

The object of this study is the process of risk management at enterprises in the metallurgical industry as a subject of foreign economic activity. Under the conditions of an export-oriented economy, it is important to have tools for early response to crises and challenges caused by various factors. Volatility of the market and global and domestic prices for key products and raw materials add uncertainty and encourage management to look for tools to protect their financial income.

The construction of a risk map and the use of mathematical tools for forecasting and minimizing the negative consequences of the occurrence of risky events could contribute to making optimal management decisions in operational activities and in the pricing process.

Interpretation of the risk management cycle for the needs of enterprises in the metallurgical industry will make it possible to adequately identify the risks inherent in the industry and devise measures for flexible response to crises and challenges. In the course of the study, it was found out that exporting companies need protection, first of all, against price risk, which increases significantly under the conditions of inflation and due to jumps in the consumer price index in a particular country. It is suggested to use hedging as a protection tool.

Determining the perimeter of risk hedging by means of a risk-oriented selection of indicators (external and internal, commercial, and non-commercial risks) depending on a certain market situation will make it possible to establish a correlation between key influencing factors.

The implementation of the risk-hedging cycle in the practice of the enterprises in the metallurgical industry will make it possible to ensure flexible management of the pricing procedure for metal products both in the domestic market and during foreign trade

Keywords: risks of exporters of metal products, price risk hedging, foreign trade, metallurgical industry

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RISK MANAGEMENT BASED ON HEDGING TOOLS IN AN EXPORT- ORIENTED ECONOMY

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1. Introduction

Any product, enterprise, industry goes through its own life cycle. Given the multitude of production and commercial properties that are inherent in the industry, it is important not only to carry out rational planning of production volumes but also to forecast future financial revenues and, if possible, to protect them.

The problems and challenges faced by Ukrainian industry in recent years are unprecedented. But on a global scale, there are also many factors that negatively affect the success of activities, especially in the metallurgical industry.

Before the COVID-19 pandemic, experts were concerned with the possibility of selling Ukrainian metal products on foreign markets. Under ordinary conditions, 80 % of the products produced by the metallurgical industry were intended for export, since the internal consumption of steel has always been insignificant, and, for example, in 2019 it was only 4–5 million tons.

Ukraine has always depended on the export of raw materials and world prices for raw materials. Of course, it is always more profitable to export finished products to foreign markets than to sell raw materials. But Ukraine is able to compete in the market of metal products mainly by exporting rolled products and other commodities (exchange goods) in the form of raw materials. Regarding commodities, it does not matter in which country and under what technical conditions these goods are manufactured. They usually have standard consumer properties and are interchangeable. Commodities are mainly traded on commodity exchanges, including in the form of commodity derivatives. So, if the exported Ukrainian metal products are positioned as commodities, then it is worth considering such a tool of protection against price risks as hedging.

Commodity prices largely depend on trade wars, the dynamics of world GDP development, and the situation in rapidly developing countries, primarily China. If in such countries there is a decrease in demand, prices for raw ma-

materials fall, then Ukrainian metallurgists have to sell their products at a lower price, even if the quality of such products is higher than their Chinese counterparts. Therefore, the slowdown in the growth of the world economy is the biggest risk for manufacturers of metal products, and, unfortunately, the country has no opportunity to influence this risk.

Of course, when there is a decrease in the growth rate of the world economy, each country tries to protect its market and, if possible, to save jobs, especially in industry. This manifests itself in protectionism. Against the background of the USA and the EU, Ukraine defends its market quite uncertainly. Regarding metallurgical production, Ukraine is one of the most liberal and open countries on the world market. Paradoxically, the Ukrainian market is primarily open to those who are direct competitors of Ukrainian metal producers on foreign markets, namely China and Turkey.

The unpredictability of the national currency rate is the next potential risk. Business entities are forced to look for ways to protect against exchange rate fluctuations. Classically, currency risks are considered from the perspective of banks and financial institutions. But exporting companies should also have protection tools, one of which can be considered hedging.

The economic policy of the state is an equally important factor that can negatively affect a particular industry. Each state forms its own priorities regarding the support of one or another industry, investment, and development of relevant sectors of the economy. Before the full-scale invasion, the state observed an increase in tax pressure on the metallurgical industry of Ukraine due to an increase in the rent for the extraction of iron ore and an increase in the environmental tax. The consequence of tax pressure is always a decrease in business activity, which can also be considered as an external risk of a business entity.

An export-oriented economy needs well-established logistics chains. The problem of export of Ukrainian metal products became especially acute after the start of military aggression.

Therefore, research into the development of protection tools or risk minimization contributes to the sustainable development of socio-economic relations on a global scale and is relevant under conditions of uncertainty.

2. Literature review and problem statement

The authors of [1] categorically structured the risks in the mining industry. Thus, the group of operational risks, according to the researchers' conclusions, consists of organizational, project, production, and technical risks. A separate group is financial and economic risks. The authors emphasize the need for up-to-date and reliable information as mining companies are very sensitive to changes in the cost of materials. Metal prices are regulated on several exchanges and depend on global demand. Therefore, there is a dependence on exchange rate changes and market fluctuations. But the authors of the study do not offer risk management models or tools for the mining industry.

