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Georgii Prokudin, Viktoriia Lebid, Oleksii Chupaylenko,
Tetiana Khobotnia, Maksym Roi, Mykhailo Holovatiuk

CHAPTER 5

APPLICATION OF PROJECT ANALYSIS TO IMPROVE THE QUALITY OF TRANSPORT SERVICES IN INTERNATIONAL ROAD CARGO TRANSPORTATION

ABSTRACT

The paper considers theoretical approaches, models and methods for assessing the quality of transportation projects as a means of increasing the efficiency of providing transport services in cargo transportation projects of a project-oriented enterprise. N-model for making an optimal decision on the importance of a set of criteria that determine the quality of transport services, taking into account expert information, has been developed. It allows determining the advantages of one criterion over another based on the theory of the importance of criteria, which can be applied in project process management. A model for ensuring the relationship between quality indicators of cargo transportation projects and determining the attractiveness of international routes has been developed. The effectiveness of the application of the developed methods and models at project-oriented enterprises of the transport industry has been proven by testing them at motor transport enterprises.

KEYWORDS

Project, project management, knowledge base, fuzzy production rules, expert information, linguistic variable, attractiveness of the traffic route, transport services, international transport corridor.

The development of cargo transportation and the intensification of the provision of services in international traffic (hereinafter referred to as IT), including along international transport corridors (hereinafter referred to as ITC), increases competition among Ukrainian carriers. It is precisely the growing competition in the international road transportation market (hereinafter referred to as IRT) that forces project-oriented enterprises in the transport industry to look for new opportunities to reduce transport costs.

The analysis of the transport support of cargo transportation by a project-oriented enterprise shows that each transportation of a project-oriented enterprise can be considered as a separate project, since it demonstrates the phased implementation of individual actions similar to the sequence of stages of project implementation.

For the transport support of cargo transportation projects (hereinafter referred to as CTP), which are implemented in a competitive environment of motor transport services, the tools of the project management theory should be used. When designing various types of transport support projects (hereinafter referred to as TSP), using project management elements, such stages as formulating a project idea, setting goals and objectives, their phased implementation and creating a project product (transport service – TS) should be followed. Providing high-quality TS for cargo transportation as a project product implementation is a dynamic process that occurs under conditions of uncertainty (the influence of internal and external factors), has time limitations, and is characterized by available resources and features of the operation of the project product.

In the conditions of dynamic development of transport and logistics services, the issue of cargo transportation in the international aspect is considered in the works of A. Vorkut, T. Vorkut, V. Racha, G. Prokudin, Y. Tsvetov, V. Dykan, K. Koshkin, A. Novikova. Scientists also comprehensively consider the issue of project management, which is covered in the works of S. Bushuyev, N. Bushueva, T. Vorkut, S. Tsyutsyura, V. Racha, Y. Teslia, I. Chumachenko, M. Dergausov, V. Kreymer, D. Montgomery, P. Crosby, W. Deming, I. Durand [1–5].

As a result of the analysis, it was found that the assessment of the satisfaction of the requirements of transportation market participants depends on the TS provided in the CTP. Transport services must comply not only with the mandatory accepted standards, but also with the principles of quality management as a product of the project, which reflect the planning of quality management, quality assurance and quality control of the transportation process. However, approaches to solving the issue of project management in the ICT field do not provide an answer to the question of how to assess the TS quality as a product of a transportation project, taking into account qualitative, quantitative and relay information received from participants in the transport process (hereinafter referred to as PTP) [6, 7].

It has been established that determining the relationship between the project product and the satisfaction of customer needs is one of the most difficult tasks: the needs of customers in the transport industry are diverse, dynamic, alternative, uneven in time and space, and are accepted in conditions of uncertainty of the ICT market. Therefore, it is practically impossible to provide them only by controlling the TS quality in the CTP. There should be a comprehensive approach, the implementation of which is possible only within the framework of a quality management system.

It is worth noting that in the term "quality management system" the main emphasis is not on the word "quality", but on the word "management". Therefore, the system is aimed not so much at quality control, but, first of all, at managing the quality of the project product, that is, TS quality management [8, 9].

This approach is a complex task given the set of assessment criteria that PTP must satisfy. The complexity is also determined by the TS specificity, which is that it cannot be withdrawn, corrected or reworked at the implementation phase of the transportation project life cycle.

It is worth noting that the TSP problems of freight transport on ITC routes have not yet received a comprehensive scientific analysis. Paying tribute to the achievements of specialists in the field of freight transport development, it should be noted that the issues of managing freight transport projects on ITC road routes require further scientific research. Despite the wide range of research conducted, the problem of assessing individual types of CTP has a number of unresolved issues, and there is no effective methodology for assessing such projects [10, 11].

In particular, insufficient attention has been paid to the assessment of projects for the quality of providing TS in the transport chain of cargo delivery along ITC road routes, taking into account the heterogeneous information received from participants in the transport process (hereinafter referred to as PTP).

In conditions of fierce competition among motor transport enterprises, it is necessary to apply new approaches to project management and the quality of services provided in them. This may be a project approach focused on qualitatively new levels of project management, that is, at project-oriented enterprises, the main attention should be paid to projects that should include other, shorter routes of vehicles, an appropriate level of transportation service and an attractive competitive tariff, namely a rational "commercial triangle" delivery time-delivery service-tariff.

Therefore, there is a need for scientific research into the assessment of the TS quality as a project product in the CTP, taking into account a set of factors such as cargo delivery time, the speed of movement of vehicles across the customs border of Ukraine and the tariff, which are determined by customer requirements. Such a task requires a detailed disclosure of their essence and relationships based on deep theoretical research using mathematical modeling and other scientific methods.

5.1 THE RELEVANCE OF IMPROVING THE QUALITY OF TRANSPORT SERVICES IN INTERNATIONAL ROAD FREIGHT TRANSPORTATION

Modern challenges facing the transport industry require new approaches to organizing transportation, especially in the context of meeting growing customer demands. Customer orientation is becoming a key factor in competitiveness, which necessitates the revision of traditional methods of route selection in transportation projects.

The paper focuses on improving approaches to managing cargo transportation routes, taking into account customer needs. Applying a systematic approach to route selection allows not only to optimize logistics processes, but also to ensure the quality of transport services at all stages of the transportation project. Underestimating these aspects can lead to breach of contractual obligations, delays in delivery, or a decrease in customer satisfaction, which, in turn, negatively affects the reputation of transport operators.

Applying a systems approach and systems analysis in managing cargo transportation projects allows to identify key problems that arise for the project team and assess the consequences of decisions made at all stages of the project life cycle.

Underestimating the importance of a comprehensive approach to quality management can lead to a decrease in the efficiency of transport services and a violation of contractual obligations to customers. This situation increases the risks of delays in cargo delivery or a decrease in the quality of service.

The work uses a systemic approach to project management, a process approach in the development of project models, qualimetry methods and elements of the theory of the importance of criteria. The theoretical basis of the work is the basic provisions of project management and quality management, the theory of fuzzy sets and fuzzy logic. A number of mathematical methods are also used, namely: the method of analyzing expert assessments for selecting criteria for assessing projects and programs, determining their hierarchy; the mathematical apparatus of decision-making theory for determining the influence of individual parameters on the quality of transport services in the CTP; simulation modeling methods for modeling the integral quality indicator of making an optimal decision on choosing a route for a specific ITC. Using the theory of fuzzy sets, the possibility of multivariate choice is provided and a linguistic model of transportation project management is proposed. The information base of the study is statistical data on the implementation of transportation projects and the results of our own scientific research.

It is worth noting that the quality of transport services can be determined by the functional-instrumental model proposed by K. Gröns [6]. Instrumental quality reflects the final result of the project for the client, that is, what he/she receives, while functional quality characterizes the service process itself at all stages of the transportation project.

The input parameters in the quality system are key indicators that affect the level of service. This includes the quality of service at the consignor, the efficiency of the transportation process, the quality of service on international routes, the level of service at the consignee.

