanka	19.12%	30.85%	6.87%	0.2226
Hallador Energy	37.92%	49.17%	13.47%	0.2740
NACCO INDUSTRIES	48.13%	50.74%	18.68%	0.3681
PT Bukit Asam	18.87%	35.50%	6.23%	0.1755
Exxaro Resources Limited	14.72%	34.34%	4.67%	0.1359
Bisichi Mining	14.31%	51.06%	3.77%	0.7390
Alliance Res.	36.29%	52.51%	10.26%	0.1955
New Hope	28.68%	19.08%	9.88%	0.5178
Whitehaven Coal	21.40%	27.44%	6.29%	0.2291
PT Adaro Energy	27.59%	44.71%	7.95%	0.1778
Banpu Public Company	11.77%	64.37%	3.61%	0.5610

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Table 10.
Net Debt to EBIT volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	2356.10	174.67	627.91	3,5947
China Shenhua Energy	1.66	0.39	0.57	1,4864
Coal India	0.00	0.00	0.00	-
Bumech	25.35	1.96	5.70	2,9075
LW Bogdanka	3.12	0.24	0.72	2,9532
Hallador Energy	64.09	7.69	17.12	2,2254
NACCO INDUSTRIES	19.80	-0.87	4.59	-5,3075
PT Bukit Asam	0.00	0.00	0.00	-
Exxaro Resources Limited	2.78	0.82	0.68	0,8290
Bisichi Mining	57.39	8.22	17.95	2,1824
Alliance Res.	9.42	0.93	2.26	2,4184
New Hope	3.11	0.04	0.67	18,2390
Whitehaven Coal	175.45	-10.85	44.34	-4,0866
PT Adaro Energy	2.88	1.14	1.03	0,9042
Banpu Public Company	82.86	4.19	18.70	4,4589

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Table 11.
Financial Debt to Equity volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	98.65%	68.18%	28.03%	0.4111
China Shenhua Energy	21.22%	20.28%	7.39%	0.3643
Coal India	19.34%	7.24%	5.61%	0.7752
Bumech	137.16%	68.49%	44.60%	0.6511
LW Bogdanka	33.40%	13.07%	12.72%	0.9732

Cont. table 11.

Hallador Energy	154.30%	63.81%	46.36%	0.7265
NACCO INDUSTRIES	112.83%	42.66%	37.33%	0.8753
PT Bukit Asam	26.25%	7.77%	8.89%	1.1443
Exxaro Resources Limited	22.10%	17.79%	7.13%	0.4006
Bisichi Mining	35.87%	43.81%	10.95%	0.2498
Alliance Res.	140.37%	73.79%	39.39%	0.5337
New Hope	34.23%	7.66%	11.55%	1.5075
Whitehaven Coal	33.28%	19.20%	11.32%	0.5896
PT Adaro Energy	66.79%	49.51%	21.80%	0.4404
Banpu Public Company	100.97%	140.06%	29.70%	0.2120

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Taking the value of 67% of total assets as the upper limit of Total Debt Ratio, it can be concluded, that in the analysed group 1 only Coal India (in the last 8 years), Bumech (in four periods) and NACCO (in four periods) exceed this safe level (Figure 7). The remaining coal companies did not have excessive debt throughout the analysed period.

During the Covid-19 pandemic and the Russia-Ukraine conflict, Total Debt Ratio is within the normal range and does not really change. Thus, the described crises do not cause changes in the capital structure of the studied companies. The coefficient of variation for the studied indicator is at a moderate level, which also means, that the sensitivity and resilience of total debt to economic changes is quite low (Table 9).

The Total Debt Ratio meets the required standards and is stable over time in 2 of the analysed groups with a share of exports in total production up to 50%. This is reflected in the low average value of this ratio and the low coefficient of variation that describes it.

The share of total liabilities in financing the assets of coal companies increases slightly during the Covid-19 pandemic. During the Russia-Ukraine conflict, the observed changes are also small, but multidirectional. Therefore, similar to group 1, the described economic crises do not significantly affect the capital structures of coal companies with an average share of exports in sales.

