Risk variables in evaluation of transport projects

Petr Vařbuchta[1], Hana Kovářová[1], Vít Hromádka[1] and Eva Vítková[1]

[1]Brno University of Technology, Faculty of Civil Engineering, Veveří 331/95, 602 00 Brno, Czech Republic

E-mail: petr.varbuchta@seznam.cz

Abstract. Depending on the constantly increasing demands on assessment of investment projects, especially assessment of large-scale projects in transport and important European projects with wide impacts, there is constantly increasing focus on risk management, whether to find mitigations, creating corrective measures or their implementation in assessment, especially in the context of Cost-Benefit analysis. To project assessment is often used implementation of certain risk variables, which can generate negative impacts of project outputs in framework of assess. Especially in case of transportation infrastructure projects is taken much emphasis on the influence of risk variables. However, currently in case of assessment of transportation projects is in Czech Republic used a few risk variables, which occur in the most projects. This leads to certain limitation in framework of impact assessment of risk variables. This papers aims to specify a new risk variables and process of applying them to already executed project assessment. Based on changes generated by new risk variables will be evaluated differences between original and adapted assessment.

1. Introduction

Transportation has always been very important part of the economy. Its importance is rooted in our society since ancient times. The trade starts on local level, gradually regional, national and transnational level, and couldn´t be so profitable and feasible without possibilities that transportation allows us. Equally transportation is important for people themselves. Only a few of us can imagine living in isolated place, without larger possibility to travel to work, to the family, or entertainment. Only just transportation, modern means of transportation and gradually development of transportation infrastructure allows this for all of us.

Investment directed to the transportation infrastructure reaching enormous amounts of financial sources. For this great emphasis the comprehensive evaluation of these investments in relation to expected effects in the context of benefits is important.

We actually know and use predominantly four types of transportation: by vehicle (road), by plane (air), by ship (water) and by train (railway). Road transportation has its own transportation network, which includes roads, highways, speedways etc. Air transportation uses point infrastructure of airports all around the world. Water transportation uses natural and artificial water surfaces, which are rivers, canals, dams, seas etc. And at last railway transportation uses its network of different types of rails, which includes local railways, major corridors etc.

For assessment of investment in transportation and for road transportation a lot of assessment methodologies exist. Some of them are the same, but some methodologies for roads have its specifics and differences. Actually there are tendencies to improve the methodologies of assessment with

respect to business as usual, real opportunities of construction projects and their risk. This paper is aimed just to road transportation infrastructure and precisely at its risk and risk variables, which are used for investment projects assessment.

2. Literature review

As already mentioned above, building of transportation infrastructure is necessary in framework of sustainable development. Transportation infrastructure is intermediary of economic improvement. But it´s important to come out of sophisticated analysis, which can evaluate every benefits and costs of the transportation project. We must realize that only well infrastructure equipped regions have the sufficient potential for economic growth. Compared to that, isolated regions will never dispose by attractiveness for entering of new economical subjects to the local market. It´s simple, because these activities wouldn´t be profitable.

In assessment of infrastructure investment there are many default aspects and methodologies, but in business as usual there is analysis of costs, benefits and great consideration is taken to the risks. All this is included in the most used analytical tool, invented for assessment of large-scale projects with enormous impacts: Cost-Benefit Analysis (CBA). This analysis is used in assessment of every important transportation projects. Methodology itself coming out of document called Guide to Cost-Benefit Analysis of Investment Projects and actually from its version for programing period 2014 – 2020. This document was published by European Commission [1]. Some authors study and adjust this methodology with aim to its use in response to feasibility studies and building of new roads and corridors as del Giudice and collective [2]. Or aim their research to perspective in transportation of specific state as MacKie in paper called Cost-Benefit Analysis in Transport: A UK perspective [3].

J Korytárová and P Papežíková deal detailed with this problematics in case of extensive projects using Cost-Benefit Analysis in their paper called Assessment of Large-Scale Project Based on CBA. [4]

In the Czech Republic is effort to the nearest connecting to Guide to Cost-Benefit Analysis of Investment Projects [1] in assessment of transportation infrastructure. This is conditioned by regulation of European Commission. Actually the document called Methodology for assessment of Economical Effectiveness [5], related to assessment of transportation projects, exists. This document is published by Road and Motorway Directorate of the Czech Republic (ŘSD ČR). This institution has in its jurisdiction the most important road corridors in the Czech Republic. This methodology is temporary document, before implementation of final methodology. This final methodology should be released in 2017.