Thus, a customer-oriented approach to quality management is aimed at ensuring a long-term partnership between transport operators and their customers by adapting services to customer needs and increasing competitiveness in the market.

5.2 THE SYSTEM OF ENSURING THE QUALITY OF TRANSPORT SERVICES IN TRANSPORTATION PROJECTS

Let's present the quality system of transport services in transportation projects (**Fig. 5.1**). The input parameters are indicators that affect the level of quality of transport services in transportation projects. Such indicators include the quality of service provided by shippers, the quality of the cargo transportation process, the quality of service provided by carriers at car service points on international routes, and the quality of service provided by consignees, the quality of preparation of transport documents, and the quality of provision of additional services (as an example of informing customers).

Effective management of such elements as planning the transportation route, monitoring and improving the quality of transport services on international routes is possible only if their properties are comprehensively assessed. This assessment requires the availability of complete, reliable and quantitative information on the quality of transport services within the framework of transportation projects. It is quantitative indicators that allow using data for making management decisions.

In modern management of cargo transportation projects, achieving a high level of transportation quality is based on the application of the science of "qualimetry". Qualimetry, which is developed on the basis of applied and theoretical approaches, allows for the calculation of complex quantitative quality indicators. This contributes to more accurate analysis, forecasting and optimization of processes.

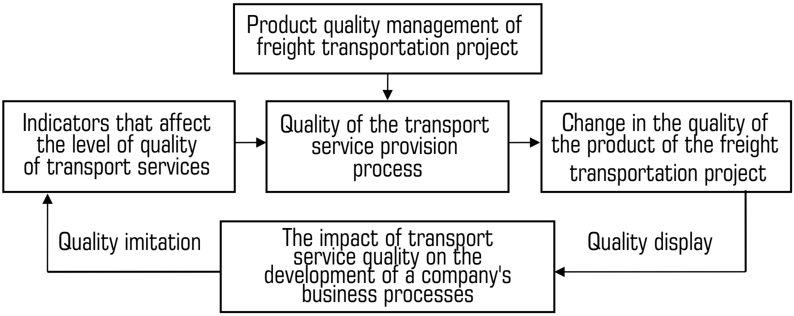

Fig. 5.1 System for ensuring the quality of transport services in transportation projects

Theoretical qualimetry studies general patterns and mathematical models of services and processes that are related to the assessment of project quality. The object of theoretical qualimetry is the philosophical and methodological problems of service development. The task of applied qualimetry is to develop algorithms and mathematical models for assessing the quality of various types of objects [7].

To assess the quality of transport services of carriers in transportation projects, it is necessary to take into account the main functions of management objects:

1. Target – according to this function, quality assessment is aimed at controlling the achievement of improving standards in transportation projects. The control goal is formed by determining key indicators that determine the quality of transport services. The target function provides the principle for building an assessment methodology.

2. Classification – this function assumes that the results of quality assessment become the basis for creating categories and classes of transport service quality, which allows for a more clear segmentation of services within projects.

3. Stimulating – quality assessment mechanisms stimulate project executors both through moral recognition and through material incentives aimed at increasing the efficiency of their work in fulfilling various types of transportation orders.

4. Information function – the quality assessment system is a key source of information for quality management in transportation projects. The information function is aimed at ensuring transparency and efficiency of management.

5. Aggregating – generalization of quality assessments is a necessary component in multi-level management projects, which determines the reliability of assessment information for making final management decisions.

6. Analytical – quality assessment is based on a deep analysis of transport service processes, which allows making informed decisions during the implementation of projects.

7. Predictive. Used both when determining assessment criteria and in the process of using assessments directly in the forecasting system.

To assess the quality of transport services in transportation projects, clear management of transportation organization functions is necessary so that all departments of a project-oriented enterprise have management and control skills, as well as methods for assessing quality and ensure the necessary level of responsibility for it.

The implementation of quality assessment functions is closely related to the tasks of managing the quality of services in freight transport projects. Quality assessment at the enterprise is an important tool for ensuring the efficiency and safety of transportation, allowing to identify weaknesses in logistics processes and adjust service delivery strategies. It includes monitoring such aspects as timeliness of delivery, compliance with safety requirements, accuracy of document flow and the level of customer satisfaction. The use of a quality management system allows to respond in a timely manner to changes in external and internal conditions, ensuring stability and improvement of transport processes. The management sphere in transportation projects takes into account the cost indicators of business operations and their impact on the project. Therefore, with sustainable management in project-oriented enterprises, the project manager, taking into account the main functions of the management object, makes rational decisions. It is worth noting here that quality is a multi-criteria and multi-factor concept, and therefore it is necessary to take into account the most influential indicators for assessment. Quality management in projects is a philosophy that can and should be the basis of any activity for the continuous improvement of all processes of the organization of management on various issues that may arise in the implementation of projects [7, 8].

Based on this, the concepts of quality of the service provision process and quality of results in transportation projects are essentially different and are defined separately from each other, that is, practically not interconnected. As a result, there are clashes of interests between workers in the automotive industry and consumers of transport services. Therefore, it is necessary to distinguish two classes of concepts in "transport qualiology" (the science of quality):

– the class of concepts of "quality of result", which includes the quality of transport products, quality of services;

– the class of concepts of "quality of process" – quality of transport service; quality of planning of the transport process in transportation projects; quality of rolling stock used in transportation; quality of preparation of cargo for transportation, quality of provision of related transport services.

One of the modern trends in the quality of transport service is the formalization of the concept of quality of service to consumers of services. In the context of international cargo transportation, this trend is particularly relevant, since ensuring high quality service at different stages of the logistics chain directly affects the efficiency of transportation and customer satisfaction.

An important aspect is the integration of a customer-oriented approach, which involves focusing on the needs and requirements of customers, as well as the ability to adapt to the specifics of each individual international route.

Formalization of this approach includes the creation of clear standards and procedures that allow assessing the effectiveness of service provision in different countries and regions, as well as taking into account individual customer wishes regarding delivery times, storage conditions and cargo safety. Thus, the process of improving the quality of any services (not only transport) must begin with "quality control", gradually defining "guaranteed quality" (quality assurance), then moving on to "standardized quality control", and the final result should be "ensuring the requirements of service consumers" (customer value) [9, 10].

In the context of military operations on the customs territory of Ukraine, it is important to take into account additional factors that may affect the quality of service, in particular, changes in the safety of transport routes, risks of damage to cargo or delays at customs. In such conditions, the strategic task becomes not only to ensure the safety of cargo, but also to promptly respond to changes in the situation, which allows minimizing possible losses and ensuring continuity of supply. This requires flexibility in approaches to organizing transportation and the use of the latest technologies for monitoring and managing quality at all stages of transportation.

It is worth noting that the assessment of the quality of transport services in transportation projects requires detailing, that is, it is necessary to establish which quality indicators should be selected for consideration, by what methods and with what accuracy to determine the results, how to process them experimentally and in what form to present the assessment result.

The criteria for the efficiency of cargo delivery are closely interrelated with the assessment of the quality of transport services, since quality allows the enterprise, on the one hand, to reduce the costs of cargo delivery in international traffic (thereby reducing the cost of services), and on the other hand, to increase its own income and customer base by increasing the attractiveness of transportation projects for customers [11, 12].

The structural scheme of quality management of cargo transportation in international traffic in accordance with quality management projects is presented in **Fig. 5.2**.

The structure of indicators of quality of transport products, from the point of view of providing services in transportation projects along international transport corridors, is characterized by the following indicators (**Fig. 5.3**):

– environment – the presence of necessary service points within the TC routes, amenities, equipment and the presence of qualified personnel at these points. The services of service facilities should include parking of vehicles; their security; cargo operations necessary for customs processing of cargo and vehicles; servicing of vehicle crews (in accordance with the

European Agreement concerning the work of crews of vehicles engaged in international road transport, AETR) and others;

– reliability – the totality of trust in the results of the performed transportation;

– psychological properties, otherwise sociability, which determines the possibility of finding contact between participants in the transportation process.

