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RELIABILITY OF LOGISTICS CHAINS IN FOREIGN TRADE OPERATIONS

The aim of the paper is to justify the decision on cooperation with entities in the transport service market for foreign trade operations based on the assessment of logistics chain reliability and shipping time on different routes. The research findings will enable cargo owners and other stakeholders to make management decisions at the delivery planning stage optimizing all processes related to customs and logistics services. **Methodology.** We assess the reliability of four logistics chain types based on a simulation model developed in the GPSS software environment using the method of statistical testing. **Results.** Customs and logistics service users challenge entities in the transport service market with the task of performing foreign trade operations in compliance with the highest level of quality and service reliability minimizing the cost of delivery and shipping time. The proposed method allows determining the probability of timely delivery of goods in different transportation directions as well as the reliability of the studied process. **Scientific novelty.** The obtained simulation results will make it possible to work out proposals and recommendations for customs and logistics service users on the choice of an optimal logistics chain type, taking into account its impact on shipping time and reliability of goods delivery. **Practical value.** The practical value of the research is that the proposed method will allow foreign economic entities to form logistics chains, taking into account available resources and the need to use the services of other companies in international goods delivery. In this case, the efficiency of a logistics chain can be further assessed by the shipping time and reliability for ex-port/import operations.

Keywords: logistics chain, foreign trade operation, shipping time, reliability of delivery, shipment route, customs and logistics service.

Introduction and problem statement

The process of logistics chain planning significantly affects the efficiency of the international goods delivery. It is determined by consumers of customs and logistics services based on its cost, shipping time, quality and reliability [1]. Given the strong competition among actors in the transport service market, the issues related to the assessment of the reliability of goods delivery organization and the completion of all related procedures are becoming especially relevant.

Typically, it is difficult for cargo owners inexperienced in dealing with actors in the transport service market to choose partner organizations that are able to offer a high level of service and perform servicing at a reasonable price respecting the delivery date. In addition, each company provides a different range of services, sets the cost of service depending mostly on their expenditures on service provision,

forms of ownership, tax burden and other costs incurred in providing services to individual customers and production activities of the enterprise as a whole. Therefore, when forming a logistics chain, each customer makes a choice of a transport market entity based on the available resources of their own company as well as the need for cooperation with other relevant companies [2].

The current practice of organizing foreign trade operations in Ukraine is characterized by the use of four types of the most common logistics chains, which provide for the division of responsibilities between the organizations that are a part of their structure as links. The operation of each link involves the direct performance of their direct responsibilities, as well as interaction with other links in a logistics chain related to the organization of document management and other operations aimed at organizing the movement of material flow [3]. This process requires the interaction of enterprises to coordinate

actions, compliance with work regulations and quality performance of their direct responsibilities. Accordingly, depending on the number of enterprises included in the logistics chain, the duration of preparatory and organizational work can change. Since each of the involved units has its own software used for paperwork that can be different in its structure and content, the distribution of functional responsibilities between the structural units of an enterprise involved in service provision is performed in accordance with the charter of the enterprise and is not changed depending on the requirements of the customer or in order to establish interaction with other parts of the logistics chain.

The key actors in the transport service market that are involved in logistics chain formation are freight forwarding companies (without their own fleet), customs brokers, transport companies, warehousing organizations and freight customs complexes [1, 4]. To date, there are four most common types of logistics chains involved in export-import operations. Each of them is characterized by its own organizational structure and division of functional responsibilities, has its advantages and disadvantages and, nevertheless, can be used by any exporter.

We take into account that logistics chain links in international road transportation are consignors (C-R); consignees (C-E); freight forwarders without their own fleet of vehicles (F); shipping carriers that provide vehicles only and no organizational support (C); customs brokerage companies (CBCs); freight forwarding companies that are able to provide the customer with organizational support as well as a vehicle that meets the shipment requirements (FFCs); warehouse complexes (CFs); freight

customs complexes that can be involved as customs infrastructure facilities for the completion of customs formalities for the export of goods at a customs checkpoint operating in its territory, or as an organization providing complex customs and logistics support for foreign trade operations (CCCs); checkpoints (CPs); customs agencies in a country of consignment (CAs); logistics centers in a country of consignment (LC) [5].

