SOCIO-ECONOMIC AND ECOLOGICAL EFFECTS IN PROBABILISTIC APPRAISAL OF RAILWAY PROJECT

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ABSTRACT
The article justifies the economic appraisal of investments in the construction of railway lines with the allowance for socio-economic and ecological effects, as well as the probabilistic nature of the project environment. Examples of external benefits associated with railway project realization would be tax payments to the federal budgets, an increase in regional employment level, the reduction of environmental costs due to decrease in levels of air pollution, noise and climate change as a whole. The study aims to develop a probabilistic model of cash flows, effects and costs to compute the effectiveness of budget investments in complex infrastructure facilities.

Keywords: Socio-Economic and Ecological Effects, Economic Appraisal, Railways

1. INTRODUCTION

A series of economic crises threaten investments in mega-infrastructure projects. These projects include railway lines, the construction of which requires significant budgetary investments (Hilmola and Panova, 2020, Raicu et al., 2019; De Rus and Nombela, 2007). The capital outflow and concentration of all efforts on other projects are among the reasons for the delay in railway construction in Russia. At the same time, there is an insufficient scientific and methodological base for the economic appraisal of these transport investments (Panova, 2016; Shiftan et al., 2002). According to Fedorova (2019) and Shiftan et al. (2002), one of the significant limitations is the external nature of the project effects that could be hardly measured. And if measured, then different models and units, e.g. monetary, minutes, grams, decibels, etc. are applied simultaneously that, in turn, complicates analysis and reduces the reliability of the final results of capital budgeting.

A comprehensive economic appraisal is essential for many transport infrastructure projects, especially those that require facilitation. Examples of such projects in Russia would be railway lines, ensuring the delivery of goods to the Northern Sea Route, and connecting the timber industry zone with the mineral deposits of the industrial Urals. Due to the change in the global economic environment and macroeconomic indicators caused by the global financial crisis the realization of these projects has been delayed (Depeconom.admhmao.ru, 2020;

Cupp.ru, 2020).

\Meanwhile, these projects are of great strategic importance for the real sectors of the regional economies. It provides economic efficiency in the region for the following objective reasons: the creation of new jobs and, as a consequence, the reduction of unemployment; growth of household income; increase in tax revenues to the budget; consolidation of the population on the territory of the region and improvement of the demographic situation. Hereby, the implementation of such projects creates social effects in addition to economic benefits (Zvereva, et al. 2015; Rozhkov, 2015, Mironova, 2013). Moreover, there are ecological externalities, associated with the reduction of the harmful impact on the environment, which is likewise a weighty argument in favour of projects implementation (Turró, 2004, Fedorova, 2019).

The purpose of this study is to identify socio-economic and ecological effects that support railway project development. The attention is focused on the inclusion of these effects into economic appraisal model to determine the efficiency of investments in railway construction. The specific research questions are: (1) 'What are the socio-economic and ecological effects that facilitate railway project development?' and (2) 'How these external effects are evaluated in the probabilistic model of project appraisal?'. These questions have been analysed through literature review and development of capital budgeting methodology.

The remainder of this paper is structured as follows: To begin with, the main external effects of railway project development are discussed in Section 2. Effects considered in the analysis grouped into three categories (e.g. social, economic and ecological). In Section 3, an appraisal model with the allowance of external effects and their probabilistic nature is presented. Finally, the study is discussed and concluded in Section 4.

2. EXTERNAL EFFECTS OF RAILWAY INVESTMENT PROJECTS

When assessing the socio-economic efficiency of a project, it is advisable to take into account all possible effects in relation to the specifics of the project and the development strategy of the region. In the scientific environment, this point of view is supported by Nagaeva (2016) and Fedorova (2019), claiming that the implementation of any investment project should not only comply with the socio-economic goals of the region's strategy but also contribute to the achievement of its target indicators. Danchenko (2016) sees an expression of the social effect from the implementation of an investment project in a direct form (construction and further operation of the facility) and indirect (formation of tax revenues, an increase in investment in sectoral and regional development). We believe that direct and indirect effects create both an accelerator and a multiplier effect, and subsequently are important for the economy of the region and its population (Zhuravleva, 2013).