Analysis of works devoted to the assessment of the quality of transport services indicates the importance of taking into account the competitiveness of transport services when servicing cargo owners. The competitiveness of a transport service affects the competitiveness of the development of the object under study.

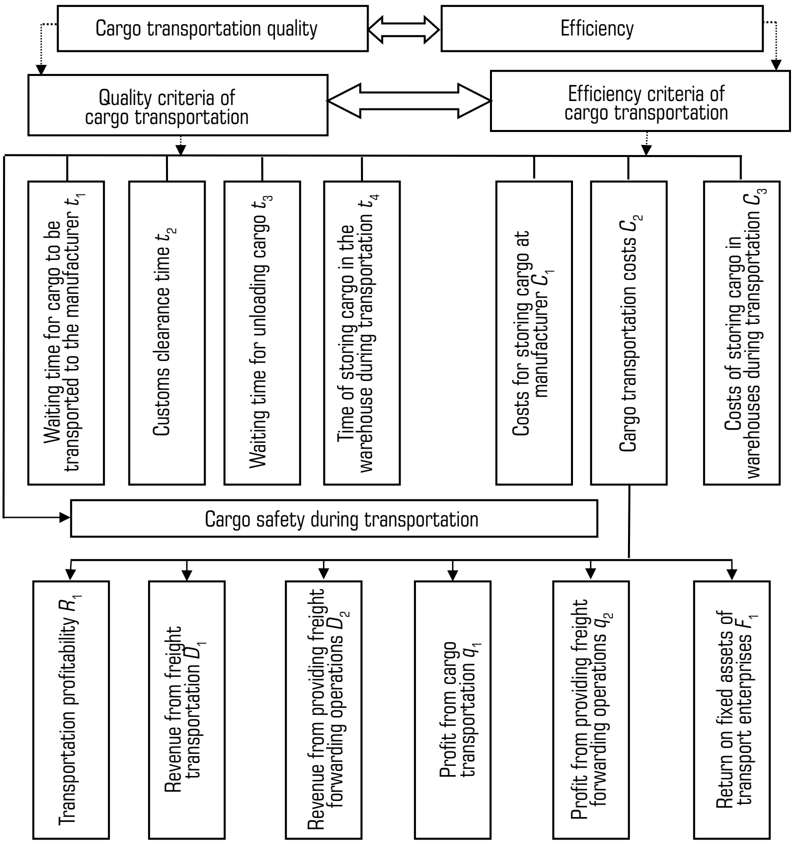

Fig. 5.2 Structural diagram of the main indicators of quality and efficiency of cargo transportation

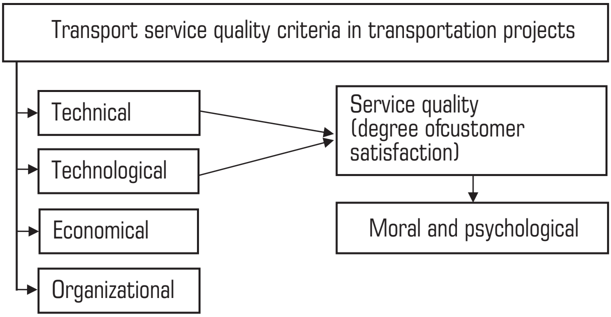

Fig. 5.3 Criteria that determine the quality of transport services

5.3 DETERMINING THE COMPETITIVENESS ASSESSMENT OF TRANSPORT SERVICES

Taking into account the improvement of the quality characteristics of a transport service, its competitiveness can vary in a wide range, taking into account the dynamics of the transport market, changes in tariffs, changes in the influence of other external factors. Since competitiveness studies should be conducted constantly to determine the level of satisfaction of participants in transportation projects, let's propose a structural scheme for determining the competitiveness of a transport service, in which K is an indicator of the competitiveness of transport services (**Fig. 5.4**).

If when calculating the competitiveness of transport services $K \leq 1$, this means that the transport service does not meet the requirements of the participants in the transportation process in transportation projects, and in the case $K \geq 1$ – all the requirements for the quality of transport services satisfy the carriers and this service meets the competitive quality.

In many works, scientists argue that improving the quality of transport services in transportation projects can occur by improving the norms of the technological process of delivering goods in international traffic. This means that scientists recognize the importance of improving the norms and standards that regulate the technological processes of transporting goods. "Technological process" in this context is considered as a set of all stages and procedures through which the cargo passes from the sender to the recipient.

These stages include route planning (i.e. choosing the optimal routes for transporting cargo, taking into account all external factors, such as weather conditions, road conditions, customs procedures, safety of the transport process, etc.); customs procedures (including timely and correct documentation for the unhindered passage of cargo across borders, which is important for compliance with international standards in modern conditions and reducing delays at the border);

transportation technologies (choosing the most effective means of transport for transporting cargo, as well as the use of modern logistics technologies, such as real-time cargo monitoring); risk management (in international transportation, it is important to anticipate possible risks (for example, military actions in the customs territory of Ukraine as a result of the Russian invasion, natural disasters) and adapt the technological process to new conditions.

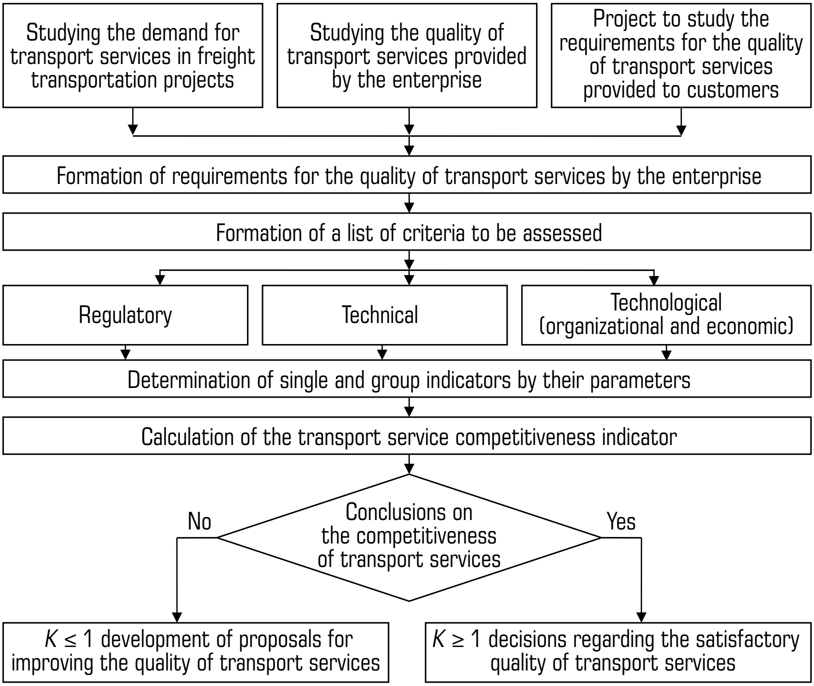

Fig. 5.4 Structural diagram for determining the assessment of the competitiveness of transport services

Thanks to the improvement of the norms of the technological process (this may be the improvement of existing procedures or the introduction of new standards), the quality of transport services can be significantly improved. This leads to a reduction in delays at the customs border (i.e., clearly defined and improved customs procedures allow to reduce the time spent on transporting goods and avoid unnecessary delays at customs or at border crossing points); ensuring cargo safety (the introduction of norms that regulate the processes of packaging, transportation and storage of cargo helps to minimize the risks of damage to cargo or its loss during transportation); improving communication between participants in the process (it is precisely the improved procedures that ensure more effective interaction between carriers, customs authorities and other participants in the transport chain).

Thus, improving technological processes is a key factor in improving the overall quality of transportation and the competitiveness of transport services, which includes not only reducing costs and time, but also increasing the level of safety and customer satisfaction.

