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OPTIMIZATION OF MATERIAL AND TECHNICAL SUPPLY MANAGEMENT OF INDUSTRIAL ENTERPRISES

Purpose. Development of an adaptive economic and mathematical model of raw material supply management for the production activities of industrial enterprises.

Methodology. In the course of the study, the following methods of understanding economic phenomena and processes were used to solve the problems posed in the work: system analysis, economic and mathematical modeling, abstract-logical and graphical methods.

Findings. The work identifies specific characteristics of the organization of supply of raw materials, equipment, inventory and finished products to industrial enterprises. An adaptive economic and mathematical model of optimization of material and technical supply of these enterprises is formulated. The proposed model simplifies the choice of raw material inventory management system depending on the specifics of the production process of a particular enterprise and the external conditions of its operation. The use of adaptive model is necessary in the formation of supply and demand change programs in the markets of finished products, monitoring the movement of own funds in the organization of transportation of raw materials from suppliers and redistribution of available financial resources to address the priorities of business entities.

Originality. The authors propose an adaptive economic and mathematical model for optimizing material and technical supply, which takes into account the possibility of violation of the delivery time of inventory items under the influence of force majeure, and also determines the optimal amount of raw materials for supply under certain operating conditions of a particular industrial enterprise.

Practical value. The use of the economic and mathematical model formed by the authors in the economic activity of industrial enterprises will allow the latter to timely forecast and plan their logistics costs and, as a consequence, avoid irrational spending of available financial resources.

Keywords: *logistics, management, adaptation model, supply, storage, transportation costs*

Introduction. In the modern conditions of activity of industrial enterprises, which are characterized by fierce competition, significant financial risks, a high level of uncertainty, limited resources, one of the conditions for ensuring the planned amount of profit is to achieve low transaction and transformation costs, a significant proportion of which are supply costs of raw materials, equipment, inventory and finished products, which, in turn, is due to the specific features of the supply process in industry. Such features include the need to ensure short delivery times for the elements of the material and technical direction of industrial production, a high degree of risk of damage during transportation of the specified raw materials, depending on weather conditions and the quality of the road surface [1, 2]. At the same time, disruption of the planned freight transportation of industrial enterprises or its delay will have catastrophic consequences for the functioning of the business entity under study, among which we can single out a stop in production, simple equipment, a decrease in the quality of finished products, a decrease in sales volumes, and a loss of competitive positions in the sales markets. In this regard, the systematization and optimization of operations becomes especially important based on the formation of an efficient logistics system, which would ensure timely, reliable with minimal costs of raw materials, finished goods to a certain place without any damage.

The use of transport systems as a factor in increasing the economic efficiency of business results involves the creation of a special organizational structure of logistics in the business entity in the presence of the required level of qualification of managers. Determining the most rational management decisions is done by formulating alternatives and carrying out their comparative analysis in order to choose the best option. At the same time, to increase the efficiency of transport systems in the context of optimizing the management processes of supply in industry, it is advisable to use economic and mathematical modeling. In this context, economic and mathematical models are a set of objective function variables that reflect various types of transformational and transaction costs that arise in the process of functioning of industrial enterprises, and restrictions for these variables, which are due to the specifics of the functioning of economic entities (production, logistics, storage), and also available material and financial resources, their qualitative and quantitative characteristics.

Literature review. Works by many scientists are devoted to the study of optimization of supply process management at industrial enterprises. Thus, S. Sorooshian, M. Jambulingam and J. Dodangeh considered the importance of rational organization of the logistics system to achieve the planned profits of business entities in East Asia [3]. Y. Ivashkin and M. Nikitina defined an agent-oriented simulation structure of the material supply system at an industrial enterprise, aimed at reducing deviations from the planned structure of the range and the timing of the order in the presence of restrictions on resource supply, volume and product range [4]. In the article by O. Ahumada and J. Villalobos, a model for planning the production and distribution of fresh products is considered and classified, and the ultimate principles for supporting the transport systems of business entities are formed [5]. In the work by Y. Yuan, N. Viet, B. Behdani, on the example of the supply chain of fruits and vegetables in the Netherlands, the advantages of horizontal logistics interaction are considered, which allows increasing the productivity of institutions by reducing transportation costs [6].