Type 1 logistics chain (Fig. 1) is the most complex in its structure and involves close cooperation of all the logistics chain links, as each of them fulfills its part of the obligations to the customer within its own organization requiring coordination and exchange of information.

According to type 2 logistics chain (Fig. 2), the activity of freight forwarding companies involves organizational support to ensure foreign trade operations and the provision of vehicles.

Type 3 logistics chain (Fig. 3) is characterized by the involvement of a customs clearance specialist employed by a freight forwarding company. This greatly simplifies and improves transportation and customs paperwork.

Type 4 logistics chain (Fig. 4) is quite new for Ukrainian customs and logistics service users. Because most domestic companies are not able to provide a full range of services due to limited financial resources and logistics. However, over time, companies have entered the market, which in terms of their staffing and infrastructure can create all the favorable conditions for complex service. A significant advantage of this logistics chain is the ability to complete extraordinary customs formalities for export at a checkpoint located in the territory of a freight customs complex.



Fig. 1. Type 1 logistics chain



Fig. 2. Type 2 logistics chain



Fig. 3. Type 3 logistics chain



Fig. 4. Type 4 logistics chain

In general, each of the studied logistics chains is quite effectively used by domestic entrepreneurs, thus contributing to the growth of demand for various types of services and boosting business activities of enterprises of various forms of ownership and specialization.

The decision on the choice of a particular logistics chain type used for the foreign trade operation is made by the customs and logistics service user and depends solely on their needs and general requirements for the shipment of goods [6].

To assess the effectiveness of the use of logistics chains, we conduct a survey of 483 customers with significant experience in export operations. Following its results, most respondents note that at the beginning of their operation they conducted foreign trade operations using mainly type 1 logistics chain; however, they increasingly prefer complex services (type 3 and 4 logistics chain) and declare a fairly high level of satisfaction with this type of operation. Figure 5 shows a histogram of the distribution of the number of customers using different logistics chain types.

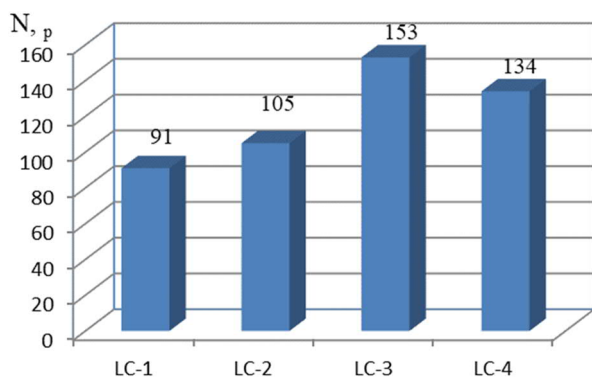


Fig. 5. Number of customs and logistics service users utilizing a certain type of logistics chain in export operations

In this case, each of the customers justifies their choice by one of the criteria including time, cost, quality and reliability. The respondents' assessments according to these criteria are the following. According to the survey results, most customers choosing type 1 logistics chain are guided by the cost criterion. In terms of this criterion, it is possible to individually agree on a lower cost of service with each entity in the transport service market. But entrepreneurs are aware of the risk of additional time expenditures involved in the search for these organizations and negotiations.

Type 2 logistics chain is chosen by customers who are guided by the time criterion. For the most part, significant time is spent searching for a carrier with the fleet of the required type and capacity, so

the possibility of organizing freight forwarding services and the availability of vehicles owned by the company makes it possible to speed up the delivery process.

According to the quality criterion, the vast majority favor type 3 logistics chain. The ability to provide a package of freight forwarding and customs brokerage services is considered quite valuable among customers.