In the 3rd group under study, the total debt ratio meets the required standards throughout the analysed period in 3 of the 4 companies. Periodically, Total Debt Ratio in Banpu Public Company is excessive. The variability of the capital structure over time is low and moderate, which indicates its stability.

As in group 2, in the Covid-19 pandemic, Total Debt Ratio increases slightly in most of the entities studied. In the second of the described crises, fluctuations in the capital structure are multidirectional and small. Therefore, it can be concluded, that the level of Total Debt Ratio is resilient to economic changes

On the other hand, significant instability and variation over time are shown in the values of the indicator illustrating the ratio of Net Debt to EBIT (Figure 8 and Table 10), which is a consequence of the high variability of the financial performance of the surveyed companies.

In group 1, the lowest ability to regulate net debt from operating profit is found in China Coal Energy, Hallador Energy and Bumech. It is also characterized by high volatility over time, as expressed by the standard deviation, the spread and the coefficient of variation.

Neither during the Covid-19 pandemic, nor the Russia-Ukraine armed crisis, is it possible to establish uniform trends in the changes of the analysed indicator in group 1 of companies. These changes vary in values and are multidirectional, which, as already mentioned, is mainly due to the instability of EBIT.

In group 2 of coal companies studied, both the value and the volatility of the ratio of Net Debt to EBIT are on a much better level. The only exception in this case is Bisichi Mining, where the average net debt exceeds the average operating profit by more than eight times.

In 3 of the 4 companies analysed in this group, the value of the analysed ratio also does not change noticeably under the influence of the analysed economic crises. Only in Bisichi Mining does the Net Debt to EBIT increase during the period of Russia's invasion of Ukraine. This confirms the low resilience to crises in coal companies with a generally weak financial condition.

The volatility of EBIT, in turn, significantly affects the ability to settle net debt on companies classified in group 3 with the highest share of exports in sales. The volatility of this indicator is high in all analysed companies. The worst parameters in this regard are shown by Banpu Public Company, which is also a company with a rather weak overall condition.

It is also the only company, in which the ratio of Net Debt to EBIT deteriorated during the Russia-Ukraine conflict. In the other analysed entities, there was no clear relationship between the crises and the described indicator.

The last of the financial variables examined is the financial indebtedness of equity expressed by the ratio of financial (interest-bearing) liabilities to equity, which should not exceed 1 (Figure 9 and Table 11).

Thus, in group 1, long-term financial security was at risk in 3 coal companies exceeding the above standard during the period under consideration, namely: China Coal Energy, Bumech and Hallador Energy. At the end of 2023, the situation in all entities of group 1 in this regard was already normal. The variability of the examined parameter is at a moderate and low level.

It is also not affected by the Covid-19 pandemic, which means, that this economic crisis capital structure in group 1 of companies remained insensitive. For the Russia-Ukraine armed conflict, the security of financial liabilities in equity in 6 of the 7 studied companies improved, which means its favourable impact on the ability to settle these liabilities.

In group 2 of companies, Financial Debt to Equity in the period under consideration can be considered excessive only at Alliance Res, and only in the early years. In the other companies it is low or moderate.

This ratio changes and is slightly different under the influence of the Covid-19 pandemic. In 3 of the 4 coal companies, its slight increase can be observed, which means a reduction in the security of financial liabilities in equity and less resilience of these entities to the effects of the analysed economic change. The Russia-Ukraine crisis, on the other hand, is associated with an improvement of the described indicator in 3 of 4 companies, which is consistent with the observations made in group 1 of coal companies.

In group 3 of companies, the Financial Debt to Equity is abnormally elevated in Banpu Public Company. It is also characterized by high volatility over time expressed by the high value of the bifurcation and standard deviation.

This group also shows the strongest response of its capital structure to the economic crises analysed in the article. During the Covid-19 pandemic, there is a marked deterioration in the value of the analysed indicator in 3 of the 4 coal companies. In turn, the armed crisis between Russia and Ukraine reduces the ratio of financial liabilities to equity in all the described entities.

