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OPTIMIZATION OF LOGISTICS INFRASTRUCTURE CHAINS IN THE COMMODITY MARKET IN THE CURRENT ENVIRONMENT

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ОПТИМІЗАЦІЯ ЛОГІСТИЧНИХ ІНФРАСТРУКТУРНИХ ЛАНЦЮГІВ НА ТОВАРНОМУ РИНКУ У СУЧАСНИХ УМОВАХ

The article examines that the optimization of logistics processes in supply chains within commodity markets is one of the key topics in the field of logistics and supply chain management. The rapid development of information technologies, as well as the globalization of economic processes, require enterprises to adopt a new approach to organizing logistics chains, which significantly enhances business efficiency. Information technologies enable the reduction of inventory levels at distribution centers, better utilization of transport

capacities, reduction in transportation costs, and a decrease in the time required to fulfill customer orders. All these factors affect the overall competitiveness of enterprises and their ability to respond quickly to changes in market conditions.

Particular attention is given to the challenges of optimizing logistics chains in the face of modern challenges, such as market instability, rising resource prices, the introduction of new regulatory requirements, and climate change. The emergence of new technologies provides unique opportunities for improving existing supply chain management models. Despite this, the implementation of new technologies requires thorough analysis and adaptation of existing logistics systems, which necessitates the continuous improvement of theoretical and practical approaches to supply chain optimization.

This article addresses the current problems and prospects for optimizing logistics chains in commodity infrastructure, providing a comparative analysis of existing approaches to solving this issue. Additionally, the author proposes a definition of the term «logistics chains», which allows for a more accurate identification of the key components and interconnections in the supply process. Special attention is given to the external environment's challenges and the analysis of opportunities for implementing new technologies in supply chain management in the context of a dynamically changing market situation. Therefore, solving the problem of optimizing logistics chains becomes a key element in improving business efficiency and sustainability in the face of global economic changes and technological transformation.

У статті досліджено, що оптимізація логістичних процесів у ланцюгах поставок на товарних ринках є однією з ключових тем у сфері логістики та управління ланцюгами поставок. Стрімкий розвиток інформаційних технологій, а також глобалізація економічних процесів вимагають від підприємств нового підходу до організації логістичних ланцюгів, що значно підвищує ефективність бізнесу. Інформаційні технології дозволяють знизити рівень запасів у розподільчих центрах, краще

використовувати транспортні потужності, зменшити транспортні витрати, скоротити час, необхідний для виконання замовлень клієнтів. Всі ці фактори впливають на загальну конкурентоспроможність підприємств та їх здатність швидко реагувати на зміни ринкової кон'юнктури.

Особлива увага приділяється проблемам оптимізації логістичних ланцюгів в умовах сучасних викликів, таких як нестабільність ринку, зростання цін на ресурси, запровадження нових регуляторних вимог, зміна клімату. Поява нових технологій надає унікальні можливості для вдосконалення існуючих моделей управління ланцюгами поставок. Незважаючи на це, впровадження нових технологій вимагає ретельного аналізу та адаптації існуючих логістичних систем, що зумовлює необхідність постійного вдосконалення теоретичних і практичних підходів до оптимізації ланцюгів поставок.

У даній статті розглядаються сучасні проблеми та перспективи оптимізації логістичних ланцюгів у товарній інфраструктурі, проводиться порівняльний аналіз існуючих підходів до вирішення цього питання. Крім того, автор пропонує визначення терміну «логістичні ланцюги», що дозволяє більш точно ідентифікувати ключові компоненти та взаємозв'язки в процесі постачання. Окрему увагу приділено викликам зовнішнього середовища та аналізу можливостей впровадження нових технологій в управлінні ланцюгами поставок в умовах динамічно мінливої ринкової ситуації. Таким чином, вирішення проблеми оптимізації логістичних ланцюгів стає ключовим елементом підвищення ефективності та стійкості бізнесу в умовах глобальних економічних змін і технологічних трансформацій.

