

ASSESSMENT OF TRANSPORT PROCESS QUALITY IN CONTEXT OF LOGISTICS DIGITALIZATION

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Abstract. Modern concepts of digital supply chain and Logistics 4.0 contribute to increasing transparency, reliability, and productivity of transportation, but limit the possibility of using formalized tools for qualitative assessment of logistics services. The study focuses on the main problems of assessing the quality of the transport process in the context of digital transformation of logistics. It argues that the quality of the transport process is a multifactorial, dynamic, and largely subjective category that cannot be adequately described by a single technical and economic indicator. A methodology for comprehensive assessment of information support for the transport process is proposed, based on a system of normalized multi-criteria quality indicators and a prioritization coefficient. The developed approach allows for a comparative analysis of the quality of alternative scenarios for organization of transportation and determines the priority of modernizing individual components of the transport process using information monitoring systems. The practical implementation of the methodology was demonstrated using the example of a logistics company, which confirmed its suitability for substantiating management decisions and improving the quality of transport services.

Keywords: supply chain, transport process, information technology, digital logistics, quality.

Introduction

Digital transformations in logistics and supply chain management are based on the widespread implementation of information technologies that ensure transparency, integration, and efficiency of transport processes. Modern logistics concepts – “Digital Supply Chain (DSC)” and “Logistics 4.0” – are focused on creating additional consumer value for services through the use of intelligent information technologies for real-time data tracking and analysis. Scientific research on this topic [1-6] shows that such solutions contribute to increasing the productivity, reliability, and manageability of logistics processes, as well as building trust and improving interaction between supply chain participants. However, despite the active development of digital logistics technologies, the issue of formalized assessment of the quality of the transport process remains underdeveloped. Most existing studies in this area focus on the technical characteristics of information systems or general parameters of logistics operations efficiency [7-9] and usually boil down to the use of a single technical and economic indicator to assess their quality, which, in our opinion, does not adequately reflect the real level of transport service quality. In this regard, it is important to develop a methodological approach to assessing the quality of the transport process based on multi-criteria indicators – a combination of expert assessments of the significance of individual service components and the level of consumer satisfaction with logistics services. This approach should ensure the formation of a multidimensional quality profile of the transport process and the identification of priority areas for its improvement. The aim of the work is to develop a methodology for assessing the quality of the transport process using information monitoring systems based on a system of indicators that take into account the key components of logistics services, their importance, and the level of customer satisfaction.

Materials and methods

Traditionally, logistics functionality manifests itself through the ability to meet established delivery deadlines and ensure service stability. Accordingly, logistics companies focus primarily on speed, flexibility, continuity of order fulfillment, and the ability to compensate for potential disruptions. Current trends in transport development and digitalization of the economy are placing new demands on the quality of logistics services, especially given that production and logistics costs are becoming the main criteria for supply chain efficiency. The latter managers seek to minimize within the limits imposed on the probability of trouble-free operation of the entire supply chain [10]. Of course, under such conditions, assessing the quality of information support for logistics processes is a rather complex procedure, but like any economic phenomenon, it can be considered from both a qualitative and quantitative perspective.

In general terms, information support for logistics processes as a qualitative characteristic can be represented as a set of consumer properties of varying importance that play a role in shaping the quality of logistics as a whole. Moreover, an analysis of the factors that influence the quality of information support for logistics processes [11-13] allows us to conclude that the views of the customer of transport services and the logistics company on the value of the properties of information monitoring of transport processes often differ. However, both sides agree that transportation using motor transport monitoring information systems satisfies not one but several needs. The most significant aspects (requirements that an information logistics system must meet) of the qualitative component of the transport process from the point of view of all participants in the transport process are as follows:

1. prompt response to emergency situations – “promptness”;
2. control of the timeliness of cargo delivery to the customer – “timeliness”;
3. improving the reliability of order fulfillment – “reliability”;
4. ensuring the safety of cargo – “safety”;
5. effective planning and control of delivery routes – “routing”;
6. reduction of logistics costs – “cost-effectiveness.”

