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RESEARCH OF ECONOMICAL EFFICIENCY OF ROAD PROJECTS

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ABSTRACT: The guidelines and recommendations for the assessment of economic efficiency of road and bridge projects are specified in two documents: "Blue Book" in range of road infrastructure projects, and in "Instructions for economic efficiency assessment for road and bridge projects for regional, district, and local roads". The result of works connected with analysis of road investments should be the documents referring to all possible issues discussed in mentioned books. The article is aimed for presenting the successive steps and assessment of economic efficiency of road projects.

KEY WORDS: cost-benefit analysis, assessment of the economic effectiveness of road and bridge projects

Standards of economic assessment of efficiency of road investments

The article is aimed for presenting the successive steps and assessment of economic efficiency of road projects. In Poland two standards are used in case of assessment of economic efficiency of road and bridge projects. They are included in two separate documents: "Blue Book" in range of road infrastructure projects, and in "Instructions for economic efficiency assessment for road and bridge projects for regional, district, and local roads".

The "Blue Book" is recommended by the Ministry of Infrastructure and Development in order to unify the methods of analysis of costs and advantages of the transport sector projects, realized in range of "Infrastructure and Environment Programme", which total value of qualified costs exceeds 75 millions of EUR. The guidelines included in the "Instructions for economic efficiency assessment" make the accuracy of realized economic analyses dependent on the road type, dividing it into the regional, district, and local roads.

The "Guide for analysis of costs and advantages of investment projects", being a tool of the economic analysis of cohesion policy for years 2014-2020, presents the analytical range of standard analyses of "large projects", including roads, which should include seven stages (Guide for analysis of costs and advantages of investment projects, 2014):

- 1 – context description,
- 2 – definition of goals,
- 3 – identification project,
- 4 – technical feasibility and environmental sustainability,
- 5 – financial analysis,
- 6 – economic analysis,
- 7 – risk assessment.

(1) *Description of the social, economic, political, and institutional context in which the project will be realized.* The investments which offer services for citizens may realize their goals through including new or modernized objects to the existing infrastructure. It is therefore necessary to cooperate with various stakeholders operating in the system range. Appropriate economic policy, suitable institutions, and strong political engagement may help in realization of some projects and managing them in order to achieve higher advantages.

Construction of roads in Poland reinforces the integrity of our country with other countries of the European Union, supports the international transport, creates better conditions for the efficient and safe traffic flow in

the European transport corridors, facilitates the mobility of goods and services by increasing the traffic safety, and activates the economic expansion of a region and country through better transport services.

(2) Definition of goals. The basic premise for realization of transport projects is the necessity of solving the existing or foreseen transport problems or fulfilling the existing or foreseen transport needs, as well as forming the demand for transport towards the sustainability. While defining the goals of a single project it is required to present their cohesion with the goals included in the transport strategy, and having such strategy (on the national and/or regional level, appropriate for a given project) is one of ex-ante conditions for applying for financing the project from the EU funds for 2014-2020 (Blue Book, 2015). The medium for achieving the goals of the road project is usually the improvement of condition of existing road, removing and limiting overcrowding, bypassing the built-up area, reducing the number of accidents, etc.

(3) Project identification. The project is defined as a “series of works, activities, or services aimed for realization of the indivisible task of specified economic or technical character, having clearly defined goals”. Each goal connected with development of the road infrastructure may be achieved in numerous ways, which means multiple possible realization variants, from which the most promising one is selected. All investment variants are compared with the input variant of costs and advantages analysis, i.e. with the non-investment variant (Blue Book, 2015). The non-investment variant is a variant describing the level of foreseen costs and efficiency of infrastructure when no investment variant is realized, which means that the costs of periodical and partial repairs, as well as costs of current maintenance must be anticipated, allowing for assuring the minimum standard of maintenance and operation of the road infrastructure. The investment variants, beside the costs of maintaining the new or renovated section, are also characterized by the investment outlays to be incurred during the first year and possibly in the next years. The investment outlays are divided into: preparation works, dewatering of the road embankment, realization of substructure layers, works connected with realization of upper layers of the pavement structure, finishing works, realization of traffic safety devices, elements of streets, road greens, engineering objects, realization of street lamps, removal of collisions (rebuilding of gas, sewage, water, power, and telecommunication networks, etc.), and others. Selected variants should be described with use of key parameters, like length, designed speed, roadway width, cross section, etc.

