Analysis of the Reliability Compliance with Delivery Time

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Abstract: The practical application of the idea of sustainable freight transportation requires improving the methods of accounting for possible deviations from the technological standards at all stages of the transportation process, increasing the reliability of meeting the transportation deadlines and assumed contractual obligations. This article presents an analysis of the reliability of compliance with freight and empty car delivery time based on a retrospective analysis of statistical data. The article provides an analysis of the number of shipments that arrived at the stop station past their delivery time, the reasons for freight delays on route and the number of claims filed, using one of the technological polygons of the transportation process management for a case study.

1 INTRODUCTION

Railroads are one of the key modes of transportation worldwide thanks to their unique characteristics, such as high capacity, safety, reliability, punctuality and environmental friendliness. By the end of 2019, all rail systems in the world had about 1.1 million kilometers of track and transported more than 4.1 trillion passenger-km and 11 trillion ton-km of freight. However, these systems often suffer from various malfunctions that are profoundly detrimental to the efficiency of their production activities (Hong, 2019). Consequently, in recent years the challenges of how to better protect railway systems and reduce systemic losses when various disruptions occur have drawn increasing attention from stakeholders and researchers.

The efficiency of production activities of transport companies depends on many factors - the changing structure of freight flows; competitive advantages concerning interchangeable types of vehicles; competition between different private owners; regional conditions affecting the transportation process; the presence of restrictions, etc. (Kozlov, 2020). Under current conditions, the train car rolling stock of operators is often out of sync with the cargo flows, causing additional shunting and freight work and often leading to non-compliance with delivery times.

Experts estimate that railway stations lose 10-15% of their productivity due to technological failures. It is believed that the bottleneck of a structure is its busiest element. The study (Timukhina, 2012) presents that the relationship between the loading of an element and delays it causes is more complex and ambiguous. Selection of the elements that cause the greatest vulnerability should be based on the bottlenecks of a structure or bottlenecks of a technology.

2 LITERATURE REVIEW

Reliability compliance with delivery time is one of the most important assets. Various international studies indicate that the guarantee of reliable delivery times is a strategic competitive advantage. Transportation time, as well as the cost of transportation represent time and money costs in the global trading system. The study of the reliability of transportation time compliance is crucial for understanding the dynamics of time costs, including in international transportation (Jia, 2020).

The international publications on the importance of freight transportation reliability are quite few in number. Reviews of the methods used and the results obtained in studies of the cost estimation of transportation time in freight transportation around

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the world can be found in (Zamparini, 2007; de Jong, 2009; Feo-Valero, 2011; Report for the Ministry of Infrastructure and the Environment, Significance, The Hague, 2013). The study (RAND Europe, SEO and Veldkamp/NIPO, 2004) is one of the first to present the value of freight transportation reliability in the form of standard deviation of transportation time. The key result in (Significance, VU University, John Bates Services, TNO, NEA, TNS NIPO and PanelClix, 2013) is that most of the empirical results of freight reliability assessment are related to the proportion of shipments that arrive too late (sometimes with a minimum delay threshold).

The works (Hague Consulting Group, Rotterdam Transport Centre and NIPO, 1992) discuss the use of the factor cost method for the cost estimation of transportation time. It is argued that the study of the cost estimate of time for freight transportation is necessary to determine the "marginal time transportation costs": transportation costs that will change as a result of changes in transportation time. It is a derivative of the total logistics cost function of transportation time. Total logistics costs are comprised of transportation personnel costs, fuel and energy costs, vehicle costs, overhead costs, which are all costs incurred by carriers and transportation companies, as well as costs of damage to goods, interest costs on the value of goods during transportation and the cost of having a safety reserve (the last three factors directly affecting the transportation component in the price of goods).

A number of authors consider the use of mathematical models to assess the reliability of the transport process and the creation, on their basis, of appropriate modules in information management systems. The use of methods to assess and ensure the reliability of transportation based on business process modeling is particularly important for increasing the competitiveness of transport companies in unstable economic conditions (Kurganov, 2018).

