

Research Article

Adaptation of Metallurgical Industry Enterprises of Ukraine in the War Conditions

Vladyslava Lyfar^{1,*} , Yuliia Sokolova² 

Zaporizhzhia Polytechnic, National University, Zaporizhzhia, Ukraine

Abstract

The article analyzed the metallurgical market in Ukraine, particularly the volumes of metallurgical production by the main categories in 2021-2023 (cast iron, steel, rolled metal). The comparison of key competitors in the metallurgical industry of Ukraine, which remained after the beginning of Russia's war against Ukraine, according to such indicators as scale of production, access to resources, export orientation, and technological development, was presented. The macro-environment factors of metallurgical enterprises are determined and analyzed: economic, political, legal, social, technological, environmental, and international. In particular, the most negative impact of active hostilities in Ukraine on the activities of the metallurgical industry and the country's economy as a whole is highlighted. The article also identifies and analyzes the micro-environment factors: the state of metal markets, price fluctuations, competition, and the situation in raw materials markets. As a result, the environmental factors are distributed by components, indicating the positive and negative factors' impact on the activities of metallurgical enterprises in war. The article outlines the risks of the external and internal environment of the metallurgical enterprise, using the example of PJSC "Zaporizhstal". A mathematical model for their estimation, which combines quantitative and qualitative analysis, is proposed. Based on the model, an integral indicator of the environmental risks of the enterprise and an integral indicator of the risks of the internal environment according to three scenarios (optimistic, baseline, and pessimistic), which allowed for determining the risks of the most negative impact. As a result, the integrated risk indicators of the external and internal environment of the enterprise of PJSC "Zaporizhstal" for various scenarios were compared. The possibilities of using artificial intelligence in the management of metallurgical enterprises are exposed in order to increase the accuracy of forecasts, minimize uncertainty, and allocate resources more efficiently.

Keywords

Metallurgical Enterprise, Business-environment, Adaptation, Factor, Risk, Sustainable Development, Artificial Intelligence

1. Introduction

The war in Ukraine has created unprecedented challenges for industrial enterprises that found themselves in the conditions of economic instability, the destruction of logistics chains, loss of markets and constant threats to physical destruction of production capacity. In such circumstances, there

is an acute problem with the survival of enterprises, including the enterprises of metallurgical industry, traditional approaches lose their efficiency, forcing business to search for ways to adapt.

The transition to flexible business models, optimization of

*Corresponding author: lyfarvlada@gmail.com (Vladyslava Lyfar)

Received: 24 March 2025; Accepted: 8 May 2025; Published: 11 June 2025



Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

production processes, diversification of suppliers and markets, introduction of digital technologies, and the use of modern approaches to management have become integral elements of enterprise strategy. In particular, using artificial intelligence (AI) for analytics and forecasting opens up new opportunities for rapid analysis of changes in demand, prompt adjustment of marketing campaigns, optimization of resources, and reducing risks in crisis. In addition, the support of the state, international partners, and strategic investors in the process of adaptation of enterprises to new realities plays an important role. Involvement in financing, providing tax benefits, supporting innovative development, and implementing policies aimed at preserving the country's industrial potential becomes critical for overcoming the challenges facing the metallurgical industry of Ukraine. Thus, adapting the metallurgical industry enterprises in the conditions of war is a complex and multifaceted process that requires a comprehensive approach, effective anti-crisis management, and the introduction of innovative technologies to ensure the stable functioning of the industry, even in the most difficult conditions.

2. Literature Review

In the classical literature [1, 6, 10, 11, 13], the foundations of strategic and anti-crisis management of enterprises are laid. M. Porter's approach [11] helps to develop strategies to create a sustainable competitive advantage. Mintzberg G. believes that successful strategies are more often formed evolutionarily than planned, strict schemes, emphasizing the importance of organizational adaptation and learning [10]. Rumelt R. distinguishes between a "good" and "bad" strategy where the first is based on clearly defined challenges and realistic plans to overcome them, and the second - on the contrary, is characterized by blurred goals, lack of clear actions and reevaluation of general statements instead of specific decisions [13]. Drucker P. focuses on the need for flexible management in conditions of instability [6].

