



CENTERIS 2015 - Conference on ENTERprise Information Systems / PROjMAN 2015 - International Conference on Project MANagement / HCIST 2015 - International Conference on Health and Social Care Information Systems and Technologies

## Risk and Efficiency of Bicycle Paths

Vít Hromádka\*, Maryna Shashko

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

---

### Abstract

This article concentrates on the cycle paths projects economic valuation and risks in the course of their realisation in the area of the Czech Republic. The objective of the paper is to assess possibilities of valuation of efficiency and risks of the cycle paths projects in the Czech Republic and design the structure of the valuation together with the recommended methods. Achievement of objectives is based on the detailed analysis of the current situation in economic valuation and risks assessment in the area of cycle paths realisation as well as in projects from the related fields as road, railway or water infrastructure. Methods suitable for the efficiency and risk valuation based on Cost-benefit Analysis principles or qualitative or quantitative risk analysis are discussed in the article. Possibilities of use of alternative methods functioning on the principles of multi-criterial analysis are also pointed out. The paper raises recommendations for valuation of cycle paths projects efficiency and risks in the area of the Czech Republic resulting from domestic as well as foreign experience and practice. It also suggests future directions of the research into the area of addressed issue. It will be usable for economic efficiency of public investment projects, esp. bicycle paths, evaluation.

© 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of SciKA - Association for Promotion and Dissemination of Scientific Knowledge

*Keywords:* Public Investment Projects; Bicycle Paths; Economic Efficiency, Risk Management, CBA; Simulation.

---

### 1. Introduction

Projects of cycle paths realisation in the Czech Republic do not represent the most important ones from the point of view of investment costs. In spite of this, especially at the municipal level, a large number of them is carried out

---

\* Corresponding author. Tel.: +420 541 148 641; fax: +420 541 148 632.  
*E-mail address:* [hromadka.v@fce.vutbr.cz](mailto:hromadka.v@fce.vutbr.cz)

which requires complex and unified approach to the optimisation of the decision making process about their realisation and effective use of available resources. The paper aims at the issue of efficiency and risk valuation of public investment projects in the area of the cycle paths realisation. Detailed analysis of the current state of the researched topic as well as of related topics is performed. Subsequently the issue of cycle paths projects realisation and valuation in the Czech Republic is analysed and recommendations for optimisation of management processes in the field of efficiency and risks of these projects are raised.

## 2. Present state references

Cost-benefit Analysis (CBA) is considered to be the most important tool for the valuation of economic efficiency of public investment projects. Generally CBA is based on comparison of economic benefits and costs concerning the valuated project while respecting the time factor at the same time by using appropriate discount rate. The methodology itself is developed in detail and closer explanation can be found for example in *Guide to Cost-benefit Analysis of Investment Projects*<sup>1</sup>. Other tools can be represented also by approaches based on multi-criteria analysis. Research<sup>2</sup> (Deluka-Tibljša, 2014) defines the possibilities of the methods used as dominant, maxmin, minmax, conjunctive method, etc.

The risk can be considered to be an element of uncertainty, which more or less influences expected results of the human work and projects as well. The risk is on the one hand connected to expectations to achieve extraordinary economic results; on the other hand it could be threatened by danger of failure leading to losses, which can significantly affect the financial stability of the project and can lead to its downfall<sup>3</sup>.

Risk can exist in a lot of different forms and it can have very different impacts, even if the attention is paid just to the construction sector and construction projects. Furthermore, many researchers analyze risks from different perspectives e.g. research<sup>4</sup> (Shen, 2007) suggests safety risks, health risks and ecological risks as an integral part of construction project sustainability performance checklist. Other authors focus on natural risks, e.g. in order to enhance risk-based decision making in case of floods<sup>5</sup>.

Regarding the high number of possible risks, which can be met during planning and realization of investment projects, it is necessary to manage particular risks<sup>6</sup>. The main objective of the project risk management is to increase probability of success of the project and to minimize the danger of its failure.

The steps of the project risk management are determination of risk factors of the project, assessment of the importance of risk factors, project risk assessment, valuation of the risk of the project, suggestion and acceptance of operations for its decreasing and preparation of the plan of correction operations<sup>7</sup>.