The competitiveness indicator of a transport service is calculated as follows:

$$K_{trans.serv.} = \frac{J_r \cdot J_t}{J_{tl}}, \tag{5.1}$$

where J_r, J_t, J_{tl} – group criteria according to regulatory, technical and technological parameters.

However, existing methods for assessing the competitiveness of transport services have some limitations. As a rule, they are focused on calculating the assessment of the actual level of quality, that is, existing at the time of the study, and are not designed for the future.

The indicator $K_{trans.serv.}$ should be critical in relation to the parameters under study, relatively simple to quantify, universal and allow for comparative analysis.

Ensuring the improvement of the quality of transport services is one of the indicators of increasing the volume of cargo transportation. Thus, studies [13, 14] confirm the relationship of the category "quality" with other market categories, and therefore the following patterns are obvious: an increase in the volume of transportation, income from transportation, a decrease in cost and operating costs, which are the final results in transportation projects, are directly related to the quality of transport services.

A developed transport network contributes to the safety of cargo during delivery and the reduction of the transport component in the cost of goods, reducing downtime at the border, ensuring timely delivery of cargo "just in time". Therefore, it is proposed to include the transport accessibility indicator, which depends on the length of the communication routes, the corresponding geographical configuration of highways, throughput and intensity of vehicle traffic, in the indicators of the quality of transport service for cargo owners and carriers in the ITC development programs.

Transport accessibility is determined by the transport network density indicator d_T per 1000 km^2 of the area of the territory along which the highway passes, per 10,000 population and per 1000 tons of manufactured products in terms of weight:

$$d_T^S = \frac{L_E}{S};\ d_T^N = \frac{L_E}{N};\ d_T^Q = \frac{L_E}{Q}, \tag{5.2}$$

where L_E – operational length of highways, km; S – area of the studied territory, through which the ITCs pass, km^2/1000; N – population, people/10000; Q – volumes of manufactured products, t/1000 respectively.

The transport network density indicator d_T is defined as:

$$d_T = \frac{L}{\sqrt[3]{S \cdot N \cdot Q}}, \tag{5.3}$$

where L – the length of the connecting routes, km.

The length of the connecting routes L is calculated using the coefficients of the reduced transport routes, determined taking into account the capacity and intensity of vehicle traffic on the studied sections of the transport corridors. Thus, the most difficult moment when taking into account this indicator is determining its optimal values. Usually, its comparison with the reference value in developed European countries is used. In this case, not only the length of the connecting routes is taken into account, but also the intensity of the use of road transport on the ITC routes and the carrying capacity of the routes.

The transport accessibility indicator $d_{A(ITC)}$ on the routes of international transport corridors can be defined as the weighted average value of the time required by carriers to deliver cargo [14]:

$$d_{A(ITC)} = \frac{\phi\left[1-(t_1+t_2)\right]+Z}{V_{av}}, \tag{5.4}$$

where ϕ – directions of secondary roads, characterizing the transport accessibility of carriers to highways, km; t_1 – coefficient characterizing the non-isolation of the departure point from the entire transport network; t_2 – coefficient characterizing the reserve of the transport network configuration; Z – transport focus of the territory, which is the shortest distance that must be overcome by the best routes when delivering cargo in international traffic, km; V_{av} – average speed of the vehicle along the route, km/h.

The transport accessibility indicator allows to determine the time of delivery of goods "from door to door" and allows to take into account the reliability of cargo delivery in transportation projects.

The quality of transport service in transportation projects will be assessed by a complex indicator of the quality assessment of the $Q_{A(trans.serv.)}$, which includes aggregated criteria, block criteria and single criteria. Aggregated indicators are represented by the set [15]:

$$Q_{A(trans.serv.)} = \left\{R_{qual}, C_{qual}, F_{qual}, S_{qual}\right\}. \tag{5.5}$$

Reliability (R_{qual}) is represented by the set:

$$R_{qual} = \left\{r_1, r_2, r_3\right\}, \tag{5.6}$$

where r_1 – savings in the transportation process (delivery of cargo without losses, damage, loss and contamination); r_2 – timeliness of transportation projects (speed of delivery, accuracy, execution of the delivery schedule in accordance with the AETR requirements); r_3 – fulfillment of contractual obligations (fulfillment of accepted applications, completeness of fulfillment of guarantees).

Complexity (C_{qual}) is represented by a set:

$$C_{qual} = \{c_1, c_2, c_3\}, \tag{5.7}$$

where c_1 – complexity of transport services (set of services by type of cargo, brand of rolling stock used); c_2 – range of transport services (availability of additional services for customs clearance, cargo insurance, loading and unloading, consulting services); c_3 – informativeness (completeness of information and its reliability, regularity of information receipt).

Flexibility (F_{qual}) is represented by the set:

$$F_{qual} = \{f_1, f_2, f_3, f_4\}, \tag{5.8}$$

where f_1 – convenience of the service provided (convenience and speed of application processing, goods and accompanying documents, convenience of cargo acceptance and delivery, availability of different levels of service, individual approach to each participant in the transportation process); f_2 – service culture of carriers (communicability, friendliness, ethics); f_3 – efficiency of service (competence and professionalism of personnel, speed of processing applications for the development of transportation projects, speed and quality of response to complaints, claims, efficiency of order fulfillment, possibility of delivering goods on demand (just-in-time delivery)); f_4 – aesthetics (politeness, responsiveness, accessibility and trust in personnel, level of skill, comfort and trust in project participants, effectiveness of communication between the contractor and the client).

Safety in transportation projects (S_{qual}) is represented by the set:

$$S_{qual} = \{s_1, s_2, s_3\}, \tag{5.9}$$

where s_1 – safety of the main service (ensuring safety during transportation in accordance with the AETR requirements); s_2 – safety of further service (ensuring the safety of the cargo and vehicle in the country of destination); s_3 – safety of the rolling stock selected for the transportation project (technical inspection of the vehicle, permit for the ICT implementation).

Thus, the proposed criteria can be used to assess the quality of transport services at all stages of the life cycle of the transportation project. The assessment of the quality of transport services in transportation projects according to the given criteria can be called complete and objective. After all, project-oriented enterprises in the field of motor transport services work to implement the final product – customer satisfaction, since it is the client who assesses the quality of the transport service by comparing the desired and obtained result.

Quality management requires a quantitative assessment of the quality of transport services as a project product in cargo transportation projects. For this, it is necessary to present a basic quality indicator, i.e. a reference value for comparative quality assessments. Depending on the purpose of the assessment, the basic indicators can take on different values. The basic indicators can be the quality indicators of transportation projects passing through the territories of foreign countries, the quality indicators of the transportation project product for the past period, or indicators calculated using a simulation model.

According to the number of parameters studied in the process of determining the assessment of the quality of transport services in transportation projects, single, complex and integral quality indicators are distinguished.

Single indicators, as a rule, characterize only one property. This can be only reliability, or only the safety of cargo delivery in transportation projects or on other class E roads.

A complex assessment determines a service quality indicator that characterizes several properties of the service at the same time.

An integral quality assessment is a type of complex service quality indicator (not only transport), which reflects the ratio of the total useful effect of a given service to the costs calculated for the purchase or provision of the service to users:

$$J = \frac{E}{Z} = \frac{E}{Z_c + Z_{cr}}, \tag{5.10}$$

where E – the total useful effect of providing transport services; Z_c – the capital investment in creating services; Z_{cr} – the sum of current costs for the purchase or provision of transport services (money units).

Integral assessment is used in most cases and is carried out in two stages. First, simple properties are assessed, and then complex properties are assessed, in particular, quality as a whole (**Fig. 5.5**).

In [16], the shortcomings of the comprehensive quality assessment method are noted. The author notes that comprehensive quality assessment does not take into account ergonomic ("person-machine-environment"), aesthetic and other properties of the service. In addition, comprehensive quality assessment is defined only for those services for which the total useful effect is calculated only in natural or cost units. Therefore, in most practical problems, the final result of qualimetric calculations is not an absolute indicator P_{ij}, but a relative K_{ij} [16].

