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## ANALYSIS OF LOGISTICS PROCESSES IN THE METALLURGICAL INDUSTRY

### АНАЛІЗ ЛОГІСТИЧНИХ ПРОЦЕСІВ МЕТАЛУРГІЙНОЇ ГАЛУЗІ

*The article analyses the current state of the Ukrainian metallurgical industry, explores the logistics system of metallurgical enterprises, and proposes strategic logistics solutions. To maintain objectivity, subjective evaluations have been excluded. The decline in the production of rolled products and iron and steel in 2022 has caused Ukraine to drop from 14th to 25th in the global ranking. Therefore, the article suggests exploring alternative transportation methods to reduce costs and improve efficiency.*

*Following the Russian invasion, Europe has become the sole market for steel products. However, shipping goods by rail has become challenging and costly. The costs of delivering rolled products for steelmakers have nearly doubled, while demand for these products has decreased due to unfavourable market conditions.*

*Therefore, the operation of steel companies in today's environment requires the maximum use of management tools for the steel industry, particularly in sales and logistics management.*

*In Ukraine, just over 20 % of the total volume of rolled steel production is shipped to the domestic market, while exports account for about 80 %.*

*Logistics issues are closely related to the key development issues of the steel industry. The state of the logistics infrastructure allows for active participation in conquering new markets and increasing volumes in the global metal market.*

*The article examines the logistics systems of metallurgical enterprises, focusing on their characteristics and features that impact efficiency and production costs.*

**Key words:** steel industry, logistics, sales market, production decline.

*Стаття присвячена аналізу стану металургійної галузі України та вивченню функцій логістичної системи металургійних підприємств, напрацюванню стратегічних логістичних рішень в умовах їх динамічного розвитку. У 2022 році відбулося скорочення виробництва прокату, чавуну та сталі, що призвело до зниження частки України у світовому виробництві до 0,3 %. У 2016 році цей показник складав 1,5 %. Спад виробництва пов'язаний з логістичними проблемами, негативною ситуацією на світовому ринку, а також знищенням в результаті бойових дій двох найбільших металургійних підприємств України.*

*Після російського вторгнення, Європа стала єдиним ринком збуту металургійної продукції. Однак, доставка товарів залізницею стала складною та дорогою. Витрати металургів на доставку прокату зросли майже вдвічі, а попит на продукцію зменшився через несприятливу кон'юнктуру ринку.*

*Функціонування металургійних підприємств у сучасних умовах вимагає своєчасної реакції на зміни ринкових вимог та кон'юнктури, при максимальному використанні інструментів управління діяльністю підприємств металургійної галузі, зокрема, в управлінні збутом та логістичною діяльністю.*

*У загальному обсязі виробництва металопрокату в Україні частка відвантажень на внутрішній ринок становила трохи більше ніж 20 %, тоді як на експорт припадало близько 80 %.*

*Таким чином, проблеми логістики тісно пов'язані з ключовими питаннями розвитку металургійної галузі, оскільки стан логістичної інфраструктури дозволяє активно брати участь у завоюванні нових ринків збуту і збільшити їх обсяги на світовому ринку металів.*

*При вивченні та аналізі існуючих логістичних систем підприємств металургійної галузі були виділені характеристики та особливості логістичних процесів підприємств цієї галузі, які впливають на їх ефективність і суттєво відображаються на зростанні собівартості виробленої продукції.*

**Ключові слова:** металургійна галузь, логістика, ринок збуту, спад виробництва.

**JEL Classification:** D81, L10

**Introduction.** In comparison to 2021, Ukrainian enterprises in the metallurgical industry have reduced the production of rolled metal by 71.96 %, cast iron by 69.8 %, and steel by 70.7 %. As a result, Ukraine has dropped out of the top 15 largest steel producers in the world, falling from 14th to 25th place [1].

The decline in production by Ukrainian metallurgists is associated with logistical problems, the situation in the global market, and the destruction of two major metallurgical enterprises in Ukraine – "Azovstal" and MMK named after Ilyich in Mariupol, as a result of the armed conflict.

After the Russian invasion of Ukraine in February 2022, Europe became the only market for Ukrainian products. However, transportation of goods by rail has become difficult and expensive. The costs of delivery for metallurgists have almost doubled, and demand for products has decreased due to an unfavorable market situation.