In the scientific work by E. Alfonso-Lizarazo, J. Montoya-Torres, E. Gutiérrez-Franco, mathematical models for realizing the potential of managing reverse logistics flows in the food industry are proposed using the palm oil supply chain as an example [7]. X. Zhao, P. Wang, R. Pal studied the impact of internal integration and integration of suppliers and customers, which together represent the industrial supply chain, on product quality and key financial performance of production in China [8]. R. Raut, B. Gardas, V. Narwane, B. Narkhede identified a vague multi-criteria approach to management decisions to reduce food losses in the fruit and vegetable supply chain by assessing and selecting the optimal suppliers of supply services [9]. Q. Qiang, K. Ke, T. Anderson, J. Dong investigated the elements of a closed-loop supply chain and identified a list of conditions under which optimal decisions are made at each stage of logistics in a given chain [10]. In the study by R. Furmann, B. Furmannová, D. Więcek, a methodology was developed for interconnecting the structure of interactive integration and process planning with real logistics elements that are necessary when forming a general strategy for the development of production [11].

The study by D. Prajapati, A. Harish, Y. Daultani, H. Singh, and S. Pratap analyzed the urban logistics of fresh food by e-commerce enterprises and proposed a unique vehicle routing system that reduces transportation costs and increases the efficiency of consumer order fulfillment [12]. B. Scholz-Reiter, K. Windt, H. Liu noted a progressive approach to optimizing logistics goals, taking into account the short lead time of the production cycle, a low amount of work in progress and reliable work of suppliers in the supply chain [13]. The article by A. Gonzalez, S. Patroni, and J. Vidal formulated an integrated approach to assessing the level of qualification of specialists in terms of their ability to identify problems in the functioning of logistics systems at certain enterprises and the ability to develop optimization models aimed at improving the functioning of the latter [14]. Y. Riahi, T. Saikouk, A. Gunasekaran, I. Badraoui identified the most modern adaptive chains of transport support products. Of particular interest are the authors' recommendations on the use of artificial intelligence and robotics in support of the transport supply chain [15]. M. Bučková, R. Skokan, M. Fusko, R. Hodoň with the help of computer simulation formed a material flow that can increase the speed of completion of orders in the warehouse or the receipt of raw materials directly into production [16]. In their scientific work, P. Mishkurov, O. Fridrikhson, V. Lukyanov, S. Kornilov, V. Say proposed a new approach to the study on the operation of railway transport, based on system-dynamic modeling of the logistics system of the mining enterprise [17]. M. Kovalský, B. Mičieta compare the advantages and disadvantages of using two dynamic economic and mathematical models of internal logistics planning in the automotive industry [18].

Paying tribute to the above scientific works, we should note the need for further research to optimize the management of transport systems of industrial enterprises.

Methods. In the course of the study, the following methods of understanding economic phenomena and processes were used to solve the problems posed in the work: system analysis – to reveal the foundations of the conceptual apparatus of the process of formation of logistics systems by subjects of production activity with their subsequent optimization and adaptation to the conditions of functioning of economic entities in the environment; economic and mathematical modeling – to develop a model for managing the supply of raw materials for the production activities of industrial enterprises; abstract and logical method – to formulate conclusions and make theoretical generalizations to determine the method for forming the optimal order of raw materials needed for production activities of industrial enterprises, and calculate the logistics costs associated with the organization of logistics of economic entities; graphic method – to visualize the additive approach to the management of logistics of production systems.

The purpose of this article is to develop an adaptive economic and mathematical model of raw material supply management for the production activities of enterprises in industry.

Results. The organization of effectively functioning systems of transportation of products at industrial enterprises in conditions of lack of information necessary for making sound management decisions and limited financial and material resources is one way to ensure quality indicators of economic activity based on rationalization of available resources, optimization of acquisition, production, sales and transportation of goods and finished products, as well as increasing control over these processes.