But our attention should be focused mainly on risks of projects, which is able to affect project itself by higher costs, or its infeasibility in reality. This all is coming out of imminent risks. Andrei Soeanu and collective pursued more attention to problematic of risks in paper Transportation risk analysis using probabilistic model checking. [5]

J Korytárová together with B Pospíšilová describes risks in framework of Cost-Benefit Analysis in paper called Evaluation of Investment Risks in CBA with Monte Carlo Method [6]. This describes the relation between default cash flow and affected cash flow by risk. In this case they also handle with its impacts to principle of 3E (Economy, Effectiveness and Efficiency). This paper output is connected to decision making bounded to risk analysis and its managing.

Many of authors aim its research to specific branch of risks connected with environment. This risk impacts are described in paper aimed to environmental impact assessment of transportation projects inscribed by E Igondova, K Pavlickova and O Majzlans called The ecological impact assessment of a proposed road development (the Slovak approach) [8]. This paper describes main ecological risks of transportation infrastructure projects.

Risks are usually similar in assessment of projects in transportation infrastructure. The most emphasis is given to analysis of risks bound to increasing of total costs and extension of construction time. This paper is based on this problematics and its aim is to specify new and detailed important risks.

3. Methodology

In the assessment of investment projects of transportation infrastructure is used the methodology of Directorate of Roads and Motorways of the Czech Republic, consequential from Guide to Cost-Benefit Analysis of Investment projects, as stated above. In one of the most important chapter, risk analysis, ongoing sensitivity analysis, quantitative and qualitative analysis are defined.

Risks for detailed analysing and their choice are misleading. In feasibility studies it is not often explained, how the choice of risks was carried out. We can assume that the choice is based on subjectivity and business as usual. The most often risks are related to extension of construction time or increase of total costs of projects. This is proved by searches of realised project assessments.

Especially for projects in transportation we should take into the consideration the environmental risk, because transportation construction can severely disrupt ecosystem, the integrity of landscape, bio corridors etc. The aim of this paper is to refer on threats connected with environment and their impact on results of project assessment and project realisation itself.

Exactly in case of project assessment the environmental impacts are implemented in external costs. This paper applies methodology Monte Carlo connected to one part of total costs. Total costs are except external costs consisted from investment and operation costs, costs of travel time and costs from car accidents.

For thus chosen risk variable the appropriate setting of Monte Carlo Methodology (distribution, deviation etc.) is chosen. Following simulation shows relations of economic indicators.

All of this will be done on the case study, which is developed for one real project and its most effective variant (based on conducted feasibility study and verified variants).

4. Results and discussion

For this paper the most important part of Cost-Benefit Analysis is the economic analysis. Inputs for economic analysis are costs/benefits from basic and design variant of the technical-economic study, used as case study, of project "I/13 Děčín – Nový Bor." [9] This paper works with summary of discounted financial cash flow.

In original case study as risk variables for the analysis were used change in construction costs and change of total benefits (and costs) of project. In detail, new risk variables are sought among external costs, otherwise the external costs are new risk variable. External costs consist of several parts: valuation of air impacts, valuation of noise impacts and valuation of CO_2 pollution. In the case study several design variants were solved:

- option S1: transfer of the road Folknáře junction and bypass of village called Markvartice,
- option S2a: transfer of the road Děčín – Manušice,
- option S2b: transfer of the road Děčín – Markvartice – Volfartice – Manušice,
- sub-option S3a: transfer of the road Folknáře junction and Děčín – Manušice,
- sub-option S3b: transfer of the road Folknáře junction + bypass of Markvartice + transfer of the road Děčín – Markvartice – Volfartice – Manušice (without transfer in village Huntířov).

Considering to construction and assessment was selected variant S2a (transfer of road Děčín – Manušice), which includes the carrying out of transportation infrastructure through Central Bohemian Uplands. Central Bohemian Uplands is nature reserve, and it is the reason, why it could be really risky option. There are threatens of disruption of local ecosystem, there could be impact on bio corridors and biotopes, which weren´t included in external costs.