A greater share of contemporary strategic management literature considers the need and ways of adaptation of enterprises in the post-core period, since a global pandemic (COVID) has covered the whole world and created strategic problems for enterprises of all industries and in the conditions of a new reality of the digital economy [3, 5, 7, 8].

But even though these researches are paid much attention in instability and uncertainty, they all relate to changes in the competitive environment, technologies, consumer benefits, the issues of critical events such as war are regarded as force majeure. Still, none of these studies considers the enterprise experience in the conditions of the "hot" phase of modern war. Therefore, the search for strategic decisions of adaptation of enterprises in war is a topical scientific task.

3. Data, Methods, and Measures

During the study, such general scientific research methods as analysis, deduction, description, comparison, and visualization of content analysis data in the form of diagrams were used.

The analysis of statistics of production the metallurgical products in Ukraine by the main categories (cast iron, steel, rolled metal) in 2021-2023 was conducted. Using official reports and internal documentation allowed for evaluating the main trends, including the decline in production in 2022 and its partial restoration in 2023-2024.

To evaluate the risks of the business environment, a multifactorial approach, a method of calculating the integral risk indicator with the addition of a scenarios method for determining optimistic, basic, and pessimistic scenarios of the metallurgical enterprise development depending on the further course of the war and the market environment, was used. This approach and methods were used to assess the risks of the external business environment and the risks of the internal business environment. The approach also assesses the probability of developing negative and positive trends, including the dependence of enterprises on hostilities, the availability of investments, and the restoration of export opportunities.

4. Empirical Results

The Ukrainian metallurgy market is characterized by high competition among large vertically integrated companies engaged in ore production, steel production, rolled metal production, and often exporting a large part of their products. The key factors of competition in the market are:

- 1) scale of production;
- 2) access to resources;
- 3) export orientation;
- 4) technological development [2].

After Russia has destroyed the largest production capacities of the metallurgical industry of Ukraine in Mariupol, there are three major metal producers in Ukraine: PJSC Zaporizhstal, MC ArcelorMital Kryvyi Rih, and MC Interpipe Steel. [Table 1](#) presents a Comparison of the listed manufacturers by key competition factors.

As can be seen from [Table 1](#), PJSC Zaporizhstal is the second largest steel manufacturer in Ukraine, and the first in the structure of the Metinvest Holding since 2022 [9]. PJSC "Zaporizhstal" supplies products to both the domestic market of Ukraine for different industries - from construction to mechanical engineering and to the markets of EU countries, the Middle East, Asia, and Africa.

The company has access to the raw material base of Metinvest and can therefore compete by this parameter with metallurgical company "ArcelorMital Kryvyi Rih". Metallurgical company "Interpipe Steel" is inferior to both competitors in volumes of steel production, but is more focused on pipe production and more sophisticated and quality products,

so it is a strong competitor that prevails in technology, especially in foreign markets.

Table 1. Comparison of key competitors in the metallurgical industry of Ukraine in 2024*.

Indicator	The main manufacturers of metallurgical products		
	PJSC Zaporizhstal	Metallurgical Company ArselorMital Kryvyi Rih	Metallurgical Company Interpipe Stal
Scale of production, mln tons of steel per year	4	6	2
Access to resources	Dependent on Metinvest Holding	Has its own iron ore assets	Dependent on ore suppliers
Export orientation	Up to 80% of products go for export	The main focus is exports to 50+ countries	Up to 70% of exports to the EU and the USA
Technological development	Active modernization, eco -projects	Large-scale modernization of production	Innovations in pipe production

* based on [9, 15].

To date, the enterprises of the metallurgical industry of Ukraine operate in a business environment, the factors of which are constantly changing. For the metallurgical enterprise, the following factors of macro environment can be distinguished: economic, political, legal, social, technological, environmental, and international. The microenvironment factors include the state of metal markets, price fluctuations, competition, and the situation in the raw materials markets.