Consequently, by the reliability criterion, customers seek to minimize the number of transport service market entities involved in the logistics chain. Customers choose type 4 logistics chain because only within the framework of complex customs and logistics services it is possible to ensure a high degree of efficiency of goods delivery and the concentration of responsibility for the process within the activities of one legal entity. Figure 6 shows the distribution of the number of customs and logistics service users according to the criteria underlying the choice of certain logistics chain types.

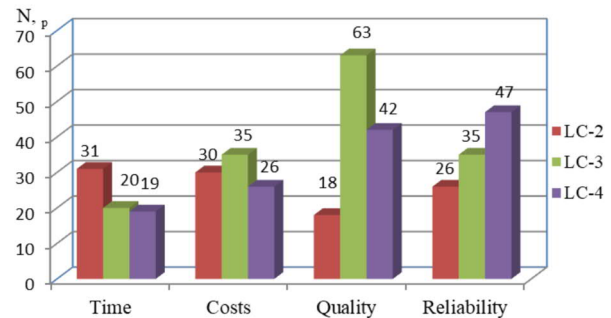


Fig. 6. Distribution of the number of customs and logistics service users according to the criteria for the choice of certain logistics chain types

The analysis of the survey results shows that the issues of quality and reliability of delivery are becoming increasingly important among customs and logistics service users, which will ensure a high level of confidence that contractors have in domestic exporters and reduce the number of violations of foreign trade contracts due to delays, loss or damage to the goods during transportation or poor preparation of shipping documents.

We evaluate the reliability of the four types of logistics chains based on a simulation model developed in GPSS [7, 8] using the method of statistical testing or the Monte Carlo method. The essence of the method of statistical testing is to make playouts using a procedure generating a random result [9, 10]. With the help of a playout we get one implementation. When playouts are repeated, statistical material is accumulated and then processed using the method of statistical testing. The GPSS simulation system uses a pseudo-random number sensor as

a random element, which uses Lehmer's multiplicative congruent algorithm to simulate random processes [11].

The reliability of the logistics chain lies in the timely delivery of goods to the consignee in full and ensuring appropriate quality.

When assessing the reliability of the logistics chain, the following features can be identified [12-14]:

1. The logistics chain has a rather complex structure. Cooperation of legal entities providing different types of services and having their own requirements for document management and information support need to be quickly adapted to interaction with other actors in the transport service market in order to organize actions in the interests of the customer.

2. There is not always a clear functional relationship between the processes that take place within the logistics chain, and in most cases this relationship is probabilistic.

3. Occurrence of some processes in a logistic chain or deviation of current processes from the set characteristics has probabilistic character and is defined by the influence of the external environment.

In such conditions, it is difficult to trace all the reasons that may lead to a service refusal or a failure in the logistics chain as well as to assess its reliability based on analytical methods used for the analysis of technical systems.

In this case, to assess the reliability of the logistics chain, it is advisable to use a logistics chain simulation model developed in GPSS [7, 15]. With the help of the simulation model, we can determine:

- probabilistic indicators of the four logistics chain types, including the probability of timely shipment;

- reliability of the logistics chain as a whole and its individual elements (links);

- the structure of the four logistics chain types with the specified reliability characteristics under certain constraints that are optimal according to the selected criteria for evaluating efficiency.

Simulation modeling in GPSS, which is a machine implementation of the method of statistical testing or the Monte Carlo method, allows us to solve the problems of not only analysis (evaluation of a logistics chain structure, the impact of changing various parameters), but also synthesis, when it is needed to create a system with specified reliability characteristics and certain constraints that are optimal according to the selected performance evaluation criteria.

Processing of simulation results is carried out by a limited number of implementations of a random

process (sampling). The minimum number of tests is determined on condition of obtaining the specified accuracy and reliability.