Then the integral indicator is a function of two absolute indicators – the measured P_{ij} and the one taken as the base indicator P_{ij}^{bas}:

$$K_{ij} = f(P_{ij}; P_{ij}^{bas}). \tag{5.11}$$

In general, the quality management indicator (integral indicator) [17] is the ratio of the consumer value (CV) to the cost (C) of the services provided.

The formula for calculating the dynamics of integral quality and efficiency indicators for different levels and goals of freight transportation management is as follows [18]:

$$K_i^{tr} = \left[1 + \frac{\left(\pm \sum_{n=1}^{N} \Delta E_T \right)}{Z_{gr}} \right] \cdot 100, \tag{5.12}$$

where ΔE_T – the total economic effect (+) or (–) of the change in simple natural quality indicators in the studied period, c.u.; Z_{gr} – the total costs of the carrier for the last studied year, c.u.; $n = 1, 2, 3$; N – the number of integrated simple natural quality indicators.

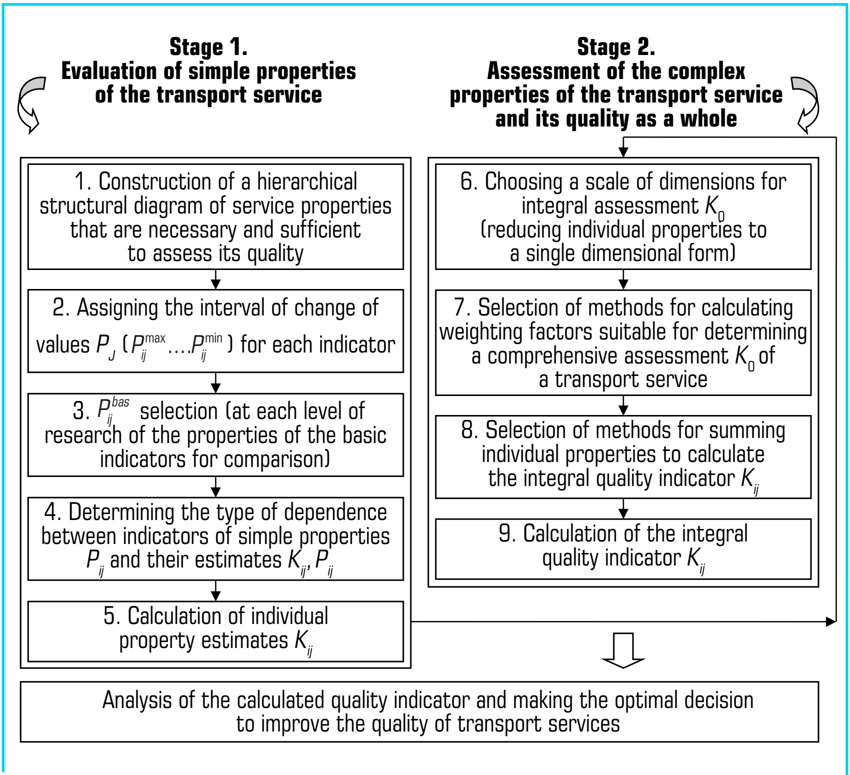

Fig. 5.5 Scheme of the algorithm for comprehensive quality assessment of transport services

An important approach in determining quality is the weighted average indicator, by which the complex indicator of the quality of transport service is determined:

$$K = \sum_{i=1}^{n} a_i \cdot g_i, \tag{5.13}$$

where a_i – the number of studied elements; g_i – the importance coefficient; $i = 1....n$.

However, it should be noted that the main mistake in developing a complex indicator is an attempt to replace the economic content of quality with formalistic methods of calculating indicators in the form of the sum of various economic, operational and environmental parameters, that is, this indicator does not reflect economic quality.

Using the method of scoring in qualimetry, it is possible to evaluate the work of all enterprises that develop transportation projects, according to the expression [19]:

$$M_S = \frac{\sum n}{S} \cdot (1 - K_{red}), \tag{5.14}$$

where $\sum n$ – the sum of the score ratings of the indicators; S – the number of quality indicators; K_{red} – the reduction coefficient of quality indicators depending on the degree of their implementation.

It is proposed to distribute the scores into three categories of transport service quality [20]:

– the highest category (with a score of 5–10);

– the first category (with a score of 3–5);

– the second category (with a score of 1–3). As an example, the distribution of scores by the indicator "fulfillment of the vehicle movement schedule along the route" in transportation projects is presented in **Table 5.1**.

Table 5.1 Determination of scores by the studied indicator

Completion percentage, %	**100**	**97–100**	**93–97**	**< 93**
Score	10	6	4	2

Therefore, the quantitative values of the integral quality assessment, which are suitable from the point of view of high-quality transport service, should be considered in the range of 5–0 points. This range is conditional and may vary depending on the requirements of carriers.

At the level of operating enterprises (for example, service enterprises, service stations, TIR parking lots), it is proposed to use a methodology widely used in construction, which involves the use of two indicators [21]:

– the average evaluation score, which is defined as a weighted average value;

– the dispersion, which is defined as the weighted average value of the deviation from its average value, and its derivatives – the mean square or standard deviation and the coefficient of variation.

The average evaluation score characterizes the level of quality and is defined as:

$$S_{av} = \frac{3m_1 + 4m_2 + 5m_3}{m_1 + m_2 + m_3}, \qquad (5.15)$$

where S_{av} – average score; m_1 – number of elements for which the score is "satisfactory"; m_2 – number of elements for which the score is "good"; m_3 – number of elements for which the score is "excellent".

The variance characterizes the constancy of the quality level, that is, the distribution of scores among themselves:

$$S_v = \frac{(S-3)\cdot m_1 + (S-4)\cdot m_2 + (S-5)\cdot m_3}{m_1 + m_2 + m_3}. \qquad (5.16)$$

However, the use of the evaluation score and dispersion is possible only when comparing individual properties over several years and, in particular, by types of services provided in transportation projects.

Therefore, a comprehensive assessment does not allow taking into account the criteria complicated by the fact that they are evaluated on different scales. After all, the criteria are divided into 3 groups by their nature: quantitative indicators; qualitative; relay (yes/no), which complicates the calculation of the integral indicator of the quality of the transport service. In addition, each quality criterion has a different weight in the totality of the studied elements.

Therefore, the indicator of the quality of transport service according to the integral assessment Q_{ij} can be understood as the fulfillment of the requirements of a set of individual parameters q_{ij} – the speed of cargo delivery, reliability, regularity, safety of cargo delivery and other factors that can affect the cost of transportation [22]:

$$Q_{ij} = (q_{ij}^1, q_{ij}^2, q^3, q^4 \ldots q_{ij}^n), \qquad (5.17)$$

where n – the number of parameters that determine the quality of transport services of carriers.

The use of such an approach makes it possible, firstly, to make an integral assessment of the quality of transport services on the routes of international transport corridors, according to all properties, and secondly, to determine the most effective measures for improving significant evaluation parameters, always starting with the most significant.

The quality system "Q" can be considered as a set of 3 subsystems: quality assurance Q_{ij}, quality management U_q and development of the quality indicator R_q. The first subsystem of quality assurance Q_{ij} should be implemented as planning the life cycle of transportation projects. Consideration of the subsystem allows to highlight all technological components (at the stages of planning, management and control).

The second subsystem of quality management U_q determines the requirements for project management and control of cargo transportation along routes. The PDCA cycle is taken as a basis (*P* – preparation of transportation routes, *D* – execution of routes in accordance with the prepared ones, *C* – verification of the route traveled in accordance with the planned routes, *A* – taking necessary measures in case of certain deviations during cargo delivery). The assessment of transportation quality is based on the concept of the permissible spread of the parameters of the controlling value $qij(+)$ in relation to $q_{ij}^{H}(t)$; $(t) \in Q_{ij}^{H}(t)$, where $Q_{ij}^{H}(t)$ – the standard of quality of transport service in transportation projects. The development of the quality indicator Q_{ij} should be understood as increasing the stability of the implementation of the given quality standard $\Delta Q_{ij}(T_{pl}) \to \min$ in the planning period T_{pl} and reducing technological and other changes, i.e. reducing transport delays ($D_{ij}^{tot} \to \min$ at $Q_{ij}(T_{pl}) = const.$), by reducing the time for customs procedures when transporting goods in international traffic.