With regard on new risk variables we take into account a possibility of change in external costs/benefits. This change means the possible impact on environment. We can consider this paper like an appropriate adjustment for assessment of transportation infrastructure, especially in places with preserved nature and ecosystem.

4.1. Analysis setting

Analysis method Monte Carlo is used for evaluation of changes in the assessment. For this method triangular distribution of external costs in basic and design variant of project is set. Triangular distribution is selected as best for this type of analysis. Limits of this distribution are set to anticipated minimum -10% and anticipated maximum +30% against likeliest value (based on the basic and design external costs in summary of discounted cash flows in the case study).

Table 1. Input values for the triangular distribution and assumption [own elaboration].

| (mil. CZK) | Basic variant | | | Design variant | | |
	Lower limit	Likeliest	Upper limit	Lower limit	Likeliest	Upper limit
Value	9 456.208	10 506.898	13 658.97	8 613.769	9 570.855	12 442.11

Triangular distribution represents random variables in basic and design variant of the project. The correlation coefficient is set for these random variables to the value 0.5, which is anticipated as suitable value for this economical issue.
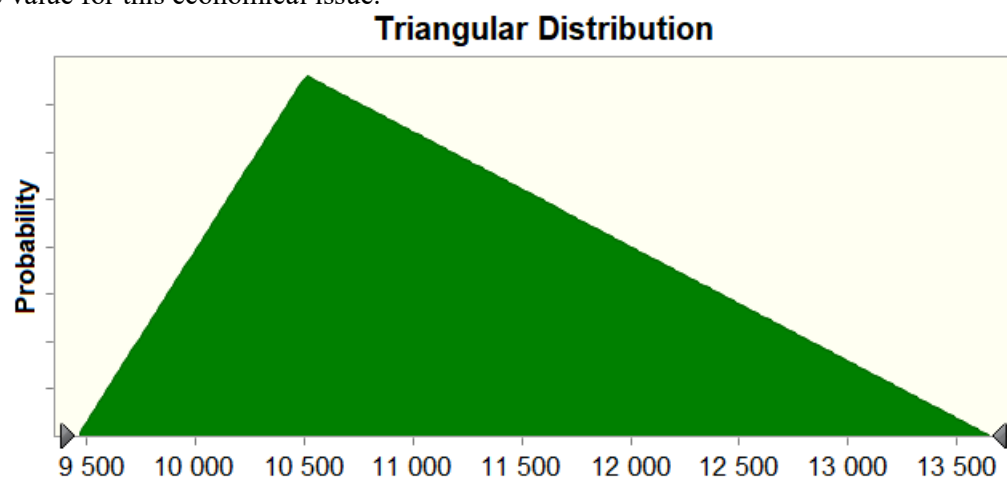
Figure 1. This is a figure which represents a triangular distribution set for assumption of external costs in basic variant of a project assessment.
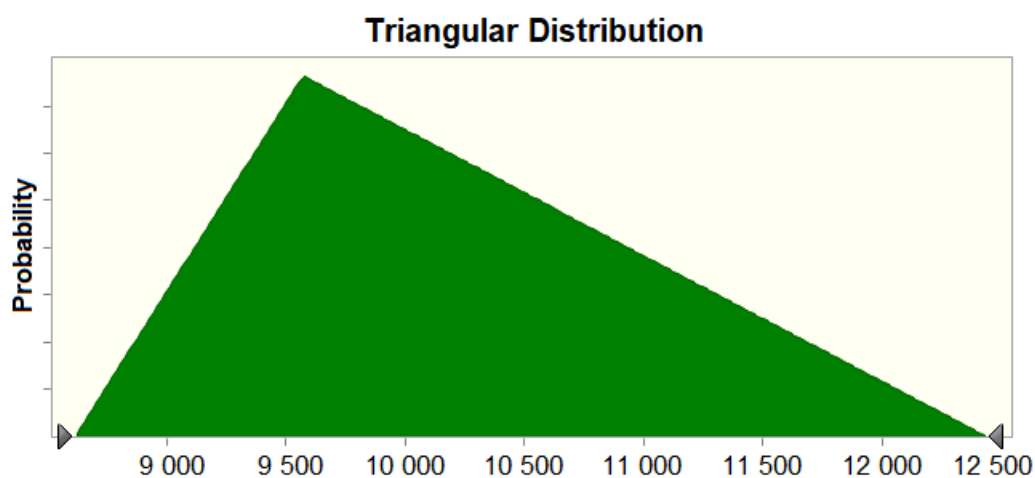
Figure 2. This is a figure which represents a triangular distribution set for assumption of external costs in designed variant of a project assessment.

