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Determination of rational parameters of the logistics chain in the process of customer service in international transportation

In this paper, we propose technological principles for determining rational parameters of the supply chain in order to establish a balance between demand and supply for goods in the chain links under conditions of variable demand and optimisation of total costs for all cargo delivery participants, which will affect the final cost of goods to customers. For the experimental research of the supply chain functioning, the forecast values of demand were determined based on the study of demand trends. As a result of the research conducted using mathematical modelling, regularities of the influence of supply chain parameters on the total costs of delivery participants have been established and rational parameters of the supply chain for consumer goods customers in international connections have been determined, minimising additional costs and ensuring a minimum level of total costs. The positive results of the economic effect estimate demonstrate the effectiveness of the proposed solutions.

Keyword: *supply chain, batch size of the cargo, delivery period, total costs, economic effect*

Introduction. The development of the supply chain management concept is driven by the need to coordinate and regulate the activities of cargo delivery participants under conditions of uncertainty. This is due to a significant level of complexity arising from the presence of a large number of links (participants), technological operations, and various flows. As the number of connections increases, the vulnerability of supply chains also increases, leading to higher costs and, consequently, to an increase in the final price of the product and a decrease in its competitiveness in the market. Guided by the concept of the 'ideal order,' logistics companies face the challenge of an imbalance between demand and supply at different points in the chain, resulting in additional costs and a decrease in the level of service quality. [1].

With the onset of military actions in Ukraine, most logistic chains were disrupted. There was a relocation of production capacities from the eastern regions of Ukraine, ongoing destruction of infrastructure, and other challenges, necessitating the use of new approaches to build flexible supply chains for goods from EU countries to Ukraine capable of responding to external threats and changes. According to data from the Transport Company "Neolit Logistics" (TC), one of the most demanded directions for the import of goods among customers is Germany-Ukraine. In this direction, a large share of imported goods consists of consumer goods. Among the urgent problems in organizing deliveries, company managers identify interruptions in supplies to Ukraine due to discrepancies in delivery times and excessive waiting times at border crossings for transport vehicles. These issues lead to failures in meeting agreed delivery times and the occurrence of associated additional costs.

All of this underscores the relevance of searching for approaches to optimizing the functioning of the logistics supply chain by determining rational parameters, batch sizes, and delivery periods to establish a balance between demand and supply in the chain links and reduce additional costs associated with undersupply or the formation of excess inventory at customer premises.

Analysis of recent research and problem statement. An important aspect of logistics system activity is maintaining inventory levels that ensure the uninterrupted supply of all units with the necessary material resources while meeting the economic requirements of the entire material flow process. The author [2] believes that logistics research should consider an integrated system of material, information, and financial flows within an enterprise, which are combined into a unified logistics flow.

The works [2-15] are dedicated to the formation of supply chains and optimisation of their parameters. Taking into account the existing approaches and methods, they can be grouped in the following directions:

– formation of inventory management systems;
– design of logistic systems;
– design of delivery systems in supply chains;
– development of models for the operation of transport and production complexes;
– formation of terminal systems, etc.

A common advantage of most of these approaches is that the authors use stochastic optimisation models and consider the random nature of technological processes. However, some models are complex to implement and are not universal, meaning they cannot be easily supplemented and expanded for specific conditions.

Improving the cargo delivery process to increase its efficiency requires solving a wide range of optimisation tasks by determining optimal connections between suppliers and consumers. From the perspective of a logistic approach, the efficiency of the cargo delivery process is determined by three factors: costs, speed, and continuity.

The logistic system should be organised in such a way that its total costs remain at a minimum level during the delivery process. Speed is related to the qualitative indicators of transport services and depends on transport costs. When designing a delivery system, it is necessary to strike a balance between speed and cost, as increasing the level of service quality leads to increased costs. On the other hand, the faster the transportation, the less time stocks are spent in transit and are unavailable for use. The continuity of transportation depends on the delivery period. Insufficient continuity of the delivery process leads to the need to create safety stocks to prevent unforeseen disruptions in production and sales processes. At the same time, the formation of excess stocks in the warehouses of the delivery process leads to additional costs, which affects the cost of the final product cost. The quality level of the delivery process has a significant impact on the activities that are sensitive to the time factor. Therefore, a balance between costs and quality of transportation is a necessary condition to choose logistic service technology and to manage it in supplies of raw materials and finished products, especially in international connections.

