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MANAGEMENT SYSTEM FOR NEUTRALIZING THE IMPACT OF RISKS ON LOGISTICS PROCESSES DURING THEIR DYNAMIC CHANGES

Purpose. To develop an algorithm for choosing alternative routes with dynamic changes in the risks of cargo transportation. To propose a structure of the management system of logistics departments and an enterprise in general to neutralize risks.

Methodology. The method of mathematical formalization was used to form a mathematical model of management of transportation routes with changes in threats in real time; the method of a system approach to the enterprise’s business processes was used to take into account their impact on logistics processes; risk stratification method – for evaluating the efficiency of logistics operations; the method of using the matrix of vectors made it possible to form a mathematical approach to solving a dynamic logistic problem and to considering it as a time-dispersed system; the method for dividing parameters by measurement scales allowed using a unified mathematical approach to the formalization of the problem; the method of sequential approximation made it possible to choose the most acceptable options for making management decisions.

Findings. It is established that the level of risks can change from minimal to unacceptable in real time, which proves the importance of assessing both the degree of risk and the rate of its change. An approach is proposed to coordinate the proposed alternative routes, taking into account the requirements of various structural departments, achieving both risk reduction, and ranking of goals, ensuring less time for transportation. The formation of a decision tree on logistics chains and continuous monitoring of risks is substantiated.

Originality. An algorithm for selecting alternative routes with dynamic changes in cargo transportation risks is developed. A structure of the management system for logistics departments and enterprises to neutralize risks is proposed.

Practical value. The proposed approach makes it possible to predict risks in the face of their dynamic changes and to ensure their effective management.

Keywords: *cargo transportation, management system, logistics processes, neutralizing risks, mathematical model*

Introduction. Large-scale military actions on the territory of Ukraine pointed to the vulnerability of the supply routes of enterprises with materials and components necessary for work and obstacles to sending finished products to customers. This greatly complicates not only the rhythmic work of Ukrainian enterprises, but also poses a threat to their survival in such conditions. Some enterprises evacuated their production facilities to the regions where there was no military action. But at present the entire territory of the country is under the threat of air and missile strikes, without exception. Infrastructural facilities, in particular the country’s transport systems, are nowadays considered one of the priority targets of the aggressor.

Traditionally, the priorities for logistics tasks were to reduce the total costs of transportation, reduce the time of transportation of goods, increase the quality of customer service, gain competitive advantages, and so on. Now one of the main tasks of logistics, if not the main task, is to reduce the risk of transportation. At the same time, logistics operators should pay attention not only to the risks of damage to loaded vehicles, but also, for example, to the growth of threats in the event of a significant delay of cargo on one of the stages of the route. The delay of cargo leads not only to an increase in transportation time and, accordingly, to technological failures of production or violation of contractual conditions. It also leads to an increase in the threat of damage to the cargo by the aggressor, since a congestion of vehicles is a desirable target, and stationary targets are more vulnerable than vehicles in motion. This determines the need for a permanent analysis of transportation routes and rapid reorientation of cargo in the event of an increase in risk not only in certain directions, but even at individual stages of transportation routes. The complexity of such a logistical task is due to its importance, multifactorial nature, the need to develop options for new routes to avoid or reduce the level of risk, so it requires the use of special approaches. And such approaches require a special mathematical apparatus, which is called the mathematical core of the information system, for effective execution of the given task. It will also require changes in the working methods of logistics departments and the management of business processes of enterprises in general.