For the Monte Carlo analysis are set 1 000 000 trials, with confidence level 95.00% and there are set two assumptions (external costs), and correlation between them. Then there are three forecasts, which are columns representing Benefit Cost Ratio, Net Present Value of project and Net Present Value of separated External costs.

4.2. Analysis outputs

Output values of the Monte Carlo analysis are impacts of risk variables (external costs) to potentially raise/decrease against default values in case study of investment project.

The following paragraphs and figures of the output of analysis show us the impact of changes of external costs/benefits caused by triangular distribution on default external costs.

4.2.1. Benefit Cost Ratio (BCR). Results of indicator BCR show, how can be the default values of this indicator affected by the Monte Carlo analysis. The results aren't alarming, but there is a 10% probability, that the project may not be approved from the perspective of indicator BCR. Minimal and maximal value of the indicator BCR reach sufficient reserve against potential environmental risk.

Table 2. Impact on the economic indicator Benefit Cost Ratio [own elaboration].

(mil. CZK)	Base case	Mean	Median	Standard deviation	Coefficient of variation	Minimum	Maximum
Result	1.574	1.591	1.587	0.239	0.1502	0.645	2.561

4.2.2. Net Present Value for separated external costs/benefits. Another monitored economic indicator is Net Present Value. As risk variables are contemplated only external costs/benefits and achieved values are marked risk variables of investment projects in transportation infrastructure. In this case there is evident impact. Default value of case study (936.04 mil. CZK) is considerably impacted in both sides, positive and negative. Minimum value achieved with analysis Monte Carlo and with assumption on basic and design variant, reached -2.361.11 mil. CZK and maximum value reached +4.442.88 mil. CZK. Negative values are achieved in 20 % of cases and decrease compared to default value is achieved in 50 % of cases.

Table 3. Impact on the separated economic indicator Net Present Value (External costs/benefits) [own elaboration].

| (mil. CZK)	Base case	Mean	Median	Standard deviation	Coefficient of variation	Minimum	Maximum
Result	936.04	997.94	981.23	849.00	0.8508	-2 361.11	4 442.88

Value of Net Present Value of external costs/benefits, is seriously impacted by the Monte Carlo analysis and this impact is reflected in total Net Present Value, which is verified in next paragraphs.

4.2.3. Net Present Value of whole project assessment. Analysis Monte Carlo and its results have proper impacts to total Net Present Value. But the most important are changes of external costs/benefits. These changes have their impacts to deviation from default value of total Net Present Value of case study (2 038.04 mil. CZK). Minimum value of Net Present Value from analysis Monte Carlo decrease to value -1.259.11 mil. CZK and maximal increase to +5.544.88 mil. CZK. Net Present Value reaches negative in approximately 10 % of cases and decrease compared to default value is achieved in 50 % of cases.

Table 4. Impact on the economic indicator Net Present Value [own elaboration].

(mil. CZK)	Base case	Mean	Median	Standard deviation	Coefficient of variation	Minimum	Maximum
Result	2 038.04	2 099.94	2 083.23	849.00	0.4043	-1 259.11	5 544.88