As a criterion of efficiency, most commonly used when optimising logistic chain parameters is the cost indicator and its derivatives (cost price, adjusted costs, etc.). [2-3, 6-7, 9-11]. The international logistic service aims to minimise total costs in resource movement management by optimising the operation of the logistic system from the moment of selecting a supplier to the after-sales service, focussing on obtaining and using synergistic dependencies and effects [9].

The construction of cargo flow distribution channels and the distribution network system in international delivery significantly affect the supply costs to the end consumer. Among the economically justified methods for quickly replenishing stocks are strategies for placing distribution warehouses near sales markets and production facilities. When forming a delivery system in the supply chains of small batches of goods in international connections, the most advantageous option is to use terminal systems [11].

As a result of the analysis of the current state of the problem, the shortcomings and advantages of existing methods for determining rational parameters of supply chains when delivering goods to customers in international connections were identified, which necessitate the development of technological foundations for determining rational parameters of the supply chain, batch size, and delivery period of goods to customers in international connections in order to maintain a balance between demand and supply in the chain links and reduce additional costs associated with waiting for delivery or the formation of excess inventory.

Purpose and objectives of the study. The purpose of the research work is to increase the efficiency of logistic services for cargo owners in international connections by determining the rational parameters of the supply chain. The object of the study is the process of delivering consumer goods to customers in international connections; the subject of the study is the influence of supply chain parameters on the total costs of delivery participants of consumer goods when serving cargo owners.

To achieve this purpose, the following tasks need to be solved: to analyse the current state of determining the rational parameters of the supply chain for customers in international connections; to form a model for determining rational parameters of the supply chain; to conduct experimental research; to analyse the research results.

Materials and methods of the study. The object of research has its own peculiarities related to the supply system, the organisation of the freight flow distribution system in the supply chain, the location of terminals and distribution centres, the distribution of their service area, the density and form of work of customers and the retail network in different regions of Ukraine. The process of supplying goods to the end consumer is a complex process and represents a multilevel distribution channel (Fig. 1), which determines the final price of the product in the retail trade network.

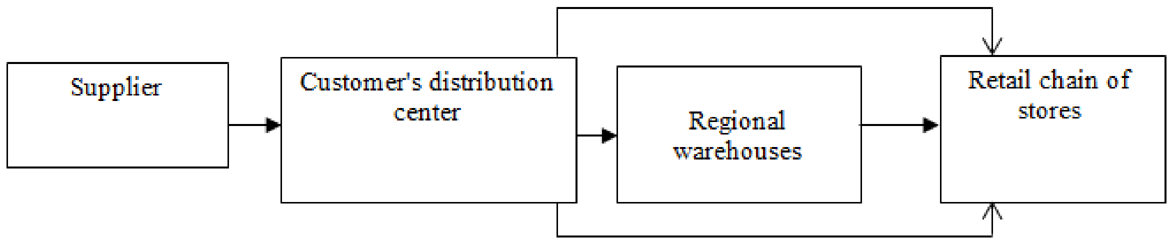

Fig. 1. **Structure of the cargo flow distribution channel in the customer supply chain**

The supply chain is characterised not only by its scheme, but also by a specific technology. Therefore, it can be said that the structural scheme determines the efficiency of the system's operation (Fig. 2). The manufacturer must supply the customer with products within the contractually agreed period. In case of a product shortage, safety stock is used in the distribution centre, which can lead to a disruption in product delivery to consumers in the region. In such a case, the customer incurs losses.

The problem statement for determining the rational parameters of the supply chain includes formalisation of the efficiency criterion, determination of controllable parameters, the change of which will affect the process efficiency, development of the process model (mathematical), determination of the system of constraints and assumptions regarding conditions, requirements, and capabilities.