Due to these factors, Ukrainian metallurgical enterprises are operating at a low capacity utilization level and even temporarily suspending operations for some of them. Additionally, since October 2022, there has been systematic damage to Ukraine's electric power infrastructure, resulting in issues with energy supply for regions and industries.

The functioning of metallurgical enterprises in modern conditions requires a timely response to changes in market requirements and market conditions, utilizing management tools to the maximum extent in the activities of enterprises in the metallurgical industry, specifically in sales and logistics management.

**Analysis of research and publications.** There are numerous scientific works dedicated to studying the improvement of industrial enterprise performance based on the logistics concept and logistics management tools by domestic and foreign scholars and practitioners. Among them, notable works include those by L.R. Abdullina, K.I. Kozeikina, Ye.V. Krykavskiy, R.R. Larina, V.S. Lukinsky, L.B. Miroten, A.A. Rudenko, and A.G. Shushakova. These works propose effective methods and measures of logistics management by economic entities in conditions of instability and uncertainty of the market situation. Under certain conditions, these measures can be applied to metallurgical enterprises in Ukraine. Along with this, researchers such as Ye.V. Afanasyev, T.P. Volkova, A.K. Golubchenko, V.M. Grebenik, S.G. Grishchenko, D.Ye. Kozhenkov, V.L. Mazur, A.Yu. Pikus, S.V. Cherednichenko, L.V. Shykova, and others have studied the problematic issues, strategic directions of development, and competitiveness of metallurgical enterprises in conditions of insufficient efficiency of the industrial sector in Ukraine.

**The purpose** of this article is to analyze the state of the metallurgical industry in Ukraine, study the functions of the logistics system of metallurgical enterprises, identify the characteristics that affect their efficiency, and develop strategic logistics solutions in the conditions of dynamic development of metallurgical enterprises to increase their competitiveness.

**Presentation of the main material.** The metallurgical industry is one of the priority sectors in Ukraine. However, the Russian Federation's invasion in 2014 and its consequences, such as the annexation of Crimea and the armed conflict in eastern Ukraine, have led to a crisis in this industry. Due to the war, our country has lost nearly 30–40 % of its metallurgical capacities. The sector suffers from damage to railway infrastructure, a shortage of raw materials, and shelling of industrial facilities [1].

Although 2016 was a year of recovery, production volumes declined again in 2017 due to the loss of assets of the "Metinvest" group in temporarily uncontrolled Ukrainian territories, such as the Yenakiieve Steel Plant, the Kharzysk Pipe Plant, "Donetsk-Koks," and others.

Over the past few years, the domestic industry has faced a new challenge – the coronavirus pandemic, which has led to market closures and a decline in consumption.

But the war played a decisive role in the decline. Compared to 2013, Ukraine has lost about 80 % of its steel production volume. The majority of this decline occurred in 2022 (Fig. 1). In 2022, Ukraine's share in global production was 0.3 %, while in 2016, this indicator was 1.5 % [1].

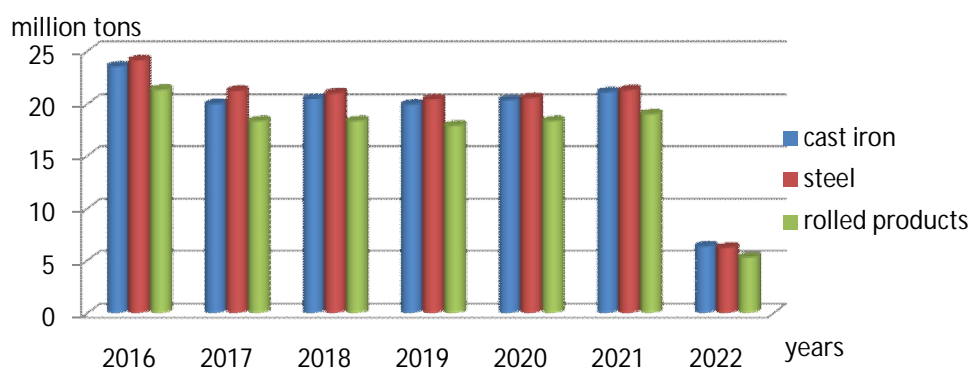


Fig. 1. Dynamics of production of iron, steel and rolled products in Ukraine

The production of iron ore products has significantly changed due to logistics problems, decreased demand, and increased production costs. This has led to temporary suspensions of ore extraction by companies.

For example, mining and beneficiation plants of the Metinvest group have experienced losses of almost 66 %. The mining department of ArcelorMittal Kryvyi Rih produced only 40 % of the iron ore concentrate in 2021 [1].