Table 1

Components of the qualitative component of the transport process that allow assessing the results of using motor transport monitoring information systems

Component	Characteristic	Result
Responsiveness	Rapid response to customer requests	Timely information about vehicle location; High level of information support for the process
Timeliness	Reduction of cargo delivery time	Minimization of delivery time; High level of compliance with delivery conditions
Reliability	Accuracy of order fulfillment	No deviations from the delivery schedule; Low probability of denial
Safety	Ensuring cargo preservation	High level of cargo safety; Reduction of insurance claims
Routing	Rational planning of directions and sequence of vehicle movement	Optimization of delivery routes; Ability to compare planned routes and delivery times with actual ones
Cost-effectiveness	Reduction of transport and logistics costs	Resource optimization; Reduction of logistics operation costs

Each of these indicators plays a significant role in the transportation process. They allow determining the importance of certain characteristics of the transportation process for logistics companies and evaluating the results of implementing an information monitoring system for both logistics companies and consumers of their services. However, it is quite difficult to clearly determine the impact of the use of information monitoring systems on the quality of the transport process, because: information technologies are constantly evolving, transport services are a specific product, and quality itself is a subjective category (Fig. 1).

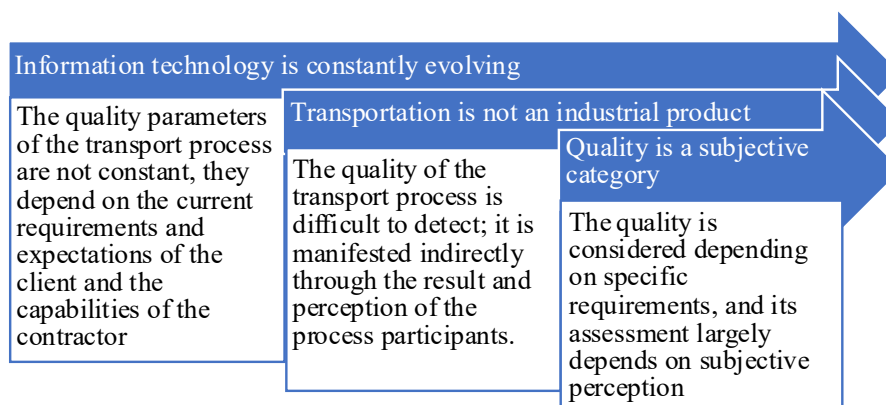


Fig. 1. Problems of determining the quality of the transport process using information monitoring systems

In addition, each component of the motor transport process is the sum of subcomponents that specify its quality of information support for the transport process difficult to identify, and therefore, in our opinion, its assessment should be comprehensive.

We propose an integrated indicator of the quality of service of a logistics company that uses information systems to monitor the transportation process, which is determined by the satisfaction of the company itself and its customers:

$$S = \prod_{i=1}^6 S_i^{k_i} \tag{1}$$

where k_i – weight of the corresponding transport process quality indicator;
 S_i – normalized level of satisfaction with the corresponding component.

It is calculated as a weighted average of individual indicators, which allows for the synergistic effect of their interaction. This approach means that a low value for even one of the components significantly affects the overall quality level, reflecting the actual conditions under which transport processes operate.

The weight coefficient of the component (k_i) is calculated using the formula:

$$k_i = \frac{W_i}{\sum_{j=1}^6 W_j}, \tag{2}$$

where W_i – average expert assessment of the significance of the i -th component;
 W_j – average expert assessment of the significance of all components.

The level of satisfaction with each component is determined by an expert (client) depending on the selected scale (five-point, ten-point, etc.) and is calculated using the formula:

$$S_i = \frac{C_i}{N}, \tag{3}$$

where C – assessment of customer satisfaction with the component;
 N – maximum value of the accepted scale.

The quality indicator of the transport process using information monitoring systems can be represented as a 3D model (Fig. 2a) with a vector in an n-dimensional coordinate system, or as a radar chart (Fig. 2b), in which the levels of the corresponding quality indicators are plotted on rays emanating from the common starting point of the coordinate axis. The evaluation involves identifying the components, determining their weights and satisfaction levels, and calculating an integrated score.