The efficiency of the supply chain operation is advisable to assess using an economic criterion - supply costs for a certain period, as this indicator significantly affects the final product cost. Value indicators of the elements of the supply process and the total demand for the planning period are established as parameters of external influence.

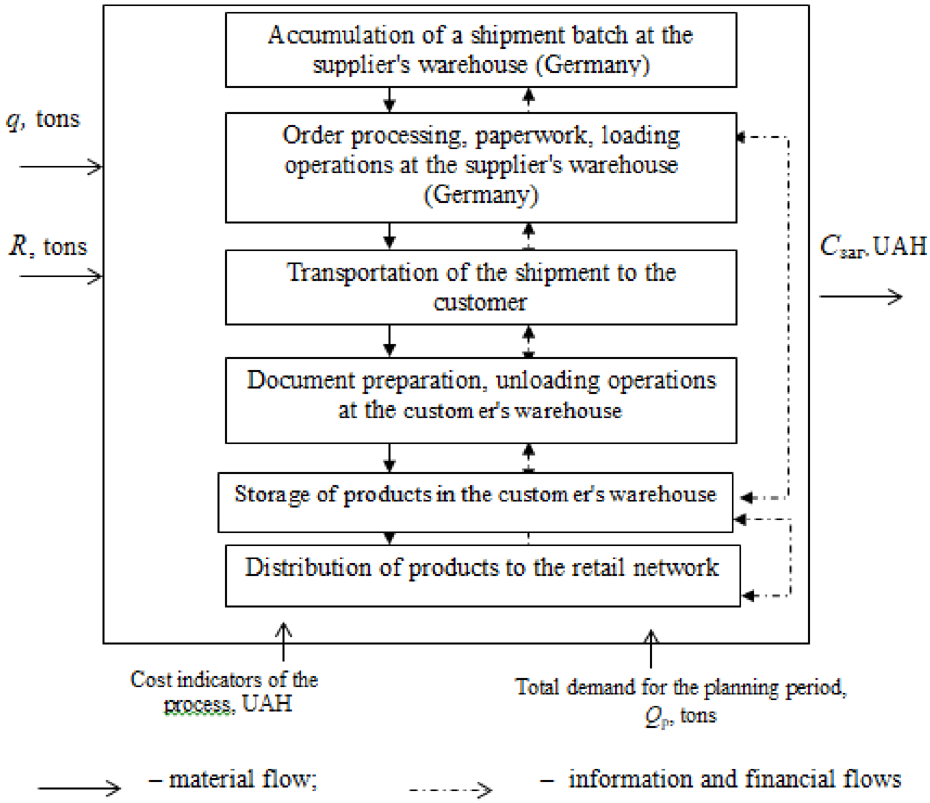

Fig. 2. **The structural scheme of the research object**

The complexity of the channel of distribution of freight flow in the supply chain of consumer goods to the customer in international connections requires consideration of the interests of all participants in the delivery process. According to the approach proposed in [11], it is proposed that the efficiency criterion should be considered as the total costs (C_{tot}) for the entire supply period of product (T). In this case, the target function is as follows

$$C_{tot} = f\left(q, R, C_1, t_1, C_2, t_2, C_R, Q_p, T\right) \rightarrow min. \qquad (1)$$

where q – batch size, tons;
R – stock of finished products at the customer at time, t_1, tons;
T – period during which the supply is made, months;
Q_p– total demand for the planning period, tons;
C_R – order processing cost associated with document processing, receipt and delivery, transportation of the batch of cargo, UAH;
C_1– cost of storing 1 ton of product at the customer per month, UAH/month$
C_2 – losses incurred by the customer in case of undersupply of 1 ton of product, UAH/month.

The input parameters of the model are the batch size (q, tons) and the stock of finished products at the customer at time t_1 (R, tons); the output parameter is the total costs ($C_{заг}$, UAH) for the entire period of product supply T; the parameters of the external environment are the value indicators of the process (C_1, C_2. C_R) and the total demand for the planning period (Q_p, tons). Some indicators are uncontrollable, while others are controllable, and their rational values need to be determined.