4.4. Assessing the threat of bankruptcy in crisis situations

Due to the multiplicity of the considered indicators, as well as their differential nature, in the last research stage, the econometric bankruptcy prediction model, described in the methodology section, was used to aggregate the results, which uses 2 parameters for assessing profitability and 1 parameter each for assessing liquidity and capital structure. This is consistent with the areas described in the previous subsections. The modelling results are shown in Table 12.

Table 12.
The value of the bankruptcy risk function in the Poznań model in the Covid-19 pandemic and during the Russia-Ukraine armed conflict

Company	Years/direction of change					
	2019	2020	Direction	2022	2023	Direction
China Coal Energy	4.39	4.51	↑	4.01	3.49	↓
China Shenhua Energy	3.14	4.35	↑	4.14	3.64	↓
Coal India	2.49	3.16	↑	2.30	2.73	↑
Bumech	0.40	0.96	↑	4.70	0.72	↓
LW Bogdanka	1.84	0.41	↓	0.98	0.28	↓
Hallador Energy	2.43	3.38	↑	1.25	1.62	↑
NACCO INDUSTRIES	4.52	3.78	↓	7.16	-0.63	↓
PT Bukit Asam	3.47	2.44	↓	4.51	1.36	↓
Exxaro Resources Limited	2.82	2.46	↓	8.07	7.33	↓
Bisichi Mining	3.20	0.98	↓	5.05	0.24	↓
Alliance Res.	4.86	1.97	↓	5.65	4.21	↓
New Hope	2.24	0.22	↓	7.75	7.18	↓
Whitehaven Coal	2.30	1.47	↓	6.06	7.20	↑
PT Adaro Energy	4.87	3.37	↓	7.27	4.95	↓
Banpu Public Company	7.87	9.30	↑	10.29	8.18	↓

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Thus, in group 1, the value of the function describing the risk of bankruptcy during the Covid-19 pandemic worsens in 2 of the 7 coal companies studied. However, the function does not take a negative value in any of the companies, which means, that there is no immediate and significant threat of bankruptcy.

For Russia's invasion of Ukraine, the value of the bankruptcy function did not decrease in only 2 of the 7 entities studied, indicating a more intense combined impact of this crisis on the results in terms of profitability, liquidity and capital structure. In addition, in the case of US-based NACCO Industries, there was a high risk of bankruptcy (negative function value).

Notably, in group 1, there are 2 companies, whose situation does not deteriorate in any of the analysed crises. Therefore, they can be considered the most resilient to changes in the economic situation. These are Asian Coal India and US-based Hallador Energy, which mine thermal coal for the needs of local economies. With the former being the largest coal producer in the studied group, and the latter one of the smallest, this may mean that low sensitivity to crises is not directly related to company size.

In group 2, all coal companies in both the Covid-19 pandemic and Russia's invasion of Ukraine experience a reduction in the value of the bankruptcy function. At the same time, in the case of the latter crisis, it is deeper due to a stronger reaction of the function value. This is due to the focus of the described model on indicators relating to current profitability and liquidity, i.e., the parameters that were most strongly affected by the analysed crises, and which are also the most important for the survival of the company.

In group 3, both described economic crises cause an increased risk of bankruptcy in 3 of the 4 analysed coal companies. However, in this group, as in the previous one, there are no companies immune to economic changes. Companies with a higher share of exports in sales, therefore, find it more difficult to maintain financial equilibrium during economic turmoil.

5. Discussion

5.1. Analytical results vs. conclusions of previous studies and considerations

The study found that both the Covid-19 pandemic and Russia's invasion of Ukraine affected the operations of the surveyed coal companies and their financial performance. Nevertheless, the impact was not homogeneous, which clearly signals the variation of crisis resilience in the mining industry. It is determined by such factors, as the share of exports in total sales, geographic location, diversification of production and proximity to the crisis focus, as well as initial financial condition. The above insights complement and expand the knowledge of the economics of mining companies and their financial responses in crisis situations.