Literature review. Scientific works devoted to the study on logistics processes can be divided into two large groups: those that use qualitative approaches and those that use quantitative approaches. This is confirmed by thorough analytical reviews of the literature on this topic, for example, Ardakani, et al. [1]. The first group includes the use of general qualitative approaches to planning reverse routes by Gardas, et al. [2], as well as the indicative-criterion approach by Perevozova, et al. [3], which is interesting because it opens up opportunities for comprehensive analysis of all business processes of the enterprise, an example of which is the article by Prokopenko, et al. [4]. Unfortunately, the relevance of the results when applying qualitative methods for complex logistics problems is not sufficient. Scientific works that apply quantitative approaches rely more often on mixed integer linear programming (MILP). Thus, Abdi, et al. [5] use the MILP model with ε-constraint, hybrid and meta-heuristics. The use of MILP is proven to solve certain logistics problems, for example, supply chain management by Gelareh, et al. [6]; cross-docking by Tavallali, et al. [7]. Modeling cross-docking is a complex task and some of its general approaches are used in our work, in particular, a multi-step and non-deterministic approach by Tabatabaeia, et al. [8]. The complexity of using MILP methods in practice, the significant amount of computing resources required by problems with a significant amount of branching routes require scientists to make changes to the model. Thus, Küçükoğlu, et al. [9] propose a hybrid meta heuristic algorithm (HMA) that integrates the tabu search (TS) algorithm into the simulated annealing (SA) algorithm. Liao [10] proposed to strengthen the MILP method with a hybrid genetic algorithm for solving reverse logistics problems. In addition to modernization and expansion of the MILP method with additional models, scientists are looking for other options for modeling logistics processes. So Wang, et al. [11] propose a two-stage hybrid algorithm based on k-means clustering and multi-element particle swarm optimization. Unfortunately, this algorithm, designed for two-stage routing with time intervals, also requires a significant amount of computing resources. Euchi [12] proposed adaptive memory programming (AMP) based on Scatter Search to save the amount of computing resources. Unfortunately, this option is designed for multiproduct logistics and its use in many route tasks is complicated. According to our analysis, using of fuzzy programming by Nozari, et al. [13] is not reliable enough for multi-route problems. Yu, et al. [14] developed a two-stage stochastic dual-objective MILP model for designing a network of a multi-product multi-echelon sustainable reversible logistics system under conditions of uncertainty. Since this model is designed to provide a set of Pareto decisions between profitability and environmental indicators for the purposes stated in this paper, its use will not provide sufficiently reliable results. The general approach of Rattanamanee, et al. [15] regarding the need to build a logistics network with several suppliers also proved to be useful for the formation of the model proposed and presented in the article.

There are also different approaches to taking risks into account when implementing logistics processes. In particular, Rahimi, et al. [16] also used the MILP model under multi-periodic multi-objective programming for the development and planning of a reverse logistics network. Their general approach regarding the need to form routes in such a way as to avoid risk is used in the presented work. Unfortunately, the use of conditional value of risk (CVaR) as a measure of risk by Rahimi, et al. [16] is not, in our opinion, sufficiently reliable. At the same time, since the risks of military actions are characterized by uncertainties, some researchers like Kozachenko, et al. [17] limit themselves to the analysis of only their deterministic components, others like Nitsenko, et al. [18], Kotenko, et al. [19] consider their dynamic changes insignificant.

The conducted analysis shows that researchers use modeling methods that require significant resources, in particular, time for calculations, and non-selective use of those main factors influencing the resulting function, which are characterized by a non-dynamic nature.

Unresolved aspects of the problem. The results of the review of scientific research on the specified problem indicated that, despite certain success in the development of mathematical approaches for planning and optimization of logistics processes, the issue of modeling in the conditions of rapid changes in the routes of transportation of products of enterprises to supply the production process with raw materials, components, etc. remained outside the attention of scientists. Also the concomitant need to change the structure of the management system of logistics departments and, as a whole, the enterprise to neutralize the impact of risks on logistics processes and, as a result, on the business processes of the enterprise remained out of attention.

The purpose of the article. To develop an algorithm for choosing alternative routes with dynamic changes in the risks of cargo transportation. To propose the structure of the management system of logistics departments and the enterprise as a whole to neutralize risks.

Methods. When forming approaches to solving the problem of creating a set of possible solutions regarding expedient logistics chains, organizing round-the-clock monitoring of risks on transportation routes and, when risks increase beyond certain threshold values, changing the specified routes in real time, the methods and modified mathematical formalization proposed in the study were used [18] and detailed in works [19, 20].