Paper [2] presents the possibility of forecasting prices for iron ore since China is significantly dependent on its import. A hybrid EEMD-GORU model and a new data reconstruction method based on signal decomposition technology and artificial neural network are proposed to investigate internal correlations and relationships between different iron ore markets. The need to combine various information on the volatility of the iron ore spot and futures markets is

emphasized, and risk changes in iron ore futures are simulated to provide producers with reliable information on risk management. The authors focus precisely on forecasting the state of the market, which is very important but insufficient for full-fledged risk management.

A number of studies are aimed at the possibility of using hedging tools in the energy resources market [3, 4]. Volumes of electricity production and prices for it are not constant. Parametric insurance, "weather derivatives", forecasting the fair price of hedging the risks of revenues from renewable energy sources, such as wind or solar power plants, are the areas of research of the above-mentioned scientists. But the issue of the possibility of applying such insurance protection tools in other industries, in particular in mining and metallurgy, requires separate research.

With the beginning of Russian Federation's military aggression against Ukraine, geopolitical risks began to be investigated more actively. The authors of [5, 6], by using the wavelet-coherent approach, investigated the impact of war on various classes of assets. Green bonds, gold, silver, Swiss currency, and real estate proved to be the most resistant to changes in geopolitical risk in various areas. The impact of investing in precious metals for the purpose of hedging was analyzed in [7]. Attention is focused on the strengthening of the relationship between markets and the transmission of shock caused by the crisis (in particular, the military aggression of the Russian Federation). The authors concluded that rising political risks lead to increased volatility even for safe-haven assets such as gold. But such assets as commodities and the impact of geopolitical risks on them were not considered.

An interesting hypothesis is the influence of sentiment in mass media on market volatility [8], especially under extraordinary conditions and extreme events. The authors suggest considering sentiment along with other sources of market volatility. They provide evidence of a relatively constant relationship between sentiment and markets, arguing that sentiment associated with one market can transmit volatility to other markets.

In work [9], it is believed that the following can be handed over to insurance companies for maintenance:

- property and technical risks;
- risks related to personnel (from health insurance to liability insurance);
- most liability risks (especially environmental liability).

However, in their opinion, not all risks are insurable. Among the risks that can be identified and quantified is currency risk. For enterprises in the mining and metallurgical industry, the use of financial market instruments, such as forward and futures contracts, hedging is complicated from many points of view, and it requires separate thorough studies.

Therefore, the absence of hedging tools in the metallurgical industry negatively affects the ability of companies to withstand crises. The relevance of these tools increases with increasing market volatility. The futures market so far only operates in China for such commodities as ore and rebar. The crisis of 2019 spurred the development of the derivatives market for metal products outside of China, as the need to hedge price risk is an urgent need of the industry.

3. The aim and objectives of the study

The purpose of our study is the risk management process of export-oriented enterprises based on hedging tools. This

will make it possible to determine the perimeter of hedging to minimize risks in the metallurgical industry.

To achieve the goal, the following tasks were defined:

- to analyze the dynamics of export of metal products;
- to group the risks inherent in the metallurgical industry, with a ranking according to the possibility of managing them;
- to design a model for hedging the risk of pricing metal products.

4. The study materials and methods

The object of the study is the management of risks during the export of metal products, in particular price risks, using hedging.

Based on the fact that export activity is inevitably associated with risk and its occurrence has a fairly high degree of probability, it is necessary to determine the goal of risk management. The definition of the goal will become the basis for the formation of information support for the management decision-making process.

The ambiguity of the consequences of the occurrence of risk events creates difficulties for the quantitative reflection of this phenomenon. The peculiarity of foreign economic activity, in terms of the export of metal products, is that the level of risks associated with it is very significant. And the sale of products for export requires not only careful planning but also constant tracking of changes in influencing factors and forecasting their consequences for an individual enterprise and the industry as a whole.

The study of the relationship between risk events and insurance protection tools is possible through the use of methods of theoretical generalization, analysis of actual data, comparison, and logical-structural modeling.

Owing to the use of economic and statistical methods of analysis of actual data, the method of extrapolation and correlation, it is possible to obtain a relationship between risk-hedging indicators.

The impact of the metallurgical industry on the key indicators of the country's economy, as well as the dependence of the price of certain types of metal products on inflation and the exchange rate, is determined using a correlation-regression relationship.

5. Results of investigating the process of risk management using hedging tools

5.1. Dynamics of export of metal products

In 2022, world steel production decreased by 3.9% compared to previous year, to 1,885 million tons, and the apparent consumption of finished steel products decreased by 4.0%, to 1,768 million tons. As for global exports, there was a reduction of 10.5%. This decrease was evidenced by a difficult year for global metallurgy [10].