Currently, metallurgical enterprises are most felt by the influence of economic factors, since hostilities have significantly worsened the situation in the economy of Ukraine, and especially affected Donetsk, Dnipropetrovsk and Zaporizhzhia regions - traditional regions producers of metallurgical products, through the occupation of part of the territory and active hostilities in the territory of Ukraine. The country's economic development level determines the demand for the enterprise's products, particularly in construction, mechanical engineering, and infrastructure projects. Real GDP in 2022 decreased by 39% compared to 2021, which was negatively reflected in all economic processes, but in 2023, GDP growth was 6%, revitalizing economic conditions and business activity. Along with the fall of GDP in 2022, prices increased significantly, which caused an increase in inflation and, therefore, influenced the cost of resources, logistics, and total costs of metallurgical enterprises, which also increased significantly and adversely affected the profitability.

Military status and active hostilities in Ukraine have a negative impact on the presence of domestic and external investments in the industrial sector. Investors do not want to take risks, so the sources of investment resources for the enterprise are now limited.

In 2024, the Ukrainian economy suffered significant losses due to the destruction of most of the energy-generating ca-

capacity, electricity loss, and forced closures of businesses due to electricity restrictions.

The next factor in the business environment that significantly influences the activities of metallurgical producers is the state of metal markets. The metallurgical industry depends on global demand, especially in developing countries. The production of metallurgical products in Ukraine in 2023 remained almost at 2022, – 17.6 million tons and 18 million tons, respectively, but was three times less than in 2021, when 61.4 million tons were made. The change in the production of the main categories of metal products in 2021-2023 of all Ukrainian producers is shown in Figure 1.

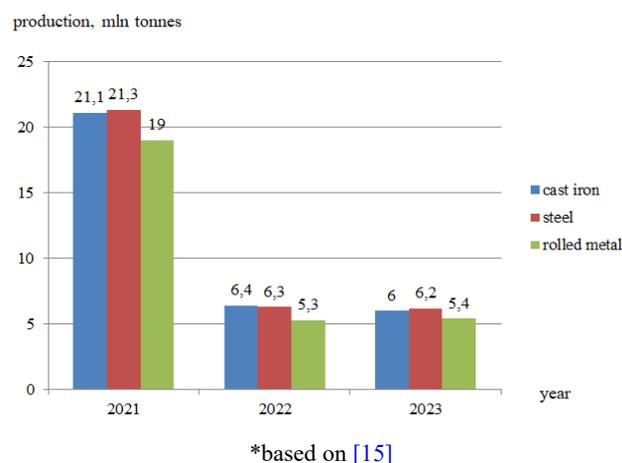


Figure 1. Metallurgical Production of Ukraine by the Main Categories in 2021-2023, mln tons*.

At the same time, after a significant fall, as a result of 2022

(1.9 million tons in 2022 and 4.4 million tons in 2021), demand for metal products in Ukraine in 2023 increased significantly by 44% – up to 2.7 million tons (not including polymer-coated rolling, stainless rolling and white tin). The restoration of construction can explain the growth of demand, both frozen objects and destroyed during active fighting and shelling, as well as the development of Ukraine's military industry, and the increasing its metal needs. In 2022, the consumption of metal structures in Ukraine was 64 thousand tons, which is 59% less than in 2021. In 2023, the market demonstrated a restoration, and according to the year's results, demand increased by 19%, reaching 79 thousand tons. The main factors of such growth were implementing critical infrastructure protection and restoring infrastructure and commercial objects.

Fluctuations in prices in the world market affect the competitiveness of products. In 2023, prices increased by 12%. In 2021-2023, the metal rolling was raised by 56% with a peak price in August 2022, when the cost of the metal rolling was twice as high as in early 2021. Prices strongly impact the world of metallurgy, including China, India, and Turkey.