Studies have appeared recently in the field of reliability of intermodal transportation, in particular transportation with the use of railway-automotive and railway-water transport. According to the goals stated by many countries, by 2030 30% of freight transport over 300 km should be transferred from road transport to other, more environmentally friendly modes of transport. Most importantly, this assumption applies to rail transport and water transport. Rail transport has the best chance of taking over some of the freight traffic in the coming years.

Rail transport, like water transport, has much more inertia (larger vehicles and ships used for transportation, longer transportation times, etc.). Goods transported by these modes of transport tend to have a lower cost per tonne than goods transported by road and air, therefore, the transport component in the price of goods will be relatively small.

The development of rail transportation depends on its ability to adapt to a number of market requirements related to transportation time, cost, flexibility, information flow and reliability of the production process. Currently, the main obstacle to development is its low competitiveness, especially in relation to road transportation. This is mainly influenced by low flexibility, limited cost-effectiveness over long distances, and lack of reliability, manifested mainly in problems with timely transportation (Zhao, 2020). The bottleneck may be an underdeveloped railway connection (Roso, 2013), the low flexibility of rail transport (Behrends, 2015), the low quality of railway infrastructure, the use of different information systems, the reluctance to share information (Kramarz, 2021), the higher priority of passenger trains over freight trains, the lack of integration between transportation tasks and terminal tasks (Hu, 2019). Such limitations reduce the reliability of the entire transport system. Transportation services performed with such restrictions will not be able to meet the requirements of modern supply chains, which require a high degree of flow reliability (Elbert, 2017).

3 MATERIALS AND METHODS

Carriers, operators and owners of railway rolling stock estimate delivery time through the costs of providing transportation services. If transportation time were reduced, vehicles and personnel would be freed up to perform other productive activities, resulting in savings in vehicles and labor. Greater reliability means that the carrier and operator can have confidence when planning transportation. The results of foreign researchers obtained to date show that the value of time related to transport services is indeed more or less equal to the cost of the vehicle and labor per hour (de Jong, 2009).

For shippers, the valuation of transportation time is directly related to the goods themselves. It includes the working capital invested in the goods during the time required for transportation (especially important for high-value goods), the potential reduction in value of perishable goods during transportation, and the possibility of disruption of the production process due to lack of resources or inability to deliver due to lack of inventory. The two latter factors play a significant role in assessing the reliability of freight

transportation. Shippers with their own rolling stock evaluate both the costs of transportation proper and their component in the cost of goods.

Estimation of violation of cargo delivery time through train delays using the average delay does not reflect the full picture. The value of delays increases slower than the risk of their occurrence. In other words, reducing the risk of delays by half reduces the cost of delays by less than half. This provision can be derived from a simple microeconomic model, where more and more customers choose sufficient margins to eliminate late delivery and contractual failure, as the risk of delay increases (Börjesson, 2011). For small risks of delay, this phenomenon can also be caused by low planning costs: the higher the risk of delay, the more customers find it appropriate to make contingency plans, including overstating the necessary norms for bringing in cargo and empty rolling stock, thereby creating additional reserves of necessary resources.

Every year more than a billion tons of cargo of various nomenclature are moved through the Russian railroad network. The Russian Railways Holding Company sets itself many objectives, among which are: increasing production and economic efficiency, scaling up transportation business, and improving transportation safety and service quality. However, for various reasons, including through no fault of the carrier, there are cases of violation of the technology of organization of the transportation process and failure to meet deadlines for delivery of cargoes and empty cars. All technological violations of manufacturing processes have a direct impact on the reliability of cargo delivery time - compliance by railroads (carriers) with obligations to freight owners in terms of meeting delivery time in accordance with the accepted contractual obligations. Reliability is measured as a percentage and reflects the share of shipments that arrived without violation of delivery time.

In the carriage of goods, the carrier assumes responsibility for the safety of cargo en route, as well as for the performance of other obligations under the contract of carriage, including, but not limited to, the delivery of cargo and empty cars on time. In cases where the carrier has not fulfilled one or more obligations, the cargo owners are entitled to file a claim, specifying what clauses of the contract the carrier violated and the amount of penalty they want to recover.