Generally, risk management has to be carried out efficiently. It has to permeate all areas, functions and processes of the project<sup>8</sup>. Projects of bicycle paths do not belong to big projects or megaprojects, but it is clear that risk management is appropriate also for these smaller projects, because the impact of the project realization could be important for the investor. Approaches to economic valuation of cycle paths projects are mentioned for example in research<sup>9,10</sup> by Saelensminde (2004) or TemaNord (2005). Using different approaches to economic valuation of cycle paths projects in the Czech Republic is dealt in research<sup>11</sup> by Brůhová Foltýnová and Vohnická (2007) on the model of case study. Risks of the cycle paths projects are discussed in detail in the material<sup>12,13</sup> by (Wardlaw, 2012) or (Wachtel & Lewiston, 1994). For the efficiency and risk management of projects, it is crucial to define and choose an appropriate method or methods. The most important methods, according to the opinion of the authors, are described in the following chapter.

## 3. Methodology and methods

As it is mentioned in the previous chapter, the basic tool for economic efficiency valuation of investment projects is Cost-benefit Analysis which besides the economic valuation also comprises the risk analysis. *Guide to Cost-benefit Analysis of Investment Projects* by European Commission<sup>1</sup> is considered to be the basic tool for carrying out Cost-benefit Analysis. It contains detailed methodology both for carrying out economic valuation as well as risk analysis. Standard CBA is structured in seven steps: description of the context, definition of objectives, identification of the project, technical feasibility and environmental sustainability, financial analysis and economic analysis risk assessment<sup>1</sup>. This article deals mainly with the last two points in relation to cycle paths projects.

Economic analysis concentrates on examination of the overall economic efficiency of the project; financial flows used in financial analysis are therefore adjusted and completed by valuated benefits which primarily do not contain financial dimension. Adjustment and completion of the financial flows lie especially in the following steps:

- fiscal corrections,
- conversion from market to shadow prices,
- evaluation of non-market impacts and correction for externalities.

Social discount rate is recommended for the calculation of valuation criteria (ENPV, ERR, BCR), which range between 3% (other countries) and 5% (cohesion countries).

Guide at the same time recommends steps for the risk analysis processing. The recommended steps for assessing the project risks are as follows:

- sensitivity analysis,
- qualitative risk analysis,
- probabilistic risk analysis,
- risk prevention and mitigation.

The basic difference of the new Guide (2014) compared to the previous (2008) version is the use of probabilistic analysis and simulation carried out by the Monte-Carlo method, which on one hand put increased demands on determination of probability characteristics of input values and require the use of special software, on the other hand they enable risk quantification and taking into account impacts of risk factors on the valuation criteria.

#### 4. Efficiency valuation and cycle paths projects risk assessment

##### The issue of cycle paths in the Czech Republic – need for their quality economic valuation

Construction of cycle paths in the Czech Republic has recently represented an important phenomenon of investment constructions of the past 5 years. During this period, approximately 1,500 km of cycle paths have been constructed in the Czech Republic area with the cost of 7.3 billion CZK (267 mil. €) including provided grants<sup>14</sup>. The importance of presented figures is emphasized by the fact that the total length of cycle paths in the Czech Republic reaches 1,903 km. The largest network of cycle paths and communications suitable for cyclists in the Czech Republic can be found in the area of the capital city of Prague (224 km) as well as in the Central Bohemian Region (215 km)<sup>15</sup>. Even if in most cases these are relatively small scale projects (in tenth of million CZK), the total investments into this area are quite high which puts certain demands on the resource management used for their realization. The most frequent resources used for realization are the national resources in the form of municipalities own resources and state grants (MMR, SFDI) as well as international resources especially in the form of EU Structural Funds. The efficiency of cycle paths projects realization lays especially in the assessment of the relation between the investments costs of the project and anticipated benefits supported by the sufficient quality of the work carried out. The survey of average investment costs per 1 km of realized cycle paths for individual countries can be seen in Table 1.

Table 1. Investment costs of cycle paths – comparison.

State	Germany	Belgium	Austria	Czech Rep.	Netherlands	Finland	Denmark
IC (€/km)	168,037	219,178	230,137	146,118	138,813	109,589	284,932

Source<sup>14</sup>

It is necessary to mention that individual countries differ in legal and technical regulations and important role is played also by the demandingness of the terrain in which the cycle path is built.

Projects of bicycle paths seem to be similar to the projects of road and highway infrastructure. In the case of valuation of road and highway infrastructure projects it is necessary to respect Implementing Guidance for Evaluation of Economic Efficiency of Projects of Road and Motorway Constructions. In the case of preparation of cycle paths projects realisation in Czech conditions, no implementing guidelines specialised only in cycle paths realisation are applied. The basic strategic document in the area of cycle transport is National Strategy of the Cycle Transport Development in the Czech Republic. In the process of economic valuation and risk analysis, it is possible

to build on general practices for processing similar analyses of public projects. In case where economic valuation and risk analysis form part of application for grant funds, it is essential to follow the requirements as well as structure defined by the grant provider. In the Czech Republic conditions it is possible to use a universal tool for Cost-benefit Analysis which is eCBA application. It has already been used for processing the applications for EU grants and thus respects the required structure.