Fators C_1, t_1, C_2, t_2, C_R, Q_R are uncontrollable, while others are controllable, and their rational values (C^*_{tot}, q^*_{rat}, R^*_{rat}, t^*_{Rrat},) are need to be determined.

The defined function has a system of restrictions and assumptions. Based on the research goal set in the paper, the task of optimising the parameters of the supply chain to the customer in international connections should be addressed. It is proposed to consider the delivery process from the distribution centre in Germany (Berlin) to the distribution centres located in Ukraine. Thus, the system of restrictions and assumptions is as follows

$$\begin{cases} T = 12, month; \\ 380 \le Q_p \le 820, tons; \\ L_{del} = 1300, km; \\ 3 \le R \le 30, tons; \\ 8 \le q \le 28, tons; \\ g > 0, tons; \\ t_1 > 0, hours. \end{cases} \quad (2)$$

Improving the delivery process of goods in the supply chain aims to minimise logistic costs throughout the lifecycle of the logistic system, taking into account the system's ability to adapt to possible changes under the influence of external factors. Let’s present the total costs for the planned customer service period in the form of a mathematical model [11].

The number of batches for the planned period (year) is determined

$$g = \frac{Q_p}{q}. \quad (3)$$

Frequency of batch delivery to the customer

$$t_R = \frac{T}{g} = \frac{T \cdot q}{Q_p}. \quad (4)$$

Exceeding the demand value over the stocks is acceptable.

The time interval during which a certain level of R stock will accumulate is

$$t_1 = \frac{R}{q} \cdot t_R. \quad (5)$$

The time interval when there is a shortage of stocks is equal to

$$t_1 = \frac{q - R}{q} \cdot t_R. \quad (6)$$

The average stock during time t_1 is equal to

$$\bar{R} = \frac{R}{2}. \quad (7)$$

Storage costs for the entire time t_1 amount to

$$C_{st} = \frac{R}{2} \cdot C_2 \cdot t_1. \tag{8}$$

The average level of undersupply (exceeding demand over stock level) during time t_2 is calculated as follows

$$q > R = \frac{q-R}{2}. \tag{9}$$

The losses incurred by the customer due to the shortage of products during time t_2 amount to

$$C_{loss} = \frac{q-R}{2} \cdot C_2 \cdot t_2. \tag{10}$$

The target function for inventory management can be represented as a mathematical model

$$C_{tot}(q,R) = \left(\frac{R}{2} \cdot C_1 \cdot t_1 + \frac{q-R}{2} \cdot C_2 \cdot t_2 + C_R \right) \cdot \frac{Q_R}{q} \to min. \tag{11}$$

Taking into account the described dependencies for t_1, t_2 , t_R, we obtain

$$C_{tot}(q,R) = \frac{R^2}{2 \cdot q} \cdot C_1 \cdot T + \frac{(q-R)^2}{2 \cdot q} \cdot C_2 \cdot T + C_R \cdot \frac{Q_R}{q} \to min. \tag{12}$$

The solution to the problem lies in finding the extremum of the target function (9), which is found by differentiation, allowing us to find models to determine rational values of inventory indicators.

Thus, the rational values for the parameters are as follows:

– batch size

$$q^*_{rat} = \sqrt{2 \cdot \frac{Q_p \cdot C_R}{T \cdot C_1}} \cdot \sqrt{\frac{C_1 + C_2}{C_2}}; \tag{13}$$

– frequency of batch delivery to the customer

$$t^*_{Rrat} = \sqrt{2 \cdot \frac{T \cdot C_R}{Q_p \cdot C_1}} \cdot \sqrt{\frac{C_1 + C_2}{C_2}}; \tag{14}$$

– minimum costs

$$C^*_{tot} = \sqrt{2 \cdot Q_p \cdot T \cdot C_1 \cdot C_R} \cdot \sqrt{\frac{C_2}{C_1 + C_2}}.. \tag{15}$$

Thus, a mathematical model has been developed to determine the rational technology of cargo delivery in supply chains. It is possible to conduct experimental studies to determine the rational delivery parameters that will ensure the minimum total costs of the process participants.