Next graph shows total Net Present Value and process of distribution function, which response to normal distribution. Graph also shows distribution of reached values, lower and higher than default value of Net Present Value by analysis Monte Carlo.
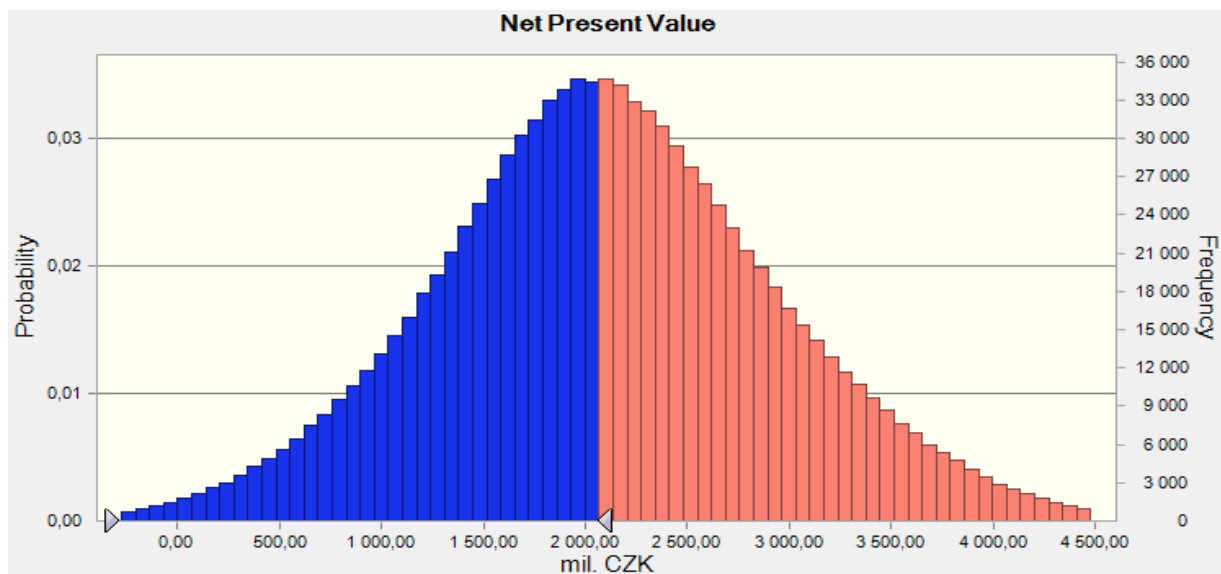
Figure 3. Normal distribution of Net Present Value, impacted by changes of external costs/benefits.

4.3. Discussion
There is a sufficient information based on the Monte Carlo analysis and from impacts of implementing of triangular distribution on default external costs/benefits in basic and design variant of the case study.

Impact of the risk variables (external costs/benefits) is considerable and this problematic is bearer of many other unknowns. These risk variables may not be directly exhaustively parts used in external costs/benefits, but there could be others, that aren't taken into account in external costs and benefits. Indicator of total Net Present Value and its evaluation shows strong impact of changes in external costs/benefits. This is approved by differences between analysis of outputs and default value of Net Present Value from case study. [9]

The threat of whole project assessment and realization of transportation investment project is inconsiderable. Threat arises from risk variables hidden in external costs/benefits. It is alarming, that the main parts of external costs/benefits are only air pollution impact, noise impact and CO_2 impact. Especially in cases as that one represented in case study, is necessary to focus in detailed assessment of environmental risk variables and its impacts.

Ecosystem damage and disruption of corridors in construction process or in process of usage in sensitive locations are examples of neglected external impacts. This is connected with possibility of damage of important biotopes. After construction process is nature able to revitalize any of environmental damages, but not all of them and not at all if people will be unscrupulous.

The most important question is connected with future assessment of this problematics, which can contain more detailed Monte Carlo analysis.

Detailed Monte Carlo analysis could be able to specify risk variables in detailed perspective of external costs/benefits. Future assessment could contain evaluation of biotopes, which are neglected in default project assessment in case study. For example: change of quality of biotopes and inspiration for their evaluation could be found in methodology of evaluation of biotopes by AOPK Czech Republic [10].

5. Conclusion
Finding of new risk variables in assessment of transportation investment projects was aim of this paper. These variables were predicted and identified in one part of financial cash flow of economic assessment. This part is external costs/benefits. In this part is hidden a lot of risk variables bound with ecosystem and ecological impacts. Assessment has to be more focused on impacts to landscape and nature. Permanently marginalization of these impacts could bring important problems to project realisation and natural incalculable consequences.

It´s necessary to be more focused on risk variables bound to environment and on solving of its reasons and impacts (financial, spiritual or material). This paper fulfilled its purpose and pointed to issue which need to be developed and not neglected. Assessment methodologies of investment projects are still developed and it´s important to edit them with regard to environmental risk variables.

Acknowledgement

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