Choice of a logistics route for cargo delivery in modern conditions

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Abstract. The current conditions of the global movement of goods under sanctions make it necessary to build new logistics routes along those international transport corridors that will ensure the reliability of transportation. Crisis points in any industry are at the same time a potential for development and growth, which is confirmed by the history of the development of logistics in the XX century. Basic principles of logistics and methods of quality management theory should serve as a basis for choosing the vector of transport and production development. Transit potential of the Russian Federation is unlocked by the Northern Sea Route, latitudinal corridor "East-West" and meridional corridor "North-South". Tough policies of some countries make it necessary to redirect commodity flows along new logistic routes. The analysis of goods traffic promotion through the North-South corridor shows its serious competitive advantages in comparison with the Southern sea route in terms of transportation distance, time, and cost of delivery. The study analyzes the problems of the international transport corridor. These include technological, documentary, and infrastructural unresolved problems. The multivariant logistic route in the central part of the North-South corridor poses the problem of choosing the optimal route. The article analyzes the existing methods of route choice based on equal advantageous transportation distance and full cost for solving this task. The limitation of the listed methods leads to the search for a cost minimization function for a logistics route.

1 Introduction

Today's realities are such that established logistics chains are undergoing changes starting with the pandemic year 2020. However, the crisis year of 2022 had an even more acute impact on the global movement of goods and transport. The sanction policy of several countries seriously impacted domestic air transport, to a lesser extent affecting railway and sea transport [1-3]. It should not be forgotten that all parties are inconvenienced by this, eventually, the market reacts by increasing the price of goods, including the increase in the transport component in their price. It is difficult to underestimate the role and significance of the Russian Federation in the world system of transport and trade, it is reflected in the works of many scientists [4-7]. Business reaction to these processes is of interest: for example,
operator and logistics companies optimize their business processes, change the logistics of freight flows, adjusting to modern conditions [8-11]. However, timely decisions are made at the state level to level out the negative consequences. Traditionally, the solution to supply problems should be based on basic logistics principles, logistics outsourcing, and quality management system methods [12-14]. The adaptability of logistics systems is reflected in the redirection of cargo flows along the latitudinal and meridional transport corridors that run through the territory of the Russian Federation. These corridors compete with the Southern Sea Route, which has several significant disadvantages, and the promotion of domestic cargo flows through it is extremely difficult. The requirement for the reliable functioning of logistics systems also forces us to interact with partner states that do not participate in the sanctions policy [1, 15]. Analysis of the international transport corridor reveals several problems, some of which can be solved by choosing the optimal branch of the route.

2 Materials and Methods

The choice of logistic route of cargo delivery is connected with logistic principles of cargo delivery, which can include: the system approach, consideration of market needs, the principle of adaptability/flexibility of logistic systems, the principle of cargo delivery to the consumer with the fulfillment of seven conditions, etc. In modern conditions, when many cargo flows change directions, when the policy of sanctions "breaks" established logistics chains, the problem of supply chain design about changing factors is particularly relevant. If we turn to the history of the XX century, we can see that the development of logistics was promoted by crisis points in the development of world trade and economy. It can be explained by the fact that business was pushed to search for effective and optimal solutions by rising costs and the desire to save money while maintaining and expanding the range of their customers. Today, it is useful to draw historical analogies with the key periods of the last century because of the similar political and economic situations. There are several phases in the development of logistics. In the sixties of the last century, the so-called physical distribution comes to the fore. This phase is characterized by the emergence of stable links between transport and warehouses, and the purpose of their functioning becomes common, aimed at a single economic result. This is achieved through the use of standardized care, taking into account the characteristics of the cargo when choosing the type of transport. Warehouses handle cargo traffic, their function used to be loading, unloading, and storage. The energy crisis of the 70s hit the countries of Europe and the United States, oil prices increased by 4 times, increased logistics costs up to 70% of the final price of goods, as shown by several studies. Gradually, businesses came to understand the effectiveness of the introduction of logistics principles to connect the stages of the promotion of goods in a single system. The '80s are characterized by the addition of a production planning tool to the warehouse and transport systems. The period from the '80s to '90s is considered the heyday of logistics. Logistics circuits are set up, from the purchase of raw materials, through production and distribution, right up to the point of sale. This is facilitated by the arrival of the personal computer, the globalization of the market, and the introduction of quality management. In the Western world, the political and economic agreements for the free movement of goods between Europe and North America have boosted logistics growth. Politics comes to the fore in today's situation as well. Applying basic logistic principles and successfully proven "lean manufacturing" principles, the domestic transport industry can increase profits and cut costs and expand the geography of transportation. In any case, the transit potential of the Russian Federation will be used. It is relatively easier to endure sanctions for land and water transport. Regarding air transport, the restrictions are also temporary, since they are bilateral in nature, and here it is more likely that Western companies, which are forced to make round-the-world flights with high costs, will suffer the
greatest damage. However, this study will assess only land routes using one or more modes of transport.