Traditionally, the assessment of the impact of risks on decreasing the efficiency of logistics operations was reduced to a static analysis of the results of the specified impact. That is, it was believed that the consequences of exposure to risks are so slow that they do not threaten the business processes of the enterprise in real time. The approaches available in the scientific literature did not give an opportunity to provide a relevant solution for dynamic problems of logistics chain management in the presence of a significant probability of reaching unacceptable risk values in the process of transporting goods of the enterprise.

At the same time, the introduction of a comprehensive system approach to all business processes of an enterprise, including the logistics process, is a significant advantage of automated business process management systems used by Ukrainian enterprises. It is due to the fact that the enterprise as a complete system has all system properties, including the property of emergency – when each individual process affects the entire set of processes and the entire set of business processes determines certain limits for the implementation of each individual process. This puts additional requirements for mathematical models of logistics processes.

Mathematical formalization of the task of neutralizing the impact of risks on logistics processes during their dynamic change required preliminary stratification of threats by level of danger (Table below).

Analysis of the rates of change in risks under the conditions of conducting hostilities on the territory of Ukraine indicates that the level of risks can change from $R1$–$R2$ to $R4$–$R5$ in a short time (Table). Therefore, as the basis of the formalization method, the approach of assessing the change rate of the aggregate risk with the subsequent check of whether such a rate of risk change will threaten business processes over a certain period of time is adopted. This time period may be determined by relevant technological, organizational or business conditions. But, first of all, the time necessary for the transportation, routing and cross-docking of cargoes and, also, in the case when the cargo is transported by the company's transport, the time of its return via the return route, needs such an assessment.

It is proposed to evaluate the probability of cargo passing through a separate link of the logistics route using the method of vector formation

Table

Stratification of the impact of risks with the conditions of their dynamic change on logistics operations

Interval of changes in aggregate risk, R	The level of aggregate risk	Probability of threat, z	Semantic assessment of the level of aggregate risk
$0 < R < 0.15$	$R1$	1	Minimum
$0.15 < R < 0.25$	$R1$	$z_1 = 10 \cdot (0.25 - R)$	Small
	$R2$	$1 - z_1 = z_2$	Small
$0.25 < R < 0.35$	$R2$	1	Average
$0.35 < R < 0.45$	$R2$	$z_2 = 10 \cdot (0.45 - R)$	Average
	$R3$	$1 - z_2 = z_3$	Average
$0.45 < R < 0.55$	$R3$	1	High
$0.55 < R < 0.65$	$R3$	$z_3 = 10 \cdot (0.65 - R)$	High
	$R4$	$1 - z_3 = z_4$	High
$0.65 < R < 0.75$	$R4$	1	High
$0.75 < R < 0.85$	$R4$	$z_4 = 10 \cdot (0.85 - R)$	Maximal
	$R5$	$1 - z_4 = z_5$	Maximal
$0.85 < R < 1$	$R5$	1	Critical

$$\vec{\theta} := \varphi(\vec{P}, \vec{t}),$$

where $\vec{\theta}$ is the evaluation vector of all risk options, which can be represented in the form of a linear matrix; $\vec{P}$ is the probability significance vector of the corresponding risk factor; $\vec{t}$ is the vector of the consequences of the specified risk.

This makes it possible to form a mathematical approach to solving a dynamic logistic problem, considering the model as a time-dispersed system. From the point of view of general approaches of systems theory, this model implements such a system for which the dimensionality of the vector of transportation options is greater than the dimensionality of the vector of input parameters, the array of which includes variables of the aggregate risk of cargo transportation at all stages of the logistics chain. The next step of the proposed algorithm, which follows the determination of the most appropriate route option from the point of view of risk minimization, is a recursive check of the state vector of the parameter area of the selected option using the Kalman method [18]. We chose this method because it not only allows finding the system state vector, but is also suitable for use in the presence of undetermined parameters of this vector. For the effective implementation of the Kalman method, it is proposed to apply the Bayesian method, which allows taking into account the dependencies between the risks of successive stages of the logistics chain.