According to the results of 2022, steel production in EU countries decreased by 10.5% year-on-year – to 136.7 million tons. In general, steel production in the world fell by 4.3% y/y – up to 1.83 billion tons.

During 2022, the situation in European metallurgy was affected by such factors as high prices for energy resources, high volatility of prices and demand, and a decrease in steel exports from the EU.

Regarding the export of steel by the main producing countries, in 2022, compared to previous year, only Mexico, Brazil, and the USA managed to increase the volume of foreign trade (Table 1, Fig. 1). In other countries, there was a decrease in sales, but not as critical as in Ukraine (–57.5%).

Table 1

Steel exports by the main producing countries, thousand m.t. [11]

Steel-producing country	2019	2020	2021	2022	Change 2022/2021
CHN	63,841.7	53,236.0	66,349.4	62,830.1	–5.30 %
EU27	33,202.6	25,432.4	25,815.4	23,030.5	–10.80 %
IND	13,069.2	17,131.4	19,999.4	16,360.2	–18.20 %
JPN	33,081.9	31,041.3	33,731.0	32,652.2	–3.20 %
USA	7,226.0	6,562.3	8,109.8	8,631.5	6.40 %
RUS	29,454.1	28,653.4	32,547.6	21,388.2	–34.30 %
KOR	29,913.8	28,517.3	26,702.7	26,264.5	–1.60 %
TUR	19,542.0	18,527.9	21,928.1	18,850.0	–14.00 %
BRA	12,727.2	10,710.5	11,488.2	13,479.6	17.30 %
TWN	11,240.4	10,564.6	10,803.7	10,649.6	–1.40 %
UKR	15,554.7	15,205.2	15,699.4	6,665.8	–57.50 %
MEX	5,105.1	5,150.6	5,889.9	9,776.2	66.00 %
CAN	5,686.3	5,140.6	7,538.8	6,824.8	–9.50 %
...
Global aggregate	314,904.2	293,911.6	327,282.1	292,916.9	–10.50 %

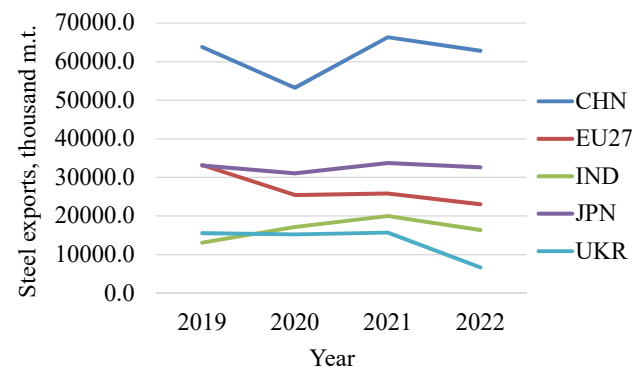


Fig. 1. Steel exports, annual data [11]

The general macroeconomic situation has caused a decrease in demand for steel products, as the consistently high inflation in world markets has led to higher interest rates in leading economies and reduced costs. While the coronavirus pandemic continued to negatively affect markets, Russia's unleashing of a full-scale war in a European country added to global volatility [12].

Statistics of Ukrainian production and export of metal products show a steady downward trend.

Based on GMKCenter data: according to the results of 2019, steel production decreased by 1% – to 20.85 million tons, production of rolled products decreased by 1% – to 18.39 million tons, iron production decreased by 2% – to 20.06 million tons t. In 2020, steel production decreased by 1.4% to 20.55 million tons, pig iron production increased by 1.5% to 20.36 million tons, rolled products increased by 0.7% to 18.34 million tons [13].

Despite the pessimistic expectations and difficulties faced by the industry in 2020 due to the COVID-19 pandemic, experts consider the results of Ukrainian metallurgists to be quite acceptable.

In 2021, commodity markets saw a recovery in both supply and demand as the global economy recovered from the lows experienced during the COVID-19 pandemic. The prices of steel, iron ore, and coking coal reached multi-year highs, although they slightly decreased at the end of the year [14, 15]. According to the results of 2021, the global production of steel increased by 3.7 % compared to 2020 – up to 1.95 billion tons. Over the year, Ukraine increased smelting by 3.6 % to 21.4 million tons. Ukraine took fourteenth place in the global ranking among sixty-four steel-producing countries[13].

2021 is considered the most successful year for the metallurgical industry both on a global scale and for Ukraine, in particular, but the unprecedented events of 2022 contributed to a significant deterioration of the situation (Table 2, Fig. 2, 3).

Against the background of a significant improvement in export indicators in 2021, the situation in 2022 looks catastrophic. In 2022, there was a significant decrease in the export of Ukrainian metal products. In natural terms, the export of iron ore raw materials (–56 %), metal semi-finished products (–72 %), flat rolled metal (–73 %), and cast iron (–59 %). The decrease in foreign exchange earnings for

these types of metallurgical products is in the same range as the indicators in natural terms.

