Improvement of the Feasibility Study of Investment Projects Aimed at Increasing the Throughput and Carrying Capacity of Railway

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Abstract. Increasing the efficiency and improving the quality of railway transport operations largely depends on the validity of investment projects for its development. However, the existing techniques for the feasibility study of investment projects aimed at increasing the throughput and carrying capacity of railroad sections are summarized and do not take into account some features of the evaluation of project activities. The weakest link in the feasibility study of the projects under study is the determination of cost parameters for the formation of the cash flow of the investment project. In the existing methodological provisions, only a description of the methods for evaluating the effectiveness of the project based on the calculated cost indicators is provided, therefore they can be identified as universal for all types of projects. They lack clear calculation algorithms (the exception is the cost of construction), recommendations, assumptions that need to be taken into account in the form of uncertainty in primary information and the structural changes that have taken place in recent years in the work of railways. Therefore, with the help of logical-analytical, systemic and other campaigns, the authors developed an algorithm (methodology) that can be used to select an effective method for organizing the movement of cargo flows along sections of the railway network, and the application, which is intended to facilitate a more justified choice of priority measures for the development of the railway infrastructure.

1. Introduction
The completed evolutionary study of methods for assessing the economic efficiency of measures in the national economy and in rail transport [1,3,8-11,13,14,21] showed that the methods considered are universal and do not fully take into account the specifics of determining cost indicators in the evaluation of projects, aimed at increasing the capacity of sections of the railway network. Therefore, there was a need to develop a model for the economic justification of design decisions, which should be used to select an effective way of organizing traffic flows across sections of the railway network, as well as its application will contribute to a more justified choice of priority measures for the development of the railway infrastructure. The need for modeling is due to the fact that when evaluating an investment project a complex and multifaceted process of its implementation has to be simplified, discarding low-value factors and focusing on more significant ones. As a result, the object of analysis is not the project itself, but the associated material and cash flows. Thus, the problem of evaluating an investment project is reduced to "translate" project documentation into a language of cash flows, and the interests of project participants are reflected in calculation formulas that allow us to estimate cash flows relative to these interests.
2. Methodology for evaluating the effectiveness of investment projects aimed at increasing the throughput and carrying capacity of railways

The key in the process of predictive and planned calculations is the determination of the need for transportation and the capabilities of the transport system for their implementation. Since the ways to organize the advancement of the long-term train traffic depend on the capacity of the landfill and the infrastructure features of the railway, it is advisable to divide the modeling of the choice and economic evaluation of reconstructive measures into several steps (figure).

2.1. Preconditions for the formation of variants of design solutions for the implementation of prospective volumes of transportation

The first step establishes a calculation scheme for determining the capacity based on the number of main tracks on the haul, signaling and communication facilities for the movement of trains, the development of separate points, the adopted type of train schedule and other conditions. The determination of the capacity of the railway landfill is carried out in accordance with the provisions of the existing instructions [2,4], provided that the existing infrastructure of the landfill is used to determine the reserve capacity and identify infrastructure elements that limit the missed trains in the landfill.

At the second stage, the forecasted volume of transportation by type of message, nomenclature and correspondence determines the perspective loading of the site (landfill) for the calculation period. The organization and decoupling of the carload streams is designed to establish the most rational way of following laden and empty traffic flows along the lines of the network, to correctly distribute sorting work between stations, to reduce idle time of cars under the accumulation and processing, to intensively use sorting devices and shunting means, thereby increasing the level of operational work.

Variants of design decisions should be directed to the intensification of the transport process and the accelerated introduction of the achievements of scientific and technological progress. The variants selected for the technical and economic comparison must provide specified (calculated) performance indicators (throughput, delivery and processing capacity, train speed, etc.), as well as fully comply with the established design standards. Options that do not meet mandatory requirements and standards are not competitive and are not subject to review.

2.2. Determination of the expenditure and income components of the project for each project solution

The third step determines the cost parameters (construction and operating costs, revenue receipts, capital investments in rolling stock) separately for each variant of promotion of the prospective train traffic.

Let us consider in more detail the methodology for determining the operating costs and revenue from the implementation of prospective freight traffic.