Based on a supply chain simulation model, we determine the reliability of the four logistics chain types in goods delivery of on Kyiv – Budapest (Hungary), Kyiv – Bordeaux (France), Kyiv – Madrid (Spain) routes.

To ensure the specified accuracy of the assessment of probabilistic characteristics by the method of statistical testing in GPSS, it is required 87,600 hours of the simulated time of the logistics chain simulation model operation [16].

To assess the reliability of logistics chains in the delivery of goods on the route Kyiv – Budapest and with the use of GPSS, we conducted 558 implementations of the simulation model for type 1 logistics chain, 603 type 2 logistics chain model implementations, 685 type 3 logistics chain model implementations, and 1189 implementations of type 4 logistics chain model. The logistics chain performance assessment in shipment on the route Kyiv – Budapest is given in tables 1-4.

Table 1

Performance assessment of type 1 logistics chain (Kyiv – Budapest route)

Characteristic	Assessment	
Mathematical expectation of shipping time	157.5 hours	
Standard deviation of shipping time	30 hours	
Probability of timely shipment on the route Kyiv – Budapest (the norm is 200 hours)	163 hours	0.62
	182 hours	0.72
	200 hours	0.75
	248 hours	0.83
	295 hours	0.89

Table 2

Performance assessment of type 2 logistics chain (Kyiv – Budapest route)

Characteristic	Assessment	
Mathematical expectation of shipping time	147 hours	
Standard deviation of shipping time	30 hours	
Probability of timely shipment on the route Kyiv – Budapest (the norm is 180 hours)	153 hours	0.70
	174 hours	0.75
	180 hours	0.79
	231 hours	0.86
	265 hours	0.90

Table 3

**Performance assessment of type 3 logistics chain
(Kyiv – Budapest route)**

Characteristic	Assessment	
Mathematical expectation of shipping time	128 hours	
Standard deviation of shipping time	31.5 hours	
Probability of timely shipment on the route Kyiv – Budapest (the norm is 165 hours)	135 hours	0.77
	153 hours	0.85
	165 hours	0.89
	195 hours	0.91
	235 hours	0.93

Table 4

**Performance assessment of type 4 logistics chain
(Kyiv – Budapest route)**

Characteristic	Assessment	
Mathematical expectation of shipping time	74 hours	
Standard deviation of shipping time	18.5 hours	
Probability of timely shipment on the route Kyiv – Budapest (the norm is 120 hours)	81 hours	0.79
	102 hours	0.85
	120 hours	0.92
	166 hours	0.94
	194 hours	0.96

To assess the reliability of logistics chains in the delivery of goods on the route Kyiv – Bordeaux and with the use of GPSS, we conducted 327 implementations of the simulation model for type 1 logistics chain, 332 type 2 logistics chain model implementations, 346 type 3 logistics chain model implementations, and 440 implementations of type 4 logistics chain model. The logistics chain performance assessment in shipment on the route Kyiv – Bordeaux is given in tables 5-8.

Table 5

**Performance assessment of type 1 logistics chain
(Kyiv – Bordeaux route)**

Characteristic	Assessment	
Mathematical expectation of shipping time	267.5 hours	
Standard deviation of shipping time	51 hours	
Probability of timely shipment on the route Kyiv – Bordeaux (the norm is 330 hours)	285 hours	0.59
	302 hours	0.67
	330 hours	0.72
	386 hours	0.78
	417 hours	0.89

Table 6

**Performance assessment of type 2 logistics chain
(Kyiv – Bordeaux route)**

Characteristic	Assessment	
Mathematical expectation of shipping time	263.7 hours	
Standard deviation of shipping time	58 hours	
Probability of timely shipment on the route Kyiv – Bordeaux (the norm is 320 hours)	278 hours	0,69
	290 hours	0,74
	320 hours	0,78
	363 hours	0,86
	395 hours	0,92