In order to conduct experimental studies, primary information was collected at the enterprise TC "Neolith Logistics", which provides transport and forwarding services to customers, particularly in international communication. A significant client of the TC is a wholesale trading network in Ukraine. According to the company's data for the last three years, a significant portion of cargo volumes (consumer goods) is imported from Germany (distribution centre in Berlin) to Ukraine to the customer's distribution centre located in Vinnitsa. From distribution centres, the goods are distributed to regional warehouses, from where deliveries to the retail network occur twice a week. Delivery is carried out by motor transport of carrier enterprises with which TC "Neolith Logistics" has cooperation agreements. Tarpaulin-sided trucks are used for the transportation of consumer goods. Monthly supply plans are drawn up according to orders and TC employees search for available transport from partner companies to transport batches of goods from Germany to Ukraine on specified dates. Shipments of cargo batches from the distribution centre in Germany to distribution centres in Ukraine are made every Sunday along established routes. The route length is 1300 km, and the average shipment volume is 18.0 tons, with a frequency of twice a month. The further distribution of goods to the retail network of stores from the distribution centre is carried out through both regional warehouses and directly to the retail network. The volume of cargo transport in tons is planned based on the turnover plan of the store network. Supply to the retail network from regional warehouses is carried out according to the daily schedules of deliveries and distribution routes of the mobile fleet. For supply to the retail network in the regions, the mobile fleet of local carrier enterprises is involved.

The goal of determining the optimal parameters of the supply chain is to maintain a balance between demand and supply at the links of the chain. To model dynamic processes, it is necessary to identify the main trends in their development. Therefore, an important stage is the qualitative planning of the transport process for the future period based on the study of demand change trends.

Special forecasting methods include building dynamic series, based on which forecast values of the process development can be determined, taking into account the regularities of previous periods. To describe the trend of change in demand, we propose using least squares. To choose the type of function as alternatives, we suggest considering linear, hyperbolic, and parabolic functions.

The determination of the components of the system of equations is carried out based on the initial data on the volumes of orders for the delivery of consumer goods to the distribution centre of the customer – a trading company located in Vinnitsa, by months for the year 2023 according to the data of the transport company "Neolith Logistics", which serves the customer on a permanent basis.

The determination of the coefficients of all three trend models is solved using systems of normal equations, which are constructed separately for each model.

By the criterion of assessing the adequacy of trend models, the minimum sum of squares of deviations of forecast values from empirical ones, we choose the hyperbolic model, since according to this model, the sum of squares of demand deviations has the lowest value (7.94047 tons). Therefore, it is the hyperbolic trend model that determines the forecast demand values for the year 2024.

The results of the calculations of forecast demand values for 2023 are presented in Table 1.

Table 1. **Results of calculations of forecast demand values for the year 2024**

Month	Demand, tons	Month	Demand, tons	Month	Demand, tons	Month	Demand, tons
1	37,51	4	37,53	7	37,54	10	37,55
2	37,51	5	37,53	8	37,54	11	37,55
3	37,52	6	37,53	9	37,54	12	37,55

The total expected demand for the delivery of consumer goods from Germany to Ukraine for 2024 is 488 tons.

The values of the input parameters for modelling according to the proposed mathematical model are given in Table 2.

Table 2. **Input parameters of the model**

Indicators	Unit of measurement	Value of indicators
Period during which delivery is made	month	12
Order processing cost	UAH	300
Kilometre tariff	UAH /km	[20;38]
Cost of storing 1 ton of cargo at the consignee's warehouse	UAH /month	1800
Losses incurred by the customer in case of non-delivery of 1 ton of cargo	UAH /month	1300
Batch size	tons	[8;20]
Reserve cargo stock in the warehouse	tons	[3;30]

The results of calculations of the efficiency criterion at the minimum values (q_{min}=8 tons; R_{min}=5 tons), average values (q_{mid}=14 tons; R_{min}=5 tons) and maximum values (q_{max}=20 tons; R_{max}=25 tons) of the input parameters are graphically shown in Fig. 3 as dependencies of the components of the efficiency criterion and the total costs according to the size of the shipment batch.