Ukrainian ferrous metal export statistics continued to deteriorate in 2023 after a 67.5 % drop in 2022. Metallurgical enterprises of Ukraine in 2023 reduced ferrous metal export earnings by 41.59 % compared to 2022 – to USD 2 billion 647.722 million.

According to the State Customs Service of Ukraine [16], during that period, ferrous metals accounted for 7 % of the total revenue from the export of goods, while in 2022 the share was 10.26 %.

Exports of steel billet and semi-finished steel from Ukraine in 2023 fell by another 36 % after a 72 % drop in 2022.

In 2023, Ukraine reduced the export of carbon steel semi-finished products in natural terms by 36.7 % compared to 2022 [16].

The metallurgical industry has an impact on the formation of the overall structure of the country’s economy, which is confirmed by the study of the correlation between the cost of products produced in this industry and the country’s GDP by constructing a one-factor nonlinear regression (Fig. 4):

$$Y(x) = -1580.0x + 0.239x^2 - 0.00001692x^3 + 5.703 \cdot 10^{-10}x^4 - 7.37 \cdot 10^{-15}x^5 + 3.98 \cdot 10^6.$$

The value of the correlation coefficient at the level of 0.878 shows a direct and quite significant relationship.

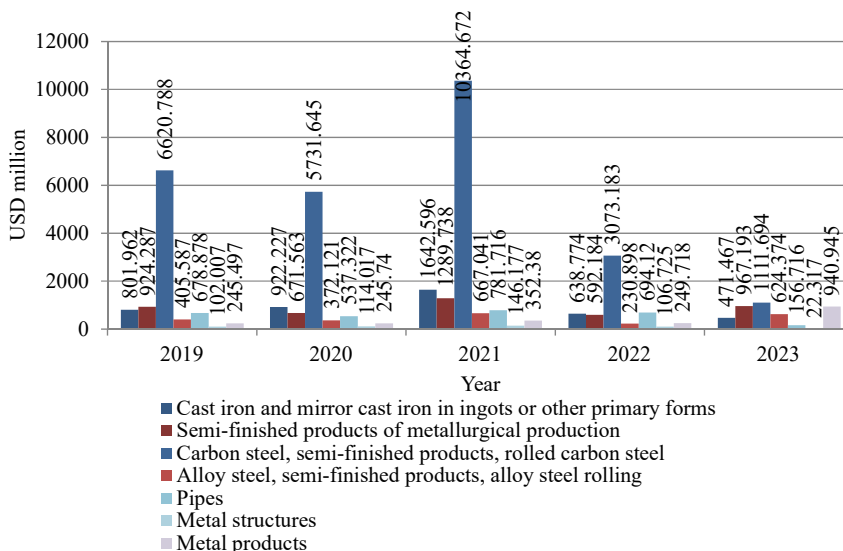


Fig. 2. Dynamics of export of Ukrainian metal products, USD million [16]

Table 2

Export of Ukrainian metal products, USD thousand [16]

Types of metal products	2019	2020	2021	2022	2023
Cast iron and mirror cast iron in ingots or other primary forms	801,962	922,227	1,642,596	638,774	471,467
Semi-finished products of metallurgical production	924,287	671,563	1,289,738	592,184	967,193
Carbon steel, semi-finished products, rolled carbon steel	6,620,788	5,731,645	10,364,672	3,073,183	1,111,694
Alloy steel, semi-finished products, alloy steel rolling	405,587	372,121	667,041	230,898	624,374
Pipes	678,878	537,322	781,716	694,120	156,716
Metal structures	102,007	114,017	146,177	106,725	22,317
Metal products	245,497	245,740	352,380	249,718	940,945
Total export	9,779,006	8,594,635	15,244,320	5,585,602	4,294,706

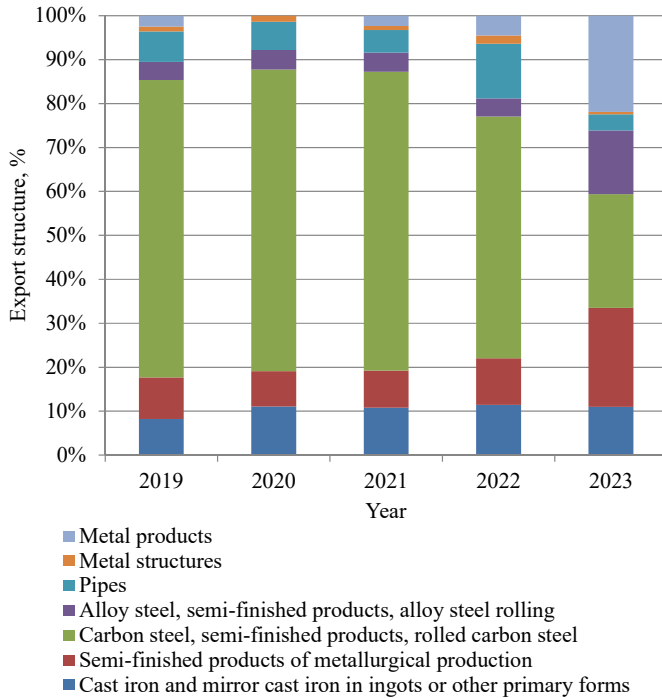


Fig. 3. Export structure of Ukrainian metal products, % [16]

