

## Algorithm for Choosing a Cost-Effective Tourist Railway Route

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### Abstract

Railway transport is one of the most competitive modes of transport. To provide high-quality transportation for passengers, railways require various types of resources, particularly, financial ones. A significant part of the financial resources of railways can also be obtained from tourist activities. Therefore, the article presents an algorithm for choosing a cost-effective tourist route by railway transport. Thanks to the algorithm, it is possible to ensure the maximum net present value with the established system of requirements for railway activity.

**KEY WORDS:** *railway transport, tourist route, net present value*

### 1. Introduction

Railway transport is one of those types that provides the sectors of the world economy with cargo, passenger, baggage, tourist, and other types of transportation [1-4]. It is one of the most competitive among other types of transport. Such factors as overloading and accidents on roads, air pollution, noise from cars, etc. have made the railway one of the main components in the reliable mobility of the population [5-7]. Railway transportation meets the requirements of sustainable development in society because it aims to achieve economic, social, and environmental effects. To provide high-quality transportation for passengers, railways need various types of resources, particularly, financial ones. A significant part of the financial resources of railways can also be obtained from tourist activities. Tourist railway routes are gaining increasing popularity every year. Therefore: – stakeholders should pay attention to the development and improvement of the efficiency in the functioning of the tourist infrastructure; – the management structures of railways need to contribute to increasing the effectiveness of management, increasing the efficiency in the processes of formation, positioning, and consumption of railway services. At the same time, it is important to adhere to the basic principles in the organizational and economic support for the development of railways: scientificity, justification, consistency, and innovation.

### 2. Research Results

In recent years, railways have been intensively developed and modernized. This is facilitated by: the low cost of tickets and tourist services; maintaining a balance between capacity and comfort in trains; and the possibility of crossing the territories of countries with different terrains and climates [8, 9]. This is ensured by:

- use of safe, reliable, environmentally friendly, energy-efficient, comfortable rolling stock [10-12];
- a professional approach to the management of transport processes, increasing the availability and quality of services [13-17];
- implementation of advanced technologies [18-22], scientifically based achievements in the field of transportation process organization and of the experience of leading global companies [23-25].

To ensure the safety of transportation, it is also necessary to develop the tourist infrastructure of the railways, considering the requirements for the development in society. For this, an algorithm for choosing a cost-effective tourist railway route was developed (Fig. 1). It is based on the use of description, explanation, and prediction of the choice between two or more fragmentary quantities. Empirical analysis of discrete planning is applied to determine alternative effective tourist routes. When forming the algorithm, the options of railway routes are considered as given ones. Therefore, it is necessary to determine what exactly is considered a selection task, that is, what constitutes the implementation of an optimal plan. It is important to consider potentially possible solutions depending on external conditions and the type of source information [26-30].

This algorithm was developed in line with the existing restrictions: requirements for rolling stock; the number of passengers, train runs, defined categories of routes, etc. The implementation of the algorithm in practice can: – ensure the maximum of the net present value criterion (with the established system of requirements for railway activity); – allow to determine the factors that are related to the choice of the most cost-effective tourist route; – to influence the individual decision of the management structures of railways with their further development.

At the same time, railway managers need to apply a set of scientific and methodological principles for regulating

production and consumption processes to ensure effective activity for managing railway tourist transportation. These principles are a chain of formal and informal rules of socio-economic interaction, which is consistently implemented in the process of managing the transport and tourist service system.