Keywords: logistics, supply chain, optimization, automation, commodity market.

Ключові слова: логістика, ланцюжок постачання, оптимізація, автоматизація, товарний ринок.

The problem statement in general terms and its connection with important scientific or practical tasks. Today's economy is characterized by the increasing pace of integration processes and the emergence of new dynamic relationships between suppliers, producers and consumers. The flow of materials and finished products goes beyond the boundaries of individual enterprises and forms logistics links between them, which constitute separate links in the supply chain. The efficient operation of modern enterprises no longer depends solely on the availability of high-tech equipment or innovative developments. The market success of enterprises largely depends on the improvement of supply chains, systematic optimization of the entire complex of supply, production and sales processes based on modern logistics methodologies for organizing the movement of material and information flows [18].

In Ukraine, the term "logistics" was first proposed by the prominent Ukrainian economist and mathematician E. Slutsky in the context of considering praxeology in his work "Research on the Problem of Building Formal and Praxeological Foundations of the Economy" (1926), emphasizing that logistics is related to logic in the same way as praxeology is related to formal economics [10, p. 13]. Therefore, the ideas of integrating supply, production and distribution systems that combine the functions of supplying materials and raw materials, manufacturing products, and distributing them, which emerged in a market economy at the beginning of the economic crisis of the 1930s ("pre-logistics" period), were transformed into an independent scientific research area and a form of economic activity - logistics. It was in the mid-1950s (the period of classical logistics) that the concept of logistics entered the US economic terminology in the sense of enterprise logistics [10, p. 13]. In 1951, an American expert in systems analysis, Professor O. Morgenstern, first pointed out the possibility of using the logistics approach in the field of economics. Thus, in his work "Note of the Formulation of the Study of Logistics", he considers logistics as part of the doctrine of the organization and economics of production, which includes procurement, production and sales logistics. In particular, he wrote: "...there is an

absolute similarity between the approach to management and methods of supplying troops and the problems of material management that are solved in industry" [10, p. 13].

In the late 1970s, the final period of «classical logistics» marked a conceptual changes in logistics science. If earlier the emphasis was on the trade-offs between the functions of logistics applications in one firm, later it shifted to trade-offs between firms.

In the mid-1980s, a new approach to the development of logistics emerged in Western countries, called the «concept of total responsibility», which can be generally described as a logical and natural extension of the integrated approach. Its peculiarity is that the logistics system goes beyond the economic environment and considers social, environmental and political aspects. The criterion is the most favorable ratio of benefits and costs.

The current stage of logistics development (since 2000) is characterized by the influence of two main factors: globalization of the world economy and the scientific and technological revolution, which generate new consumer needs for logistics services and various forms of satisfaction [11].

The realities of modern enterprise development require improvement of supply chain management tools as a component of production and business process management in general. Thus, the importance of the problem of supply chain management in modern conditions determines the relevance and validity of the study.

Analysis of the relevant research and publications. In the context of the problem under study, the works of many scholars should be highlighted among the modern scientific achievements.

Professor H. Pavellek of the University of Hamburg notes that even in the Roman Empire there were servants who had the title of "logisticians." They were engaged in the distribution of products [10, p. 12; 6, p. 11]. According to Archimedes, in the fourth century BC - the period of Athens' greatest power, the greatest democratization of the social system and the flowering of culture - there

were 10 logisticians in ancient Greece. In ancient Rome, logistics meant the distribution of products [2, p. 12; 6, p. 226]. In Byzantium, logistics was defined as the art of supplying the army and managing its movements, considering the number of soldiers, the tasks of their distribution and deployment depending on the characteristics of the terrain, weapons and the number of soldiers in the enemy army. In the first millennium AD, the military vocabulary of some countries associated logistics with activities aimed at providing the armed forces with material resources and maintaining stocks. For example, under the Byzantine king Leon IV (865-912 AD), the tasks of logistics were timely and proper arming of the army, provision of its military property and full satisfaction of its needs in each act of military campaign [10, p. 12]. The German philosopher, mathematician, physicist Gottfried Leibniz (XVII-XVIII centuries) called mathematical logic, formal logic logistics. According to mathematical logic, this term was officially established in September 1904 at a philosophical conference in Geneva [10, p. 12; 17, p. 20].