Ferrexpo, which is the largest exporter of iron ore pellets among post-Soviet countries, reduced concentrate production by 40 % last year.

One of the reasons for this situation in the industry was the suspension of the VAT refund process to exporters due to the malfunctioning of the VAT administration system and the Unified Register of Tax Invoices. This led to a lack of working capital for metallurgical and mining enterprises. Although this occurred only for three months, in March-May and partially in July, it resulted in a shortage of almost 20 % of working capital, forcing some companies to seek funding from international credit institutions to finance their operations.

The metallurgical industry is one of the most energy-intensive sectors of the economy. In 2020–2021, the share of metallurgy in total electricity consumption in Ukraine was 23 %, second only to residential consumers.

Attacks on critical infrastructure facilities led to a blackout of the energy system in Ukraine. Not only residential consumers, but also the industry were left without electricity. In November, Ukrainian metallurgists announced a forced shutdown of main production processes for the second time since the start of the war.

After stabilizing the situation, they continued to operate within allocated quotas for energy consumption, implementing maximum energy efficiency measures and reducing equipment load.

In early 2023, the government allowed industrialists to import electricity from the EU until the end of April. They are guaranteed "non-disconnection" for the purchased electricity volumes.

"Metinvest" started importing electricity for its needs in February, which allowed increasing the capacity utilization of the "Kametstal" plant to 65 % after the shutdown in November.

Only in February 2023, the energy system achieved a deficit-free production.

According to estimates from trading companies, consumption of metal products in the domestic market decreased by at least half to 2 million tons in 2022, while prices increased on average by 25 %. Prior to the start of the Russian invasion, domestic consumption exceeded 5 million tons of steel per year, a quarter of which was accounted for by imports.

In the total volume of metal product production in Ukraine, shipments to the domestic market accounted for just over 20 %, while exports accounted for about 80 %.

Ukraine's metallurgical industry is export-oriented. In the list of goods in foreign trade, iron ore exports occupy a place in the top three both in terms of volume and value.

If in 2021 this category provided 10 % of the country's export revenues, last year the shipment of ore dropped to first place due to agricultural products (corn, sunflower oil) thanks to a grain agreement.

Since the supply of ore is not covered by an agreement, its export volume in 2022 nearly halved to 24 million tons, and the foreign currency revenue decreased to \$2.9 billion. This constitutes approximately 7 % of Ukraine's income.

Before the war, China was the main buyer of Ukrainian raw materials. Last year, exports to China were only carried out in the first four months, after which Ukrainian suppliers redirected their volumes to the nearest markets – the Czech Republic, Poland, Slovakia – due to blocked ports.

Considering that Ukraine's share in China's iron ore imports was 2 %, the loss of these volumes was not a problem for Asian manufacturers. For Europeans, Ukraine partially replaced the volumes that the aggressor previously supplied and lost due to sanctions.

Annual metal product exports fell by 68 % to 6.5 million tons, leading to a 65 % decrease in export revenues from its sales.

The war has created problems not only for the Ukrainian economy, but also for the global metallurgical market, as traditional trade flows have changed. Although Ukraine cannot be considered a player that sets world prices for iron ore, domestic manufacturers have still dominated in some foreign markets.

For example, according to the International Trade Centre, in 2021, Ukraine accounted for 72 % of Lebanon's imports of hot-rolled flat products, 55 % of Senegal's rolling segment, 58 % of semi-finished products of the Dominican Republic, and 63 % of cast iron in the UAE.

As a result, foreign companies were forced to find new suppliers without Ukrainian volumes. A notable example is the situation in the EU. On the one hand, they faced a decline in Ukrainian production volumes, and on the other hand, they had the task of breaking free from import dependence not only on Russian gas but also on Russian steel.

To achieve this, the European Commission imposed a ban on external trade operations with Russian metal products, and some European importers self-restricted.

According to Eurofer, in 2021, Ukraine accounted for 43 % of the total import volume of heavy plate products for EU countries. However, due to the loss of suppliers of this product, such as factories in Mariupol, the Ukrainian volume in 2022 accounted for only 11 %.

The deficit was covered by Asian manufacturers, who provided more than 60 % of the import volume of the bloc.

A similar situation arose in the semi-finished products segment of the EU, where, in addition to demand from local rerollers, companies of the Metinvest group and Russian metallurgical holdings (NLMK) import the products. For example, Metinvest supplies square billets for the production of long products to a plant in Bulgaria, and slabs, which are semi-finished products for the production of flat products, to plants in Italy and the UK.