By performing all the above measures, it is possible to get the effect of implementing transportation projects, which is manifested in an increased number of orders for a project-oriented enterprise (**Fig. 5.6**).

The process of determining the level of transportation quality by quantitative assessment is complex and time-consuming. This is due to the lack of clear criteria for measuring and assessing quality, the inability in most cases to use quantitative methods for measuring the level of service quality, as well as the subjectivity of expectations and perceptions of the services provided. In addition, the assessment of service quality is complicated by the fact that each quality indicator has a different weight in the set of elements. Therefore, this task reflects the relevance of the work being conducted.

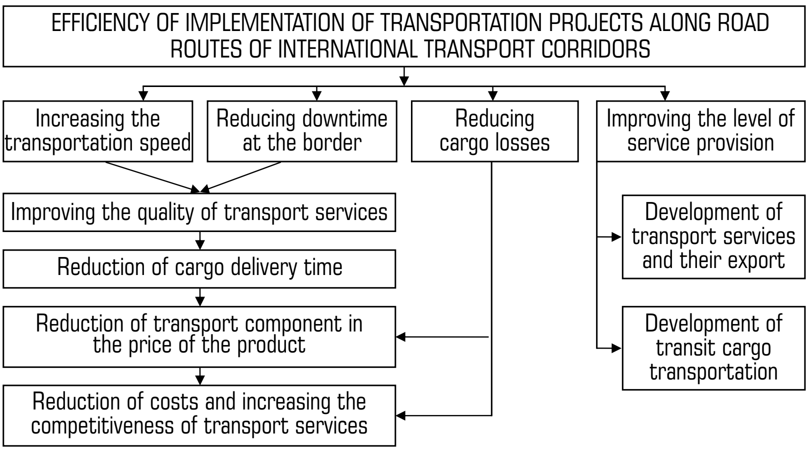

Fig. 5.6 Components of the effect in the implementation of transportation projects

The development of a method for assessing the quality of transport services will create a kind of legal field for competition in the market, granting the right to provide transportation to the most competitive carrier.

A significant number of components of transport service quality is due to the fact that breaking down indicators into small elements and assessing each separately, and then combining them can lead to a distortion of the average score of the group of indicators.

Thus, today, enough methods have been developed to assess the quality of various project management objects (transport service, operational work, cost indicators), at the same time, none of the considered methods is used in the practice of quality management for making management decisions when developing transportation projects [23].

Studies on the assessment of the quality of transport services in transportation projects prove that to increase the efficiency of a project-oriented enterprise, it is necessary to manage the quality of transport services throughout the entire life cycle of projects, and especially at the stage of project initiation.

This approach defines information about quality as the main component of managing international cargo transportation projects. For participants in the freight transportation market, the efficiency of cargo delivery in international traffic is determined by the quality of transport services in transportation projects, which is characterized by qualitative and quantitative indicators. The following quality indicators should be included [24, 25]:

– timeliness of cargo transportation;
– ensuring the safety of cargo transportation;
– reliability of delivery within a certain period;
– acceptable cost of transportation by international routes;
– regularity of cargo delivery;
– capacity of the transport corridor;
– speed of the route;
– quality of service provision to carriers.

Studies of the assessment of the quality of transport services prove that the practical formulation is reduced to a multi-criteria problem. Quite often, when studying the problem of multi-criteria, all criteria, except one, chosen as dominant, are taken as constraints. In this case, optimization is carried out according to the dominant criterion. This approach to solving practical problems greatly simplifies, but also reduces the accuracy of the decisions made [9, 10].

In the tasks of assessing efficiency by several criteria, it is necessary to determine the value of the objective function that corresponds, for example, to achieving the maximum throughput of the studied corridor at given transportation costs or achieving the given maximum effect at minimum costs to improve the quality of freight transportation in transportation projects.

The fundamental complexity of solving a multi-criteria problem is that there is usually no single solution that would be the best for all criteria at once. Therefore, it is proposed to apply elements of the theory of the importance of criteria, which is based on the mathematical justification of the basic definition "one criterion is more important than another with a certain coefficient of relative importance".

When comparing criteria by importance, that is, finding out whether one criterion is more important than another, it is assumed that the criteria are homogeneous. This means that the criteria must have a single dimensional scale. In addition, the condition of homogeneity must be met, in which each gradation of the scale reflects the same level of preference for each of the criteria.

However, when assessing transport services, there is a set of heterogeneous criteria, the values of which are measured within certain scales and expressed in separate units of measurement.

Therefore, usually when developing a single complex quality indicator (Φ), all criteria must be reduced to a single (dimensionless) form, in other words, normalized [11, 26]:

$$\Phi = a_1K_1 + a_2K_2 + \ldots + a_nK_n, \tag{5.18}$$

where a_1, $a_2, \ldots$, a_n – the importance coefficients, the values of which characterize the relative importance of the criteria.

But this approach to constructing a complex indicator is not always attractive, since it can lead to an unsuccessful choice of solution. When determining the importance of heterogeneous criteria, it is necessary to reduce them to a single ordinal (qualitative) scale. This is the main difference from the criterion normalization method, which assumes the quantitative superiority of each criterion when constructing a complex evaluation indicator in projects.

If the scale is single with an accuracy of an arbitrary monotonically increasing transformation, then it is ordinal. The numbers in this scale are compared with each other according to the usual numerical relations "greater than or equal to", "greater than" or "equals". At the same time, in an ordinal scale, the numbers do not answer the question: how much or how many times one criterion is more important than another. On this basis, the ordinal scale is often referred to the class of qualitative scales.

The mathematical model of making an optimal decision in the presence of many criteria includes three elements: a set of decisions (V), a vector criterion (K), a ratio of preference and indifference of the decision maker (hereinafter referred to as the DM). The criterion (K_i) is a function defined on the set (V), and takes values from the set of decisions (X_{ij}), which is called a scale, or a set of estimates [6, 27].

The estimates can be numerical (for example, the throughput of a particular TC, thousand vehicles per day), verbal (for example, "high level of service provision within the transport corridor" or "low level of service provision") and symbolic (for example, the category of roads – I, II, etc.). In the following, let's consider only criteria with a numerical scale.

Thus, each option (v) is characterized by evaluations (m) according to the criteria $K_1(v)$, $K_2(v)$, ..., $K_n(v)$, which make up the vector $K(v) = (K_1(v), \ldots, K_m(v))$, which is called the "vector evaluation of the option". Its designation can be either $K(v)$ or $x(v)$, i.e.:

$$K(v) = (K_1(v),\dots,K_m(v)) = x(v) = (x_1(v),\dots,x_m(v)). \tag{5.19}$$

To demonstrate the practical application of the theory of the importance of criteria, let's give a conditional example.

5.4 ASSESSING THE OPERATION QUALITY AND EFFICIENCY OF FOUR INTERNATIONAL TRANSPORT CORRIDORS

Let's assess the quality and efficiency of the functioning of four international transport corridors, which it is possible to propose for transportation projects passing through the territory of Ukraine, according to the following criteria:

1) transport corridor capacity, thousand vehicles per day (A) – this criterion assesses the ability of the transport corridor to handle a certain number of vehicles per day. A higher capacity indicator indicates higher efficiency and the ability of the corridor to cope with large volumes of transportation;

2) actual traffic intensity, thousand vehicles per day (B) – this criterion determines the actual load on the corridor, that is, the number of motor vehicles that actually carry out transportation. By comparing the actual traffic intensity with the capacity, it is possible to determine whether the corridor is overloaded and whether its resources are used efficiently;

3) ensuring the safety and reliability of cargo transportation along ITC routes (C) – this criterion assesses the level of safety on each route, taking into account the risks of road accidents, natural disasters, abuse, as well as the effectiveness of cargo control. Transportation reliability is an important aspect for ensuring the timely delivery of goods without loss or damage;

4) conditions for providing service services within the selected ITC (D) – this criterion assesses the level of service provided within the transport corridor. It includes the availability and quality of infrastructure for technical maintenance of transport, the availability of control points, customs offices, gas stations, as well as the level of information services and support for cargo owners.