According to many Western scholars, logistics became a science thanks to military affairs. The founder of the first scientific works on logistics is a French Swiss baron, French general (later a Russian lieutenant general), military theorist of the early XIX century Antoine Henri Jomini (1779-1869). In his work "Treatise on the Art of War" (1837), he defined logistics as a practical art of management, transportation, planning, organization of troop supply and rear support of the front, the success of which is determined by the degree of interaction between different units involved in the movement [1, p. 12; 2, p. 65; 3, p. 127].

In the following decades, the term "logistics" was used only in the military literature of the United States, England, Italy and Germany. During the Second World War, the US Army widely used logistics approaches in organizing the interaction of military-industrial complex enterprises, transport and army supply services. Such interaction allowed timely and systematic provision of the American army with weapons, fuel and lubricants, and food materials in the required volume [1, p. 12-13; 2, p. 66; 3, p. 128]. Therefore, in many Western countries, logistics

have been used to ensure effective management of material flows in the economy. First of all, it was formed as a new type of theory on the management of the movement of goods and material resources in the sphere of circulation, and then production. Therefore, in many Western countries, logistics began to be used to ensure effective management of material flows in the economy.

Both in literature and in business practice, there are many opinions on the reasons for developing a supply chain, including the benefits it can provide to an enterprise. On a logistics basis, this translates into motivations for using logistics outsourcing or deferral, which further complicates the development of a unified approach. However, despite the many views and disagreements about the supply chain, not enough attention is paid to the reorganization of the supply chain and the redistribution of functions among its participants depending on the changing goals, objectives and external environment.

Formulation of the objectives of the article (task statement). The scientific study of the tasks of optimizing logistics chains was carried out using methods of scientific analysis. A comparative method in the scientific sense comparing the characteristics of different theories on the interpretation of the concept of "logistics" in order to identify common and different things in them, form classifications or conduct typology. The objects of this study were various ideas, research results, and qualitative characteristics of logistics presented by different scientists. This method is empirical and allows us to gain theoretical knowledge about the object of study. Based on the results of the analysis of logistics theories, the author's definition of the scientific problem was formed by the method of generalization.

Like other methods of applied mathematics (operational research, mathematical optimization, network models, etc.), logistics has gradually moved from the military sphere to the sphere of economic practice.

The theoretical basis of the information concept is a systems approach, which is used both to model objects themselves and to synthesize information and computer support systems. The main strategic decisions are to automate trivial

tasks and use information and computer support to solve a larger set of logistics optimization tasks.

The analysis of scientific and periodical literature allows us to identify a number of systems and methods of logistics chain management that will be useful in communicative interaction in any area of economic activity. Namely: Demand-Driven Techniques, Just-In-Time, Requirements/Resource Planning, Lean Production, Total Quality Management. It should be noted that Demand-Driven Techniques allows the company to respond as quickly as possible to changes in market demand by quickly replenishing stocks in places where demand is expected to grow. This concept also helps to improve coordination and relationships between producers, intermediaries and retailers when viewed as components of an integrated supply chain.

TQM or Total Quality Management is total quality management. This approach is based on the fact that quality is the focus of attention in every area of the company's activities. The most important goal is always quality, the high level of which guarantees customer satisfaction and, therefore, the benefit of the enterprise.

A detailed analysis of the methods allowed us to form a model for optimizing logistics chains to make effective management decisions to improve logistics in the company's operations and increase its profitability. The information base of the study was based on data from analytical publications and expert opinions of specialists in various fields of activity.