The situation in the raw materials market has a significant impact on the activities of metallurgical enterprises. Metallurgical manufacturers of Ukraine are included in vertically integrated metallurgical holdings, such as PJSC Zaporizhstal, which belongs to the Metinvest Holding, which has several mining and processing companies, mines, and other sources of raw materials.

Therefore, the enterprise can use primary resources such as iron ore, coke, etc. That's why their price is not a critical factor in influencing the enterprise's activity. Still, hostilities have significantly complicated logistics and led to the occupation of the territories where part of the enterprise assets are located. Therefore, there are also some problems with the supply of raw materials.

Metallurgy is an energy-intensive industry, so electricity and gas prices have a significant impact on the cost of production. In 2024, the cost of these resources for industry increased significantly due to the sanctions and generation restrictions. During 2021-2024, energy prices for industrial consumers in Ukraine have undergone significant fluctuations due to internal and external factors. In 2021, energy prices for industry remained relatively stable, reflecting the gradual restoration of the economy after the COVID-19 pandemic. Still, in 2022, due to a full-scale invasion of Russia into Ukraine, the market price increased by 30% compared to the previous year, reaching 3617.6 UAH/MWh. In 2023, the trend of energy prices for industry has remained. In the domestic market, the weighted average price amounted to 3857.7 UAH/MWh, which is 6.6% higher than in 2022. The increase in prices was the result of a stable shortage of generating capacity in the power system and the need to bring price restrictions to actual prices in the EU markets for the possibility of maximizing imports. From November 1, 2024, the weighted average price amounted to 5734.46 UAH/MWh, and

on November 4 – 6 733.67 UAH/MWh. This indicates a further increase in the cost of electricity for industrial consumers, which may be associated with prolonged calls in the energy sector and the need for energy imports. In general, during 2021-2024, energy prices for industry in Ukraine have increased, caused by internal problems in energy infrastructure and external economic and geopolitical factors [4, 5, 12, 14].

The activities of enterprises are influenced by the legal component, particularly the regulation of environmental activities (Ukrainian and European legislation), labor legislation, tax regulation, antitrust legislation, and regulation of international trade (product certification). Different areas of legal regulation determine the limits within which an enterprise can carry out its activity and stimulate it to development following modern requirements. Compliance with legal norms ensures stability, competitiveness, and long-term enterprise development.

The metallurgical industry is closely linked to the scientific and technological progress and the development of innovative solutions, so the technological component of the macro environment also has some influence. Unlike economic, political, and legal components, the impact of technological components is positive. Thus, the modernization of equipment, automation of production processes, and the use of new modern materials for production allow for the reduction of the cost of production, the improvement of its quality, and the expansion of the range.

Technologies are positive not only on production processes, but also allow for the increase in the efficiency of management functions at the enterprise, in particular, the introduction of artificial intelligence in the processes of inventory management, finance, purchases, and staff allows for the acceleration of decision-making processes, optimization of costs, and an increase in productivity, etc. Large data technologies can optimize demand and cost forecasting, and digital monitoring facilitates the tracking of the equipment and its maintenance.

Increasing requirements for environmental responsibility stimulate the enterprise to introduce technologies that contribute to reducing the negative impact on the environment, namely the modernization of filtration systems, reducing the level of emissions of CO₂ and other harmful substances, the use of metallurgical slag in construction and other industries, the use of energy from production processes. The introduction of environmental technologies will allow the enterprise to meet international environmental standards (ISO 14001), reduce environmental tax burden, and improve the company's reputation among partners and investors.

The challenges of military status related to energy needs require the enterprise to use modern technologies – alternative energy sources, in particular the use of gases generated during production, to generate electricity, and the transition to the use of green energy (solar or wind) in the long run.

The factors of the social component have a significant impact on the activity of the enterprise. First, the labor market and the number of able-bodied population in the region. Data

on the number of able-bodied population in the Zaporizhzhia region for 2021-2024 vary depending on the socio-economic situation. In 2021, the economically active population of Zaporizhzhia region was approximately 700-800 thousand people. However, due to the war, emigration, and other socio-economic factors, in 2022-2023, there was a significant reduction in this indicator [15]. Metallurgical enterprises are the largest employers in the regions where they work, so their activities are influenced by factors as employee qualification, level of education. Today, skilled workers are not enough, and

enterprises suffer from a lack of workers, which negatively affects their sustainable development.