This vector assessment method allows for a comprehensive comparison of transport corridors according to all criteria at the same time. Each corridor receives assessments for each of the criteria, and based on these assessments, a vector is formed that shows its overall efficiency. By comparing these vectors with each other, it is possible to draw conclusions about which corridor is the most effective for implementing transportation projects, in particular, in terms of throughput, traffic intensity, safety and service conditions. The initial data is given in **Table 5.2**, namely, the comparison of routes by the efficiency of implementing transportation projects is based on their vector assessments.

Conditionally, each criterion is evaluated with the usual scores 2, 3, 4, 5. As an option, conditional ITCs are used, that is, a set of solutions $\nu = \{v^1, v^2, v^3, v^4\}$. There are $m = 4$ criteria in total, which are represented by a single common scale and form a vector score for each ITC, for example $K(v^1) = (3, 5, 5, 4)$. Thus, there is a set of vector scores, which are called real or achievable.

Table 5.2 The value of the criteria for the effectiveness of the ITC operation functioning in Ukraine, proposed in transportation projects

ITC	Criteria			
	A	B	C	D
ITC I	3	5	5	4
ITC II	4	4	4	5
ITC III	3	5	5	4
ITC IV	3	5	3	5

Scores of the relative importance of criteria can be qualitative and quantitative. The qualitative importance of criteria is qualitative estimates, which are expressed by statements that one criterion is more important than another, or the criteria are equivalent. The statement "criterion K_i is more important than criterion K_j" is denoted as $i \succ j$, and the statement "criteria K_i and K_j are also equivalent" is denoted by $i \approx j$.

According to the data in **Table 5.2**, ITC I and ITC III have equivalent vector estimates, which is denoted as follows: $v^1 I_o v^3$, and is identical to $v^3 I_o v^1$. Here I_0 reflects the indifference relation, which means that when choosing an effectively functioning ITC, one can give preference to both ITC I and ITC III, which are equivalent to each other according to the selected criteria. Let's introduce the notation P^0, which means the preference relation between vector scores yP^0z, i.e. y prevails over z. This means that (4, 4, 4, 5) P^0 (4, 2, 4, 5). However, when comparing ITC I and ITC II, it is not possible to write:

Not (3, 5, 5, 4) P^0 (4, 4, 4, 5), not (4, 4, 4, 5) P^0 (3, 5, 5, 4), since such vector estimates are incomparable with respect to P^0.

If the statement $v' P^0 v''$ is true for two options v', v'', then the option v'' cannot be considered the best and is called the dominant option. If for option v^* there is no such value of v that is the best with respect to P^0, that is, for which it would be correct to write vP^0v^*, then it is called non-dominant, or optimal according to Edgeworth-Pareto. In other words, the set of such options is the Edgeworth-Pareto set (V_0) [13, 28].

It becomes clear that only those options that belong to the set (V_0) can be optimal. Therefore, a preliminary analysis of all possible options allows to narrow the set of options (V) to the set (V_0).

In our example, as is usually the case in many applied multi-criteria problems, the set of options does not have a unique solution. Then the question arises, how exactly to choose the single best one from the set of heterogeneous options? To do this, it is proposed to introduce additional information from the DM (in our case, these are the participants in the transport process). The role of additional information is data on the relative importance of the criteria, as well as their scales. Additional information can reflect both the indifference ratio I_Ω for probable options and the preference ratio I^Ω for vector estimates [13, 29].

It is assumed that the TC capacity is more important than the actual intensity of vehicle traffic on the ITC routes according to information from the DM. In this case, the actual intensity of vehicle traffic and ensuring the safety and reliability of cargo transportation along the ITC routes are equivalent. Then this information can be written in the following form:

$$\Omega = \{1 > 2, 2 \approx 3, 3 \succ 4\}. \tag{5.20}$$

If the criterion K_3 is more important than the criterion K_4, then the vector estimate $x(v^1) = (3,5,5,4)$ prevails over y, then it is correct to write $x(v^1)P^{3 \succ 4}y$. In particular, if K_1 and K_3 the criteria and are equally important in making the optimal decision, then their vector estimates $x(v^1) = (3,5,5,4)$ and $x(v^3) = (3,5,5,4)$ are equivalent, i.e. $(3,5,5,4)I^{1 \approx 3}(3,5,5,4)$.

Analyzing this information, we would like to have effective methods with which we could build a chain of two arbitrary vector estimates x and y. Such methods exist and are called "combinatorial methods". They indicate that it is impossible to arbitrarily compare the vector estimates v^1, v^2, v^3 based on information Ω. Therefore, the variants v^1, v^2, v^3 are not dominant with respect to P_Ω. Thus, the information Ω makes it possible to narrow the set (V_0) to the set $V_\Omega = \{v^1, v^2, v^3, v^4\}$, in which two options for vector estimates are equivalent.

Therefore, the optimal solution from the set of possible ones is a solution that is non-dominant with respect to I^Ω and is determined by quantitative information about the importance of the criteria [30].

To check the relations xP^Ω and $xI^\Omega y$, there are also algebraic methods that are effective when comparing equivalent criteria. Information about the equal importance of two criteria is denoted by S. Let $x_\downarrow$ be a vector estimate formed from the values of x in decreasing order. For example, if $x = (3,4,2,3,5)$, then $x_\downarrow = (5,4,3,3,2)$. Therefore, the statements underlying this method can be described in the following form as $xP^\Omega y$ in the case if $x_\downarrow P^0 y_\downarrow$; $xI^S y$ in the case if $x_\downarrow = y_\downarrow$.

Unlike the qualitative importance of criteria, quantitative – can appear in two main forms:

1) in the degree of superiority of the importance of one criterion over another, that is, the criterion K_i is h times more important than the criterion K_j, if $h > 0$, however, if $h < 1$, then in fact the criterion K_j is $1/h > 1$ times more important than the criterion K_i, and under the condition $h = 1$ that the criteria under study are equivalent;

2) in the importance values of individual criteria, which are qualitatively measured on one general scale of importance, that is, the importance of the criterion K_i is expressed by the value β_i, where $\beta_j \geq 0$.

The degree of superiority (h) of the criterion over K_j is determined by the ratio of their importance values β_i and β_j:

$$h = \frac{\beta_i}{\beta_j}. \tag{5.21}$$

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If a criterion K_i is more important than a criterion K_j by h times, then this statement is denoted by the expression $i \succ^h j$. Determining the superiority of the importance of one criterion over another by several times is based on the concept of the N-model, which takes into account only quantitative information about the importance of the criteria. This information is denoted by the Greek letter Θ (theta) and is formed on the basis of the DM experience about the advantages of some criteria over others.

If, when calculating the importance of the criteria β_i are summing to unity, they are called "importance coefficients". These coefficients determine the share of the "unit importance" of the set of all criteria that falls on each individual criterion K_i.

By the N-model let's mean a model with $n_1 + \ldots + n_m$ homogeneous criteria, and the first n_1 criteria can be obtained as a result of repeating the first criterion n_1 times, the next n_2 criteria – by repeating the first criterion n_2 times, etc. By analogy, the vector estimates of the initial model are formed into "extended" vector estimates of the N-model, which are called "N-fold estimates", or N-estimates. This means that each estimate for each criterion K_i is repeated n_i times [17, 31].