Nowadays, the analysis and evaluation of transport infrastructure external effects are used for the project appraisal and ranking (Shiftan et al., 2002; Fedorova, 2019; Raicu et al., 2019). In many cases, such indirect effects justify the investment in high-speed railways (HSR) projects (Fedorova, 2019, De Rus and Nombela, 2007). For instance, the economic efficiency of the HSR project 'Moscow - St. Petersburg' was calculated with the allowance of cash inflows and outflows, characterizing the external economic effects of the project (Lapidus, 2009).

Examples of these effects would be additional profit of industrial enterprises that is formed during the construction of the high-speed rail; additional profit of electricity producers associated with the operation of the HSR; an increase in revenues to the budgets of all levels due to tax payments from Russian Railways and indirect participants with the implementation of the project; reduction in the profit of air carriers due to the switching of part of the passenger traffic to high- speed rail; reduction of budgetary expenditures on the implementation of state policy to promote employment of the country's population; cash inflows generated by the cost estimate of reducing the time for passengers to travel on high-speed lines from Moscow to St. Petersburg and back; additional profit for construction companies creating residential and commercial real estate in areas gravitating towards the new railway line that is explained by increased income of the population and , as a result, demand for housing.

Generally speaking, external effects of an economic nature are the effects in the form of costs or income of legal entities, while the effects in the form of costs or income for individuals are social effects (Mironova, 2016). Examples of the latter would be a growth of employment of the population and increase of population income; the reduction in morbidity and mortality of the population in the region of influence of the railway in connection with the normalization of transport connectivity in the region; cost estimate of the reduction in time spent on travel travelling in connection with the commissioning of the railway line; reduction population spending on food and non-food products due to the expansion of the consumer market associated with the possibility of transporting food and non-food products to the areas of people residence (Mironova, 2013; Fedorova, 2019; Makeeva and Kalachev, 2016; Rozhkov, 2015).

The third group of effects are of ecological nature, such as reduction of air pollution, climate change, noise, etc. The same groups of factors are presented by European railway project appraisal guidance (Turró, 2004). Particularly, these are the benefits for users and operators in terms of time and money savings, then safety benefits, values for vehicle operating costs, as well as ecological externalities. Some authors additionally mention about growth of gross domestic and gross regional product, agglomeration effects (Zhuravleva, 2013; Lapidus & Nesterov, 2017; Rozhkov (2015). Zhuravleva (2013) also highlights the effect of the growth in national wealth, which consists of an increase in the value of existing real estate and the value of newly built ones that all together with other benefits constitute a so-called multiplicative affect (Panova and Hilmola, 2018).

Naturally, the set of factors that determine the external effects of a particular project depends on the category of the project (e.g. railway line), the significance of the project for society as a whole, for a particular region, and a branch of the economy. Different external effects for the projects and their influence on capital budgeting decision-making have been comprehensively presented by Mironova (2013) and Rozhkov (2015). Meanwhile, the deterministic nature of models doesn't allow to assess investment projects in a probabilistic environment. According to our research, there is a gap in the sphere of probabilistic models that would contribute to advanced capital budgeting. Therefore, we propose an appraisal of railway investment with the allowance for socio-economic and ecological effects, as well as the probabilistic nature of project environment by means of Monte Carlo simulation.