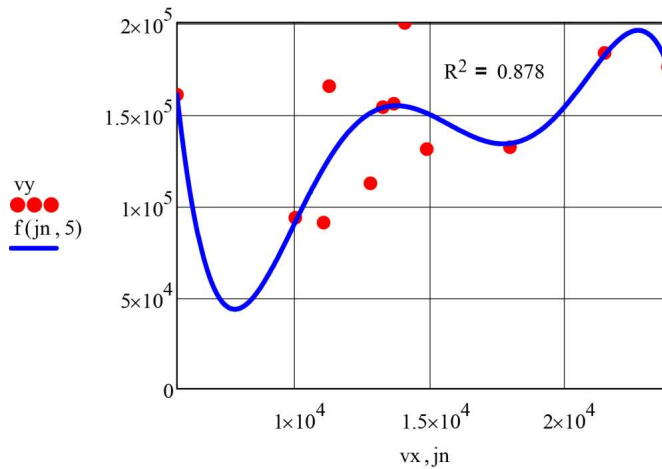


Fig. 4. Correlation between the cost of manufactured products and GDP, USD million

Note: built by the authors in the Mathcad environment based on data [17, 18]

The presence of such a significant link underlines the importance of the industry, especially in the context of the country's defense capability and post-war recovery.

5. 2. Risk map of the metallurgical industry

Carrying out export activities is associated with types of risks, which are distinguished according to various classification features. Modern researchers are actively discussing which risks are the most influential and unpredictable for participants in international trade (external or internal, strategic or operational, country risks or counterparty risks, etc.). Regardless of the approaches to the classification of risks, from the point of view of risk management, in relation to the business entity, risks are divided into external and internal.

Risks can be managed using various tools and models that help predict possible risk events and minimize losses

from the occurrence of such events. Export-import activity is characterized by risks throughout the entire logistics chain, starting with the supply of material resources and raw materials, and ending with the delivery of finished products to consumers.

But a significant part of commercial deals remains unimplemented, or implemented on extremely unfavorable terms as a result of:

- uncertainty and constant instability of economic processes on a global scale;
- insufficient (and sometimes unreliable or provided with a significant delay) information on the state of the economy of the leading players;
- lack of clear objectives of business entities.

So, in general, the risks inherent in the metallurgical industry can be grouped as follows (Fig. 5).

In this case, the matrix of probable risks and control procedures (Table 3) helps structure the work, which will help keep the identified risks at an acceptable level. An important condition is the constant addition and updating of matrix data. When forming a matrix, it is important to use such a structure that corresponds to the circumstances specific to a certain industry or individual business entity.

Table 3

Risks of exporters of metal products in terms of the possibility of control and management

First-level risks (external) (no possibility to control)		Risks of the second level (internal) (arising in the course of activity)	
Non-commercial	Commercial	Commercial	Non-commercial
Damage (destruction) of production facilities and stocks	Sanctions risks	Use of production facilities	Labor safety
Political risks, military conflicts	Volatility of world and domestic prices for key products and resources	Pricing (price risk)	Cyber security
Protectionism	Demand volatility	Settlements with counterparties	Compliance
Economic policy of the state	Exchange rate fluctuations	Attraction of financing	Business ethics
The environment	Infrastructure		-
Climate change	Logistics		-

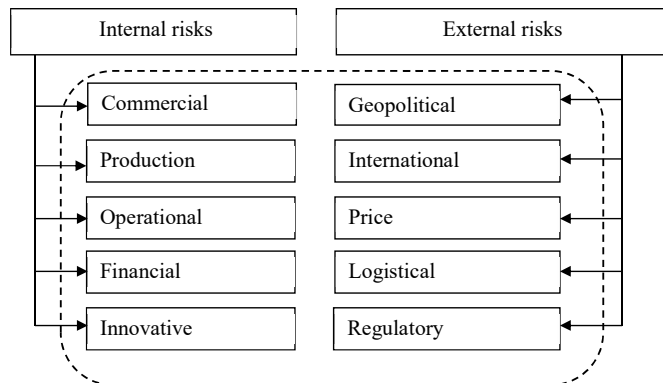


Fig. 5. Risks of exporters of metal products by nature of origin

Internal risks mainly depend on the activity and management decisions of the business entity, and there are many models of their management. External risks are difficult to predict and quantify. We suggest focusing on price risk.

Price risk is the probability of unexpected financial losses due to changes in product prices. Factors causing price risk are:

- increase in purchase prices for raw materials, components, etc.;
- probability of dumping by competitors;
- regulatory changes by the state regarding pricing;
- tax policy of the state and introduction of new or increase of existing taxes and payments included in the price of products;
- tariff increases from other industries (electricity, transportation, etc.).