Analysing the calculation results, the following conclusions can be made: at the minimum level of input parameter values (q_{min}=8 tons; R_{min}=5 tons), the maximum value of the efficiency criterion and the costs of order processing and the level of customer losses due to nondelivery of products are observed. Thus, the interval of time when there is a shortage of stocks exceeds 2 days, which indicates supply disruptions and a demand-supply imbalance in the customer's chain in the supply chain.

This, in turn, leads to additional costs associated with customer losses. Also, there is a high level of order processing costs, the lion's share of which consists of transportation costs since at the minimum shipment batch size, it is necessary to make the maximum number of shipments, 61 units over a distance of 1300 km, which is economically impractical.

At the maximum level of the values of the input parameters (q_{max}=20 tons; R_{max}=25 tons), an increase in the costs of storing goods in the distribution warehouse is observed since supply exceeds demand, and intensive accumulation of stock levels occurs. Also, there is a slight increase in order processing costs, but compared to the minimum level of input parameter values, they are lower by 325050 UAH per year.

At the average values of the input parameters, the efficiency criterion reaches a minimum, mainly due to a decrease in order processing costs. Also, at a shipment batch size of 14 tons, the lines of functions of storage costs of goods and the sum of customer losses associated with nondelivery intersect. This indicates the presence of a demand-supply balance in the chain links, precisely at a shipment batch size of 14 tons.

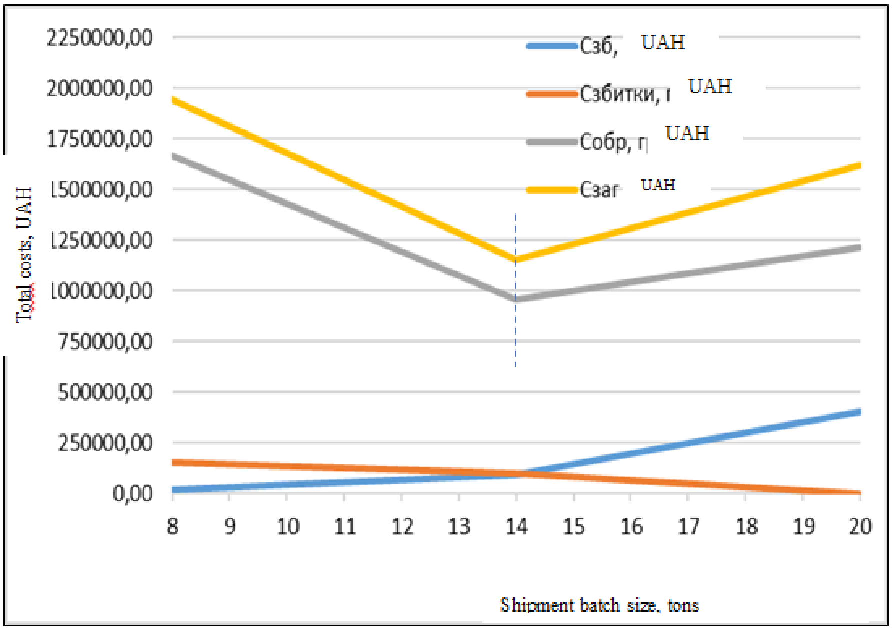

Fig. 3. **Dependence of the components of the efficiency criterion and total costs on the size of the shipment batch at different levels of input parameters**

Thus, it was determined that the minimum level of total costs, amounting to 115196,0 UAH, is achieved when supplying a rational batch size of 14 tons to the customer of TC "Neolith Logistic" in the direction of Germany - Ukraine with a delivery period 3 times a month.

The effect associated with the total cost of delivery, is determined by the following formula

$$E = C_{tot}^{min(max)}(q_{min(max)}, t_{Rmin(max)}) - C_{tot}^{*}(q_{rat}^{*}, t_{Rrat}^{*}) \qquad (16)$$

where $C_{tot}^{min(max)} = \left(q_{min(max)}, t_{Rmin(max)}\right)$ – the total cost total costs at minimum and maximum values of input parameters, UAH;

C_{tot}^{b} – the total costs at rational values of input parameters, UAH.