Table 7

**Performance assessment of type 3 logistics chain
(Kyiv – Bordeaux route)**

Characteristic	Assessment	
Mathematical expectation of shipping time	255 hours	
Standard deviation of shipping time	70 hours	
Probability of timely shipment on the route Kyiv – Bordeaux (the norm is 305 hours)	269 hours	0.70
	281 hours	0.76
	305 hours	0.85
	350 hours	0.89
	381 hours	0.94

Table 8

**Performance assessment of type 4 logistics chain
(Kyiv – Bordeaux route)**

Characteristic	Assessment	
Mathematical expectation of shipping time	200 hours	
Standard deviation of shipping time	56 hours	
Probability of timely shipment on the route Kyiv – Bordeaux (the norm is 250 hours)	215 hours	0.77
	232 hours	0.83
	250 hours	0.90
	285 hours	0.93
	307 hours	0.96

To assess the reliability of logistics chains in the delivery of goods on the route Kyiv – Madrid and with the use of GPSS, we conducted 273 implementations of the simulation model for type 1 logistics chain, 285 type 2 logistics chain model implementations, 307 type 3 logistics chain model implementations, and 342 implementations of type 4 logistics chain model. The logistics chain performance assessment in shipment on the route Kyiv – Madrid is given in tables 9-12.

Table 9

**Performance assessment of type 1 logistics chain
(Kyiv – Madrid route)**

Characteristic	Assessment	
Mathematical expectation of shipping time	324 hours	
Standard deviation of shipping time	62 hours	
Probability of timely shipment on the route Kyiv – Madrid (the norm is 250 hours)	345 hours	0.59
	388 hours	0.65
	250 hours	0.69
	455 hours	0.75
	486 hours	0.85

Table 10

**Performance assessment of type 2 logistics chain
(Kyiv – Madrid route)**

Characteristic	Assessment	
Mathematical expectation of shipping time	314 hours	
Standard deviation of shipping time	73 hours	
Probability of timely shipment on the route Kyiv – Madrid (the norm is 390 hours)	333 hours	0.65
	364 hours	0.71
	390 hours	0.73
	425 hours	0.80
	460 hours	0.89

Table 11

**Performance assessment of type 3 logistics chain
(Kyiv – Madrid route)**

Characteristic	Assessment	
Mathematical expectation of shipping time	290 hours	
Standard deviation of shipping time	89 hours	
Probability of timely shipment on the route Kyiv – Madrid (the norm is 375 hours)	311 hours	0.68
	330 hours	0.74
	375 hours	0.82
	400 hours	0.87
	448 hours	0.91

Table 12

**Performance assessment of type 4 logistics chain
(Kyiv – Madrid route)**

Characteristic	Assessment	
Mathematical expectation of shipping time	250 hours	
Standard deviation of shipping time	75 hours	
Probability of timely shipment on the route Kyiv – Madrid (the norm is 330 hours)	271 hours	0.76
	293 hours	0.80
	330 hours	0.86
	368 hours	0.90
	405 hours	0.94

The reliability of the logistics chain and its links is determined both by assessing the probability of

timely execution of individual foreign trade operation procedures, and the process as a whole. In particular, we consider the process of goods delivery on Kyiv – Budapest route. The total shipping time for the various logistics chains significantly differs. And as experts of the enterprises in the field note, these differences are caused by time expenditures on the search for entities in the transport service market, agreeing terms and conditions of cooperation and the cost of service – it takes a considerable amount of time (Fig. 7).

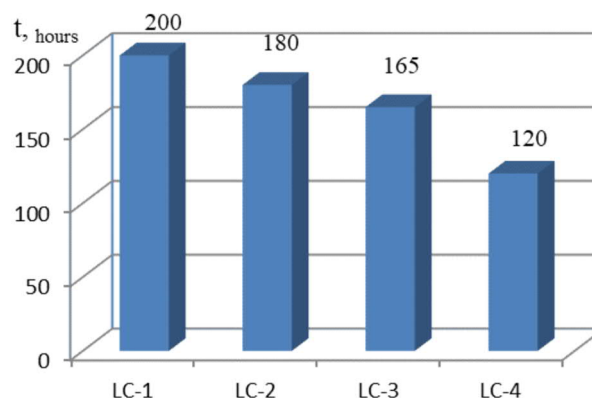


Fig. 7. Shipping time for different logistics chain types on Kyiv – Budapest route

Accordingly, we determine the reliability of delivery along the route when customer service is provided utilizing different logistics chains (Fig. 8).