In this case, material flow management within a logistics system should be based on an additive approach, which involves summing up the effects of the entity's interaction with suppliers and customers, as well as the results of the main functions of the enterprise (acquisition of resources and materials, transportation, production, sales of finished products, customer service, etc.) in the process of material flow. According to this approach, the main processes of the enterprise and its interaction with counterparties operating in a particular market are integrated into a single logistics chain in terms of material flow. The level of efficiency of relationships in this logistics chain is determined by the infrastructure of the entity, the optimality of HR management and qualifications of employees, the level of logistics of business, the efficiency of transportation of raw materials and finished products, the degree of innovation in the production process, rationality of the organization of financial, material and information flows. Graphical representation of the additive approach is presented in Figure.

Taking into account the additive approach reflected in Figure, we believe that one of the ways to organize the optimal system of logistics for industrial enterprises is the development of an economic and mathematical model that can take into account numerical changes in the constituent parameters under the influence of environmental factors. Among the most significant factors causing the growth of logistics costs, one can single out: violation of the planned delivery dates due to

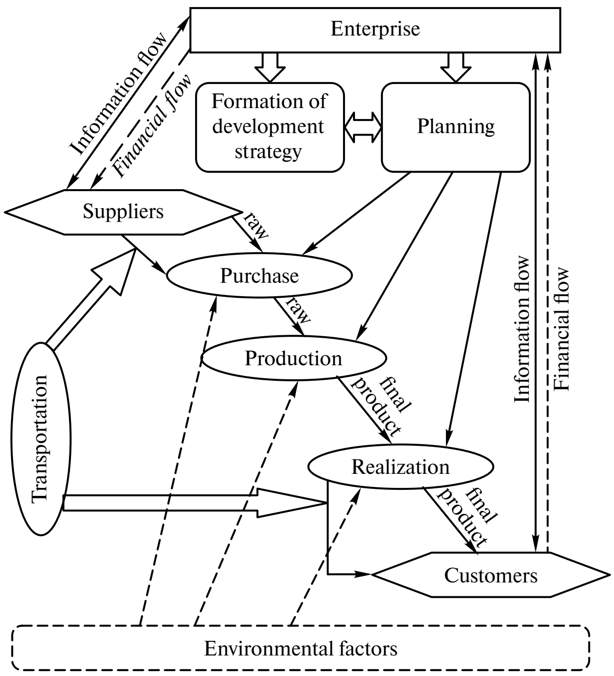

Fig. Additive approach to the management of logistics of industrial enterprises certain force majeure circumstances, as well as changes in tariffs and, accordingly, the cost of logistics services for raw materials [19, 20]. Therefore, the proposed adaptive economic and mathematical model should reflect the influence of these factors on the main logistics costs

$$C_{V_i}^{\log} = f\left(C_{V_i}^{tr}; C_{V_i}^{st}; C_{V_i}^{l}; C_{V_i}^{unl}\right) \to \min, \quad (1)$$

where $C_{V_i}^{\log}$ is the total logistics costs of the industrial enterprise in the process of obtaining a certain amount of resources of the i^{th} type (V_i) from the supplier in the time period t; $C_{V_i}^{tr}$ is the cost of transportation from the supplier to the industrial enterprise-buyer of a certain amount of resources (V_i) in time period t; $C_{V_i}^{st}$ is the cost of storage of a certain amount received from the supplier of goods (V_i) type in the warehouse of the industrial enterprise-buyer in the time period t; $C_{V_i}^{l}$ is the costs of the industrial enterprise-buyer for work on loading into vehicles of a certain amount of raw materials (V_i) in the time period t for transportation from the supplier's warehouse; $C_{V_i}^{unl}$ is the costs of the industrial enterprise-buyer for works on unloading of certain quantity of raw materials (V_i) at their own warehouse in the time period t after transportation from a warehouse of the supplier.