According to some calculations, a 1 % error in the price of sold products leads to losses amounting to at least 1 % of sales revenue. If the demand for such a product is elastic, then losses can amount to 2–3 %. With indicators of product profitability at the level of 10–12 %, an error in the price of 1 % can mean losses in the amount of profit at the level of 5–10 %. The price

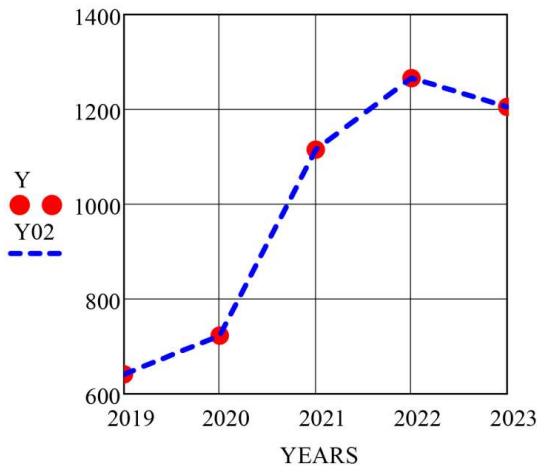
risk also increases significantly under the conditions of inflation and due to jumps in the consumer price index in the country.

Fig. 6 shows a model of the correlation dependence of prices for certain types of metal products on inflation and exchange rates.

Calculations of the value of the correlation coefficient for four types of metallurgical products (hot-rolled coils, fittings, scrap, iron ore raw materials) showed the presence of a direct and significant correlation between the influence of currency exchange rates and inflation on the price of metal products.

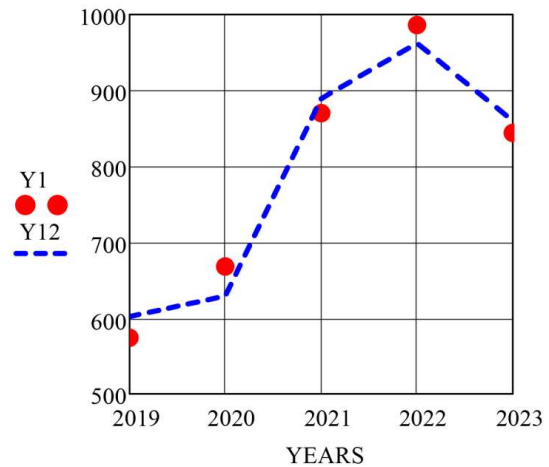
According to ICU macroeconomic research: in 2023, the consumer price index in Ukraine increased significantly, as inflation was 5.1 % against 26.6 % in 2022. Price growth is predicted for 2024 due to a low base of comparison from a mathematical point of view. Since the beginning of Russia's full-scale invasion of Ukraine, there has been a moratorium on tariff increases, as well as administrative regulation of some prices. All that time, this kept inflation somewhat in check, but those restrictions are gradually being eased. Last year, administratively regulated prices increased by 10.7 % [12, 19, 20].

$$Y = -206.515 \cdot X_1 + 114.074 \cdot X_2 + 16.463 \cdot X_3 - 7407.0$$



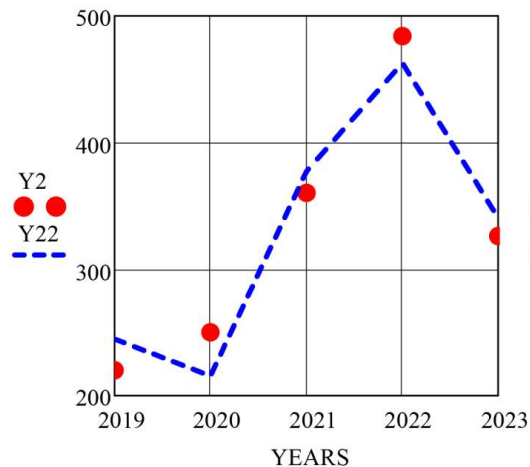
a

$$Y = -149.56 \cdot X_1 + 75.259 \cdot X_2 + 9.916 \cdot X_3 - 4277.0$$



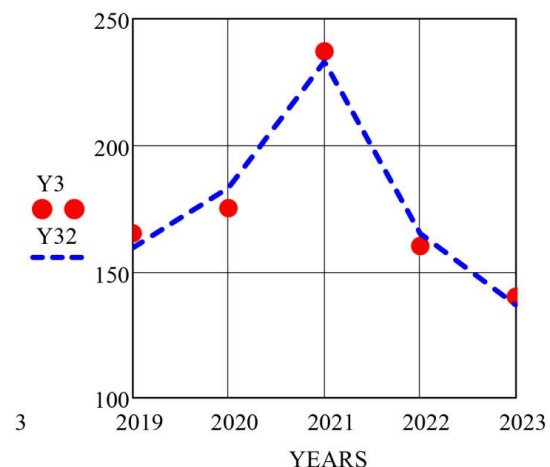
b

$$Y = -97.557 \cdot X_1 + 43.113 \cdot X_2 + 3.232 \cdot X_3 - 2019.0$$



c

$$Y = -38.685 \cdot X_1 + 17.88 \cdot X_2 + 3.988 \cdot X_3 - 1068.0$$



d

Fig. 6. Model of the correlation dependence of prices for certain types of metal products on inflation and exchange rates: a – HC roll ($R^2=0.999$); b – rebar ($R^2=0.968$); c – scrap ($R^2=0.936$); d – iron ore raw material ($R^2=0.972$)