(4) Technical feasibility and environmental sustainability. The feasibility analysis is aimed for identifying the alternative investment solutions which may be considered feasible mainly in the technical, economic, environmental,

and institutional range. In particular it is required to prove in what range the project (Guide for analysis of costs and advantages of investment projects, 2014):

- contributes in achievement of goals in range of efficient resources management and climate changes for 2020;
- conforms to the directive regarding prevention and rectification of the natural environment damages;
- follows the rule “the polluting party pays”, the prevention rule, and the repair rule mainly at the source;
- conforms to protection of areas Nature 2000 and protection of species covered by the habitats directive and the birds directive;
- is realized as a result of plan or programmed covered by the strategic assessment of environmental influence;
- conforms to the directive on the assessment of the effects on the environment, as well as other regulations including the requirement of such assessment.

The roads location areas should be selected in a way minimizing the potential ecological conflicts and avoiding the direct collisions with areas covered with environmental protection. In the situations of excessive interference with environment, resulting from the character of road investments, it is required to use the environmental compensation reducing the negative influence on environment and compensating the environmental losses (Act from 27.04.2001, Environment Protection Law). In case of particularly heavy influences use the technical measures reducing those influences. In order to limit e.g. negative influence of rain and snow melt sewage on the natural environment it is required to design the solutions limiting the possibility of their penetration to the underground and surface waters. In order to improve the acoustic climate use the road tunnels, anti-noise covers, or acoustic screens.

(5) *Financial analysis.* Range of the financial analysis includes determination of the project financial efficiency indices values, verification of the project financial durability, and determination of appropriate (maximum) financing from the EU funds. It is usually realized from the infrastructure owner’s point of view. In order to determine the financial efficiency indices and calculate the financing gap the financial analysis uses the method of discounted flow of financial means. The analysis of financial durability is aimed for verification if the financial resources are sufficient for covering all financial expenses, year after year, during the whole reference period. The financial durability of an investment is confirmed when the cumulated net cash flow are not negative in any of analysed years.

(6) *Economic analysis* is the assessment of project contribution in the prosperity (Guide for analysis of costs and advantages of investment projects, 2014). It includes the quantitative and financial expression of costs and calculation of the net economic advantages upon the basis of so called the increment method. Such approach requires preparation of the forecast of the economic flows for the non-investment variant, preparation of the forecast of the economic flows for the project realization variant, and then determination of differences in the flows between those scenarios. Generally the economic advantages are the difference between the total economic costs in the non-investment variant and the analogical costs in one of investment variants.

Skilful and precise estimation of the investment outlays is the basis for the ANALYSIS OF COSTS AND ADVANTAGES. For the road projects it is recommended to divide them into the categories including the documentation and technical assistance costs, investor's supervision costs, archaeological costs, project promotion costs, road works costs, "contract-related" costs, and reserves for the non-foreseen works.

(7) *Risk assessment* is an activity aimed for avoiding the uncertainty accompanying the investment projects. The recommended stages of the risk assessment (Blue Book, 2015) include: risk identification, risk qualitative analysis, preventive actions and their allocation, monitoring, and risk quantitative analysis.

The procedure of the economic assessment of the road and bridge projects is a procedure (Instructions for economic efficiency assessment..., 2008) based upon CBA method, taking into consideration the advantages of users of analysed investment and the road costs (construction, repairs, maintenance).

The economic analysis of costs and advantages presented in (Instructions for economic efficiency assessment..., 2008) includes comparison of two incremental economic flows:

- net road and bridge costs – NC,
- net savings of users and environment – NB.

The difference of NB and NC flows gives the net value NV being the basis for calculation of the investment economic efficiency measures.

The calculation of economic efficiency is realized upon the basis of independently prepared input data and the parameters of elements being a part of the economic account including:

- traffic measurement and calculation of the average daily traffic,
- forecast of the average daily traffic,
- travel speed,
- road costs,
- vehicle operational costs,

- time costs in the passenger transport,
- time costs in the cargo transport,
- costs of the road accidents,
- costs of emission of the toxic components of exhaust gases,
- costs of users and environment.