Implementation of the proposed algorithm is carried out alternately for each of the transportation route options. This allows creating a set of cargo transportation options. The advantage of this algorithm is that it allows estimating the cost and time of transportation for each of the transportation options, which, in turn, allows establishing the level of feasibility of each of the options according to the requirements of the technological, organizational, and business processes of the enterprise. We propose a modified version of the method proposed in [20] to coordinate various tasks: minimizing risks, minimizing the cost (or time) of transportation. It is also possible to take into account the consequences of the management decision for the previous stage for the subsequent stages of the logistics route. This is the methodological basis for the proposed method of mathematical formalization regarding the transportation option, when the cargo is already being transported, but the dynamic modeling of the aggregate risk at one of the following stages of the route indicates a significant increase in the level of threat.

Mathematically, the solution proposed by us is represented by a system of equations

$$\frac{d\Omega}{dt} = f(\vec{z}, \vec{\vartheta}) + \varphi(\vec{z}, \vec{\vartheta})\vec{\mu}g = \delta(\vec{z}, \vec{\vartheta})\vec{\vartheta} = M(\vec{z}, \vec{\vartheta}),$$

where $\Omega(t) \in S_n$ is a vector that determines the state of the n-dimensional area of parameters at the moment of time t; $\vec{\mu}(t) \in S_k$ is a vector determining a set of management actions (k) at a time (t) under the condition $t \in t_i \ldots t_{i+1}$, where t_i is the start time of the i^{th} stage of the transportation route; t_{i+1} is the end time of the $(i + 1)^{th}$ stage of the transportation route; $\vec{g}(t) \in S_k$ is a vector that determines the limits of the intervals of acceptable changes in the level of aggregate risk as a result of management actions at the moment of time (t); $\vec{v}(t) \in S$ is a state vector of external influence on the enterprise's business process system; $u \in S$ is a vector of undetermined parameters; δ, φ, f, M are vector functions of parameters.

The mathematical correlation of the tasks of cost (or time) minimization and transportation risk minimization is presented as follows

$$t_i \in [0, t]; \quad \sum_{1}^{n} t_i \le t_{\max}\, c_i \le c_{\max}\, R \to R_{\min}\, q_j \in Q\ ,$$

where $t_{\max}$ is the maximum acceptable transportation time; c_i is the cost of the cargo transportation stage by the corresponding route; $c_{\max}$ is the largest acceptable cost of cargo transportation; R is the total risk of transportation, $R_{\min}$ its minimum level; Q is an array of parameters; q_j is subarrays of deterministic, stochastic and fuzzy parameters. The method of dividing parameters by measurement scales allows using a single mathematical approach to the formalization of the problem.

To predict the possible achievement of dangerous values for the cumulative risk of transportation for a certain time, the rate of change in the cumulative risk $\frac{dR}{dt}$, that is the slope ratio which is tangent to the response surface, is determined as

$$R = f(x_1, x_2, x_3, \ldots, x_n),$$

where $x_1, x_2, x_3, \ldots, x_n$ are risk parameters.

In the next step of the algorithm, the rate of change in the cumulative risk $\frac{dR}{dt}$ is integrated at the given time interval. This allows finding the value of the cumulative risk of the implementation of the transportation route option for the time interval $t_i - t_{i+1}$ and the subsequent check, to which the predicted value of R_t of the intervals of the risk scale (Table) will belong.

Next, using the method of successive approximation, several of the most acceptable options are selected from the set of possible transportation routes and offered to the persons who have to make the final decision. This method facilitates the implementation of logistics process management in real time by choosing route options to neutralize the impact of risks.

Results. The use of an automated information system to support the logistics process requires the need to reorganize the logistics process. This is due to many factors caused by the use of this technology. For example, our analysis found out that making decisions about the reorientation of transportation routes will require quick, urgent decisions by operational personnel. And this, in turn, will require an appropriate level of communication between operational personnel and persons authorized to make such decisions. In addition, management actions of this level should be formed with an appropriate level of detailed awareness about the situation by the persons authorized to make decisions. And for this, it is necessary to ensure the permanent provision of such information to the indicated persons. Under real circumstances, this may have certain complications at the informational, technological, organizational and other levels. The given analysis indicates the need to allot a much higher level of authority to operational personnel regarding urgent management actions to solve logistics problems as a result of emergency situations with dynamic changes in threats. And this, in turn, will require revision of established practices of working with personnel.