Summary of the main research material. According to research by the International Monetary Fund, logistics costs are at the enterprise level – from 4% to more than 30% of revenue, at European enterprises this figure ranges from 9% to 11% [12, p. 148]. In the process of globalization of production and trade, logistics plays an important role. This increases the importance of logistics at each enterprise, since most of its costs are often, for example, transportation costs.

In the Anglo-American literature on logistics, the following synonyms for supply chains are common: logistics channel, distribution channel, etc.

In Germany, the term logistics chain (die logistics Kette) is very common and is reflected in one of the national standards. A logistics chain is a linearly ordered number of individuals or legal entities (producers, intermediaries, warehouses, etc.) that perform logistics operations aimed at bringing an external material flow from one logistics system to another or to the end consumer. There is another interpretation of the logistics chain, which is understood as a set of logistics operations performed sequentially from the moment of inception to the moment of termination of the flow of goods, works, services in the relevant consumer market. However, in our opinion, it is more appropriate to consider enterprises that choose to participate in the processes of delivering goods, services and information to end consumers. Logistics chains are extended between logistics links to illustrate the organizational structure of logistics systems.

In the simplest case, when a logistics system is characterized as a system with direct links, the supply chain consists of a supplier and a consumer. In more complex cases, when tiered systems operate, this chain may have a tree-like structure or a form of an oriented schedule with cycles (flexible logistics system). In most cases, a logistics chain connects a producer and a consumer, although it often has a rather complex structure. The main components of a supply chain are external logistics (outsourced production), internal logistics (in-house production), sales and customer service. The effectiveness of logistics links largely depends on factors such as enterprise infrastructure, human resource management, and staff qualifications,

The analysis of the above information allows us to offer our own definition: logistics chains are a well-established sequence of operations between participants in the production process, i.e. between producers and consumers of the final product, which involves the coordination of information flows on the management of finished products.

According to the National Transport Strategy of Ukraine for the period up to 2030, "...the conceptual framework for the formation and priorities for the implementation of state policy in the field of transport aimed at integrating the

national transport network into the international transport network, meeting the needs of the population in transportation and improving business conditions in order to create a competitive and efficient national economy" [10]. In this regard, the main task in developing the country's transport strategy for the coming years is to ensure the unity of Ukraine's economic space, improve commodity and material flows on the basis of logistics, reduce specific costs, transport costs, and complete the formation of a unified transport system without bottlenecks in the system of cargo and goods movement through the integrative interaction of different modes of transport in mixed transportation. These activities should be carried out in a single information space.

Considering the logistics supply chain as a complex organized whole, in which information is the core, the "nervous system of the organization" [14], the creation of a single information space should be considered the basis for interaction between all participants in the movement chain. The formation of a single commodity and transport flow should be based on comprehensive planning of commodity and transport flows, which contributes to the interests of all participants in the logistics chain. Commodity and information exchange should be carried out within one single process, which contributes to the stability of supply and acceleration of all processes.

Due to the development of integration processes, the number of logistics providers that provide integrated logistics services has increased [5, p. 15]. In the international classification of logistics activities, there are five levels of logistics services in the commodity market that differ in the range of services and technological level (Table 1).

Supply chain optimization can be defined as the search for the best possible way to operate out of many possible options. In order for the supply chain optimization process to take place, it is necessary to clearly understand what and how to achieve the end result, i.e., there must be an "ideal" model that has been created and tested in the management of other supplies, a methodology for using

best practices or developed in the laboratory, the parameters of which must be achieved.