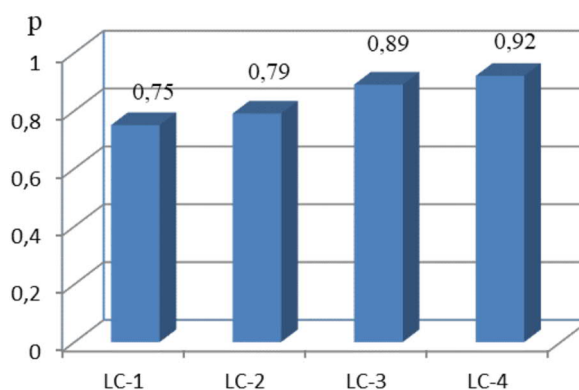


Fig. 8. Reliability of different logistics chain types on Kyiv – Budapest route

According to the obtained findings, we can conclude that in case of complex customs and logistics services, the reliability is the highest and amounts to 0.92, while type 1 logistics chain is characterized by 0.75 reliability

To put it into perspective, let us analyze Kyiv – Bordeaux route. In this case, the delivery relying on type 4 logistics chain is reduced by 80 hours as compared to type 1 (Fig. 9).

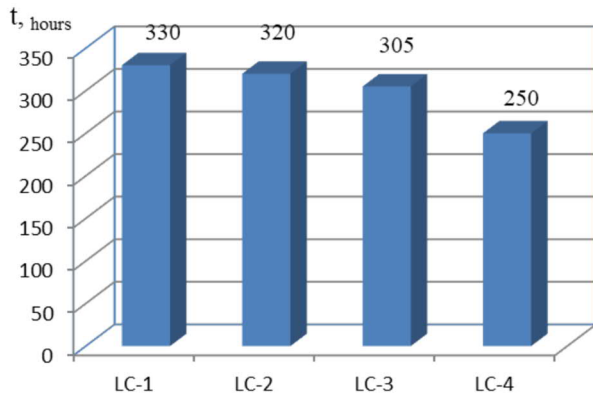


Fig. 9. Shipping time for different logistics chain types on Kyiv – Bordeaux route

Accordingly, similarly to Kyiv – Budapest route, type 4 logistics chain is characterized by the highest reliability (Fig. 10).

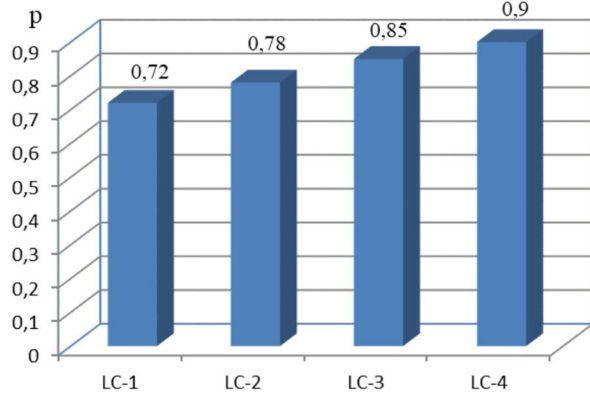


Fig. 10. Reliability of different logistics chain types on Kyiv – Bordeaux route

Carriers are usually reluctant to take orders for long-haul transportation. This type of transportation is characterized by a significant number of risks associated with the technical condition of the vehicle, the driver's psychophysical state and the need to take into account many transportation and customs formalities when organizing traffic in transit countries. Nevertheless, for comparison, let's examine the indicators of shipping time and reliability of delivery on Kyiv– Madrid route. Accordingly, shipping time on the first route is 420 hours, and when completing export formalities at the freight customs complex, it equals 330 hours (Fig. 11).