3. MONTE CARLO ANALYSIS OF SOCIO-ECONOMIC RAILWAY PROJECT

If the contribution of public funds has the largest share in the structure of project investments, there is a need to identify not only commercial efficiency of the project but also socio-economic efficiency of the project should be determined. In this regards, it is essential to consider both, direct and indirect effects. Direct effects are generated directly by the project itself, without taking into account intersectoral relationships. These include the following:

- the volume of goods, works and services produced within the project;
- the number of jobs created as part of the project;

- the average salary of workers employed in the project;
- the volume of tax revenues to the regional budget;
- the number of resources saved as a result of the project;
- social and transport infrastructure created within the project.

Indirect effects, arise as a result of the indirect influence of the project on the socio-economic system of the region through the impact on other projects and sectors of the region's economy, for example, creating tax revenues from the project for the development of the social sphere, transport infrastructure, priority areas of economic activity, because initiate an additional increase in investment in various sectors of the region's economy.

The model of cash flows, investments and costs for assessing commercial efficiency of the project could be assessed by a simple model of net present value (Kazaku and Narkevskaya, 2013; Panova, 2016):

$$NPV = \sum_{t=0}^{T} \alpha_t (P_{Tt} - I_t) \quad (1)$$

where NPV is the net present value for the estimated period T, years; α_t - is the discount factor at step t; Pтt - net profit from cargo transportation; I_t – investments.

The model of cash flows, effects, results and costs for assessing the socio-economic efficiency of investments should additionally include external effects, for instance, federal taxes, the effect of increasing the level of regional employment and decreasing of ecological costs.

There are two types of tax on profit. That is of federal and regional level. The tax on profit from the sale and transportation of goods deducted to the federal budget from 2017 to 2024 equals 3%. If the project is included in the register of regional investment projects, then the rate of contributions to the constituent entities of the Russian Federation during the first five years after the commissioning of the facility will be no more than 10% and no less than 10% over the next five years (Tax Code of the Russian Federation, 2000).

Value-added tax is determined at the rate of 0% for the export of goods and 20% for domestic sales during the quarter. Excise goods include crude oil, i.e. a mixture of hydrocarbons (oil; stable gas condensate). Excise taxes are charged monthly with the calculation of the rate according to the formula given in the Tax Code. Personal income tax is determined at the rate of 13% of the wages fund per year. Mineral extraction tax is determined for each type of minerals and is calculated from their value for a calendar month at the rates regulated by the Tax Code.

The effects of an increase in the level of regional employment of the population include the total increase in physical terms of the level of wages in the region, due to an additional influx of population for the implementation of the project, as well as an increase in the purchasing power of the population as a whole, taking into account the redistribution of workers to new positions and places.

The inflows of the investment project additionally include ecological externalities. Their detailed measurements are provided in the European railway project appraisal guidance (Turró, 2004) and the Handbook on the external costs of transport (Move, 2019). If the latter is used than the savings on ecological cost could be computed as a difference between the "no-project" status and the "completed project" situation. Move (2019) provides the cost estimate of environmental damage by mode of transport, including air pollution costs, climate change cost and noise costs measured as €-cent per tkm.

To account for the uncertainty and estimate the probability nature of the investment environment, the Monte Carlo method ca ne used. It has number of advantages in comparison with the risk adjustment method (Kazaku and Narkevskaya, 2013). Monte Carlo uncertainty accounting is based on the use of statistical data, which increases the level of confidence in the assessment results. Whereas the risk adjustment method uses assigned values of risk adjustments depending on subjective perceptions of the degree of uncertainty (Panova and Hilmola, 2015).

The essence of the Monte Carlo method is the generation of pseudo-random values of the project parameters, the calculation of project performance indicators (e.g. NPV; discounted payback period, DPP) and the assessment of their average value (mean) and standard deviation. Specifically, the standard deviation can be used as a measure of risks (Kazaku and Narkevskaya, 2013; Panova, 2016; Hilmola and Panova, 2020).

In conditions of an increased level of risk and uncertainty accompanying the implementation of capital-intensive projects, it is advisable to supplement the aggregate criterion of payback period by taking into account the uncertainty of the main parameters of the project. The discounted payback period is widespread in business practice, especially when uncertainty is included in the decision support systems. It is explained by the reason that the acceptance of the project by the positive NPV alone omits the exposure of the project's useful life to risks (Panova, 2016).