Note: built by the authors in the Mathcad environment based on data [17, 18]

Certain price controls and restrictions on the growth of prices and tariffs are gradually being relaxed. Consequently, prices are gradually released, the situation becomes less predictable and controlled.

Logistics costs are also a significant component of the price. The situation with the logistics of Ukrainian products to world markets remains difficult. Ukraine independently established a “sea corridor” through which metal products are exported, among other things. But the blockade of land corridors with the EU in early 2024 adds uncertainty.

5. 3. A model of hedging the risk of pricing metal products

Classically, it is considered that for risk management it is first advisable to carry out preventive actions:

- to analyze the markets where products will be exported; partners with whom the agreement is concluded;
- possible force majeure situations of risks;
- choose an appropriate strategy, model, or tool for influencing risks.

According to the theory of risk management: in the presence of risk situations, it is necessary to directly influence the risk; exercise control and introduce corrective actions regarding the risk management process. The study is aimed at insuring risks through hedging, based on the assumption that risks are inevitable. And the main task at the same time: to ensure balance and, if possible, to minimize losses from the occurrence of risky situations.

Selection of indicators for hedging should be carried out by means of risk-oriented selection. The formation of the model is proposed to be structured in the following sequence:

- determination of the risk-hedging perimeter (at the level of the exporter of metal products, these will be, first of all, commercial risks (both external and internal));
- identification of risks (the process of their identification, awareness, and description);
- analysis and assessment of risks in a quantitative dimension (understanding their nature, determining the level, comparing the obtained results with the defined criteria);
- implementation of the risk hedging procedure.

When determining the risk-hedging perimeter, it is important to choose from a set of risks those that are amenable to quantitative measurement and for which it is possible to establish a correlation-regression relationship. When performing the hedging procedure, it is advisable to consider several options for choosing derivative financial instruments.

So, the price risk hedging model is proposed to be represented as follows (Fig. 7).

When choosing derivatives, it is important to understand the range of potential hedgers. Note, for example, that insurance companies are not able to take on such risks due to legal restrictions and financial stability management policies [21, 22].

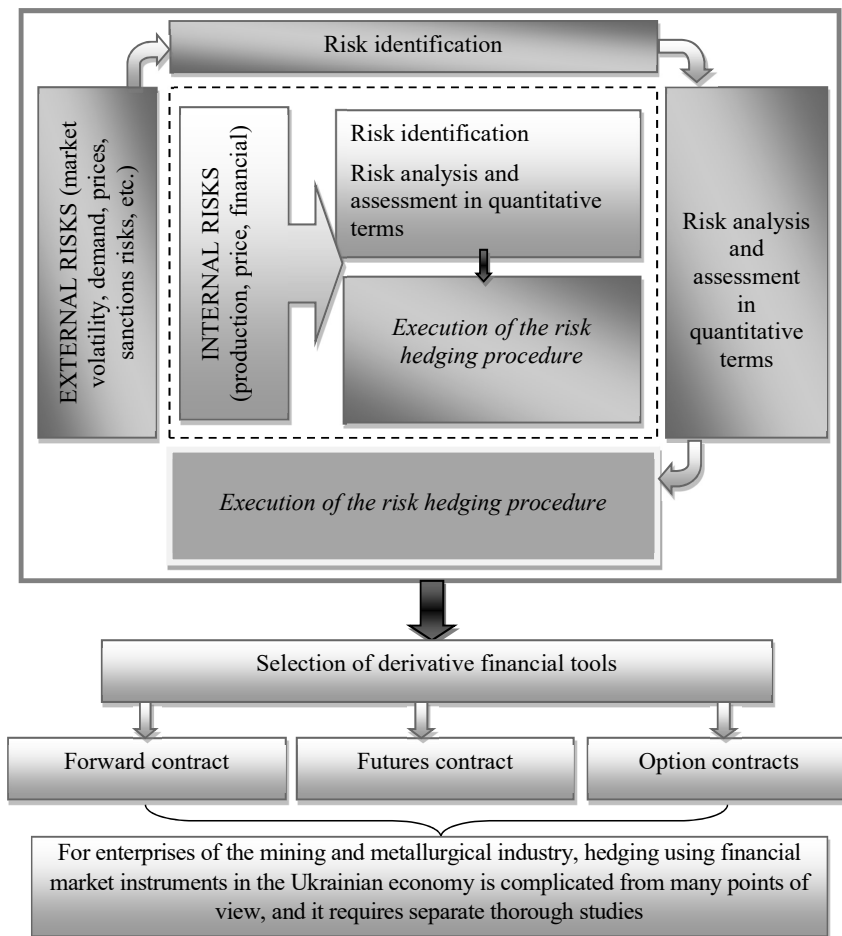


Fig. 7. Price risk hedging model

6. Discussion of results of investigating risk management of enterprises exporting products of the metallurgical industry based on hedging tools

