FACTOR INFLUENCE ON THE MULTIMODAL DELIVERY CONDITIONS OF SPECIAL CATEGORIES OF CARGO IN ECONOMIC SYSTEMS

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Abstract: The article aims to determine the factor influence on the multimodal delivery conditions of special categories of cargo in economic systems. Within the framework of study, an analysis of scientific sources on the specifics of the delivery of special categories of goods by various transport modes and in multimodal transportation was carried out. The methods that have been used in previous scientific studies have been identified and it is proposed to rely on the principles of a system approach and logistics, methods of theoretical generalization, statistical analysis, and expert assessments in solving the tasks. The basic requirements and necessary conditions for ensuring delivery were determined, which made it possible to identify and formulate the factors influencing the conditions for the multimodal delivery of special categories of goods in economic systems. The consequences of the uncontrolled state and the basic conditions for the delivery of special categories of goods were also outlined. It is noted that the value of some categories of special cargo is determined not by their real value, but by the extent to which their absence can disrupt the supply chain.

Keywords: delivery; special cargo; multimodal transportation; factor influence.

1 Introduction

The specifics regarding delivering special categories of cargoes in multimodal transportation are clearly defined. These categories of cargo require special delivery conditions, which may be associated with strict compliance with temperature conditions, the need for consolidation and deconsolidation, the involvement of special means for their maintenance, separate transportation and storage, etc. Frequently, air transport is involved in multimodal supply chains, as it can significantly speed up the delivery of goods. Cargoes delivered with the participation of air transport are affected by various factors that are directly related to the change in altitude, namely a decrease in pressure, temperature, and humidity. Consequently, both shippers and cargo agents must comply with the requirements for the packaging, packing, marking of goods, taking into account the peculiarities of cargo transportation by air by various types of aircraft. At the same time, air transport is a main mode of transport and provides only airport-to-airport delivery, therefore at least a road transport should be involved. The same can be applied to the maritime mode of transport, as it is also the main mode of transport, which provides port-to-port delivery and which requires at least road transport for the initial and final delivery segments. Rail and inland waterway transport can also be involved in these supply chains. The latter is gaining popularity in Europe due to its high level of environmental friendliness.

To enable successful delivery of special cargoes that have specific properties, their constant maintenance in a transportable condition must be ensured. In general, the cargo can be attributed to transportable, when it fully retains its properties after delivery, without creating danger, its tare and packing meet the delivery terms on a particular transport mode, and also this cargo is suitable for its volume and mass characteristics for placement inside vehicles. In particular, it is especially relevant for hazardous cargo. For example, portable tank is a tank with a capacity of more than 450 liters, designed for multimodal transportation and used for transporting non-refrigerated liquefied gases of class 2. It should be noted that the specific properties of the cargo, especially perishable and hazardous, significantly increases the probability that during the delivery process it can get out of transportable condition.

2 Materials and Methods

The methodological base of the study was a set of general and special scientific methods used to determine the factors affecting the conditions of delivery of special categories of cargo during multimodal transportation.

In particular, the deduction method was applied to study the general laws and principles that apply to multimodal delivery conditions and their impact on economic systems. This method was used to formulate general theoretical principles of multimodal delivery and their impact on economic systems, as well as to build logical arguments and hypotheses regarding the influence of factors on multimodal conditions.

The method of induction was used to obtain general conclusions based on observations and data about the actual state of multimodal delivery and its impact on economic systems [6]. Also, the inductive method was applied to assess the practical experience of logistics and transportation problems. In addition, on the basis of induction, general trends in the development of multimodal delivery conditions and their impact on economic systems were identified.

For the formulation of hypotheses and assumptions, a logical method was used to build logical arguments explaining the relationship between factors and results, as well as to analyze the available evidence from the point of view of logic and consistency. Also, with the help of this method, based on data analysis and argumentation, conclusions were formulated regarding the determination of the influence of factors on multimodal delivery conditions.

The method of generalization was used to bring together information from various sources and research on the factors influencing multimodal conditions of delivery of special categories of cargo into a single entity. Based on it, a literature review of scientific sources related to the research topic was carried out, as well as a systematization was carried out. In addition, the method of generalization was used when formulating the general conclusions of the study.

3 Literature Review

The problems related to delivery of special categories of goods by various transport modes have been actively studied by many scholars.