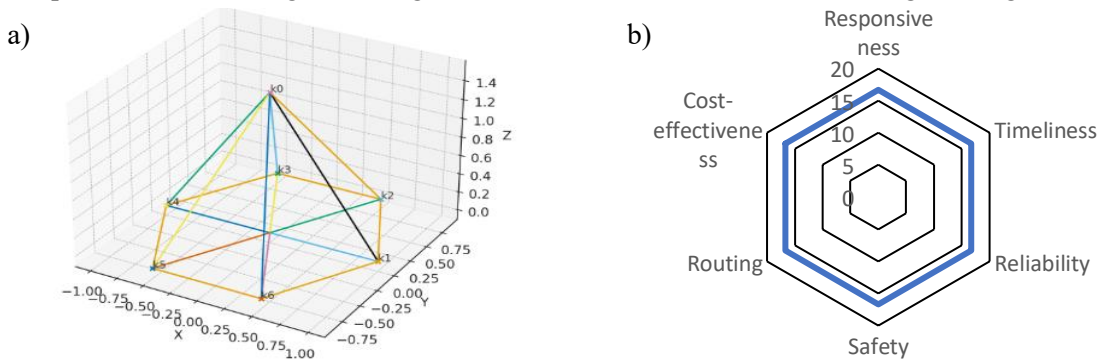


Fig. 2. Transport process quality indicator using information monitoring systems:
 a – 3D model; b – radar chart

This representation of the indicator clearly reflects the fundamental difference between the categories of “quantity” and “quality,” since the latter is difficult to express with a single coefficient. Unlike traditional approaches that reduce quality to a single integral indicator, the proposed model forms a multidimensional quality profile that takes into account both the value of individual components and their significance for customers. Further, the obtained distribution of the integrated indicator for each expert is normalized to the maximum value in the sample to ensure a correct comparison of alternative scenarios for organizing the transport process.

$$S_{norm} = \frac{S}{\max S}. \quad (4)$$

Normalized values of the integrated indicator will allow for a correct comparative analysis of the relative contribution of each service component to the overall quality of the transport process, regardless of their absolute value, and will show the effectiveness of the measures taken to improve the quality of the transport process. After all, identifying the consumer value of information support for the transport process requires maximum attention to the possibility of its further adjustment. In order to make informed management decisions to improve the quality of the transport process, it is necessary to identify the properties with the minimum value (C_{ij}) and maximum significance (W_{ij}) based on the postulate: the lower the criterion of total satisfaction, the greater the need for its adjustment; the lower the weight of the component, the greater the need for its adjustment [14];

To determine the need for adjustment or modernization of the transport process, we propose introducing a coefficient of adjustment necessity (weighted index of improvement prioritization) for the i -th component, combining its relative importance to customers with its contribution to overall satisfaction.

$$NCC_i = k_i \times \left(1 - \frac{C_i}{C_{total}}\right). \quad (5)$$

where NCC_i – coefficient of the need to adjust the transport process component;
 C – level of satisfaction with the i -th component;
 C_{total} – total assessment of satisfaction with the transport process.

Unlike the integrated indicator, the NCC_i coefficient does not measure the quality of the transport process; it is a management analysis tool that allows for the prioritization of improvements to individual components (the lower its value, the greater the need to improve the component).

Results and discussion

The methodology for evaluating the transport process using information monitoring systems was tested using the example of the logistics company UTS. The components of the qualitative component of the transport process that allow assessing the results of using motor transport monitoring information systems in accordance with the developed methodology were: efficiency, timeliness, reliability, safety, routing, and cost-effectiveness. The assessment was based on an expert survey of the using a component significance scale (W_i) from 1 to 6 and a satisfaction scale (C_i) from 0 to 10. The assessment results are shown in Table 2.

Table 2

Results of the expert survey

Expert	Significance of the property						Property assessment					
	W1 Responsiveness	W2 Timeliness	W3 Reliability	W4 Safety	W5 Routing	W6 Cost-effectiveness	C1 Responsiveness	C2 Timeliness	C3 Reliability	C4 Safety	C5 Routing	C6 Cost-effectiveness
1	3	6	5	1	2	4	4	6	5	8	5	3
2	2	4	3	5	2	1	8	7	4	6	4	6
3	6	4	1	2	3	5	7	6	9	5	4	5
4	1	4	5	3	2	6	4	4	5	3	4	6
5	4	5	6	1	3	2	5	6	5	7	6	4
6	2	6	4	5	3	1	7	6	4	5	3	6
7	5	4	1	2	3	6	8	7	8	9	4	5
8	1	6	4	3	5	2	4	5	4	5	4	4
9	2	3	4	6	5	1	6	7	4	6	5	6
10	5	6	4	3	1	2	5	6	5	6	4	6

It should be noted that these are limited by the conditions specific to a single company, the subjectivity of expert assessments, and the dynamic nature of quality parameters in the context of logistics digitization.