We note that with the growth of traffic volumes, operating costs are increasing. The ratio of the growth rates of traffic volumes and costs is different and largely determined by the conditions for increasing traffic volumes. Scientists-transport workers, such as V.V. Mishanin [12], V.A. Kamenov [5], N.Yu. Khristenko [22], N.Yu. Smekhova [19], L.A. Mazo [6], N.P. Tereshina [17], L.V. Shkurina [16] rightly noted that with the increase in traffic volume due to the increase in the operational length of the railway, the growth rates of operating costs may be higher than the growth rates of traffic volume, and especially in the first years of reconstruction. With the increase in traffic volume due to intensity, the rate of change in costs is lower than the rate of traffic volume. As a result, operating costs increase relatively slower than the volume of traffic and the cost of transportation decreases. The slower rate of growth in operating costs is due to the fact that there are two groups of costs in the railroads (variables and constants), which change in different ways with the increase in traffic volume under certain conditions. The division of the costs of railways into these groups is of great economic importance. It allows you to correctly determine the impact on operating costs, and, consequently, on
the cost of transportation, changes in traffic volume and traffic. The mathematical relationship between costs ($E$) and traffic volumes ($P_l$) can be expressed as:

$$E = \Delta E_1 + \Delta E_2 = \Delta E_{xN} + (r_N \cdot P_{l_N} - r_0 \cdot P_{l0})$$  \hspace{1cm} (1)

where

- $\Delta E_1$ - additional costs associated with the maintenance, repair and amortization of newly introduced technical means, million rubles;
- $\Delta E_2$ - increment of the dependent costs, mln rubles;
- $(r_0 \cdot P_{l0})$ - part of the cost of transportation, consisting of variable costs for the "base", million rubles;
- $(r_N \cdot P_{lN})$ - part of the cost of transportation, consisting of variable costs for the n-th year of the project project, million rubles.

Determination of the throughput and carrying capacity of the railway landfill when using the existing infrastructure with the identification of elements limiting the skipping of trains along the landfill

**Step 1**
Determination of the throughput and carrying capacity of the railway landfill when using the existing infrastructure with the identification of elements limiting the skipping of trains along the landfill

**Step 2**
Modeling of the perspective transport situation with the development of options for the development of prospective cargo flows and a list of measures for the development of railway infrastructure facilities

**Step 3**
The simulation calculation of network load for the future, taking into account planned activities for the development of infrastructure and projected traffic volumes. Determination of cost parameters of the project for each variant of advancement of perspective cargo traffic

**Step 4**
Calculation of indicators of economic efficiency. Choosing the best option

- The project is effective
- The project is not effective and is not recommended for implementation

**Step 5**
Analysis of the sensitivity of the project to a change in the initial parameters. Determination of the final indicators and the effectiveness of the project

- The project remains effective
- The project is effective and recommended for implementation

**Step 6**
Accounting for project support. Determination of the final indicators and the effectiveness of the project

- The project is effective
- The project is not effective and is not recommended for implementation

**Step 7**
Development of a financing scheme that ensures financial feasibility for each participant. Performance evaluation for each participant

- The project is effective
- The project is not effective and is not recommended for implementation

Figure 1. The order of organization of works on the evaluation of the effectiveness of investment projects aimed at increasing the throughput and carrying capacity of railways (compiled by the authors).

When calculating the operating costs for the railways being designed and reconstructed, the same methods apply as for calculating the costs of the operated lines [18].

The total value of the dependent costs ($E_{x}$) for the promotion of the i-th load by the years of the project period is determined by the formula

$$E_{iN} = r_i^i \cdot P_{lN}^i$$  \hspace{1cm} (2)

Thus, as a result of comparing the estimated values of the dependent costs over the years of the project period, the so-called "increment" of the dependent costs ($\Delta E$) associated with the project is determined.
For the "base" level of traffic, the amount of costs (Eo) corresponding to the maximum allowable load of the site should be adopted. It should also be noted that the value of "growth" can be decomposed into two components, namely:

- additional costs from the development of the increase in the volume of freight traffic to the "base" level (E1);
- saving of transportation costs for the "base" cargo volume as a result of the expected decrease in the "conditionally dependent" component of the cost of transportation from the implementation of the activities envisaged by the project (E2).