An urgent task in the application of an automated information system for logistics process support will be:

- formation of a reliable uninterrupted flow of information as to all factors influencing the implementation of transport flows on all possible variants of transportation routes at all their stages;
- notification of operational personnel of logistics departments about all changes in risks for transportation, both in absolute values of their indicators and significant rates of their change.

The requirement to inform operational personnel about the rates of change in threat factors is due to the expediency of forming an analysis of changes in threats over time and their forecasting.

The use of an automated information system to support the logistics process will be more effective if it is an integral component of the organizational strategy for the integration of production and business operations, and the management of enterprise resources.

First of all, a detailed analysis of the risk assessment of the vulnerability of the enterprise's technological processes to supply failures is required. Such an analysis should include the development of measures to neutralize the risks of supply failures and an assessment of the amount of necessary resource support for the specified measures. For example, the formation of warehouse stocks necessary for the uninterrupted operation of the enterprise for a certain time interval will require the allocation of working capital for this. In addition, the form of warehouse reserves will require a significant increase in the level of warehouse costs. That is, effective forecasting of the probability of a delay in the supply of resources for a continuous technological cycle for a certain time interval should also be aimed at optimizing warehouse stocks and linking them both with the value of the integral risk of transportation and with the rate of its change.

Delays in the delivery of finished products to the customer are also associated with the possibility of losses for the enterprise. It is known that the detentions of sea vessels with the products of Mariupol enterprises by the Russian Federation in 2019 were in some cases accompanied by consumers' refusal of the ordered products.

It is possible to conditionally divide this set of management tasks into three subgroups (Figure):

- management of technological and business processes;
- transportation management with dynamic changes in risks on the company's cargo transportation routes;
- information and reference.

The subgroup of management of technological and business processes has the task of establishing the level of vulnerability risks for technological processes of the enterprise due to supply failures. In particular, given the need to comply with contracts for the supply of finished products of the enterprise to customers; development of a policy for neutralization of hazards for technological processes due to irregular supply; assessment of the cost of measures to neutralize hazards and associated costs. In fact, this is a necessary component when choosing options for transportation routes or their stages. This is related to the need for an overall assessment of the time and possible increase in the cost of transportation required when choosing other options for transportation routes.

The subgroup of transportation management with dynamic changes in risks on the company's cargo transportation routes performs the tasks of determining the consequences of risks, their probability, developing a reliable forecast, on which basis it is possible to propose options for risk management measures, their neutralization, in particular, changes in transport routes or their stages.

In order to effectively perform the tasks assigned to the subgroups of transportation management with dynamic changes in risks on the company's cargo transportation routes and management of technological and business processes, it is necessary to introduce a subgroup, which we tentatively named information and reference. The task of this subgroup is the accumulation, processing, storage and supply of the entire set of necessary information, including current information in real time about the state of transport routes, risk factors and their rates of change (which is necessary for the formation of relevant forecasts), transportation conditions, availability of vehicles, tariffs, etc. This subsystem should also take care of the bank of options for transport routes, informational and methodological support for transport risk management, including the preparation of a package of documents accompanying the cargo.

Also, in the conditions of significant dynamic changes in risks and high rates of their change, a problem that has several implications: mathematical, technological and managerial ones, needs to be solved.

From a mathematical point of view, the coordination of cost (or time) minimization and transportation risk minimization requires variables that are independent of each other. But, with a significant increase in the level of risks and the choice of another route of transportation in the total number of cases, the time and cost of transporting goods by another route will not decrease, but also increase. This is not a direct connection and, as the research conducted by the authors showed, it is quite conditional, but it should be taken into account.

This led to the need to break some, albeit insignificant, dependence of the specified variables and propose measures to ensure the continuity of technological and business processes.

This can be achieved by reducing the urgency and necessity of changing the route by introducing some technological and management measures.