It is worth noting that an important aspect in minimizing transportation costs is to determine the optimal amount of resources that must be purchased from suppliers to ensure uninterrupted production process in a certain time period t. To do this, by systematizing the results of observations, it is necessary to determine the minimum and maximum values of the required amount of resources of the i^{th} type for the manufacture of specific products of one or several types in a certain time period t, and also use the law of distribution of random discrete variables. Taking into account these indicators and cost characteristics of the production process, it is possible to determine the optimal volume of raw material purchases with minimal costs for ordering from suppliers and losses due to lack of sufficient goods in a given period of time t. Given the above, definition of the appropriate volume of orders for resources can be displayed as follows

$$F(V_i(t)) = V_i^{ord}(t) \cdot C_{plac_i}^{ord} + \\ + D_i^{mat}(t) \cdot \int_{V_i^{ord}}^{\infty} f_i^t(V_i^{fact}(t)) \cdot (V_i^{fact}(t) - V_i^{ord}(t))dx \to \min, \quad (2)$$

where $V_i^{ord}(t)$ is the volume of orders from suppliers of raw materials of the i^{th} type in a certain retrospective period t; $C_{plac_i}^{ord}$ is the cost of placing an order with contractors for the supply of resources of the i^{th} type; $V_i^{fact}(t)$ is the actual volume of goods of the i^{th} type, used in a certain period of time t; $f_i^t(V_i^{fact}(t))$ is the probability of demand for raw materials of the i^{th} type in a certain period of time t; $f_i^t(V_i^{fact}(t)) \cdot (V_i^{fact}(t) - V_i^{ord}(t)$ is the volume of shortage of raw materials of the i^{th} type, predicted for a certain time period t; $D_i^{mat}(t)$ are losses caused by the lack of a sufficient volume of raw materials of the i^{th} type in a certain time period t, whose value is calculated by the formula

$$D_i^{mat}(t) = Y_i^{lost}(t) \cdot (Y_i^{cost} - Pr_{Y_i}^{real}(t)), \quad (3)$$

where $Y_i^{lost}(t)$ is the loss of production due to the inability to produce the planned quantity of goods Y in a certain period of time t due to lack of sufficient volume of goods of the i^{th} type; Y_i^{cost} is the unit cost of goods Y, for the manufacture of which raw materials of the i^{th} type are used; $Pr_{Y_i}^{real}(t)$ is the profit of the business entity from the sale of product Y, manufactured using products of the i^{th} type in the time period t.

Substituting (3) into expression (2), we obtain the following function

$$F(V_i) = V_i^{ord}(t) \cdot C_{plac_i}^{ord} + Y_i^{lost}(t) \cdot (Y_i^{\cos t} - Pr_{Y_i}^{real}(t)) \times \\ \times \int_{V_i^{ord}}^{\infty} f_i^t(V_i^{fact}(t)) \cdot (V_i^{fact}(t) - V_i^{ord}(t))dx \to \min. \quad (4)$$

We equate to zero the partial derivatives of the first order by $V_i^{ord}(t)$, based on the conditions of existence of the extremum of the function, and then we obtain the expression

$$\partial(V_i(t)) \cdot \partial(V_i^{ord}(t)) = C_{plac_i}^{ord} - Y_i^{lost}(t) \times \\ \times (Y_i^{cost} - Pr_{Y_i}^{real}(t)) \cdot \int_{V_i^{ord}}^{\infty} f_i^t(V_i^{fact}(t))dx = 0. \quad (5)$$

Using the elements of probability theory and differentiation of the integral by the parameter $V_i^{ord}(t)$ from expression (5) we obtain

$$\int_0^{V_i^{ord}} f_i^t(V_i^{fact}(t))dx = (Y_i^{lost}(t) \cdot (Y_i^{cost} - Pr_{Y_i}^{real}(t)) - C_{plac_i}^{ord}) / Y_i^{lost}(t) \times \\ \times (Y_i^{cost} - Pr_{Y_i}^{real}(t)) = 1 - C_{plac_i}^{ord} \cdot (Y_i^{lost}(t) \cdot (Y_i^{cost} - Pr_{Y_i}^{real}(t)))^{-1}. \quad (6)$$