The assessment of the importance of the components and the level of satisfaction was conducted by 10 experts in the field of logistics. The experts were selected based on criteria of professional competence and experience in using monitoring information systems. Based on the expert data obtained, the average values of significance W_i and satisfaction level C_i were determined for each component of the transport process quality assessment (Fig. 3).

Component	Average W	Average C
Responsiveness	3.1	5.8
Timeliness	4.8	6.0
Reliability	3.7	5.3
Safety	3.1	6.0
Routing	2.9	4.3
Cost-effectiveness	3.0	5.1

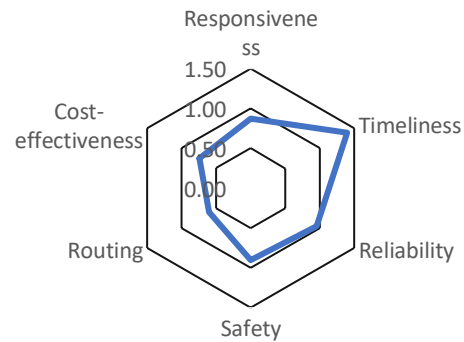


Fig. 3. Average values of W_i and C_i Fig. 4. Radar chart of satisfaction level

Normalization of assessments made it possible to calculate S_i indicators, which characterize the relative level of quality of logistics service components, and weight coefficients k_i , which reflect the priority of the relevant components from the point of view of consumers of the company’s transport services. These values made it possible to calculate the integrated indicator S and form a multidimensional quality profile of the transport process, which is clearly presented in the form of a radar chart (Fig. 4). This form of visualization allows identifying the strengths and weaknesses of the logistics service without reducing the quality assessment to a single numerical indicator. In particular, the results showed that the most positive feature is the “Timeliness” component (1.4). “Reliability” (0.95), ‘Safety’ (0.9), and “Responsiveness” (0.87) form a stable core of the quality of the transport process of UTS, characterized by relatively high values of both absolute and normalized indicators. On the other hand, the indicators “Cost-effectiveness” (0.74) and “Routing” (0.61) are significantly lower and need improvement (Table 3).

Table 3

Calculation results for satisfaction with transportation process components using information monitoring systems

Component	k_i	S_i	S	S_{norm}	NCC_i	Modernization rank
Responsiveness	0.15	0.58	0.87	0.62	0.123	2
Timeliness	0.23	0.60	1.40	1.00	0.190	6
Reliability	0.18	0.53	0.95	0.68	0.150	5
Safety	0.15	0.60	0.90	0.65	0.124	4
Routing	0.14	0.43	0.61	0.43	0.122	1
Cost-effectiveness	0.15	0.51	0.74	0.53	0.123	2

Further calculation of the adjustment priority index (NCC_i) to determine possible directions for modernizing transportation process components using information monitoring systems confirmed that the components “Timeliness” (0.190) and “Reliability” (0.150) meet the requirements of UTS customers and do not require improvement. On the other hand, “Safety” (0.124) and “Responsiveness” (0.123), which formed a stable core of the transport process quality according to the previous indicator, are equally in need of improvement, along with the worst components, “Cost-effectiveness” (0.123) and “Routing” (0.122). Moreover, the most priority area for modernization of the transport process using the information monitoring system, given its high importance for customers, is the component “Efficiency.”

The constructed matrix of modernization priorities showed that the highest priority for improvement should be given to the components “Responsiveness” and “Cost-efficiency,” which combine high importance for customers with a moderate level of satisfaction and demonstrated the presence of systemic shortcomings in terms of responsiveness to customer needs, pricing, planning, and control of routes of the logistics company “UTS” (Fig. 5).