Reliability on this route is much lower as compared to the previous ones according to all the types of logistics chains, but in case of type 4 logistics chain it is the highest (Fig. 12).

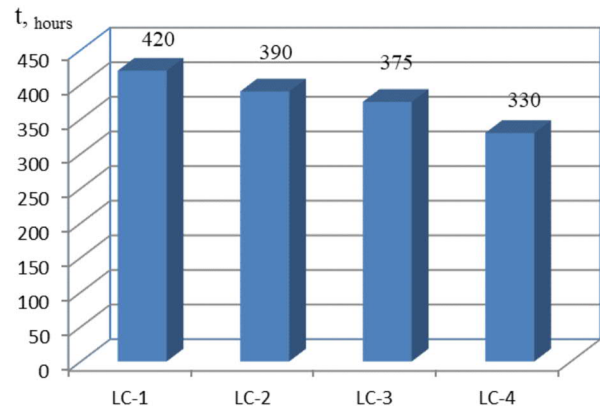


Fig. 11. Shipping time for different logistics chain types on Kyiv–Madrid route

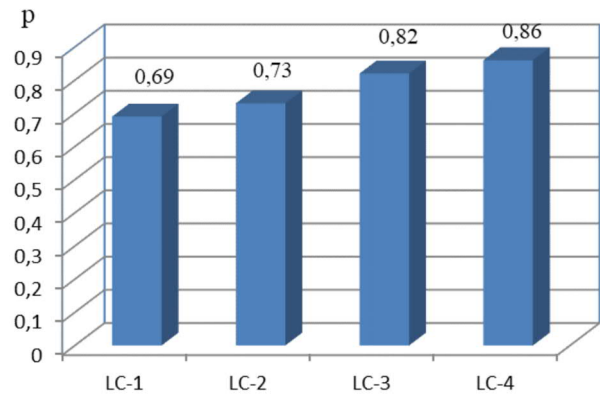


Fig. 12. Reliability of different logistics chain types on Kyiv– Madrid route

The reliability of type 1 and 2 logistics chain is characterized by lower figures because to ensure a quite high reliability level of a logistics chain as a whole it is necessary to ensure a sufficiently high reliability level of each of its links. In this case, due to a large transportation distance, there may be difficulties in finding carriers capable of performing transportation on such a route and providing a vehicle.

Conclusions

The conducted research findings indicate the demand for organizing foreign trade operations according to the four most common types of logistics chains. Each of them differs in the number of actors in the transport service market performing various functions to ensure the delivery of goods from the consignor to the consignee in international road transportation. At the same time, customs and logistics service users when choosing intermediary companies increasingly prefer indicators of service quality and reliability to shipping time and cost, which significantly affects the efficiency of foreign economic activity.

When assessing shipping time on Kyiv–Buda-pest, Kyiv–Bordeaux and Kyiv–Madrid routes, there is a clear tendency that the more entities in the transport service market are included in the logistics chain structure, the longer the foreign trade operation takes. Reliability, in turn, also increases as the number of links in the logistics chain decreases.

Accordingly, it is also found that with increasing delivery distance, reliability decreases, which is primarily due to customs and transport risks, as well as time expenditures on the choice of a carrier to ensure the transportation process.