Summarizing the material, the environmental factors that affect the activity of metallurgical enterprises in war can be represented by Figure 2. Defined factors have both positive and negative impacts. In war conditions, the positive impact is much lower, since the factors themselves are very variable and depend on investment opportunities, current conditions, external situation, and the situation at the front.



Figure 2. Environmental Factors Affecting the Metallurgical Enterprises of Ukraine in the War Conditions.

Therefore, even positive factors do not guarantee an enterprise's survival and sustainable development. For example, the technological component is generally considered a factor of positive influence; however, for metallurgical enterprises of Ukraine today, it can also pose a risk due to the impossibility of introducing innovations, artificial intelligence, and modernization of equipment, which is associated with the lack of investment resources in Ukraine.

The impact of negative factors is more substantial because war conditions and a high degree of uncertainty about the future exacerbate it. Enterprises are forced to adapt to situational factors of negative impact due to their orientation towards sustainable development goals. The question arises: Is it possible to consider the possibilities of sustainable development of enterprises in the metallurgical industry in war conditions? Yes, it is possible, but taking into account the risk assessment. A clear delineation of risks, the probability of their occurrence, and their impact on the enterprise will allow for predicting certain events in advance and reducing their adverse effects.

Analyzing metallurgical enterprises' internal and external environments using the example of PJSC Zaporizhstal showed that risks exist both in the external business environment and within the enterprise. Risks arise from external environmental factors. The following are external risks of the enterprise's activities:

- 1) military actions, which are a constant threat of destruction of production facilities, personnel, infrastructure, and logistics;
- 2) political instability in Ukraine, which negatively affects the investment climate and operational activities of the enterprise;
- 3) fluctuations in raw material prices;
- 4) energy problems, price increases;
- 5) currency fluctuations;
- 6) shortage of qualified personnel in the labor market;
- 7) difficulties in implementing new technologies and modernizing production.

To assess the risks of the external business environment of PJSC Zaporizhstal, it is advisable to build a mathematical

model that combines quantitative and qualitative analysis. One approach for such analysis may be a multifactorial approach, which includes: formalization of risks – assessing each direction according to separate parameters that reflect its impact on the enterprise; calculating the integral risk indicator as a weighted sum of individual risks, considering the probability of their impact.

For risk assessment, we will define the key variables:

a) risks (R_i) – each risk (i) is represented as a function of probability (P_i) and impact (I_i) according to the formula 1:

$$R_i = P_i \times I_i, \quad (1)$$

P_i – probability of risk realization ($0 \leq P_i \leq 1$);

I_i – the impact of risk on the enterprise's activities ($I_i \geq 1$).

б) factors of influence (risks). To assess the risks of sustainable development of PJSC Zaporizhstal, we will combine them into five groups (military, political, energy, economic, and technological). For each of the identified risks, it is nec-

essary to determine the probability and impact, as well as the weight of the overall effect on the possibilities of sustainable development of the enterprise. Based on these data, it is necessary to calculate the integral risk indicator according to the formula 2:

$$R = \sum_{i=1}^n W_i \times R_i = \sum_{i=1}^n W_i \times P_i \times I_i, \quad (2)$$

R – integral risk indicator;

W_i – the weight of a particular risk in the overall impact on the sustainable development of the enterprise is determined based on expert assessments or priority analysis.

Based on the methodology considered, we will determine each risk's weight, probability of realization, and impact level based on the above analysis. The authors of the work act as experts. Also, various approaches suggest adding the scenario method to the assessment to determine the integral risk's optimistic, baseline, and pessimistic scenarios. Separate risk assessments are given in Table 2.

Table 2. Risk assessments of sustainable development of metallurgical enterprises based on analysis of the business environment of PJSC Zaporizhstal.