In accordance with federal regulations, the consignee or consignor may file a claim for damages in the amount of 6% of the freight charge for each day of delay, but not more than 50% of the total freight charge. As a rule, cargo owners unreasonably claim damages without taking into account various factors beyond carrier's control, such as cases stipulated by Article 29 of the Statute on Railway Transport of the Russian Federation. In such cases the carrier invokes Article 333 of the Civil Code of the Russian Federation "reduction of forfeit". In 85% of cases cargo owners' claims are groundless and claims are rejected. All cases of violation of delivery time are considered by a special commission - the working group.

In accordance with the adopted technology the railway transport has a fairly wide range of reasons for freight and empty cars delays, while the number of delays due to the fault of cargo owners or owners of private tracks amounts to only 1-2% of the total number. For clarity, the entire list of causes is summarized in 7 main reasons, among them are the following:

- delays due to force majeure;
- track occupancy, non-acceptance, demurrage and accumulation;
- untimely operations and restrictions;
- waiting, refusal, diverting car traffic from the shortest routes;
- absence of or waiting for a locomotive;

Table 1: Analysis of the reliability of meeting railway delivery time.

Railway	2019		2020		2021	
	share of shipments, %		share of shipments, %		share of shipments, %	
	on time	with violation	on time	with violation	on time	with violation
Oktyabrskaya	99.00	1.00	99.50	0.50	97.10	2.90
Gorkovskaya	99.30	0.70	99.50	0.50	97.50	2.50
Severnaya	96.60	3.40	99.10	0.90	94.90	5.10
Sverdlovskaya	99.90	0.10	99.60	0.40	97.10	2.90
West Siberian	99.20	0.80	99.90	0.10	99.70	0.30
Average value	**98.80**	**1.20**	**99.52**	**0.48**	**97.26**	**2.74**

– reasons that depend on the cargo owners and owners of private tracks;
– other reasons.

4 RESULTS AND DISCUSSION

Let us consider the analysis of statistical data on the number of shipments arriving at the destination station with a violation of the delivery time, the reasons for freight delays in transit, the number of claims for 2019, 2020 and 2021 in the North-West technological polygon of the transportation process management. The period under consideration covers three years, including the year with the most adverse epidemiological situation, which affected the causes of delays in transit.

Table 1 shows statistical data on shipments arriving without and with a violation of the delivery time and empty cars.

We used Table 1 to plot the dependence of the reliability index on the roads of the technological (Figure 1).

The technological polygon of the transportation process management under consideration has quite a high level of reliability of delivery of cargo and empty cars - on average, 98.53% of shipments arrived on time over three years. As can be seen from the graph, Severnaya Road has the highest rate of late delivery, with 94.9% of shipments arriving on time in 2021, the lowest reliability level in three years. The Sverdlovskaya (2019) and West Siberian (2020) Railways have the best reliability indicator (99.9%). The amount of penalties on claims filed decreased significantly relative to 2019, by 54.22%, with the number of complaints filed decreasing as well, by 52.04%. Primarily, this may indicate an increase in the actual reliability of meeting freight delivery time, as well as a greater degree of cargo preservation relative to 2019. Payments of penalties after court proceedings decreased by 39%.

Figure 2 shows the data on the number of violations of the delivery time for freight and empty cars by the railways of the technological transportation polygon of the process management under consideration.

Despite the high value of the number of claims in 2019, their number decreased on average by 2 times as early as by 2020, however, by 2021 there is again a slight increase on the Severnaya, Oktyabrskaya and Gorky railways. The main problem remains a distorted reflection of the true causes of delays, which is the main force holding back the solution of this problem. The existing systems for monitoring and determining responsibility for violations of standard delivery times require a unified technology for determining the degree of influence of Russian Railways divisions, consignors, consignees, and third-party organizations on the permitted causes of delays in freight shipments in transit.