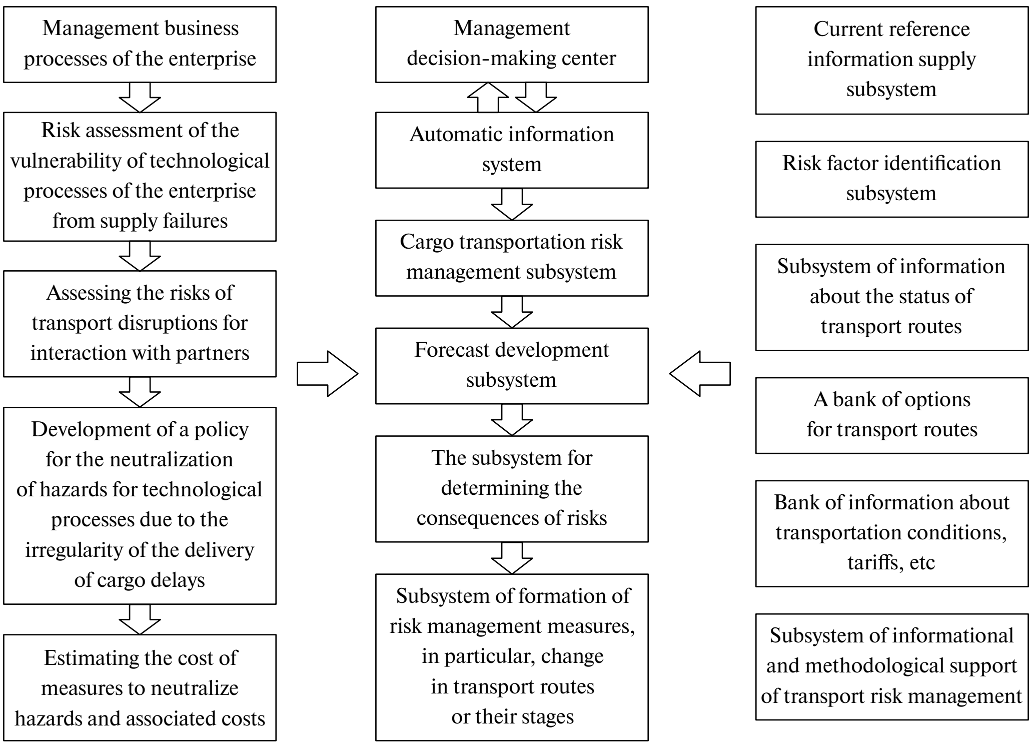

Fig. The structure of the management system for neutralizing the impact of risks on logistics processes and on the business processes of the enterprise in general

For this purpose, the authors of the presented study suggest:

1) increasing warehouse stocks of raw materials and components directly at the enterprise;

2) providing reserve intermediate warehouses for finished products in transport hubs at the intersection of the main and alternative routes of transportation;

3) preparing fuel reserves at transshipment hubs (for example, road and rail or river transport) if motor vehicle transportation is used at certain stages;

4) increasing the number and variability of transport routes.

These measures, in addition to practical recommendations for logistics departments of enterprises, implicitly formulate an additional condition for the selection of transportation routes. These routes must be segmented into stages that can be replaced by others in case of increased risk on them, i.e. fulfill the requirement of variability. To achieve this, they should pass through the transport hubs where several different transport routes intersect. And it is in these hubs that the possibility of forming transit warehouses should be considered for the uninterrupted supply of the company's products to customers.

These and other similar measures will make it possible to temporarily stabilize the situation in the face of increasing risks on certain sections of transport routes.

According to the results of our analysis, the structure of the management system was developed to neutralize the impact of risks on logistics processes and, in general, on the business processes of the enterprise (see the Figure). The use of a system approach makes it possible to implement management decisions regarding the company's cargo transportation routes, taking into account the requirements of various structural units and achieving several goals at the same time – reducing the level of the overall risk of transportation, and, taking into account the fulfillment of this requirement, ensuring a shorter time and cost of transporting the company's cargo.