In particular, the study of Archetti et al. [5] is dedicated to the generalization of scientific achievements in optimizing the implementation of multimodal freight transportation for combinations of different transport modes. The involvement of inland waterway transport in supply chains was studied by Braekers et al. [10], who proposed a decision support model for the design of a barge service network in an intermodal connection between a large seaport and several inland river ports. It is interesting that probably for the first time it was planned to provide door-to-door delivery in such a connection.

The identification of conceptual requirements for the formation of an environmentally sustainable system of multimodal container transportation in Ukraine should be recognized as notable in the scientific study of Hryhorak et al. [16]. One should also agree with the authors that the development of container rail transportation, to a large extent, along with the economic effect, will significantly improve the environmental component. The study of the sustainability of multimodal freight transport is based on the paper by Udo et al. [22]. In particular, they highlighted the economic, social, and environmental

components of the multimodal freight transport sustainability, which can significantly optimize the process. Scenario planning of unimodal and multimodal transport carried out by Cansiz and Ünsalan in [11] allowed to determine the cost by scenarios of routes by road, maritime, and railway transport under different load capacities. The study of Du et al. [12] is devoted to the modeling of multimodal freight transportation scenarios in Northern Canada under the influence of climate change, which is generally determined by the originality of the approach to solving the problem.

Ambrosino and Sciomachen in [2] focused on the choice of the optimal investments in seaports to improve the modes of interaction with railways. This type of multimodal connection is very promising, and the special value of this study is that the problems of complex logistics interaction between maritime transport and railways in multimodal freight transportation are rarely studied. Multimodal delivery of oversized cargo is also not widely covered in studies. The article by Petraška et al. [20] defines the principles of the formation of transport delivery of heavy and oversized cargo by road. It should be noted that in these deliveries, road transport is actually required, since it provides delivery to the door. Rail transport often falls behind in terms of integration into logistics chains, in particular in countries with economies in transition. The principles of feedback action in local elements of rail yards' interaction are studied by Yanovsky et al. [24]. This study aims to solve similar problems.

Overall, despite a significant number of scientific papers in the field of multimodal transportation, the problem of taking into account the factor influence on the delivery conditions of special categories of goods in multimodal transportation remains unresolved.

The active use of new methodical developments, technical and technological solutions for the transportation of perishable goods suggests that the application of the principles of a system approach and logistics will be most feasible.

In the paper by Angelelli et al. [3], the authors note the importance of synchronization processes in multimodal transportation by several modes of transport, as well as the need for a quick completion of customs formalities. One should agree with the authors that the involvement of air transportation in the delivery chain is deepening, given the reduction in delivery times. It is also interesting that the authors applied a matheuristic algorithm that can provide an optimal solution to large-scale problems. An original approach to solving the problem of managing the supply chain of perishable products in a multimodal transportation was proposed by Dulebenets et al. [13]. In particular, a set of piecewise approximations was used to linearize the nonlinear function for each type of perishable product, which should be recognized as the first successful experience of this kind.

In the scientific paper by Ambrosino and Sciomachen [1], the authors proposed a linear integer programming model that minimizes the cost of placing and delivering containers in road-rail transportation. This study is particularly valuable for its original approaches to modeling capacity constraints. As noted by Kaewfak et al. [17], in the development of multimodal transportation, there are problems associated with risks and numerous uncertainties. The authors proposed to integrate the process of fuzzy analytic hierarchy and data coverage analysis to identify and assess quantitative risks. It should be noted that the use of the fuzzy analytical hierarchy method to determine the weight of each risk criterion is an important and original author's achievement and should be further actively disseminated. The environmental friendliness of transportation is also gaining special relevance. At the same time, with the help of effective mathematical models, it turns out to be possible to significantly reduce transportation costs, which will result in saving money and ensuring the ecological component of product transportation [14].

In combined freight transport, there is a need for horizontal cooperation. The problem of equitable distribution of benefits between all participants is the subject of Kayikci's study [18], where the author investigated cost allocation models in combined freight transport, various cost allocation models, proportional distribution mechanism, segregation method, with a corresponding assessment of the adequacy and sustainability of the results on specific examples of joint operators of combined maritime and rail transport with the same cargo. In the framework of their study [19], Kumar and Anbanandam evaluated the current state of designing a multimodal freight transportation network using classification and coding methods. The application of these methods allowed identifying the existing most relevant studies, models of operations research, as well as determining new approaches to the strategic design of the multimodal freight transportation network.