From (6) follows the definition of the demand function for raw materials of the i^{th} type in the time period t $(F_i^t(V_i^{ord}(t)))$, which reflects the following expression

$$F_i^t(V_i^{ord}(t)) = 1 - C_{plac_i}^{ord} \cdot (Y_i^{lost}(t) \cdot (Y_i^{cost} - Pr_{Y_i}^{real}(t)))^{-1}; \\ 0 \geq F_i^t(V_i^{fact}(t)) \leq 1, \quad i = 1, \ldots, l; \quad t = 1, 2, \ldots, x. \quad (7)$$

The result of solving (7) will be a solution in which V_i reaches its minimum value in the time period t, and V_i^{ord} is numerically dependent on $F_i^t(V_i^{ord}(t))$. In this case, the following conditions must be met

$$Y_i^{cost} \cdot V_i^{ord}(t) < F_n(t), \quad i = 1, \ldots l; \quad n = 1, 2, \ldots k; \quad t = 1, 2, \ldots x; \\ V_i^{ord}(t) > 0; \quad i = 1, \ldots, l; \quad t = 1, 2, \ldots, x, \quad (8)$$

where $F_n(t)$ – the amount of financial support for the operation of the n^{th} industrial enterprise in a certain period of time t.

It should be emphasized that the calculation of the optimal order of raw materials of the i^{th} type in time period t, taking into account information about the actual volumes of raw materials required for the production of goods Y, is the basis for uninterrupted operation of the enterprise. This, in turn, is ensured by the fact that based on the use of these calculations can plan production with a focus on consumer demand, combining into a single logistics chain for the material flow of suppliers, consumers and transportation, according to the additive approach to logistics management of industrial enterprises (Figure).

Taking into account the determination of the optimal volume of orders for raw materials of the i^{th} type in the time period t on the basis of (2–8) in general, the adaptive economic and mathematical model of raw material supply management can be presented as follows

$$C_{V_i}^{\log} = P_{V_i}^{tr} - Pr_{V_i}^{real} + C_{V_i}^{tr} + C_{V_i}^{st} \cdot I_{prov}(V_i) + C_{V_i}^{l}(t) + C_{V_i}^{unl}(t^*), \quad (9)$$

where $P_{V_i}^{tr}$ – the purchase price of a certain amount of raw materials (V_i) taking into account the cost of their transportation from the supplier to the industrial enterprise-buyer. In the event of a change in tariffs for freight services (s), or the provision of discounts on the cost of raw materials (d) by the supplier, the purchase price adjustment index should be used $I_{P_{V_i}^{tr}} = (1 - d \cdot 0.01) + (1 + s \cdot 0.01)$; $Pr_{V_i}^{real}$ – the profit of the industrial enterprise-buyer from the sale of its products manufactured using a certain amount of raw materials purchased from the supplier (V_i) in the time period t. This model provides for the possibility of returning part of the financial resources spent on the purchase of raw materials, due to the profit from the sale of enterprise products manufactured using these materials; $I_{prov}(V_i)$ is the index of security required for economic activity by an industrial enterprise the amount of resources (V_i) in the time period t, calculated by the formula

$$I_{prov}\left(V_i\right) = V_i^{st} + V_i - V_i^c, \tag{10}$$

where V_i^{st} is the number of stocks of goods in retrospect t; V_i is the number of products purchased from the supplier in the time period t; V_i^c is the amount of products consumed in the course of economic activity in the time period t.