The map in Figure 1 shows how great Russia's transit potential is. According to the Eurasian Rail Alliance Index at the end of 2020, the Eurasian and northern routes in the east-west direction and the meridional route in the north-south direction run through the territory of Russia. Today, "Russian Railways Logistics" offers transportation along the international transport corridors (hereinafter ITC) "East-West" and "North-South". In comparison with North and South sea routes (fig. 2), RZD Logistics offers container transportation services of up to 14 days to China. For comparison, shipments via the Southern sea route, which is about 21,000 km long, take 48 days, whereas via the Northern Sea Route, which is 14,000 km long, takes 35 days. Consider the North-South ITC and the Southern Sea Route, limited by the sanctions policy against the Russian Federation. Russia, Iran, and India decided in 2000 to create the ITC. This route was planned to promote cargo flows between the above-mentioned states with access to other countries of the Persian Gulf and South Asia. According to the resource logirus.ru, it was planned that the volume of freight flow would be 20-25 million tons, however, so far it is about 5 million tons (according to the Eurasian Development Bank). ITC "North-South" is a serious competitor to the Southern Maritime Route, which in addition to its greater length has a "bottleneck" - the Suez Canal. The length of the ITC route from St. Petersburg (which is also a transport hub for the transshipment of cargo further to Europe) to Bandar Abbas (the largest port in the south of Iran) is about 7,000 km. Despite the obvious advantages of the North-South ITC, several problems hinder the growth of cargo traffic:

1) absence of a multimodal operator and a single through tariff rate;
2) Lack of agreements on unified harmonized norms of document flow for border and customs control and, as a consequence, the increase in the corresponding group of costs and duration of transport clearance. This problem does not apply only to the "North-South" corridor, but rather has a complex nature;

Fig. 1. Main international transport corridors in Eurasia.
Fig. 2. The southern and northern sea routes.

3) Insufficient development and provision of the logistics route in some sections (Volga-Caspian Canal, Trans-Caspian section). Maritime routes Russia–Iran, and Iran-India do not have a sufficient number of ships;
4) The lack of rail connections to several Iranian ports and the general "weakness" of rail connections in Iran, the change of gauge 1520 mm/1435 mm;
5) an acute shortage of container fleet for the growth and development of container transportation in Russia as a whole and on the analyzed ITC in particular;
6) Lack of terminals to handle cargo traffic on certain sections of the ITC.