The sensitivity analysis is the supplementary stage in the assessment of road and bridge investments. The research include the investment costs only. The research details level depends directly on the investment location. In case of investments out of the cities administrative limits the investment costs increase by 15% is analysed, and in case of investments in the city areas it is required to analyse the investment costs increase by 25%.

Economic indices of efficiency

Realization of the economic assessment of projects, not only the road ones, is possible after determination of the following economic indices of efficiency (Guidelines in range of problems connected with preparation of investment projects, 2015):

- a) economic net present value (ENPV), which should be higher than zero,
- b) economic rate of return (ERR), which should exceed the assumed discount rate,
- c) relation of discounted advantages to discounted costs (NB/NC), which should be higher than one.

The economic net present value (ENPV) is the difference between the total discounted advantages and costs connected with the investment. It is recognized that the project is economically efficient when the economic net present value index is positive. In case of projects where it is not possible to determine ENPV due to their character there is a possibility of realizing the cost efficiency analysis.

The economic rate of return is equal to the assumed discount rate. In case when ERR is higher than the assumed discount rate, ENPV is negative, i.e. the present value of future economic advantages is lower than the present value of project economic costs. When the economic internal rate of return is lower than used discount rate, the project is not economically efficient.

The NB/NC index (advantages/costs) is determined as a relation of summarized advantages to the summarized discounted costs generated in the reference period. It is recognized that the investment is efficient when NB/NC index is higher than one, i.e. value of advantages exceeds value of investment costs.

In case of road projects not considered “large” it is recommended to realize the economic analysis in the simplified way, upon the basis of estimation of the quantitative and qualitative results of realization of a given project.

Analysis of costs and advantages

Analysis of costs and profits is an assessment of investment projects where costs and profits for the society as a result of investment realization are taken into consideration. The analysis is based upon the assumption that in order to increase the social prosperity it is required to realize not only the economically efficient and financially profitable, but also the economically efficient and financially non-profitable, which financial profitability is achieved with use of public funds (Rudnicki, 2005, p. 332). That method is obligatory in case of applying for financing of large projects from the EU funds.

The analysis of costs and advantages may be realized in a time preceding the decision of accepting or rejecting the project (*ex ante* analysis). The basic problem of such analysis is high risk of errors connected with assessment of many aspects included in the final result, and its advantage – the possibility of abandoning or interrupting the investment which might cause big losses for society. The second type of analysis is *ex post* analysis, which is realized after the project is finished in order to assess it. The third type of analysis is *in media res* analysis, i.e. analysis realized during the project realization (Boardman et al., 2001, p. 3).

The process of CBA analysis is realized according to strictly defined rules including the project financial analysis, as well as social and economic analysis (also called the economic analysis or social and economic analysis). The social and economic analysis may have a form of the investment costs and advantages balance. It is then called the qualitative social and economic analysis. However, the investment effects for society and environment may be also quantified (express with use of enumerable parameters) and monetized (converted into money). The monetized social and economic effects are added to the properly prepared account of flows from the financial analysis. It is then called the quantitative analysis of costs and advantages. The quantitative methodology of CBA allows to determine the values of the investment economic efficiency indices (Archutowska et al., 2016, p. 9).

Assessment of economic efficiency of the investment task consisting in rebuilding the national road to the major road standards

The analysis of costs and advantages is the comparison of the project scenario for the investment variant (W1) with the base scenario for the non-investment variant (W0). In order to determine the indices of the economic assessment for the investment task consisting in rebuilding the national road to the major road standards (the required technical data are presented in table 1) the following assumptions have been made:

Table 1. Technical data of the national road rebuilt to the major road standards

No.	SPECIFICATION	UNIT	W0	W1
1	2	3	4	5
1	National	-	ROAD	
2	Segment length	[km]	22.2	
3	Terrain type	-	FLAT	
4	Road type	-	COUNTRY ROAD	
5	Road class	-	S	
6	Number of roadways	[pcs]	1	2
7	Number of roadway lanes	[pcs]	2	2
8	Roadway width	[m]	6.50	7.00 emergency lane 2.50
9	Shoulder width	[m]	1.50	0.75
10	Average allowable speed	[km/h]	90	120
11	Pavement technical condition acc. To sosn		B	A
12	Bus bays		yes	yes
13	Traffic character		ECONOMIC	
14	Investment start year	[year]	-	2009
15	Investment end year	[year]	-	2012
16	Investment net cost	[PLN]	-	884,477,342
17	Traffic category	[KR]	6	6
18	Bridge objects	[CONDITION]	4	5

Source: author's own work.