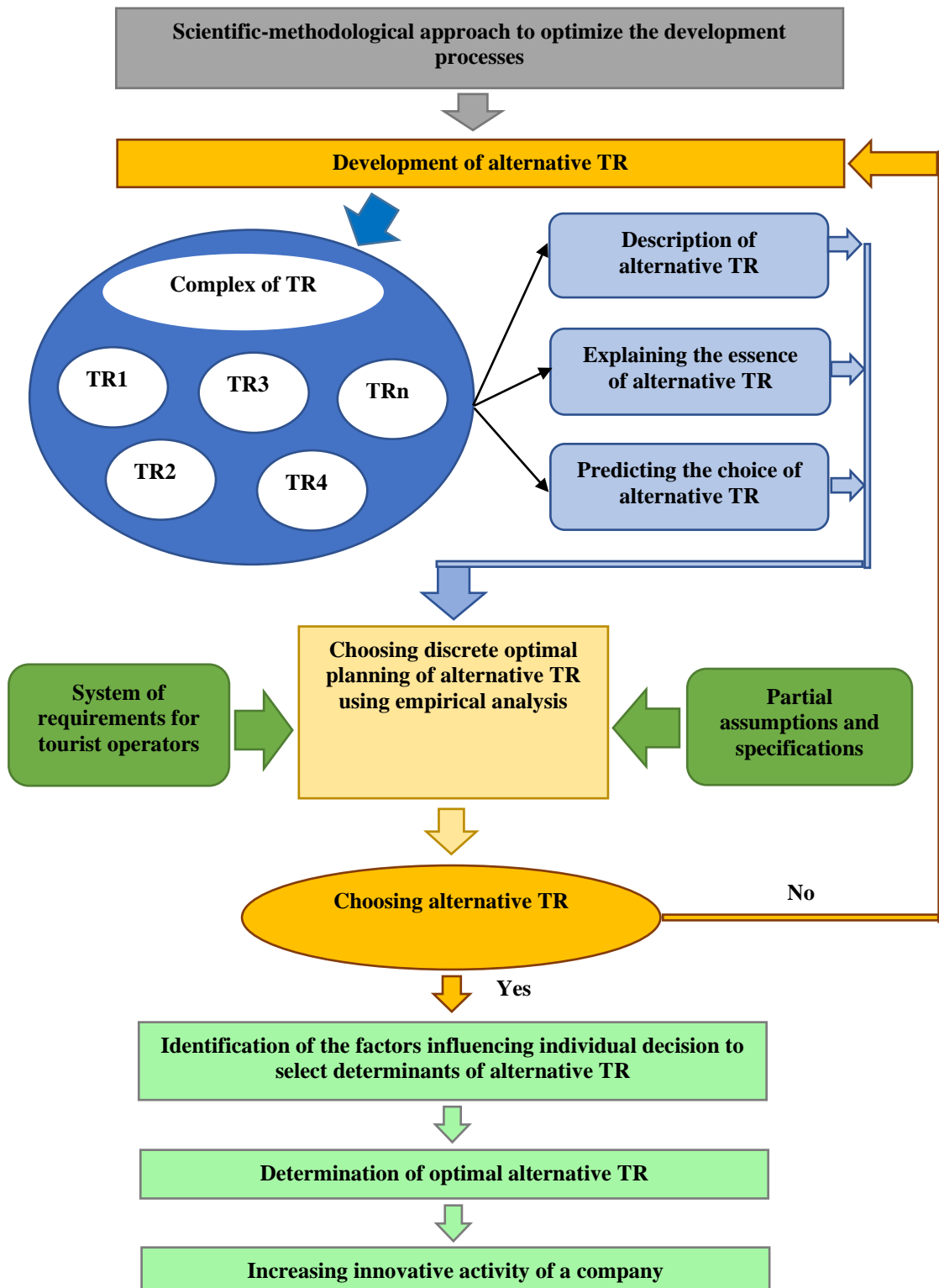


Fig. 1 Algorithm for choosing a cost-effective tourist railway route

When forming an algorithm for optimizing the processes of sustainable development of railways, it is recommended to take into account, in particular, the following:

- the independence principle of indicators on individual routes (groups of routes), which allows for building additive calculation models;
- fulfilling the requirement of connectivity of routes.