The effects of the Covid-19 pandemic had the strongest impact on the profitability of the studied coal companies. However, declines in ROA and ROE were less severe for companies with a lower share of exports in sales, including primarily Asian entities. This is consistent with the conclusions of Zhang et al. (2023) and Parra et al. (2021), indicating a pandemic increase in domestic coal production and a revival of the mining sector dictated by the need to maintain energy security. This also confirms the observations of Liu et al. (2022) on the more severe impact of the Covid-19 pandemic on hard coal exporting companies.

It's worth adding, however, that the above observations do not apply to all coal companies oriented toward supplying domestic markets. Indeed, the paper's research shows that Polish mining companies (Bumech and LW Bogdanka) have not been as resilient to the financial effects of crises as Asian companies. This could be a result of EU pressure for decarbonization, preventing the development of the mining sector in Poland. It could also be the result of unstable and inconsistent energy policies in the country.

Based on the conducted analysis, the conclusions reached by Wang et al. (2022) regarding the direct transmission of risk between the coal and oil sectors, previously observed at the macroeconomic level, cannot be fully confirmed. Indeed, from a micro perspective, it appears that coal companies with a more diversified production structure (thermal coal, coking coal, oil) had a somewhat easier time meeting the challenges of the Covid-19 pandemic.

The second of the crises described in the article, concerning Russia's invasion of Ukraine, most strongly affected Polish coal companies located in the immediate vicinity of the focus of this crisis. Unfortunately, as a result of the cessation of coal supplies from Russia, the greening of the Polish power sector could not be accelerated, as Clegg (2024) and Černoch et al. raised in their studies. (2024). Although the mining companies studied did not significantly increase internal production, Poland continued to import thermal coal, only changing the direction of its inflow, as described by Jonek-Kowalska and Grebski (2024), as well as Carmona and Dąbkowska (2024), among others. Currently, a slowdown in the pace of mining industry liquidation is also being reconsidered (Bijańska and Wodarski, 2024; Overland and Loginova, 2023; Ślusarczyk et al., 2023).

The above conundrums, as well as an analysis of the reactions and positive changes in the financial indicators of a large part of the mining companies studied during the Russia-Ukraine crisis (Yagi and Managi, 2024), entitle us to conclude, that economic crises intensify the fear concerning the possibility of losing energy security. This fear, due to the capital-intensive and time-consuming nature of energy transitions, cannot be quickly eliminated, hence the drive to increase domestic production and seek new directions for coal supply (often replacing Russian gas as well). In the face of these developments, it is difficult to support the thesis that economic crises have a positive impact on decarbonization, especially in emerging and developing economies, as Xin and Zhang (2024) also point out.

The above statement also confirms the low environmental resilience of mining companies described, among others, by Gustafsson et al. (2022) and Xiao et al. (2021), resulting primarily from the prioritization of economic objectives and the dominance of these priorities in crisis or conflict situations (Syahrir et al., 2021; Wasylycia-Leis et al., 2014). Thus, economic crises cannot be expected to accelerate the shift away from coal. It seems that energy transition is more conducive to periods of economic stability, which allows more rational planning of raw material production and energy demand.

5.2. Recommendations and policy implications

One of the more optimistic conclusions from this research, however, is that the studied companies respond very differently to crisis situations. So, as Hu and Hassik (2017) write, despite similar problems, the adaptability and resilience of mining companies in different regions can differ significantly. Thus, there is a real opportunity to strengthen the resilience of coal companies. In this regard, the following steps are recommended:

- Planning production considering national and international economic conditions, as well as opportunities for both product and geographic diversification.
- Optimizing the share of exports in sales, allowing to maximize financial results, while minimizing exposure to risk in the international raw material market.
- Securing markets through resilient logistical supply chains (Radebe, Chipangamate, 2024; Lim-Camacho et al., 2021; Maoela et al., 2024) and long-term trade contracts.
- Monitoring financial ratios and maintaining their proper levels.
- Carefully planning for net working capital requirements, which can effectively safeguard liquidity in crisis situations.
- Considering environmental and social priorities in crisis planning as well, preventing the escalation of the effects of economic changes (da Silva et al., 2021), not only for local and regional communities, but also for coal companies themselves (thinking about the continuation and development of operations in the post-crisis phase).