The problems of integration of air transport into supply chains have also been actively studied by researchers worldwide. The most relevant studies include those that propose practical tools for solving the problems of cargo delivery with the participation of air transport. In particular, Bo et al. [7] investigated the model of cargo flow management of a network air carrier, while another work of these authors [8] is devoted to the evaluation of the implementation of cargo flow management system. The description of the results of dynamic model of cargo flow management of a network air carrier is discussed in [9]. The study by Sen et al. is devoted to the implementation of a nonlinear multi-product model of cargo flow management of a network air carrier [21]. The study by Voitsehovskiy et al. focuses on the design of integrated cargo delivery systems based on logistics principles [23].

The proposed by Anoop and Panicker in [4] single-period integer programming model and multi-period programming model with constraints for optimization of multimodal freight transportation with the participation of the railway is an extremely useful methodical tool. Moreover, the advantage of the first model is better performance at small volumes of traffic and lower frequency, while the second model is more optimal for continuous mass freight traffic. The authors also proposed an original heuristic algorithm for the allocation of railways and trucks. The methodology proposed by Zhao et al. in [25] on routing for shippers in multimodal transportation by minimizing the total cost of the logistics operator provides traffic forecasts and cost estimates by using a traffic simulation model and a rail simulation model for a regional port area. These models are distinguished by their originality and the possibility of universal use. In the study by Figueroa et al. [15], a mathematical model for port selection was developed, taking into account the need to provide multimodal connections based on the current level of technical progress. The maximum coverage of modes of transport - maritime, river, rail and road, - as well as infrastructure support should be noted.

4 Results and Discussion

It is evident that in general terms, the process of delivery of special categories of goods must meet the following basic requirements: ensuring the integrity of the cargo and the tightness of the packaging; ensuring a sufficient level of transportation safety; speed of delivery of goods throughout the chain; overall reliability of the transportation process.

Despite the fact that special types of cargo have a certain number of specific properties, they can be safely delivered by various modes of transport. The main condition for the success of such delivery is the need to apply system and logistics approaches to the delivery processes.

Factors influencing the delivery conditions of special categories of cargo in multimodal transportation are shown in Figure 1.

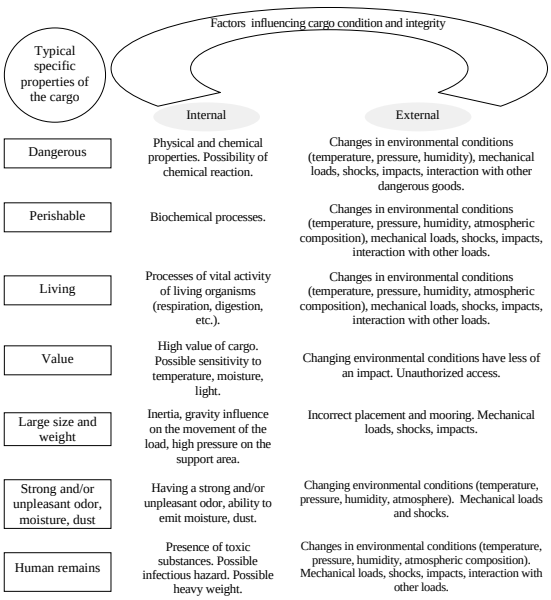

Figure 1. Factors influencing the delivery conditions of special categories of cargo in multimodal transportation
Source: [21]

The necessary conditions for ensuring the delivery of special categories of cargo should be as follows: ensuring transportable condition of the cargo; compliance with the requirements for vehicles and warehouses; observance of the optimal technology of transportation, transshipment, and storage of cargo; involvement of specially trained and certified personnel; compliance with all necessary formalities and application of security measures.

It should be pointed out that the costs of organizing the delivery of special categories of cargoes are several times higher than the costs of delivery of general categories of cargoes. Obviously, the costs of delivery of different special cargoes will also vary significantly. At the same time, for other types of special cargoes, ensuring the integrity of the cargo and safety of transportation requires increased costs at all or many stages of delivery [21].

It should be pointed out that cargo insurance in general does not guarantee the integrity of the cargo and the safety of delivery. That is, it has no preventive nature and only provides a guarantee of compensation for losses after a certain period of time. It is also worth noting that the value of some categories of special cargo is determined not by their actual value, but rather by how important they are for the supply chain.

Ultimately, the successful operation of a supply chain for multimodal delivery of special cargoes should include compliance with all legal requirements for the import, export, and transit of goods, strict adherence to the rules for the transportation of goods by particular modes of transport, as well as taking into account the best distribution practices for working with certain categories of special cargo on particular modes of transport. Proper preparation of cargo for transportation, classification, identification, compliance with restrictions should be ensured, and special containers and packaging, refrigerants should be provided. Moreover, the optimal consignment that can be transported in a timely manner should be determined.