According to the conditions of the EU's eighth package of sanctions, the aggressor country can supply steel semi-finished products until October 2024 until local consumers adapt to the new realities. At the same time, Chinese and Indian suppliers are already replacing part of Ukraine's production, for example, in Italy.

International support for Ukrainian exports, including the supply of metallurgical products abroad, primarily came from Western countries.

The first step was taken by the UK, which in April 2022 announced the early cancellation of all import duties and quotas. Later, the EU, the USA, Canada, and Australia announced their intentions to ease access for Ukrainian goods to their markets for one year.

Important decisions regarding trade protection measures are of great significance to steel metallurgists.

For the first time in 20 years, Canada has allowed the import of Ukrainian hot-rolled coil without paying anti-dumping duties. The suspension of anti-dumping duties on Ukrainian hot-rolled flat products from the UK has been in effect for nine months, starting from the end of August 2022.

However, some countries have intensified their market protection measures by implementing new restrictions or extending existing ones on Ukrainian metal products.

In June, Egypt extended the duration of anti-dumping duties on the import of reinforcement bar, wire rod, and rebar from Ukraine for another year, while Mexico applied anti-dumping duties to Ukrainian thick sheet for an additional five years.

Ukrainian metallurgists, such as "Metinvest" and "Interpipe", have positively assessed the trade liberalization. However, the decisions of the partners are seen more as acts of political support, as they do not have real chances for significant export growth due to logistical and production constraints.

Thus, logistics issues are closely related to key development issues in the metallurgical industry since the state of logistical infrastructure allows active participation in capturing these markets and increasing their volumes in the global metal market.

Logistics in this industry is perceived as a tool for eliminating discrepancies between production (industrial) and distribution-dispersed (distribution) systems.

When analyzing the logistics systems of Ukrainian metallurgical enterprises, it is important to consider the fact that this market is relatively young, with its development starting in the 1990s. Prior to that, the logistics scheme was simple: there were metal producers and metal bases. Almost all trade of metallurgical products was centralized and focused around these bases, where wholesale and retail operations were conducted.

In addition to direct manufacturers, the modern Ukrainian market of metallurgical products includes a large number of intermediaries – metal traders. Due to increasing competition, consumers often demand additional requirements from suppliers, which include expanding the range of services. As a result, metal sellers do not just deliver products from their warehouse to the end consumer, but also provide a range of metal processing services, such as cutting to custom sizes. Furthermore, the modern market of metal industry enterprises is closely linked to its infrastructure, which includes interrelated sectors such as organizational management, production, supply and sales, transportation and warehousing, finance, information and research, education, and economic and legal aspects.

All these entities serve the process of metal production and trade. The problem of optimizing the mechanisms of implementation and management of logistic systems is relevant not only in Ukraine but also worldwide. Enemy strikes on railway infrastructure and, most importantly, the blockade of seaports have become one of the most serious challenges for the industry. Approximately 65 % of metal product exports were carried out through ports. According to experts' estimates, the blockade of Black Sea ports costs Ukraine \$420 million per month. Therefore, companies have built new transportation routes through EU railway and sea ports, primarily the Romanian port of Constanta, Polish ports Gdansk, Gdynia, Szczecin, and the Lithuanian port of Klaipeda, instead of traditional Mariupol, Odessa, and Mykolaiv. In addition to quantitative restrictions, companies have also faced increased transportation costs. In July 2022, the Ministry of Infrastructure issued an order to increase tariffs for transportation by Ukrzaliznytsia (Ukrainian Railways) by 70 %.

When studying and analyzing existing logistic systems of metallurgical industry enterprises, the following characteristics that affect their efficiency were identified:

1. Within the framework of metallurgical production, a large range of raw materials and materials is circulated, which results in a monopoly position in local markets, unequal conditions for purchasing raw materials and materials from local manufacturers, and selling finished metallurgical products to them. At the same time, a significant portion of purchases is made within affiliated companies within the value-added chain (iron ore raw materials, energy, coal), and such a

procurement system leads to lower production costs. It is on this group of suppliers that the metallurgical enterprise concentrates the supply of the main group of auxiliary raw materials and technological materials (Tabl. 1).