Savings (or overruns) are determined by comparing the operating costs calculated with the initial values of the qualitative indicators of the use of the rolling stock and with the new values of all these indicators. The value of additional costs (E1) is determined by the formula

\[ E_1 = \Delta P_{i2} \cdot \gamma_{i1} \]  

The economy of the cost of transporting the "basic" volume of cargo (E2) arises from the improvement of the qualitative indicators of the use of rolling stock, on the basis of improving the technological processes of operational work. In this case, reducing the cost of transportation is the main condition for creating savings. In this case, the saving amount itself is written with a minus sign and can be determined from the formula

\[ E_2 = P_{i4} \cdot (\gamma_{i1} - \gamma_{i2}) \]  

The cost of travel on the sections that are part of the same itinerary is summarized. Search for the optimal route is made by modeling and comparing a variety of options for organizational and technical solutions, by considering several design states. Determination of the revenue component of the cash flow from the development of the prospective traffic flow by years of the project period is determined by the following formula

\[ D_{ij} = (V_{ni} \cdot T_1 + \frac{V_{ni}}{P_{ce}} \cdot T_3) \cdot L \]  

where

- \( D_{ij} \) - income from the transportation of the i-th cargo for the accounting year, million rubles;
- \( V_{ni} \) - the volume of transportations of the i-th cargo (freight base) for the accounting year, million tons;
- \( T_1 \) - freight charge, charged for the carriage of goods, rubles. per ton;
- \( T_2 \) - the freight fee charged for the return of empty wagons, rubles. for the car;
- \( P_{ce} \) - average static load of the wagon with the i-th load, t. ;
- \( L \) - tariff distance between the point of departure and arrival of the i-th cargo, km.

The calculation of the freight charges is based on the Price List No. 10-01 [15], taking into account the current tariff setting conditions. Tariff distance should be determined on the basis of the tariff guide [20]. The initial data is the name of the point of departure and destination of the goods.

Accounting for operating costs and revenue revenues, in the calculation of the economic efficiency of project activities, is carried out by including them in the composition of project cash flows for the entire study horizon.

2.3. Justification of the choice of the optimal variant of the design solution and determination of the effectiveness of the investment project for each of its participants

The fourth step calculates the absolute (total) and relative (comparative) economic efficiency indicators (separately for each variant developed). With the transition to methods and criteria for assessing the effectiveness of investment (such as net present value, internal rate of return, investment return index, etc.) adopted in modern market economy, the differences between the estimation of absolute and overall relative comparative efficiency of investments became less significant, but did not disappear. In the framework of existing new approaches, absolute (overall) efficiency is no longer associated with the macroeconomic level of the assessment, and relative (comparative) - with microeconomic or sectoral. The difference between these two types of evaluation is only that the
overall effectiveness characterizes the measure of rationality of the total amount of resources spent to obtain the desired result, therefore, when determining it, all costs and the full result resulting from these costs are taken into account. And indicators of comparative economic efficiency are used to determine the economic advantages of one management or design solution over another, and to determine it, it is sufficient to take into account only the parts of costs and results that vary in terms of options. The proposition that the overall efficiency of each project in rail transport is generally assessed by several variants of its implementation, practically ignores the assessment of overall and comparative efficiency, "dissolving" the second in the first [7].

If the most effective version of the project in question provides the required level of overall efficiency (positive net discounted income for the accounting period, an acceptable payback period for the total investment), then, based on the adopted approaches, it is advisable to implement it. If it does not, it must be concluded that both this option and the project as a whole are ineffective (provided that it is not possible to find another version of its implementation providing an acceptable level of overall efficiency).

At the fifth step, the risk indicators and the stability of the chosen variant are analyzed to change the initial parameters. Analysis of sustainability (sensitivity) takes into account the uncertainty factor in the implementation of the investment project. The analysis is conducted with the purpose of accounting and forecasting the impact of changes in the initial input parameters of the project on performance indicators. If the project is effective, then it is recognized as economically viable and recommended for implementation. Otherwise, at the sixth step, state or other support is recorded, with the final performance indicators being determined. If the option is effective in view of its support, then it is considered appropriate and recommended for implementation.

At the seventh step, the composition of the project participants is clarified, various possible financing schemes are developed, its financial feasibility is determined and after that assesses the effectiveness of participation in the project of each of its participants.

3. Results of approbation of the proposed methodology in the production process
The application of the step-by-step model of the economic justification for design decisions and valuation of the cost indicators proposed by the authors will contribute to the optimal performance of tasks related to the assessment of the economic efficiency of investment projects aimed at increasing the throughput and carrying capacity of railways. It should be noted that this model was deemed expedient for use by the investment justification sector of JSC "Far Eastern Design and Survey Institute of Transport Construction" (there is a certificate of implementation in the production process).

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