Risks	probability of realization (P_i)			The impact on the enterprise (I_i)			Weight (W_i)
	Optimistic	Baseline	Pessimistic	Optimistic	Baseline	Pessimistic	
1. Military	0,4	0,7	1,0	0,5	0,8	1,0	0,3
2. Politic	0,3	0,6	0,8	0,2	0,7	0,8	0,2
3. Energetic	0,5	0,8	1,0	0,4	0,9	1,0	0,3
4. Economic	0,1	0,4	0,8	0,2	0,3	0,8	0,1
5. Technologic	0,1	0,5	0,8	0,3	0,6	0,9	0,1

*The table presents data obtained by the study's authors as a result of analyzing the external environment of the enterprise for the period 2022-2024 years.

So, based on the obtained estimates, we will calculate the integral indicator of external environmental risks according to three scenarios:

a) The optimistic scenario:

$$R_1 = 0,3 * (0,4 * 0,5) + 0,2 * (0,3 * 0,2) + 0,3 * (0,5 * 0,4) + 0,1 * (0,1 * 0,2) + 0,1 * (0,1 * 0,3) = 0,06 + 0,012 + 0,06 + 0,002 + 0,003 = 0,137$$

b) The baseline scenario:

$$R_2 = 0,3 * (0,7 * 0,8) + 0,2 * (0,6 * 0,7) + 0,3 * (0,8 * 0,9) + 0,1 * (0,4 * 0,4) + 0,1 * (0,5 * 0,6) = 0,168 + 0,084 + 0,216 + 0,016 + 0,03 = 0,514$$

c) The pessimistic scenario:

$$R_3 = 0,3 * (1 * 1) + 0,2 * (0,8 * 0,8) + 0,3 * (1 * 1) + 0,1 * (0,8 * 0,8) + 0,1 * (0,8 * 0,9) = 0,3 + 0,128 + 0,3 + 0,064 + 0,072 = 0,864$$

So, as can be seen from the calculations, in the optimistic scenario, external environmental risks negatively affect the sustainable development of PJSC Zaporizhstal with a probability of 13.7%; in the basic scenario – 51.4%; in the pessimistic scenario – 86.4%. Military and energy risks have the most negative impact on sustainable development.

The internal environment generates the second group of risks for the sustainable development of PJSC Zaporizhstal. The analysis conducted in previous studies by the authors allowed us to identify the following risks within the enterprise:

- 1) lack of competitive advantages;
- 2) dependence on energy resources;
- 3) lack of qualified personnel, staff turnover;
- 4) high level of costs;
- 5) need for investment resources;
- 6) outdated technologies.

We will also assess the risks of the internal environment based on the methodology for calculating the integral risk and the scenario method. Table 3 shows the relevant initial data for calculations.

Table 3. Assessment of risks of sustainable development of PJSC Zaporizhstal based on analysis of the internal environment of the enterprise*.

Risks	probability of realization (Pi)			The impact on the enterprise (Ii)			Weight (Wi)
	Optimistic	Baseline	Pessimistic	Optimistic	Baseline	Pessimistic	
1. Lack of competitive advantages	0,3	0,7	1,0	0,5	0,7	1,0	0,2
2. Energy dependence	0,4	0,8	0,9	0,7	0,8	0,9	0,25
3. Staff	0,6	0,8	1,0	0,5	0,8	1,0	0,25
4. Costs	0,4	0,6	0,7	0,5	0,6	0,7	0,15
5. Investments	0,3	0,5	0,7	0,2	0,4	0,6	0,1
6. Technology	0,1	0,4	0,7	0,3	0,7	0,9	0,05

*The table presents data obtained by the study's authors as a result of analyzing the internal environment of the enterprise for the period 2022-2024 years.