*Table 1.* Generalized structure of raw materials and consumed materials at enterprises of the metallurgical industry

Group	Subgroup	The main groups of CMV	Share of value in the total volume of purchases, %
Raw	Essential	Iron ore raw materials, coal	60,0
	Additional	Ferrous alloys, ferrous metal scrap, non-metallic materials, non-ferrous metals	20,0
Equipment	Technological	Refractories, graphite electrodes, etc.	12,0
	Additional	For current and capital repairs	5,0-7,5
Equipment	Standard	To support the existing production technology	3,0-5,0
	Investment	Modernization of production	One-time deliveries

2. The limited availability and sufficient distance of raw material resources and consumption centers. In the eastern regions of Ukraine, a large part of the fuel and energy resources and raw materials for metallurgical enterprises are concentrated. On the other hand, the main consumption of products of metallurgical enterprises occurs in the north and south of the country, in central and eastern Europe, and Central Asia, which creates problems associated with high transportation costs.

3. Metallurgical enterprises implement differentiated pricing policies in different markets, which allows for selling at prices lower than the cost in some regions through selling at higher prices in others. The predominant types of sales are selling finished metal products through metal traders, directly to consumers, through representative offices in other countries, as well as through service metal centers.

4. The location of metallurgical industry enterprises affects the development of infrastructure, namely the availability of production and social infrastructure facilities and their level of development. Regions with higher levels of infrastructure development are usually more attractive for the placement of metallurgical enterprises, as there is no need to build new additional facilities for energy supply, water supply, transportation communications, and social services.

5. The environmental characteristic in the placement of metallurgical production is an objective necessity for the development of the economy of Ukraine. At the current stage of national economic development, the environmental situation has worsened in many regions of Ukraine, which cannot be ignored in the process of placing metallurgical enterprises, which have a strong impact on the environment and natural resources utilization, and are significant polluters of the atmosphere, water bodies, forest areas, and land. It is known that the higher the level of environmental pollution, the higher the costs of pollution prevention. Further increase in these costs can ultimately make any production unprofitable. For the enterprises of the ferrous metallurgy, the following is observed: 20–25 % of dust emissions, 25–30 % of carbon oxide emissions, and more than half of sulfide oxide emissions from their total volume in the country.

Metallurgical enterprises also take up to 20 % of water from the total consumption of water in industry and significantly pollute surface water.

6. The presence of stable economic relationships between suppliers of basic technological raw materials, equipment, and the enterprise.

In long-term and established partnerships between suppliers and metallurgical industry businesses, it is possible to create consignment warehouses based on the storage facilities of the enterprise. For businesses, such consignment warehouses serve as a kind of free insurance reserve and an effective way to reduce losses from excessive inventory. The supplier also benefits from the opportunity to deliver a large batch of raw materials at once. A well-drafted agreement on the

conditions for the creation of a consignment warehouse guarantees the supplier long-term storage and replenishment of their inventory on the territory of the metallurgical enterprise.

The analysis of the potential increase in economic efficiency of industrial metallurgical enterprises shows that about 50 % of optimization of financial costs depend on cooperation with suppliers. When organizing the process of procurement and delivery to the production warehouse, the main part of the cost of the final product is formed.

One of the most common forms of organizing the procurement process in industrial metallurgical enterprises is the centralized supply system, which allows for effective systematization of procurement services' work.

Centralized equipment supplies to metallurgical industry enterprises are carried out within the framework of technical re-equipment or modernization plans at the enterprises. Usually, initiators of procurements are technical services that develop these plans. The selection of equipment for procurement is carried out by the procurement service based on tender with specified technical parameters by the technical service. Direct targeted procurement from a specific manufacturer is also possible. This form of supplier selection mainly occurs during the joint development of new equipment by the technical services of the metallurgical enterprise and the manufacturer, as well as in the case of repair or modernization of existing equipment, when the supply is carried out by the manufacturer of the equipment installed at the enterprise.

There is no universal scheme for organizing centralized logistics support. The management of each company sets specific goals and tasks for its supply services, based on which work methods are determined. Within one company, not one, but several supply organization schemes may be applied. It all depends on the specifics of production and the will of the management. However, the following features of such a centralized system of organizing logistics processes are distinguished:

1. The form of interaction between suppliers and metallurgical enterprises is selected. The chosen form is fixed by a contract signed by authorized representatives of suppliers and metallurgical enterprises.

2. The analysis of all procured range of raw materials is conducted. Based on the analysis, a decision is made on the feasibility of centralized supplies.