### Economic eCBA valuation

From the point of view of economic valuation, eCBA software provides standard background for input parameters definition and economic efficiency criterial parameters calculation. Above standard options are represented by the possibility to assess several benefits brought by the projects. Software eCBA concentrates on economic valuation processing of various types of public projects and structure of benefits for which the valuation is carried out based on the structure required by the application users themselves. Benefits for cycle paths are not uniquely determined as it is the case of road and water infrastructures. With respect to the frequency of the processing the cycle paths projects via eCBA application, benefits related to these projects are already included in the database. The survey of benefits valued in the framework of eCBA application is listed in Table 2.

Table 2. Benefits related to the cycle paths realisation.

Benefit specification	Benefit unit	Impact unit price (€/unit)
Prevention of minor injuries occurrence	Prevention of minor injury	24.103
Prevention of serious injuries occurrence	Prevention of serious injury	175.345
Prevention of fatal injuries occurrence	Human life	636.494
Extension of cycle paths	User and km	0.072

Source: software eCBA ([www.ecba.cz](http://www.ecba.cz))

Benefits listed in Table 2 are determined in accordance with the Guide<sup>1</sup> using Value of Statistical Life, Human Capital Approach and Willingness to Pay methods. The efficiency valuation carried out within the eCBA method is based on the CBA approach comparing discounted positive and negative economic cash-flow. Key indicators resulting from the CBA are Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit-Cost Ratio (BCR).

### eCBA risk assessment

Valuation and risk assessment through eCBA program is exclusively based on the principles of expert valuation e.g. qualitative analysis. For identified risks, the impact of risk and probability of its occurrence are determined. Based on the combination of these two characteristics of the risk, its importance is derived within verbally expressed scale ranging from the negligible to critical risk. Component of the risk assessment is also the possibility to define ways leading to risk elimination and prevention.

### Proposed solution for cycle paths and recommendations

In the frame of economic valuation, authors recommend to expand economic valuation especially in taking into account other non-financial impacts connected to increased usage of cycle transport in response to supporting documents<sup>9,10,11</sup>. Besides own benefits of the users and savings related to the impact of the decrease in traffic accidents on the human health, it is possible to incorporate into the cycle paths projects realisation also following benefits:

- decrease in the probability of occurrence of serious illnesses thanks to the regular movement,
- shortening of the travel time of the road users due to decrease in congestions in relation to the transmission of the part of the car transport to the cycle paths,
- lower costs for the acquisition and operation of the means of transport due to change in preferences,
- decrease in noise and emissions due to transition of part of the transport from cars to bicycles,
- lower costs in relation to parking cars,
- increase in the attractiveness of the area as well appreciation of the property thanks to new cycle paths.

For the possibility to include the above mentioned impacts into economic valuation, it is necessary to define in detail both the quality and quantity of the partial impacts. Concerning quality, for determination of the unit impact

expressed in monetary units, it is possible to use a range of methods developed for valuation and especially based on „Willingness to Pay“. Similarly it is possible to use already existing values of impacts used for valuating e. g. projects of road infrastructure –decrease in noise and emissions of harmful substances, decrease in the number of road accidents, savings in time and operational costs<sup>16</sup> or other material in research<sup>11</sup> by (Brůhová Foltýnová & Vohnická, 2007). In case of quantification of individual impacts, it is essential to carry out corresponding research into the interest in using of already realised cycle paths and willingness to change already existing ways of transport. Correctly performed research can provide appropriate base for processing a traffic model which can identify possible changes in the behaviour of the transport system users. In case of project risk valuation, it is possible in relation to the Guide<sup>1</sup> and while respecting the experience from the field of valuation of the road, railway and water projects to recommend a detailed quantitative analysis building on qualified identification of risk factors and involving determination of the impact and probability of risk factor occurrence. It is useful to subsequently complete the qualitative analysis by the approach to the partial risk factor solution. Qualitative analysis should be completed by sensitivity analysis expressing the sensitivity of resultant criterial indicators to the changes in selected input values and probability analysis using an appropriate simulation method (e.g. Monte-Carlo) focusing on quantification of the risks using probability characteristics (mean, median, distribution, standard deviation and coefficient of variation).