- reference period – 25 years (for the road projects; since the construction beginning, in this case years 2009-2034),
- year consists of 365 days.

In order to define the values of indices of the economic assessment the recommended forms have been prepared: traffic forecast, road costs, vehicle operational costs, time costs in the passenger transport, time costs in the cargo transport, costs of the road accidents, costs of emission of the toxic components of exhaust gases, cumulative summary of costs of users and environment, economic analysis if outlays and advantages, values, and economic indices (table 2). The forms include costs for both variants: W0 and W1. The road net costs and savings for users and environment have been calculated for all years of the analysed period.

Table 2. Values and economic indices for the investment task consisting in rebuilding the national road to the major road standards [thousands of PLN]

DESCRIPTION		VALUE OR INDEX FOR DISCOUNT RATE r			
		0,02	0,04	0,06	0,08
<i>1</i>		<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>
NC	Discounted investment net cost	-1 106 447,36	-1 019 179,79	-952 022,77	-898 805,58
	Discounted savings of vehicles operational net costs	337 443,85	246 606,03	183 927,28	139 885,92
	Discounted savings of time net costs in passenger transport	13 357 319,20	9 538 485,37	6 946 666,03	5 157 453,90
NB	Discounted savings of time net costs in cargo transport	5 424 987,06	3 942 518,75	2 919 701,57	2 201 773,84
	Discounted savings of accidents net costs	636 781,21	475 115,95	361 681,27	280 609,48
	Discounted savings of environment net costs	1 330 965,04	986 547,31	744 943,07	572 434,93
ENPV	Economic net present value [-]	19 981,05	14 170,10	10 204,90	7 453,40
NB/NC	Advantages – costs index [-]	19,06	14,90	11,72	9,29
EIRR	Economic internal rate of return [%]	36,3061			

Source: author's own work.

The realized analysis has revealed, for various values of discount rate, that in each of the analysed cases:

- 1) the discounted savings exceed the discounted net costs including all investment, repair, and maintenance outlays (*ENPV is positive*), which

- means that the project consisting in rebuilding the national road to the major road standards is efficient,
- 2) the sum of discounted savings divided by the sum of discounted net costs is higher than 1, i.e. the task is economically justified,
 - 3) the interest rate of 36.3061% is the rate for which the economic net present value of advantages expected from a given investment will be equal to the value of outlays.

Summary

The analysis of costs and advantages is the practical and versatile assessment of the investment project and determination if a given project “deserves” to be realized from the social point of view. To that end the social, environmental, and health advantages/savings are valued and the economic efficiency indices are determined being the economic basis for the investment decision.

The assessment of economic efficiency of road and bridge projects is realized upon the basis of guidelines and recommendations included in two separate documents: “Blue Book” in range of road infrastructure projects, and in “Instructions for economic efficiency assessment for road and bridge projects for regional, district, and local roads”.

The “Blue Book” is recommended by the Ministry of Infrastructure and Development in order to unify the methods of analysis of costs and advantages of the transport sector projects, realized in range of “Infrastructure and Environment Programme”, which total value of qualified costs exceeds 75 millions of EUR. Whereas the “Instructions for economic efficiency assessment of road and bridge projects” make the accuracy of realized economic analyses dependent on the road type, dividing it into the regional, district, and local roads.

The costs and social and economic advantages of the road infrastructure projects are estimated dividing them into the categories including vehicle operational costs, time costs of the road infrastructure users, costs of the road accidents and victims, costs connected with emission of pollutants, costs of excessive noise influence.

All savings in the social costs should be treated as the project advantages, while all negative results influencing the rise of social costs should be treated as the project costs.

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