3. A regulation of interaction is developed for the process of supplying subdivisions of metallurgical enterprises, which determines the entire process of interaction, the rights and responsibilities of each subdivision involved in the supply organization.

Analyzing the peculiarities of logistics processes in the metallurgical industry, the following significant drawbacks can be identified, which affect their efficiency and significantly reflect on the cost increase of the produced goods:

1. Modern management concepts are not utilized. Today, a new integrated management paradigm is emerging, which generates a new ideology of managing logistics processes and business as a whole – Supply Chain Management (SCM) – managing supply chains. It reflects a new understanding of business: individual enterprises are viewed as links in a supply chain, connected in a single (integrated) process of managing flows of all types of resources to optimally satisfy customers' specific needs.

2. The practice of multiple intermediaries has become widespread, noticeably increasing logistics costs and therefore the final price of the product for the buyer.

The main reasons that justify the use of trade intermediaries by metallurgical enterprises in the formation of logistic channels and chains are:

- 1) Managing flow processes based on the logistics concept requires certain financial, material, qualification, and other resources. The higher the efficiency requirements of management, the more funds and resources may be needed.

- 2) The attempt to form an efficient structure of logistics channels and chains, as well as its further improvement, requires knowledge and experience in the market structure of commodity flows, methods of implementation, and distribution in the industry.

3. Purchasing logistics methods, taking into account the specifics of the steel industry, are not sufficiently studied. Most works dedicated to these issues are characterized by a descriptive approach. Problems of inventory management and supplies, management of inventories in multi-item

warehouses, organization of distributed warehouses, automation of management, and other issues still remain without sufficient attention.

4. Complex decision-making mechanism in the process of preparing a request for material and technical resources.

5. Many companies in the metallurgical industry have fragmented management of the budget for material and technical resources. The source of the problem of fragmented application of risk management tools in the budget process is the low level of methodological and methodical development in this direction, as well as the lack of a systemic approach to risk assessment, monitoring, and minimization.

6. Often, inventory is valued in monetary terms rather than in physical quantities. The final value of inventory in monetary terms only approximately reflects the actual value of available inventory. This is especially pronounced if different price markups are applied when purchasing different production supplies, or if these markups vary widely in each specific case.

7. The presence of significant non-matching (non-liquid) inventory. The presence of non-matching (non-liquid) inventory in warehouses leads to significant diversion of funds for metallurgical companies. Depending on the speed of reaction to the emergence of this inventory group, the amount of diverted funds can vary greatly. Therefore, the development of a mechanism to increase the speed of identification and elimination of non-liquid inventory is an extremely relevant task for the implementation and management of the logistics system of a metallurgical enterprise.

8. Limited criteria for selecting suppliers. Supplier selection is one of the most critical drawbacks of procurement logistics in metallurgical companies. This problem is one of the four main tasks of the supply/procurement department. Some managers underestimate the importance of choosing the right supplier for the effective functioning of the entire company. Some studies show that in many companies worldwide, at least 50 % of quality-related problems arise from products and services provided by suppliers. Therefore, choosing the "right" supplier is the basis for the successful operation and creation of a stable supply base for any company.

9. Inefficient use of warehouse premises and space. Among the obstacles that hinder increasing the efficiency of warehouse complexes in metallurgical enterprises, the following groups are highlighted: organizational (functions, responsibilities, zones of responsibility); technological (sequence of operations, methods, and algorithms); informational (accounting and data processing systems, communication tools); technical (availability of equipment, resource wear and tear, compliance with requirements).

**Conclusions.** By February 2022, metallurgical companies had announced ambitious development plans for their assets, but within a month it became clear that the main plan was to continue the operation of surviving enterprises.

As a result, the Ukrainian mining and metallurgical complex managed to withstand, according to various estimates, around 15–30 % of its capacity, primarily through the support of Western partners who provided their ports and reduced trade barriers.

Based on the analysis of existing implementation and management systems for logistics systems in the metallurgical industry, the following research needs can be identified to address the following current issues:

- development of a mechanism for synthesizing industry centers of logistics responsibility that would solve existing problems in the implementation of logistics business processes in the industry.

- development of a mechanism for determining the parameters of an optimal outsourcing strategy for logistics processes in an individual enterprise in the metallurgical industry that would solve the problems of cost reduction in the implementation of logistics business processes.

- development of procedures for integrating logistics processes into the overall concept of improving production in the metallurgical industry, as well as principles of innovation and information transformation of logistics processes.



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