It should be noted that this model reflects the possibility of calculating logistics costs in case of violation of planned delivery times due to certain force majeure, which is expressed in the specifics of calculating the time of transportation of a certain number of services (t^*) from supplier to industrial buyer

$$t^* = t_w \frac{t_{\max}}{\overline{t}} + t_{unl} + 1, \tag{11}$$

where $t_{\max}$ is the maximum possible duration of transportation of services from the supplier to the industrial enterprise-buyer; $\overline{t}$ is the average value of the duration of transportation of the resource from the supplier to the industrial enterprise-buyer; t_{unl} is the duration of unloading of delivered raw materials to the warehouse of the industrial enterprise-buyer; t_w is the actual duration of transportation of raw materials from the supplier to the industrial enterprise-buyer, calculated by the formula

$$t_w = \frac{S_{V_i}}{\overline{\upsilon}_{V_i}}, \tag{12}$$

where S_{V_i} is the distance between the warehouse of the supplier and the industrial enterprise-buyer. If the transportation is carried out by the buyer's transport, the numerical value of the distance must be doubled; $\overline{\upsilon}_{V_i}$ is the average speed of the vehicle when transporting goods (x_i).

For the correct calculation of the adaptive economic-mathematical model for optimizing the supply of services, it is necessary to introduce the following restrictions

$$C_{V_i}^{\log}\left(t\right) < F_n\left(t\right), \quad n = 1, 2, ..., k; \quad t = 1, 2, ..., x, \tag{13}$$

where F_n is the amount of financial support for the operation of the *nth* industrial enterprise in the time period t.

$$V_i \le L_{tr_j} \cdot N_{tr_j}, \quad j = 1, 2, ..., m, \tag{14}$$

where L_{tr_j} is the load capacity of vehicles used to transport a certain amount of raw materials (V_i) from the supplier to the industrial enterprise-buyer; N_{tr} is the number of vehicles required for delivery.

$$V_i \cdot (W_{V_i}^l + W_{V_i}^{unl}) \le t_l^{\max} + t_{unl}^{\max}, \tag{15}$$

where $W_{V_i}^l; W_{V_i}^{unl}$ is the complexity of the work performed on loading and unloading of goods (V_i); $t_l^{\max}; t_{unl}^{\max}$ are the maximum duration of loading and unloading of raw materials (V_i).

$$I_{prov}^{\min}(V_i) < I_{prov}(V_i) \le I_{prov}^{\max}(V_i), \tag{16}$$

where $I_{prov}^{\min}(V_i)$; $I_{prov}^{\max}(V_i)$ are the limit values of the provision of the amount of raw materials (V_i) required for the implementation of economic activity by an industrial enterprise in retrospect t.

Taking into account the above formulas for calculating the main components of logistics costs (1, 9–12) and constraints (13–16), the adaptive economic and mathematical model of raw material supply management for industrial enterprises will look like

$$C_{V_i}^{\log} = I_{P_{V_i}^{tr}} \cdot P_{V_i}^{tr} - Pr_{V_i}^{real} + C_{V_i}^{tr} + C_{V_i}^{st} \cdot (V_i^{st} + V_i - V_i^c) +$$
$$+ C_{V_i}^{l}(t) + C_{V_i}^{unl}\left(\frac{S_{V_i}}{\overline{\upsilon}_{V_i}} \cdot \frac{t_{\max}}{\overline{t}} + t_{unl} + 1\right).$$

Thus, this adaptive economic and mathematical model of optimization of material and technical supply in industry in the case of its use in economic activities will simplify the choice of inventory management system depending on the specifics of the production process of a particular enterprise and external conditions of its operation, take into account timely changes in the supply of supply and demand in the markets for finished products, monitor the movement of own funds in the organization of transportation of raw materials from suppliers and redistribute available financial resources to address priorities.