Table 1. Characteristics of logistics service levels in the commodity market

The name of the logistics service	Characteristics of logistics service
1PL (first port logistic) – autonomous logistics or logistics outsourcing.	It is characterized by the fact that the manufacturer of the product independently performs all logistics operations.
2PL (second logistic) is traditional logistics or partial logistics outsourcing.	The product manufacturer takes over part of the logistics functions (planning, warehousing, forming the logistics chain) and engages a third-party transport company as a contractor (outsourcing), since it owns its own transport.
3PL (third party logistic) – complex logistics outsourcing or 3PL provider.	A specialized company of this type provides a wide range of services, namely cargo transportation, warehousing, inventory management, packaging, forwarding.
4PL (fourth tier logistic) – outsourcing of integrated logistics.	A logistics company that provides services not only in complex transport logistics, but also in the planning and design of supply chains, management of logistics business processes at the enterprise.
5PL (fifth party logistic) – "virtual" logistics or logistics outsourcer .	Using the global space of information technologies, it is able to provide the entire range of services. An example of a 5PL provider is online stores.

In modern environment, it is virtually impossible to ensure the efficiency of any logistics operation without the use of information technology and software for analysis, planning, support and decision-making. The development of information systems and technologies makes it possible to automate logistics operations of the systems.

The most well-known programs used in logistics include the following (Fig. 1).

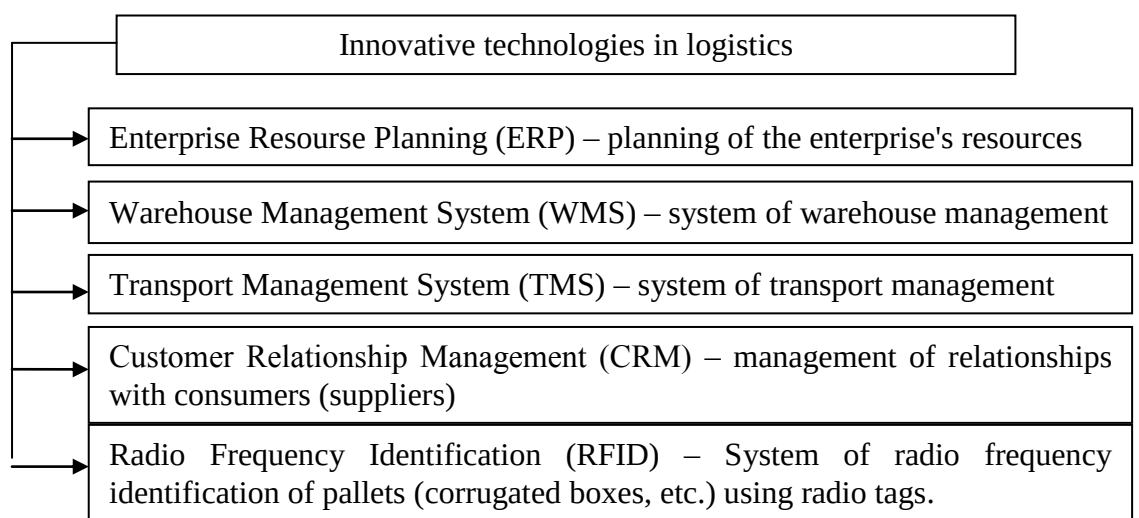


Figure 1. Innovative technologies in logistics

According to recent reports by the World Economic Forum, together with Bain & Co and the World Bank, the importance of improving administrative procedures and transport and communications infrastructure has been emphasized. The management of leading enterprises should apply new strategies in supply chain management.

With the growth of international trade and consumer demand, most businesses are adapting sophisticated supply chain management technologies, improving supply strategies to reduce the risk of missteps and minimizing costs, thereby maintaining a competitive position in the market. To effectively manage the new challenges that arise in the process of chain management, it is necessary to take into account the aspects of automation when creating integrated supply chains, transparency and data analysis for better planning and the formation of statistical models [27].

According to Allied Market Research, the digital logistics market – a set of services and tools for transportation - will grow by more than 20% by 2030. This means that companies will rely on automation, IT solutions, and cloud services. According to KPMG, about 60% of companies plan to increase investments in digitalization. The goal is to improve the processes of delivery, data collection, and analysis [20].