According to the statistics for the technological polygon the main reason for failure to meet delivery time is the absence or waiting for a locomotive - 61% (506,250 cases), with by delays, track occupancy, non-acceptance, demurrage and accumulation ranking second - 15% (121,679 cases), followed by complaints about untimely operations and rejections, as well as about waiting, technical equipment failures, diverting of car traffic from the shortest routes - 8% each (67,423 and 61,917 cases respectively). The rarest other reasons are 6% (11,461 cases), as well as

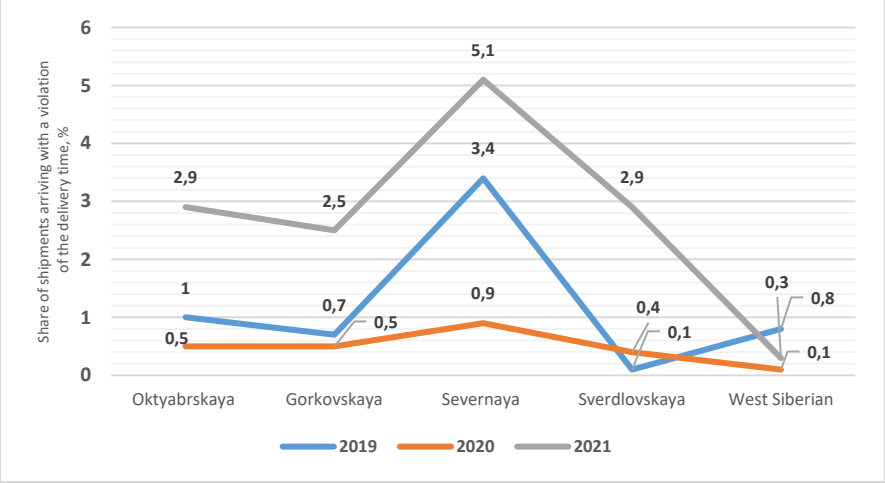

Figure 1: Diagram of dependence of reliability indices.

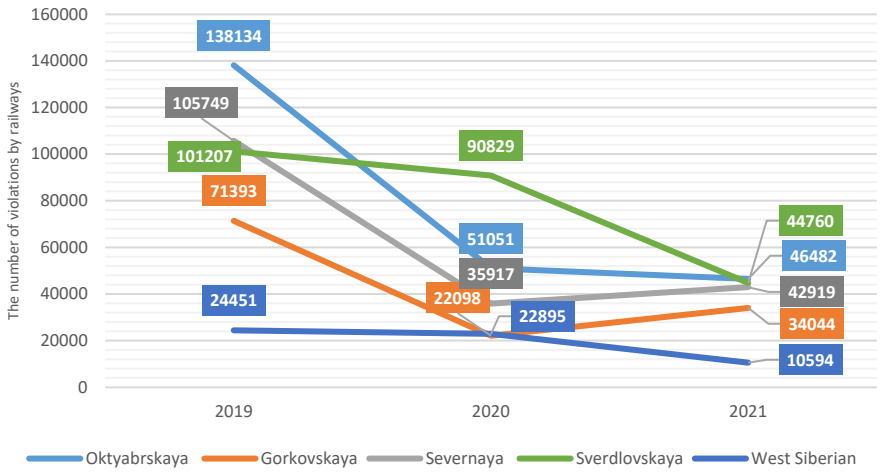

Figure 2: Diagram of comparison of the number of violations by railways.

complaints about force majeure and reasons dependent on the cargo owners or owners of private tracks - 1% each (10,961 and 11,461 cases, respectively).

5 CONCLUSION

Reliability of existing cargo flows, regardless of the organizational solutions used, along with costs and time is a priority for all participants of the transportation process and is one of the important criteria determining the choice of mode of transport. Rail transport allows obtaining the effects associated with the reduction of internal costs of freight transportation, however, due to the low flexibility, time and reliability, it is still not sufficiently competitive with other modes of transport. In order to improve the reliability of compliance with transportation times, it is necessary to monitor the passage of freight and empty cars along the infrastructure while recording all technological and temporal deviations of the transportation process from the established standard values and identifying those responsible for the violation of technology. For this purpose, the car-hours of cargo shipments on the infrastructure need to be recorded, and a forecast of delivery of cargo and empty freight cars needs to be generated, taking into account possible deviations from technological standards at all stages of the transportation process.

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