Features of the proposed risk management based on hedging tools, in contrast to study [1], are grouped risks of the metallurgical industry by nature of origin and the possibility of control and management. We have substantiated the possibility of managing risks with the help of a risk map, which is individual for each business entity depending on the market situation and other factors. Also, in contrast to [1], a risk-hedging model is proposed.

In contrast to studies [3, 4], which considered the possibility of using hedging tools in the energy resources market, we investigated risk management based on hedging tools for exporting enterprises in the metallurgical industry. And considered the impact of geopolitical risks on manufacturers of metal products, in contrast to [5, 6].

As confirmed by the results of our study (Table 1, Fig. 1), the global metallurgical industry after the crisis caused by the COVID-19 pandemic shows signs of stability, although it has not yet reached the “pre-modern” indicators. The statistics of Ukrainian production and export of metal products were quite stable during 2019–2021, but after the start of the full-scale war of Russia against Ukraine, there was a significant deterioration (Table 2, Fig. 2, 3). In addition to the war, in recent years the development of enterprises in the metallurgical industry has been negatively affected by such external factors as:

- reduction of prices for metal products on the world market;
- reduction of demand for metal products;
- increase in environmental tax rates and others.

The metallurgical industry of Ukraine does not have a dominant position on a global scale, so the metal products market must adapt to the external environment, which is dictated by more important participants, such as China, India, and Japan. Since Ukraine's economy is open and significantly dependent on exports and prices for raw materials, its mining and metallurgical industry instantly forms a negative reaction to the action of global factors.

The metallurgical industry has an impact on the formation of the overall structure of the country's economy, which is confirmed by the study of the correlation between the value of the products produced in this industry and the country's GDP (Fig. 4).

The implementation of export activities is associated with the types of risks that are present throughout the entire logistics chain, starting with the supply of material resources and raw materials, and ending with the delivery of finished products to consumers. The grouping of risks by nature of origin and possibility of control and management is an urgent need of management (Fig. 5, Table 3).

Among the risks of exporters of metallurgical products are risks that enterprises cannot control, and among them is the risk of exchange rate fluctuations. As the study showed, there is a fairly significant correlation between the influence of the exchange rate on the price of metal products (Fig. 6). Currency risk is not subject to insurance, that is, it cannot be transferred to the insurer. To reduce the impact of currency risk on enterprises, exporters can use financial market instruments, such as forward and futures contracts. But the possibility of using such tools in the realities of the national economy has been little explored.

The proposed risk-hedging model (Fig. 7) is an attempt to ensure balance and, if possible, minimize losses from risk situations during product export.

The limitations of this study are the difficulty of obtaining reliable statistical information on the prices at which metal products are sold by various exporting countries.

The disadvantages of this study are:

- certain generalization and theoretical character;
- conditionality of the proposed hedging mechanism.

This is primarily due to:

- the absence of derivatives specifically for metal products in Ukraine;
- the complexity of calculations due to the limitation of open data;
- the situation in the country as a whole.

Despite some limitations and shortcomings of the research, its potential is precisely in the search and validity of tools for protecting the financial interests of exporters of metal products through hedging.

Further research may be aimed at finding a correlation-regression relationship between various industry-specific commercial and non-commercial factors for the application of hedging instruments.

7. Conclusions

1. The dynamics of steel exports by the main producing countries were analyzed. It has been proven that the macroeconomic situation in the market of metal products is quite difficult. During the period under study, there is a decrease in demand for steel products, as the persistently high inflation in world markets has led to higher interest rates in leading economies, and as a result, the burden of price increases is transferred to consumers. At the level of Ukraine, a direct and significant correlation has been established between the volume of manufactured metal products and GDP, which emphasizes the importance of the metallurgical industry for the country's economy.

2. We have grouped risks of the metallurgical industry by nature of origin and possibility of control and management. The possibility of managing risks with the help of a risk map, which is individual for each business entity depending on the market situation and other factors, is substantiated. Correlation dependence of prices for certain types of metal products on inflation and exchange rate is constructed. It has been proven that the price risk under modern conditions is critical for exporters of metal products. To minimize it, it is suggested to use derivative financial instruments.

3. A risk-hedging model has been proposed, which, unlike existing risk management models, involves not only the identification, analysis, and assessment of risks. By establishing a correlation-regression relationship between key indicators, this model allows the application of hedging tools in those sectors of the economy where derivative financial instruments were not used until recently.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

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Data availability

The data will be provided upon reasonable request.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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