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НАДІЙНІСТЬ ФУНКЦІОНУВАННЯ ЛОГІСТИЧНИХ ЛАНЦЮГІВ ПРИ ЗДІЙСНЕННІ ЗОВНІШНЬОТОРГОВЕЛЬНИХ ОПЕРАЦІЙ

Метою роботи є обґрунтування рішення про співпрацю з суб'єктами ринку транспортних послуг при виконанні зовнішньоторговельних операцій на основі оцінки надійності логістичного ланцюга та тривалості доставки товару на різних маршрутах. Дана розробка дозволить вантажовласникам та іншим стейкхолдерам приймати управлінські рішення на етапі планування доставки товару і оптимізувати всі процеси, пов'язані з митно-логістичним обслуговуванням. **Методика.** Оцінка надійності чотирьох типів логістичних ланцюгів ви-

конувалася на основі імітаційної моделі, розробленої в програмному середовищі GPSS з використанням методу статистичних досліджень. **Результати.** Замовниками митно-логістичних послуг висувається до суб'єктів ринку транспортних послуг завдання виконання зовнішньоторговельних операцій з дотриманням найвищого рівня якості та надійності обслуговування при мінімізації вартісних та часових показників доставки товару. Запропонована методика дозволяє визначити імовірність своєчасного виконання доставки товарів за різними напрямками перевезень та визначити надійність досліджуваного процесу. **Наукова новизна.** Отримані результати моделювання дозволяють розробити пропозиції та рекомендації для замовників митно-логістичних послуг щодо вибору оптимального типу логістичного ланцюга з урахуванням його впливу на тривалість та надійність доставки товару. **Практична значимість.** Практична значимість роботи полягає в тому, що запропонована методика дозволить суб'єктам зовнішньоекономічної діяльності формувати логістичні ланцюги, враховуючи наявні власні ресурси та потребу в застосуванні послуг інших підприємств для виконання доставки товару у міжнародному сполученні. При цьому ефективність функціонування логістичного ланцюга може додатково оцінюватися тривалістю та надійністю виконання зовнішньоторговельної операції.

Ключові слова: логістичний ланцюг, зовнішньоторговельна операція, тривалість доставки, надійність доставки, маршрут перевезення, митно-логістична послуга.

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НАДЕЖНОСТЬ ФУНКЦИОНИРОВАНИЯ ЛОГИСТИЧЕСКИХ ЦЕПЕЙ ПРИ ВЫПОЛНЕНИИ ВНЕШНЕТОРГОВЫХ ОПЕРАЦИЙ

Целью работы является обоснование решения о сотрудничестве с субъектами рынка транспортных услуг при выполнении внешнеторговых операций на основе оценки надежности логистической цепи и продолжительности доставки товара на разных маршрутах. Данная разработка позволит грузовладельцам и другим стейкхолдерам принимать управленческие решения на этапе планирования доставки товара и оптимизировать все процессы, связанные с таможенно-логистическим обслуживанием. **Методика.** Оценка надежности четырех типов логистических цепей производилась на основе имитационной модели, разработанной в программной среде GPSS с использованием метода статистических испытаний. **Результаты.** Перед субъектами рынка транспортных услуг заказчиками таможенно-логистических услуг ставится задача выполнения внешнеторговых операций с соблюдением высокого уровня качества и надежности обслуживания при минимизации стоимостных и временных показателей доставки товара. Предложенная методика позволяет определить вероятность своевременного выполнения доставки товаров по разным направлениям перевозок и определить надежность изучаемого процесса. **Научная новизна.** Полученные результаты моделирования позволят разработать предложения и рекомендации для заказчиков таможенно-логистических услуг по выбору логистической цепи оптимального типа с учетом его влияния на длительность и надежность доставки товара. **Практическая значимость.** Практическая значимость работы состоит в том, что предложенная методика позволит субъектам внешнеэкономической деятельности формировать логистические цепи, учитывая имеющиеся собственные ресурсы и потребность в применении услуг других предприятий для доставки товара в международном сообществе. При этом эффективность функционирования логистической цепи может дополнительно оцениваться длительностью и надежностью выполнения внешнеторговой операции.

Ключевые слова: логистическая цепь, внешнеторговая операция, длительность доставки, надежность доставки, маршрут перевозки, таможенно-логистическая услуга.