The cumulative criterion for justifying the effectiveness of an investment in railway construction, taking into account uncertainty, should be considered by the obtained values of the mean (mathematical expectation) of the payback periods that do not have to exceed the standard values of the payback periods at each of the project investment levels:

$$K'_o(\hat{Vi}_t;\hat{Si}_t;\ldots N):\begin{cases} m\tau_o^{ф}(\hat{Vi}_t;\hat{Si}_t;\ldots N)\le \tau_н^{ф} \\ m\tau_o^{р}(\hat{Vi}_t;\hat{Si}_t;\ldots N)\le \tau_н^{р} \\ m\tau_o^{п}(\hat{Vi}_t;\hat{Si}_t;\ldots N)\le \tau_н^{п} \end{cases} \quad (2)$$

where K'_o is the aggregate criterion of the project's effectiveness, taking into account the uncertainty of the volume of cargo transportation, the cost of selling goods and other factors N;

$m\tau_o^{ф}$, $m\tau_o^{р}$, $m\tau_o^{п}$ is the average value of the payback period, respectively, at the federal, regional and enterprise levels;

$\tau_н^{ф}$, $\tau_н^{р}$, $\tau_н^{п}$ - normative (required) values of payback periods for federal, regional and enterprise levels;

Vi_t, Si_t - traffic volumes and the selling price of the i-th type of cargo for the period t, respectively.

Using a pseudo-random number generator for the specified uncertainty characteristics of random factors, such as the volume and cost of goods, as well as the population migration influx, the values of the payback periods have been determined.

The amount of risk adjustment was assumed at 8%, while the adjusted discount rate at 17.66%. Copper was singled out among the main cargoes, having the highest selling price. Monte Carlo simulation was performed 100 thousand times. With the help of Monte Carlo simulation, the probabilistic characteristics of the selected parameters were introduced into the model and the probabilistic characteristics of the capital budgeting indicator were calculated. This is the payback period for each of the investment levels. Calculations have shown that the efficiency of the project is achieved at all investment levels for each of the participants. The federal-level reflects the relationship of the largest inflow of capital investments and tax deductions to the Federal budget generated by the investment project. The regional-level demonstrates the ratio of investment investments of the constituent entities of the Russian Federation and tax deductions in the regional budget, as well as an increase in regional employment due to the inclusion of new employees in the operation of the railway and due to an increase in the average wage. The enterprise-level takes into account the interests of private investors and reflects the efficiency for Russian Railways and mining companies.

4. CONCLUDING REMARKS

The study presents a model for assessing budgetary efficiency for investments from the federal and regional budgets, taking into account the social effect of increasing local employment of the population, as well as commercial efficiency for the share of investments of enterprises, future mining companies. Based on the model, it is possible to identify the most acceptable investment volumes in order to achieve the optimal investment payback period. For example, for Russian Railways, the required investment volume is 5-8%, which ensures that the investments payback within 10 years.

The model for justifying the effectiveness of investment projects for the construction of railway lines reflects the specifics of the investment project and takes into account probabilistic uncertainties. It provides more reliable results than the results of a deterministic assessment. The Monte Carlo method has shown itself to be a more accurate mathematical assessment tool. The results obtained should be characterized as more reliable than the results of a point assessment using the risk adjustment method.

The results of the study showed that the volume and cost of goods at the time of commissioning have the greatest importance on efficiency indicators. Meanwhile, the factor of the migration influx of the population in the construction area has an insignificant effect. Due to the high rates of return on investment, the investment efficiency indicator is more sensitive to the selected factors at the early stages of assessment (up to 10-15 years). Also, the payback period for the regional level, as well as the enterprise level, is more sensitive than the payback period at the federal level.

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