Conclusions. As a result of the study, it was found that forecasting logistics processes in industry using economic and mathematical modeling contributes to the implementation of flexible management of raw material supplies to industrial enterprises and systematic monitoring of logistics costs in order to increase profits by developing a mechanism for their rationalization. The organization of efficient logistics systems will reduce the costs of the business entity for the production and sale of its products. To do this, it is necessary to study the dynamics of demand for raw materials of the i^{th} type used in the production of existing types of goods, and for finished products in different time periods. On the basis of the above research, it is necessary to organize the optimal modes of transportation of raw materials from suppliers to the company and finished products to markets, taking into account the mode of production and consumer demand. At the next stage it is necessary to calculate the optimal volumes of orders of raw materials of the i^{th} type in a specific time period t and to assess the level of consistency in the work of vehicles and loading and unloading vehicles. It is important to develop rational routes for transportation of raw materials from suppliers and finished products – to consumers, taking into account the available number of vehicles in order to minimize transport costs. There is a need to determine the optimal structure of the quantitative composition of vehicles used in business.

Given the above, it can be noted that the main approach in the formation of efficient logistics is a systematic approach that provides a comprehensive organization of production processes and sales of finished products based on information and material flows. At the same time, the amount of profit from the effective organization of the production process and sales in general in most cases exceeds the same figure from the partial optimization of specific components of these processes. This effect is due to the specifics of logistics systems, reflected in the redistribution of costs, according to which their certain growth in a particular part of a particular process causes them to decrease in another part and in general.

The efficiency of logistics systems at industrial enterprises is directly dependent on the strength of the interaction of the entity with contractors, whose level, in turn, can be increased by using an additive approach to the management of logistics of enterprises. This approach summarizes the effects of the entity's interaction with suppliers and customers, as well as the results of the main functions of the enterprise. Such functions include: purchase of raw materials; transportation; production; sale of finished products; service and post-warranty customer service, and others. In the process of material flow and integration of these elements into a single logistics chain with their characteristic contradictions, there is a need to form a strategic map to optimize existing logistics systems, its further improvement and adjustment to modern market needs.

The proposed adaptive economic and mathematical model of optimization of material and technical supply of industrial enterprises makes it possible to take into account violations of delivery of raw materials under the influence of force majeure, and determines the optimal supply of inventory in certain conditions of a particular enterprise. The use of this model in the economic activity of industrial enterprises will allow managers to timely forecast and plan logistics costs and, as a consequence, avoid irrational spending of available financial resources and optimize their use in general.

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Оптимізація менеджменту матеріально-технічного постачання промислових підприємств

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Мета. Розробка адаптивної економіко-математичної моделі управління постачанням сировини для виробничої діяльності промислових підприємств.

Методика. У ході дослідження використовувались такі способи пізнання економічних явищ і процесів для вирішення поставлених у роботі проблем: системний аналіз, економіко-математичне моделювання, абстрактно-логічний і графічний методи.

Результати. У роботі визначені специфічні характеристики організації постачання сировини, обладнання, товарно-матеріальних цінностей і готової продукції на промислові підприємства. Сформульована адаптивна економіко-математична модель оптимізації матеріально-технічного постачання зазначених підприємств. Запропонована модель дозволила спростити вибір системи менеджменту запасів сировини в залежності від специфіки виробничого процесу конкретного підприємства й зовнішніх умов його функціонування. Використання адаптивної моделі необхідне при формуванні програм постачання зміни попиту та пропозиції на ринках збуту готової продукції, здійснення моніторингу руху власних грошових коштів при організації транспортування сировини від постачальників і перерозподілу наявних фінансових ресурсів на вирішення першочергових задач суб'єктів підприємницької діяльності.

Наукова новизна. Авторами запропонована адаптивна економіко-математична модель оптимізації матеріально-технічного постачання, що враховує можливість порушення строків доставки товарно-матеріальних цінностей під впливом форс-мажорних обставин, а також визначає оптимальну для постачання кількість сировини в певних умовах функціонування конкретного промислового підприємства.

Практична значимість. Використання сформованої авторами економіко-математична моделі в господарській діяльності промислових підприємств надасть можливість останнім своєчасно прогнозувати та планувати свої логістичні витрати та, як наслідок, уникнути нераціонального витрачання наявних фінансових ресурсів.

Ключові слова: *логістика, менеджмент, адаптаційна модель, постачання, зберігання, транспортні витрати*

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