## 5. Conclusions

Valuation of economic efficiency of the public investment project is an important component of the decision making process about its realisation. The task of risk analysis is subsequently to specify the degree of uncertainty connected to the objectives achievement as well as structure and importance of risks which can threaten the project aim. Part of it is also proposal of measurements for the risk elimination and minimising their impacts. The way of economic valuation or risk assessment of the public projects depends considerably on the type and extent of the project realised. The object of the projects dealt with in this paper is cycle paths realisation in the area of the Czech Republic. The aim of the article was evaluation of efficiency valuation and risk assessment possibilities in cycle paths projects in the Czech Republic and the design of the valuation structure together with the recommended methods. This aim has been in the scope of the presented paper met. Further steps in the area of efficiency and risks valuation of the cycle path projects will consist of a detailed analysis of actually existing cycle paths projects realised in the past seven-year period in South Moravia as well as the design of specific procedures, tariffs and criteria for optimization of management process of efficiency and risks of these projects.

## Acknowledgements

This paper has been written with the support of the specific research of Brno University of Technology, Faculty of Civil Engineering, grant project no. FAST-S-15-2944 Effective Management of Processes in Civil Engineering II and The Ministry of Education, Youth and Sports Programme COST CZ project LD14113 Effectiveness of Megaproject in the Czech Republic.

## References

1. Sartori, D. (2014). Guide to Cost-benefit Analysis of Investment Projects, Economic appraisal tool for Cohesion Policy 2014-2020. European Commission, Directorate-General for Regional and Urban policy. ISBN 978-92-79-34796-2.
2. Deluka-Tibljaš, A., Karleuša, B. Šurdonja, S. & Dragičević, N. (2014). Use of AHP Multi-Criteria Method for Transportation Infrastructure Planning, In conference proceedings of People, Buildings and Environment 2014, an international scientific conference, Kroměříž, Czech Republic, pp. 123-134, ISSN 1805-6784.
3. Smejkal, V., Rais, K. (2005). Řízení rizik ve firmách a jiných organizacích. Grada Publishing, a.s., Praha. ISBN 80-247-1667-4.
4. Shen, L., Hao, J., I.; Tam, V., W.; Yao, H. (2007). A checklist for assessing sustainability performance of construction projects, *Journal of Civil Engineering and Management*, 13:4, 273-281.
5. Hall, J. & Solomatine, D. (2008). A framework for uncertainty analysis in flood risk management decisions, *International Journal of River Basin Management*, 6:2, 85-98.
6. Sanderson, J. (2012). Risk, uncertainty and governance in megaprojects: A critical discussion of alternative explanations. *International Journal of project management* 30(4): 432-443.
7. Fotr, J. & Souček, I. (2006). Podnikatelský záměr a investiční rozhodování. Grada Publishing, a.s., Praha. ISBN 80-247-0939-2.
8. Schieg, M. (2006). Risk management in construction project management, *Journal of Business Economics and Management*, 7:2, 77-83.

9. Saelensminde, K. (2004) Cost-benefit analysis of walking and cycling track networks taking into account insecurity, health effects and external costs of motorized traffic. *Transportation research Part A* 38.
10. TemaNord (2005) CBA of Cycling, Nordic Council of Ministers. Copenhagen.
11. Brůhová Foltýnová, H., Vohnická, J. (2007) Analýza nákladů a přínosů a možnosti jejího využití pro aplikaci na cyklistickou infrastrukturu. *Cyklokonference (Velké Kralovice)*
12. Wardlaw, M. (2012) Assessing the actual risks faced by cyclists. *Bicycle Helmet Research Foundation*, available on <http://www.cyclehelmets.org/>.
13. Wachtel, A., Lewiston, D. (1994) Risk Factors for Bicycle-Motor Vehicle Collisions at Intersections. *ITE Journal*, volume: 64, issue Number: 9, Publisher: Institute of Transportation Engineers, ISSN: 0162-8178
14. Němec J. (2014) Miliardové cyklostezky. *Ekonom*, 31.7.-6.8.2014, number 31, pages 6-10. ISSN 1210-0714.
15. Martinek, J. (2014) *Passport cyklostezek&kontakty*. Centrum dopravního výzkumu.
16. Ministry of Transport (2014) *Implementing Guidance for Evaluation of Economic Efficiency of Projects of Road and Motorway Constructions*. Available on <http://www.rsd.cz/Technicke-predpisy/HDM-4>.