Information Θ corresponds not to one, but to a whole set of N-models, that is, it is enough to multiply all the numbers n_i by any natural number > 1 and it is possible to obtain a new N-model. Among the set of all N-models that correspond to information Θ, the simplest is the model in which all m numbers $n_1, \ldots, n_m$ are mutually simple in calculations [32].

Therefore, based on the so-called N-models, a new basic definition of the quantitative importance of criteria can be formed. A criterion K_i is h times more important than a criterion if the N-models meet or the following conditions are valid:

1) $\dfrac{n_1}{n_2} = h$;

2) each of the n_i criteria obtained from the criterion K_i is equivalent to any of the n_j criteria formed from the criterion K_j.

Let's consider the use of quantitative information about the importance of the criteria. The previously accumulated information about the quantitative importance of the criteria is presented in the following form [33, 34]:

$$\Theta = \left\{ 1 >^{3/2} 2, 2 \approx 3, 3 \succ^2 4 \right\}. \tag{5.22}$$

In other words, let's consider the "extended" vector estimates of each ITC according to the information Θ. In particular, each estimate of the international transport corridor will be written out as many times as the equivalent criteria include this estimate:

$$\begin{aligned} x^{\Theta}(\upsilon^1) &= (3,3,3,5,5,4,4,4), \quad & x^{\Theta}(\upsilon^2) &= (4,4,4,4,4,5,5,5), \\ x^{\Theta}(\upsilon^3) &= (3,3,3,5,5,4,4,4), \quad & x^{\Theta}(\upsilon^4) &= (3,3,3,5,3,5,5,5). \end{aligned} \tag{5.23}$$

Let's note that all components of these vector estimates according to their formation can be considered as the values of eight equivalent criteria. Therefore, the developed N-model will have the form $N = (3,1,1,3)$. Next, let's present the estimates of the N-model, having previously arranged their components in descending order:

$$x^{\Theta}(V^1) = (5,5,4,4,4,3,3,3), \quad x^{\Theta}(V^2) = (5,5,5,4,4,4,4,4),$$
$$x^{\Theta}(V^3) = (5,5,4,4,4,3,3,3), \quad x^{\Theta}(V^4) = (5,5,5,5,3,3,3,3). \tag{5.24}$$

Comparing the N-estimates of the ITC II and ITC IV with respect to P^0, that is, comparing the components of the estimates by magnitude, let's obtain:

$$x\overset{\Theta}{\downarrow}(V^2)P^0x\overset{\Theta}{\downarrow}(V^1) \text{ and } x\overset{\Theta}{\downarrow}(V^2)P^0x\overset{\Theta}{\downarrow}(V^3). \tag{5.25}$$

This means that the ITC II, taking into account the information Θ, is a more effective option compared to the ITC I and ITC III.

When analyzing the N-estimates of the considered ITC II and ITC IV, ITC II is non-dominant compared to the ITC IV. Thus, the use of information Θ allows to narrow the set $V_{\Omega} = \{V^1, V^2, V^3, V^4\}$ to the set $V_{\Theta} = \{V^2, V^4\}$ in which the criterion V^2 prevails. However, the considered approach is idealized when it is possible to use for calculations the exact agreed values of the degree of superiority of one criterion over another, obtained from the DM.

But there are cases when, based on quantitative information about the importance of the criteria Θ, it is possible to obtain consistent interval estimates of the importance of the criteria.

For example, for the criteria K_i and K_j there is an unknown value h_{ij}, which is in the interval (l_{ij}, r_{ij}) and reflects the degree of superiority of the importance of the criterion K_i over the criterion K_j. If such information is available, it is impossible to apply the defined N-model. Therefore, the preference-indifference relationship must be determined using another approach, which assumes that the interval estimates of importance are consistent and that there exists an N-model that is consistent with the information Θ. This means that for each pair of criteria K_i and K_j there exists a set of values $\{h_{ij}\}$, the magnitude of which is equal to:

$$h = \frac{n_i}{n_j}, \tag{5.26}$$

and is in the interval (l_{ij}, r_{ij}), that is, the double inequality $l_{ij} < h_{ij} < r_{ij}$ is satisfied. Then the definition of the advantage P^{Θ}, formed by interval estimates of importance based on information Θ, is defined as follows: $xP^{\Theta}y$ is true if for each N-model consistent with Θ, the statement $xP^{\Theta}y$ is true.

Let's suppose that the degree of advantage of criterion V^1 over criterion V^2 is in the interval from 1.2 to 1.7, and the degree of advantage of criterion V^3 over criterion V^4 is in the range from 1.7 to 2.5. Then it turns out that with information Θ, criteria V^2 and V^1, as well as criteria V^2 and V^3,

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are incomparable in terms of the degree of advantage, that is, it is impossible to choose such an ITC that is the best according to all criteria.

However, if the degree of superiority of criterion V^2 over criterion V^1 is within narrower limits, for example, in the range from 1.3 to 1.5, and the degree of superiority of criterion V^3 over criterion V is within the range from 1.7 to $2x$, then the condition will be fulfilled:

$$V^2 P_\Theta V^1, V^2 P_\Theta V^4. \tag{5.27}$$

According to the studied criteria, the optimal one is the conditional transport corridor II. Determining the advantage of one criterion over another is based on the concept of the N-model, which allows to avoid performing cumbersome arithmetic operations when finding the optimal solution. The N-model involves using a set of weighting coefficients for each criterion, which allows to determine their importance relative to each other in conditions of uncertainty, in particular, when the information is interval. This allows to effectively process data that may have variations or shifts within given intervals, and thereby facilitates decision-making without the need to perform complex arithmetic operations. Interval information takes into account the variability of indicators, which can be important when assessing the real conditions of the functioning of transport corridors, when accurate data may be unavailable or incomplete. Using the N-model, it is possible to construct estimates for each criterion within given intervals and weigh these criteria to determine the overall efficiency of transport corridors. Given the comparison, the optimal one for the implementation of transportation projects is the transport corridor II, which demonstrates the best ratio between capacity, traffic intensity, safety and service conditions. The use of interval information and the N-model allows avoiding excessive computational complexity and provides more accurate and flexible decision-making, which is important in conditions of changing and uncertain circumstances, such as international transportation in conditions of war or unstable economic situation [35].

CONCLUSIONS

The main result of the study is to solve theoretical and practical problems in managing the quality of the project product (transport service) when performing international road transportation.

For the first time:

– a product management model for cargo transportation projects has been developed, which allows taking into account the significance of qualitative and quantitative characteristics of the transport service at each stage of the project life cycle;

– a comprehensive indicator for assessing the product of a cargo transportation project has been proposed, which takes into account the influence of indicators of a quantitative, qualitative and relay nature on the effectiveness of the project.

Improved:

– a model of the life cycle of a cargo transportation project taking into account the traditional phases of the project life cycle, which, unlike the existing one, takes into account the significance of the influence of quantitative and qualitative characteristics obtained experimentally from transport participants on the level of transport support for cargo transportation;

– a model for managing risks for transport support for cargo transportation projects in international traffic in the absence of complete and accurate information about the conditions of transportation.

Further development has been made:

– clarification of the principle of reflecting the quality of the project product, which determines the transfer of the quality of service provision to the quality of the final result;

– a terminological base for managing transport support projects by clarifying the concepts of "freight transport support project", "transportation project product", "result of the freight transportation project", "quality of transport service as a project product" by adapting them to the specifics of freight transportation projects.

The practical value of the results obtained lies in the development of a project analysis methodology for selecting freight transportation projects at project-oriented enterprises, the main activity of which is focused on international freight transportation, taking into account quality according to criteria that constitute a comprehensive indicator of the quality of the project product.

For the practical implementation of the proposed methodology for selecting a road route for transport corridors, a computer program has been developed that allows determining an integral assessment of the project product, which is based on information that is relevant in the transportation project. During the project implementation phase, the proposed program can be used to select the optimal route and enter new data or adjustments at the request of transport participants.

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