Due to the constant challenges and risks faced by Ukrainian businesses, the digital transformation of enterprises is accelerating. The transition to paperless logistics, automation of all processes, and the use of cloud services and IT solutions have become the norm for many companies. Digitalization reduces the impact of these challenges and risks, so those companies that can implement the necessary innovative solutions earlier will be effective.

The digitalization of logistics chains will eliminate the human factor during vehicle inspections and minimize corruption risks during the work of inspectors.

Logistics 2026 is about new technologies for better service.

In 2024, warehouse automation and digital technologies became the foundation of logistics strategy. In 2025, organizations will continue to rely on new

technologies to stay competitive, optimize processes, and minimize errors. The goal is to have smooth, flexible logistics that can adapt to future changes.

Conclusions and perspectives for further research. The efficiency of enterprises is directly dependent on the formation of effective supply chains and the implementation of supply chain management principles, a modern concept of enterprise management. This concept is the result of the development of management, marketing and logistics and meets the requirements of the current stage of economic development.

Unfortunately, the share of supply chain management in the structure of logistics services provided by domestic enterprises is insignificant. According to the World Bank, almost 90% of logistics services in Ukraine are transport logistics operations, 8% are warehousing operations, 2% are freight forwarding, and only 1% are supply chain management. We believe that this is unacceptable in the context of Ukraine's European integration and the entry of domestic enterprises into the markets of developed countries.

According to the results of 2024, the most negative factors for Ukrainian logistics, which were the consequences of the war, include:

- closure of ports, which in turn led to a change in export and import channels and the emergence of huge queues at the borders;

- lack of personnel;

- fuel price increase by 35-55%

- blackouts;

- change of contractual relations;

- changes in the structure of suppliers and customers;

- loss of legal capacity.

In 2024, Ukraine saw a significant decline in production, a drop in exports and imports. This, in turn, led to a reduction in cargo transportation. And maritime transportation was the hardest hit. Currently, small and medium-sized businesses are going bankrupt all over the world, so you need to keep a close eye on your partners, as their logistics companies may suffer in the event of bankruptcy. The

second factor affecting the market is the energy situation. Although gas and oil prices have stabilized somewhat, signs of an embargo on Russian raw materials are beginning to appear. The global trend of using green logistics in Ukraine has stopped a bit because of the war. However, as soon as the situation stabilizes, we should expect a recovery in demand in this area. After the massive relocation to western Ukraine, we can now say that business is gradually returning to the central regions. In the next 2-3 years, we should expect demand for small logistics hubs in both Kyiv and Dnipro regions. Transportation safety remains a key trend in logistics. It affects both the cost and geography of supply. Not everyone agrees to travel to dangerous areas. As for the trend of using modern technologies, Ukrainian logistics is not yet ready to invest heavily in systems such as artificial intelligence or telematics, so we can say that this trend is delayed.

Implementation of IT systems at enterprises helps to increase their efficiency and competitiveness. Information technology and systems are management tools that serve to coordinate and control business in general and logistics processes in particular. In order for information technologies to work most effectively, it is necessary to make appropriate changes throughout the management system, which should combine the improvement of the organizational structure of the enterprise and the introduction of a process approach to management. Ensuring the rational choice of a software product adequate to a particular enterprise for the automation of internal logistics processes and its effective use in the process of managing logistics processes in complex business systems allows the enterprise to ensure: prompt implementation, processing and formation of the initial information array of data for accounting; ensuring internal information control; reduction of physical labor; improving the quality and efficiency of work of staff members; improving the process of organizing

A promising area for further research on this issue is to assess the economic efficiency of the process of automation of internal logistics processes at an enterprise, which has both scientific and applied significance, and to develop

optimal methods that will allow implementing elements of information technology of internal logistics processes at an enterprise in a short time and at minimal cost.

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