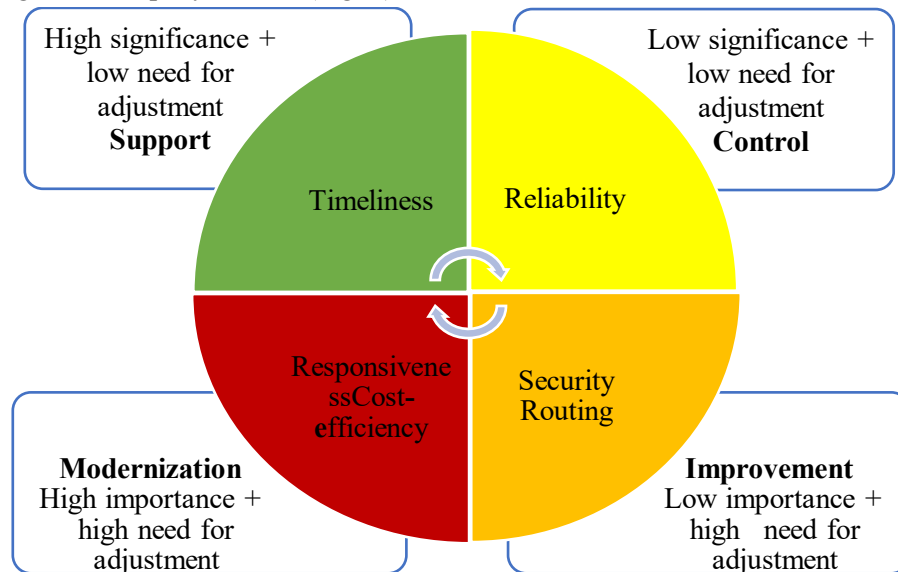


Fig. 5. Matrix of modernization priorities

The calculations showed the need to improve the quality of the transport process of the logistics company “UTS” through the application of a number of technical and managerial measures, namely:

- introduction of a customer service system (TMS/ERP system)
- introduction of delivery time forecasting systems taking into account the traffic situation (GPS route tracking);
- optimization of tariff policy and reduction of logistics costs (telematic data; fuel sensors, etc.).

The proposed methodology can serve as a practical tool to support decisions regarding the allocation of resources to improve the quality of transport services in logistics companies, which will facilitate the transition from a one-dimensional quality assessment to a multidimensional profile, thereby significantly enhancing the soundness of management decisions.

Empirical testing of the proposed approach was conducted using a single logistics company as a case study, which demonstrated the practical feasibility of the model. At the same time, the results obtained do not claim to be universal and have limitations regarding generalization. Applying the model under different conditions (company size, various cargo types, level of digitalization) may require adapting the weighting coefficients and the structure of indicators. Further research should focus on expanding the empirical base and testing the model across different segments of the transport market.

Conclusions

1. The quality of the transport process is a multifactorial, dynamic, and subjective category that is difficult to describe using a single technical and economic indicator. The methodology for assessing the quality of the transport process from information monitoring systems proposed in the article is based on a combination of multi-criteria assessment of the quality of the transport process and analysis of customer satisfaction with the company’s logistics services. It forms a multidimensional profile that takes into account both the significance of individual components and the level of their perception by customers, and allows to take into account the interdependence of the components of the transport process and avoid compensating for critically low values of individual components.
2. The application of the NCCi adjustment coefficient enables a shift from a formal assessment of the quality of the transport process to the identification of priority areas for its modernization, which in turn makes it possible to combine an analysis of the current level of logistics services with tools for the strategic management of its development. The proposed approach allows for a transition from

a one-dimensional quality assessment to a multidimensional profile, thereby enhancing the soundness of management decisions.

3. The calculations of the quality assessment of the transport process using information monitoring systems for the logistics company “UTS” showed that the highest priority for improvement is given to the components “Responsiveness” and “Cost-efficiency,” which combine high importance for customers with a moderate level of satisfaction. This indicates the feasibility of developing tools for analytics, forecasting, and adaptive route planning in transport monitoring systems. In further research, the nonlinear perception of transport service quality to account for threshold effects in critical service parameters can be modeled using desirability functions.

Author contributions

Conceptualization, formal analysis and writing – Zagurskiy O.; original draft preparation methodology and project administration – Savchenko L.; data curation and visualization – Opalko V.; funding acquisition – Bondariev S.

All authors have read and agreed to the published version of the manuscript.

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