In accordance with the most advanced logistics approaches to the transportation of special categories of goods, the entire delivery chain should be analyzed, and the logistics operator should think not of a separate delivery, but of a delivery network, thereby creating additional value. It is important to emphasize that the carrier itself usually works with the cargo that has been prepared for transportation.

The growing demands of the freight clientele on the cargo delivery time imply that there should be enough time left after delivery to use the cargo for its intended purpose. For perishable goods that are delivered for commercial purposes, delivery time requirements are crucial. Certain types of perishable goods may still be partially used for their intended purpose for some time in case of spoilage. After the expiration of the intended use period, perishable goods lose their properties much faster than other categories and are subject to disposal.

In addition, organizing the delivery of special categories of cargo significantly increases the probability of losses for the logistics operator or carrier due to possible damage to the cargo or loss of its properties, or due to damage to third parties. The consequences of uncontrolled condition and the main conditions for the delivery of special categories of cargo are presented in Figure 2.

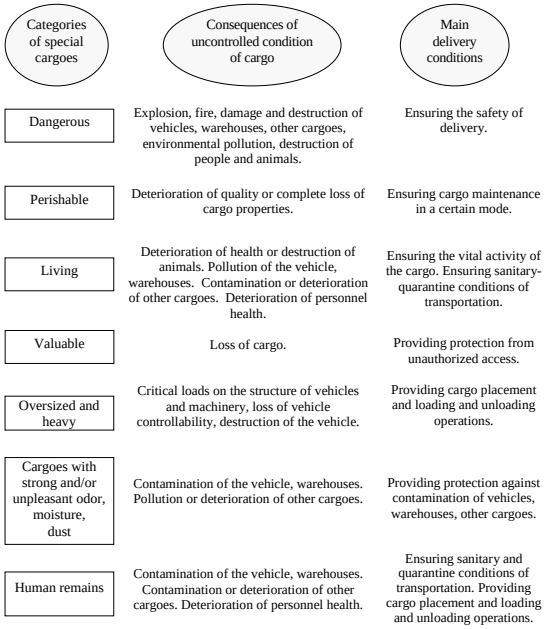

Figure 2. Consequences of uncontrolled condition and the main delivery conditions for special categories of cargo
Source: [21]

For cargoes that have specific properties, the complex of services to ensure the preparation of cargo for transportation is critically important, since at this stage the main precautions should be taken to prevent the risks of damage to the cargo and ensure the safety of transportation. In some cases, this process is carried out by logistics operators themselves, but even if they do not carry it out themselves, they must ensure full control over its implementation by freight agents or other companies hired for this purpose. Nowadays, the main task of the logistics operator is to create and control the supply chain.

It is necessary to specify that when delivering cargoes by air transport, the requirements for ensuring the safety of transportation are more stringent than on other modes of transport due to the peculiarities of the air transportation process. Consequently, when delivering cargo in mixed transportation with the participation of air transport, the requirements for the preparation of goods for transportation by air will be a priority. In addition, risks may arise at the junctions of different modes of transport, which requires complex interaction of participants in the delivery process in the combination of modes of transport due to possible disruption of supplies. Only if these conditions are met, it is possible to ensure a sufficient reliability level for the delivery of special categories of cargo in multimodal transportation.

5 Conclusion

The delivery of special categories of cargo in multimodal transportation is characterized by considerable specificity, which must be taken into account to ensure the reliability of the supply chain. The systematic transformation of the logistics operator into the organizer of the supply chain requires to perform a key function - the creation and control of the supply chain, with the obligatory monitoring of the processes that occur with consignments. Work in the multimodal delivery requires coordinated interaction of all chain participants, especially carriers, freight agents, and logistics operators.

Within the framework of the study, the factors influencing the delivery conditions of special categories of goods in multimodal transportation were identified for each of the modes. The division of factors into internal and external allowed identifying those factors that the carrier can influence, and which are less or not dependent on it. The defined consequences of uncontrolled condition and the main conditions for delivery of special categories of goods allow minimizing their occurrence through the use of appropriate risk management mechanisms. Namely the effective provision of complex supply chains of special cargoes can turn a transport and logistics company into a full-fledged modern smart logistics operator having the main task of creating added value for the client.

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Primary Paper Section: A

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