In conclusion of the recommendations, it is also worth noting that energy resource extraction companies are closely linked to the state and its key role in ensuring energy security. In crisis situations, therefore, the importance of and requirements for state interventionism grows, as also highlighted by Wang et al. (2022). With that said, the role of the state in mitigating economic shocks should become apparent long before economic changes occur, as the energy market is insensitive to ad hoc and short-term decisions. Therefore, key issues in this regard are the following:

- A consistent, long-term energy policy, that also considers environmental and social goals.
- Contingency plans relating to energy resource supply in the event of the loss of major import markets.

- The use of the potential of renewable energy sources in effectively enhancing energy security.
- Monitoring of the strategy, operations and financial condition of domestic energy resource extraction companies.

6. Conclusions

6.1. Diagnosis of crisis resilience of coal companies

The main conclusions of the analysis can be divided into two groups. The first concerns the financial responses to the economic crises described in the article. In this respect, the following were found:

- A decline in the profitability of coal companies during the Covid-19 pandemic and a marked, but short-lived, increase in profitability after the outbreak of the Russia-Ukraine armed conflict.
- Very good levels of profitability in Chinese and Indian companies with low volatility over time.
- A decline in liquidity during the Covid-19 pandemic in companies with a higher share of exports in sales; also, no clear impact of the Russia-Ukraine conflict on the ability to settle current obligations in mining companies of all the groups analysed.
- The association of a weak level of profitability with low (or no) liquidity, indicating a coupling of parameters assessing the financial performance of operations and ineffective financial management.
- High volatility and low levels of net working capital in most of the coal companies studied, indicating a lack of consistent management of this capital and significant exposure to liquidity risk.
- A decrease in net working capital as a reserve for liquidity in both analysed economic crises in companies with a higher share of exports in sales.
- The very low sensitivity of Total Debt Ratio to economic changes and the fulfilment by this indicator of the postulated norm in most of the coal companies studied.
- The high volatility of the ratio of Net Debt to EBIT, especially in companies with the lowest and highest shares of exports in sales, mainly due to the high volatility of operating results.

The second group of observations relates to the resilience of the surveyed coal companies to economic changes. In this regard, the following were found:

- Higher vulnerability to the financial consequences of economic crises for Polish, American and South African coal companies than for Asian and Australian companies.
- More rapid response to economic crises in companies with the weakest financial performance.
- The best crisis resilience (expressed as a weak response of financial parameters to economic changes) in coal companies with the lowest share of exports in sales.
- The possibility of developing high resilience to economic crises in coal companies operating primarily in domestic markets (no deterioration of the bankruptcy rate in the case of both crises in Indian Coal India and US Hallador Energy).
- Better average and interim financial performance (profitability, liquidity, net working capital levels, debt) at companies with the average and highest share of exports in sales, suggesting that crisis resilience is compensated for as exposure to international risk increases by the ability to realize higher financial returns.
- The relative balance between crisis resilience and financial performance in coal companies with a medium share of exports in sales (indicators that meet the norm, with moderate volatility).

6.2. Research limitations and directions for further research

This analysis is financial in nature and does not focus on other aspects of the business, which may pose a certain research limitation. Nevertheless, by doing so, it fills a research gap relating to the microeconomic view of the impact of economic changes on the operation of coal companies.

Furthermore, the relationships and reactions described are not statistically confirmed and, aside from crises, the impact of other factors on the financial condition of the companies studied is not analysed. This may impair the quality of inference, but it is in line with the ceteris paribus assumption, that allows for rational economic analyses.

Further research in the area of the resilience of companies to economic crises could be more individualized and refer to case studies of companies considered most and least resilient. This would allow for identifying the determinants of crisis resilience more broadly.

Moreover, the present study could be expanded to include macroeconomic themes relating to changes in demand, supply and, consequently, coal prices over the business cycle and their impact on the financial situation of the companies studied. This would allow a more precise link between the observed reactions and their market causes.

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