So, based on the data in Table 3, we will calculate the integral indicator of internal environment risks under three scenarios:

a) The optimistic scenario:

$$R_4 = 0,2 * (0,3 * 0,5) + 0,25 * (0,4 * 0,7) + 0,25 * (0,6 * 0,5) + 0,15 * (0,4 * 0,5) + 0,1 * (0,3 * 0,2) + 0,05 * (0,1 * 0,3) == 0,03 + 0,07 + 0,075 + 0,03 + 0,006 + 0,0015 = 0,2125$$

b) The baseline scenario:

$$R_5 = 0,2 * (0,7 * 0,7) + 0,25 * (0,8 * 0,8) + 0,25 * (0,8 * 0,8) + 0,15 * (0,6 * 0,6) + 0,1 * (0,5 * 0,4) + 0,05 * (0,4 * 0,7) == 0,098 + 0,16 + 0,16 + 0,054 + 0,02 + 0,014 = 0,506$$

c) The pessimistic scenario:

$$R_6 = 0,2 * (1 * 1) + 0,25 * (0,9 * 0,9) + 0,25 * (1 * 1) + 0,15 * (0,7 * 0,7) + 0,1 * (0,7 * 0,6) + 0,05 * (0,7 * 0,9) == 0,2 + 0,2025 + 0,25 + 0,0735 + 0,042 + 0,0315 = 0,8$$

So, the calculations show that in the optimistic scenario, the risks of the internal environment of PJSC Zaporizhstal negatively affect its sustainable development with a probability of 21.25%; in the basic scenario - 50.6%; in the pessimistic scenario - 80%. The most negative impact on sustainable development is the lack of competitive advantages, problems

with personnel, and dependence on energy sources, mainly electricity.

To fully understand how the risks of the internal and external environment of PJSC Zaporizhstal affect its sustainable development, let's compare the data on the integrated risk indicators for different scenarios in Table 4.

Table 4. Scenarios of the integrated indicator of sustainable development risks PJSC Zaporizhstal.

Scenarios	External environment risks	Internal environment risks
Optimistic	$R_1 = 0,137$	$R_4 = 0,2125$
Baseline	$R_2 = 0,514$	$R_5 = 0,506$
Pessimistic	$R_3 = 0,864$	$R_6 = 0,8$

As can be seen from Table 4, in the optimistic scenario, the internal environment has a more significant negative impact on the sustainable development of the enterprise; in the basic and pessimistic - the external one.

Adapting enterprises to war conditions requires new business approaches and forecasting tools since the existing ones require significant time to collect and process information. One such approach is using AI in enterprise management, which will significantly improve scenario forecasting because it can analyze large volumes of data, build multifactor risk models, and predict their impact in different scenarios. AI can automatically assess the probability of risk realization, find hidden patterns in changes in key indicators, and develop optimal anti-crisis strategies.

AI allows enterprises to increase the accuracy of forecasts, minimize uncertainty, and allocate resources more effectively. By automating risk assessment processes and optimizing production and logistics strategies, companies can respond faster to changes in the business environment. This is especially important in times of war and economic instability when speed and accuracy of decision-making are critical to ensuring the sustainable development of enterprises.

5. Conclusions

So, as a result of the study, the analysis of the metallurgy market in Ukraine showed a significant reduction in production by main categories (steel, cast iron, rolled steel), starting from 2022, which is primarily due to active military operations in Ukraine, with the occupation of a significant part of the territory, including where the production facilities of metallurgical enterprises were located. The remaining metallurgical enterprises continue to operate but are forced to adapt to situational factors. The identified and analyzed external environmental factors allowed them to be divided into positive and negative impact factors and then to determine the risks, combining them into five groups: military, political, energy, economic, and technological. Based on the analysis conducted by the authors, the risks of the internal environment of a metallurgical enterprise were also determined using the example of PJSC Zaporizhstal. Using a multifactor approach and a mathematical model, the value of the integral indicator of external and internal environmental risks was calculated for

three scenarios: optimistic, basic, and pessimistic. The results of the calculations made it possible to find out that in the optimistic scenario, the internal environment has a more significant negative impact on the sustainable development of the enterprise, and in the basic and pessimistic - the external one. Assessing the risks of sustainable development of the enterprise, especially in war conditions, will allow enterprises of the metallurgical industry to better adapt to situational factors, foresee the possibility of threats, and prevent the possible negative impact of these factors. It will also allow us to anticipate obstacles in advance and eliminate them.