Conclusions and prospects for further development in this direction. Analysis of risks under the conditions of conducting large-scale military operations on the territory of Ukraine indicated that the level of risks can change from low to maximum or even critical in a short time.

This determined the need to assess the rate of change in the aggregate risk with the subsequent check whether the change in its influence over a certain period of time will threaten the logistics and business processes. This time may be determined by relevant technological, organizational or business conditions. But, first of all, the time of transportation, routing and cross-docking of goods and, if the goods are transported by the company's transport, the time of return of the transport on the return route needs such an assessment.

The given results of the analysis made it possible to form a mathematical model for solving a dynamic logistics problem. But the analysis of the algorithm proved that obtaining proper practical results and achieving the necessary level of efficiency of logistics operations require changes in the work methods of logistics departments and, in general, approaches to the administration of business processes of enterprises.

Therefore, the structure of the management system for neutralizing the impact of risks on logistics processes and, in general, on the business processes of the enterprise, which helps to increase the efficiency of the interaction of the enterprise's divisions, has been developed.

For this, a detailed analysis of the peculiarities of the proposed mathematical model was carried out together with the coordination of this work with the work of all services and divisions of the enterprise.

The application of a system approach to the developed structure of the management system allows for the real-time implementation of management decisions regarding the company's cargo transportation routes, taking into account the requirements of various structural subdivisions and, subject to the condition of ranking goals, achieving several goals at the same time – reducing the level of aggregate risk of transportation, and, taking into account fulfillment of this requirement, ensuring a shorter time and cost of transporting goods of the enterprise.

From the point of view of research perspectives, it is worth forming an algorithm of a single enterprise information system in which the proposed approach will be one of the subsystems. The main task of such a system will be the processing of information flows of data regarding the conditions and circumstances of the company's cargo transportation along all possible routes in real time, the analysis of resources in the company's warehouses and transit warehouses, with the subsequent coordination of this information flow with the proposed algorithm for choosing alternative routes under dynamic changes in the risks of cargo transportation.

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Система управління нейтралізації впливу ризиків на логістичні процеси за динамічної їх зміни

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Мета. Розробити алгоритм вибору альтернативних маршрутів за динамічної зміни ризиків транспортуванню вантажів. Запропонувати структуру управлінської системи логістичних підрозділів та, у цілому, підприємства для нейтралізації ризиків.

Методика. Метод математичної формалізації використано для формування математичної моделі управління маршрутами перевезення за зміни загроз у реальному часі; метод системного підходу до бізнес-процесів підприємства для врахування їх впливу на логістичні процеси; метод стратифікації ризиків – для оцінювання ефективності логістичних операцій; метод задіяння матриці векторів дозволив сформувати математичний підхід до вирішення динамічної логістичної задачі й розгляду її як розосередженої в часі системи; метод розділення параметрів за шкалами виміру дозволив задіяти єдиний математичний підхід до формалізації задачі; метод послідовного наближення дозволив обирати з набору маршрутів перевезення найбільш прийнятні варіанти для прийняття управлінських рішень.

Результати. Встановлено, що рівень ризиків може змінюватися в реальному часі від мінімального до неприйнятного, що доводить важливість оцінки як ступеня ризику, так і темпу його зміни. Запропоновано підхід щодо узгодження запропонованих альтернативних маршрутів за врахування вимог різних структурних підрозділів і досягнення як зменшення рівня ризику, так і, за ранжуванням цілей, забезпечення меншого часу на перевезення. Обґрунтоване формування дерева прийняття рішень щодо логістичних ланцюгів і постійного моніторингу ризиків.

Наукова новизна. Розроблено алгоритм вибору альтернативних маршрутів за динамічної зміни ризиків транспортуванню вантажів. Запропонована структура управлінської системи логістичних підрозділів і підприємства для нейтралізації ризиків.

Практична значимість. Запропонований підхід дозволяє прогнозувати ризики за динамічної їх зміни й забезпечити ефективне управляння ними.

Ключові слова: *транспортування вантажів, система управління, логістичні процеси, нейтралізація ризиків, математична модель*

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