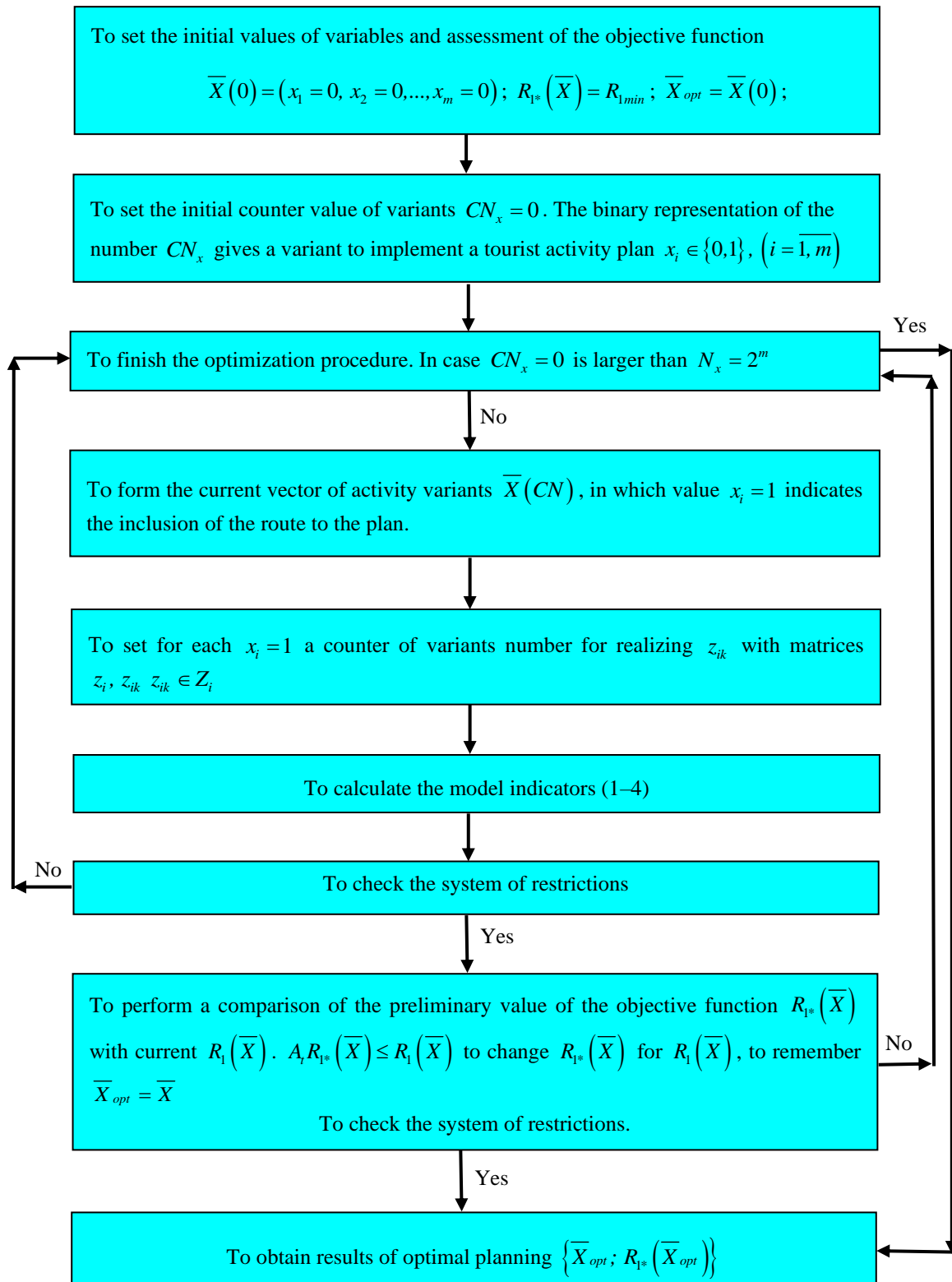


Fig. 2 The implementation scheme of the economic-mathematical model (1-4)

With the help of the algorithm, it is possible to determine the optimal (according to the criterion of maximum cost-effectiveness) tourist railway route. For this, we have to perform economic and mathematical modelling. Let us consider the formation of structures and model components in planning. In the conditions of the existence of certain variants for tourist routes  $M_i, i \in MI$  any implementation of optimal plans is to calculate numbers or indices of some subset of routes  $MI$ . Let us denote binary variables that correspond to some route with  $x_i \in \{0,1\}, (i = \overline{1,m})$ , where:  $m$  = the total number of tourist routes, and the value  $x_i = 1$  means a decision on the inclusion of the route to the optimal plan. The general vector in problem solutions of planning has the form:

$$\bar{X} = (x_1, x_2, \dots, x_m). \quad (1)$$

The optimal planning task will be:

$$\{W(\bar{X})\} = R_1(\bar{X}) \Rightarrow \frac{\max}{X \in G_x}, \quad (2)$$

where  $G_x$  is the tolerance region of the parameters of plans defined on the base  $\bar{X}$  (1);  $R_1(\bar{X})$  corresponds to the optimality indicator of  $N1$  variant,  $W(\bar{X})$  corresponds to any other model of optimal planning. A set of constraints  $G_x$  consists of the following components in organizing tourist railway transportation:

$$k \in \{T, V, C, t, I, P\}; \quad (3)$$

$$x_i \in \{0,1\}, \quad (i = \overline{1,m}); N_x = 2^m, \quad (4)$$

where  $G_T(\bar{X})$  – availability of a traction rolling stock;  $G_V(\bar{X})$  – availability of a passenger rolling stock;  $G_C(\bar{X})$  – coherence of routes;  $G_t(\bar{X})$  – restrictions on the travel time;  $G_I(\bar{X})$  – availability of infrastructure;  $G_P(\bar{X})$  – investment restrictions.

The implementation scheme of the economic-mathematical model takes the form (Fig. 2).

The general criterion for optimal planning will be as follows:

$$NPV = \sum_{t=0}^T \frac{(D_t - B_t) \left(1 - \frac{\gamma}{100}\right) + A_t \frac{\gamma}{100} - K_t}{(1 + E_m)^t} + R \rightarrow \max, \quad (5)$$

where  $NPV$  – is net present value;  $D_t$  – is the annual income that the railway can receive from all types of activities under various options;  $B_t$  – are annual total expenses of the railway from all types of activities under various options without depreciation deductions;  $\gamma$  – is an amount of income tax, %;  $A_t$  – are depreciation deductions;  $K_t$  – are annual investments for the implementation of tourist railway transportation on various routes;  $t$  – a number of the target year,  $t = 0, 1, 2, \dots, T$ ;  $R$  – is the reversion or investments that income-generating after the deadline in the investment payback period;  $E_m$  – is the real discount rate.

Equation (5) establishes the possible variants of tourist railway routes, among which it is necessary to determine the cost-effective one (in our example – according to the criterion of the maximum net present value).

### 3. Conclusions

For the organization of cost-effective tourist railway routes, the authors developed an algorithm for selecting one route from many available routes. Thanks to this, it is possible to ensure the maximum net present value with the established system of requirements for railway activity.

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