Results of calculations of the economic effect are given in Table 3.

Table 3. **Results of calculations of the economic effect**

Indicators	Value of indicators		
	Minimum	Rational	Maximum
Total costs of supplying products to customers, UAH	1946850,0	1155196,0	1621800,0
Economic effect, UAH	E_1=791654,0		E_2=466604,0

The results of the economic effect calculation demonstrate the effectiveness of the proposed solutions for determining the optimal size of the cargo batch and the delivery period to customers of TC Neolith Logistic in the direction of Germany - Ukraine. This is achieved while maintaining the balance of supply and demand and reducing the likelihood of additional costs associated with shortages or excessive stocks, which would impact the final cost of goods.

When comparing the total cost of delivery with rational supply chain parameters with the total cost at the minimum and maximum levels of variation of input parameters, positive values were obtained $E1$=791654,0 UAH and $E2$=466604,0 UAH, which indicates the effectiveness of the solutions proposed.

Conclusions. In this paper, propose technological principles for determining rational parameters of the supply chain in order to establish a balance between demand and supply for goods in the chain links under conditions of variable demand and optimisation of total costs for all cargo delivery participants.

Analysis of the current state of determining rational parameters of the supply chain with service of customers in international connections has revealed the relevance of the chosen research direction. The drawbacks and advantages of existing problem-solving methods have been identified based on the results of studying literary sources. Existing approaches and methods have been grouped into the following directions: inventory management system formation, logistic system design; delivery system design in supply chains; development of functioning models for transport-production complexes, terminal system formation, and so on. Based on the results, the object and subject of the research have been characterised and the purpose and objectives of the study have been formulated.

The input parameters, output parameter, external environmental factors, system elements, and relationships between them have been determined based on the formed structure of the research object. To determine the nature of the influence of controlled parameters on the efficiency of the functioning process of the research object, the method of mathematical modeling has been chosen. A mathematical model has been developed to determine the rational parameters of the supply chain - the cargo batch size and the delivery period to customers - at which the efficiency criterion value will be minimized

In order to conduct experimental studies of the supply chain functioning on the example of customer service at TC “Neolit Logistic”, it was important to conduct high-quality planning for the future period based on the study of demand trends. Taking into account the complexity of studying trends, the method of dynamic series construction has been chosen for demand forecasting. The total forecast demand, determined by the hyperbolic model as the most adequate model for forecasting, based on the criterion of minimal sum of squared deviations, is 488 tons.

Based on the results of experimental studies, the nature of the impact of model input parameters on the efficiency criterion has been determined at different levels of controlled parameters, and rational values of supply chain parameters have been identified. Specifically, the minimum level of total costs is achieved with the supply of a rational cargo batch size of 14 tons to the customer TC "Neolit Logistic" in the direction of Germany - Ukraine, with a delivery period of 3 times a month.

The positive results of the calculation of the economic effect testify to the effectiveness of the solutions proposed in the research work.

REFERENCES

1. Prunenko, D. O. (2016) Upravlinnya lantsyuhom postachan'. [Supply chain management]. *Lecture notes,* 140 [in Ukrainian].
2. Musatenko, O. V. (2018) Pidvyshchennya efektyvnosti lohistychnoyi systemy postachan' z vykorystannyam avtomobil'noho transportu [Improving the efficiency of the logistics supply system using road transport]. *Abstract of Doctor’s thesis*. Kyyiv, 20 [in Ukrainian].
3. Hrytsyshyn, A. V. (2020) Oblik i analiz lohistychnoyi diyal'nosti pidpryyemstv kondyters'koyi promyslovosti. [Accounting and analysis of logistics activities of confectionery industry enterprises]. *Doctor’s thesis*. Ternopil', 238 [in Ukrainian].
4. Holovanenko M.V. (2015) Optymizatsiya lohistychnykh vytrat z vykorystannyam EOQ-modeli v umovakh retsesiyi. [Optitmization of logistics costs using the EOQ-model in recession]. *Teoretychni ta prykladni pytannya ekonomiky,* 1(30), 238-249 [in Ukrainian].
5. Rykovanova, I.S. (2021) Lohistyka postachannya vyrobnychoho obladnannya na pidpryyemstvo. [Supply logistics of production equipment to the enterprise]. *Abstract of Doctor’s thesis*. L'viv, 27 [in Ukrainian].
6. Shulika, O., Orda, O., Potaman, N., &Yashchuk, Y. (2023) Developing an efficient road-based batch freight delivery technology for intercity connections with a focus on resource conservation. *Collection of Scientific Papers of the State University of Infrastructure and Technologies of the Ministry of Education and Science of Ukraine: Series "Transport Systems and Technologies", 41*. Kyiv:SUIT, 195-212. https://doi.org/10.32703/2617-9059-2023-41-16.
7. Lutsenko, I. S. (2021) Lohistychne upravlinnya zapasamy [Logistics inventory management]: *Study guide*. Kyyiv, 69 [in Ukrainian].