Depending on the implementation of a particular scenario, measures to ensure the sustainable development of the enterprise should be more focused on working with internal efficiency, forming competitive advantages, retaining and developing personnel, reducing costs, introducing advanced technologies, and social responsibility, which will allow eliminating the negative impact of the external environment on the enterprise. But in the event of continued hostilities and deterioration in the energy situation, the sustainable development of PJSC Zaporizhstal is under significant threat, which will negatively affect its competitiveness, the ability to operate in foreign markets and provide the region with jobs, and the state with taxes and quality products.

Abbreviations

DAM	Day-Ahead Market
GDP	Gross Domestic Product
MC	Metallurgical Company
PJSC	Public Joint Stock Company

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Ansoff, H. L. (1965). *Corporate Strategy*. McGraw-Hill, New York, 241 p.
- [2] Biliomistniy, O. Bilomistna, I. and Galushko, Y. (2017), "Influence external and internal factors to financial security of enterprise", *Financial and Credit Activity: Problems of Theory and Practice*, № 1 (22). <https://doi.org/10.18371/fcaptp.v1i22.109935>
- [3] Bundy J., Pfarrer M. D., Short C. E., Coombs W. T. (2017). Crises and Crisis Management: Integration, Interpretation, and Research Development. *Journal of Management*. 43(6): 1661-1692. <https://doi.org/10.1177/0149206316680030>
- [4] DAM indexes and weighted average prices. Electricity market operator, 2024. Available at: https://www.oree.com.ua/index.php/indexes?utm_source=chatgpt.com (accessed March 10, 2025).

- [5] Dyer J. H., Godfrey P., Jensen R. & Bryce D. (2023). *Strategic Management: Concepts and Cases*, 4th Edition, Wiley Plus, 512 p.
- [6] Drucker P. F. (1980). *Managing in Turbulent Times*, New York: Harper-Collins, 239 p.
- [7] Levine A. G. (2021). *Crisis Management: Challenges and Opportunities in the Post-Pandemic World*. <https://doi.org/10.1016/j.resglo.2021.100037>
- [8] Maslak O., Sokurenko P., Grishko N., Buriak I. & Maslak M. (2020). Anti-crisis approach in the industrial enterprise management: methodological tools of preventive regulation. <https://doi.org/10.1051/shsconf/20207301018>
- [9] Metinvest official website. About Zaporizhstal during the war, 2024. Available at: <http://surl.li/zgzxllh> (accessed March 03, 2025).
- [10] Mintzberg H. (1994). The Rise and Fall of Strategic Planning, *Harvard Business Review*, January-February, 1994, PP. 107-114.
- [11] Porter M. E. (1990). *Competitive strategy: techniques for analyzing industries and competitors: with a new introduction* Michael E. Porter. p. cm... Originally published: New York: Free Press, 390 p.
- [12] Report on the results of the activities of the National Energy and Public Utilities Commission, 2023. Available at: https://www.nerc.gov.ua/storage/app/sites/1/Docs/Byuleten_do_richnogo_zvitu/broshura_do_richnogo_zvitu_nkrekp-2023.pdf?utm_source=chatgpt.com (accessed March 10, 2025).
- [13] Rumelt R. P. (2012). *Good Strategy Bad Strategy: The Difference and Why It Matters*, 246 p.
- [14] The Main Department of Statistics. Socio-economic situation of Zaporizhzhia region for January 2022. Available at: https://www.zp.ukrstat.gov.ua/images/stories/povidom_2022-01_04032022.pdf (accessed March 10, 2025).
- [15] Ukrainian Center for Steel Construction: The Metal structures market overview at 2022-2023. Available at: https://uscc.ua/uploads/page/images/publications/oglyad_rynku_2023.pdf (accessed March 15, 2025).