In the central part, the ITC divides into four routes: the Trans-Caspian (sea), western (Azerbaijan), eastern (Turkmenistan, Kazakhstan), and road (Georgia, Armenia). Already now cargoes are delivered along the eastern branch in 15-18 days. And solving the problem of rail support on the Astara-Resht section in Iran will further reduce the delivery time. To select a route branch on the central section of the North-South ITC, one can use the well-known method of route selection based on the calculation of the equally advantageous distance. The choice of the mode of transport based on the calculation of the range can be represented in general terms by the expression:

\[ L_p = \frac{Z_{nk1} - Z_{nk2}}{Z_{d2} - Z_{d1}}, \]  

where \( Z_{nk1}, Z_{nk2} \)-specific costs of initial and final operations of the cargo delivery chain by the first and second modes of transport, respectively;  
\( Z_{d1}, Z_{d2} \)-specific costs of traffic operations for the first and second modes of transport.
The numerator of expression (1) is considered to contain fixed costs, and the denominator—variable costs. The formula (1) is applicable for comparison of the transportation variant by different modes of transport.

However, when choosing a route, the distance of transportation may vary, which affects the cost of transportation in the traffic component. It is also advisable to consider loading and unloading operations on different multimodal routes. Ultimately, the choice of transportation route is related to the minimization of costs for different groups.

Another method of selection is associated with the analysis of the full cost of transportation. In addition to moving costs, this method takes into account the costs associated with the increase in delivery time, insurance, additional storage costs, etc. This method is based on the assessment of total costs, which consist of the sum of the tariff for transportation and secondary costs. In particular, the costs of inventory in transit significantly increase the total cost when the value of the cargo being transported increases. As an example, Fig. 3 is a graph that shows that if the cost of cargo is less than 31,000 c.u./t. it is feasible to ship by rail. More expensive cargo, under the same equal conditions, is more profitable to deliver by road.

![Diagram of the dependence of the cost of transported cargo and the total reduced costs.](image)

**Fig. 3.** Diagram of the dependence of the cost of transported cargo and the total reduced costs.

When comparing several transportation routes, it is advisable to make a target function of the total costs of all elements of the logistics chain, which should strive to a minimum:
\[ F = \min \left\{ \sum_{i,n} c_{i,n} x_{i,n} + \sum_{n,j} c_n \left( x_{n,j} q_{n,j} \right) + \sum_{n,j} c_{n,j} x_{n,j} \right\}, \]  

(2)

where \( x_{i,n}, x_{n,j} \) – correspondence of material flows or sending cars/containers from point \( i \) (departure terminal) to \( n \) (intermediate terminal) and from \( n \) to \( j \) (arrival terminal):

- \( c_{i,n}, c_{n,j} \) – costs attributed per wagon/container/unit for a given shipment condition;
- \( c_n \) – costs of wagon/container flow maintenance in the system of cargo flow processing at the junction of interacting modes of transport:
  - \( q_{n,j} \) – weight of cargo (number of containers) delivered from the terminal of departure \( n \) to the terminal of destination \( j \).

The costs of maintaining the flow of cars or containers in the system of interaction of related modes of transport include the following components:

- the cost of vehicle downtime - non-productive, waiting for cargo operations;
- costs of accumulation of cargo per transport batch;
- the cost of loading and unloading work;
- costs of information and document flow, border and customs operations, etc.

The result of the research of this article was the justification of the relevance of the choice and construction of logistics transportation routes in the conditions of sanctions restrictions. The current state of international transport corridors is described. The potential and disadvantages of the ITC "North-South" were analyzed. Options for selecting a route in the central part of the ITC to assess the four branches of the corridor are proposed.

3 Conclusion

The construction of logistical chains for the delivery of goods within international transport corridors with reliable partner states seems to be an important task. The North-South meridional corridor is a serious competitor to the Southern Sea Route in terms of delivery time and cost. The analysis of ITC problems has shown the insufficient elaboration of issues of the documentary, customs and border clearance of transportation, infrastructure, and operator support. The central part of the "North-South" ITC poses the problem of selecting the route of transportation, in this connection three methods are proposed. The choice of route type based on the methods of an equitable range of transportation and full cost analysis have a limited scope of application. The construction of the cost function for each option is reasonable and justified, as it takes into account the costs of transportation in a multivariant task.

References

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