8. Tyurina, N. M., Hoy, I. V., & Babiy, I. V. (2015) Lohistyka. [Logistics]. *Study guide*. Kyyiv, 392 [in Ukrainian].
9. Yarova, I. Ye. (2020) Mizhnarodni lohistychni posluhy. [International logistics services]. *Lecture notes*, 107 [in Ukrainian].
10. Ol'khova, M. V. Optymizatsiya lohistychnykh protsesiv. [Optimization of logistics processes]. *Lecture notes*, 75 [in Ukrainian].
11. Nahornyy, Ye.V., & Shramenko, N. Yu. (2016) Komertsiyna robota na transporti [Commercial work on transport]. *Lecture notes*. Kharkiv, 298 [in Ukrainian].
12. Shramenko, N. Y. (2015). Effect of process-depen-dent parameters of the handling-and-storage facility operation on the cargo handling cost. *Eastern European journal of Enterprise Technologies*, *5/3*(77), 43-47. https://doi.org/10.15587/1729-4061.2015.51396 [in Ukrainian].
13. Krykavs'kyy, Ye.V. (2014) Lohistyka. [Logistics]. *Study guide*. L'viv, 476 [in Ukrainian].
14. Bowersox, D., & Closs, D. (2017) Logistical Management: The Integrated Supply Chain Process. McGraw Hill Education. 752.
15. Kononenko, A. V., Romanenkov, Yu. O., & Hatylo, V. P. (2019) Lohistyka [Logistics]. *Study guide*. Kharkiv, 56 [in Ukrainian].

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Визначення раціональних параметрів ланцюга постачань при обслуговуванні замовників у міжнародному сполученні

Логістичні компанії постійно знаходяться у пошуку раціональних рішень при організації доставки вантажів у міжнародному сполученні, що дозволяли б досягнути балансу між попитом та пропозицією на товари в ланках ланцюга та зменшити додаткові витрати, пов'язаних із очікуванням поставок або зі зберіганням надмірних запасів. В роботі вирішена задача підвищення ефективності логістичного обслуговування вантажовласників у міжнародному та запропоновано технологічні основи з визначення раціональних параметрів ланцюга постачань з метою встановлення балансу попиту та пропозиції на товари в ланках ланцюга в умовах мінливого попиту та оптимізації сумарних витрат усіх учасників доставки вантажів, що матиме вплив на кінцеву вартість товару у замовників. Для вирішення поставленої задачі використано системний підхід, методи математичного моделювання та прогнозування. Для проведення експериментальних досліджень, враховуючи складність вивчення тенденцій, для прогнозування попиту обрано метод побудови динамічних рядів. Для заданих умов функціонування ланцюга постачань товарів у міжнародному сполученні визначено характер впливу вхідних параметрів моделі на критерій ефективності при різних рівнях керованих параметрів та визначено раціональні значення параметрів ланцюга постачань, при яких досягається мінімальний рівень сумарних витрат на доставку вантажів. Про ефективність запропонованих рішень свідчать позитивні результати розрахунку економічного ефекту.

Ключові слова: *логістичний ланцюг, розмір партії вантажів, період постачання, сумарні витрати, економічний ефект*