The Economic Evaluation of Megaprojects – Social and Economic Impacts

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Abstract

In the economic evaluation of megaprojects it is very important to take into account many aspects. Usually the most important aspect is connected with investment and operation costs and their possible overflows and the fulfillment of time period intended for the project. But it is necessary also to monitor impacts of the projects on their surroundings. The HDM-4 model developed by University of Birmingham takes into account impact of transport infrastructure projects in the form of changes in the time consumption, changes in operation costs for vehicles, social costs connected with car accidents and newly impacts on environment. But it is possible to calculate also with other impacts, e.g. impact on economy of related areas, barrier effect caused by highways and motorways, sprawling connected with better availability of urban area, etc. The main objective of the paper is to discuss, which of possible social-economic impacts could be taken in evaluation of particular megaprojects into account and which it is useful or not useful to begin to project into economic evaluation. Very important it is also to discuss the available or new methodology of the projection of specific impacts into the project evaluation.

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1. Introduction

Economic evaluation of the large projects is very important not only from the aspect of investor and direct users of the infrastructure. Those results are very important for the society as a whole. “Due to large amount of money involved and great impact of project results on its environment, large infrastructure projects attract great attention of media and public. It is hard to hide when expected results are not met.” (Burcar Dunović, 2012, p. 51) This paper presents possible principles and methods suitable for the evaluation of the whole society impacts of the large scale megaprojects oriented on the transport (mainly highway and road) infrastructure. The results are in the final part of the paper used in the case study of the large project in the north-east Moravia in the Czech Republic.

2. Present state references

The research area of this paper involves theoretical knowledge necessary for the economic valuation of investment projects, mainly megaprojects in the transport infrastructure. The economic evaluation is based on the essential principles of the CBA (Cost-Benefit Analysis). The CBA approach is in detail described in the European Commission Methodology (Florio, 2002).

2.1. Megaproject

2.2. A megaproject is an extremely large-scale investment project. Megaprojects are typically defined as costing more than US$1 billion and attracting a lot of public attention because of substantial impacts on communities, environment, and budgets. Megaprojects can also be defined as “initiatives that are physical, very expensive, and public”. (Altshuler, 2003). Care in the project development process may be needed to reduce any possible optimism bias and strategic misrepresentation. The logic on which many of the typical mega-projects are built is on its collective benefits. The most common megaprojects are in the categories of hydroelectric facilities, nuclear power plants and large public transportation projects. Authors of this paper focus as the members of research team of cost project TU 1003 “The effective design and delivery of megaprojects in the European Union” (more on www.mega-project.eu) on economic evaluation of public transportation project with support WLC and CBA methodology. Whole Life Costs

The building Whole Life Cost (WLC) includes all associated and relevant current and future costs and benefits of a building that may occur in the course of the whole life cycle of the building (ISO, 2008). The WLC method is a continuation of the Building Life Cycle Costs (BLCC) and the Life Cycle Assessment (LCA) methods that work with the analysis of the building being examined. The Whole Life Costs supplement the view of the analyzed issue with costs that occur in the building surroundings and may also affect other entities that are not directly related to the building construction and use.

WLC method represents global evaluation of costs and benefits associated with construction, operation and liquidation of buildings from internal and external view. Determining WLC is support for making decisions on investments put in the construction or reconstruction of a building. (Korytárová, 2010)

2.3. Methods for economic impacts valuation – general approaches

Approaches for non-appreciable costs evaluation are represented mainly by pricing methods and valuation approaches. Detailed information about non-market cost and benefit valuation is available in (Edwards, 2000).

Pricing methods are represented by simple approaches. They don’t come out from the generally defined demand curve, but they set the value of the specific goods or events directly for the specific case. Those methods are not as direct and general as valuation approaches, but for utilization they are easier. It concerns mainly about methods using opportunity costs, costs for alternatives, shadow project costs and the other methods.

The opportunity costs method is based on the finding of the value that it is necessary to sacrifice for increasing of the amount of certain goods or events. In the case of method based on expenditures for avoiding of losses there
are expenditures, which individuals pay for purpose of avoiding negative impacts on environment, considered as a simple expression of monetary value of these impacts.

Shadow project costs method deals mainly with the evaluation of environment and mainly losses on environment caused by realized projects. Principle of the method is based on the assessment of costs connected with the offering of alternative environmental goods in other place then it was situated before and later by development project degraded. These costs express the value of environment that enters into costs of development project during its economic efficiency valuation. However by the choice of the shadow project it must be discussed and valuated the adequacy of chosen shadow project in comparison with the rate of devaluation of environment caused by the development project.

The dose - response method is probably the most difficult pricing method, because it requires a lot of statistical information. Basic principle of this method it is the identification of the relation between devaluation of environment (dose) and the rate of its damaging (response) caused by the project realization. However through quite high difficulty the dose - response method is not usually able to take into account all environmental costs caused by the project’s realization. Usually it is possible to enumerate only economic losses, thus losses caused on goods appreciable by the market system. (Edwards, 2000)

Valuation approaches offer more general way of evaluation of nonprofit costs and benefit caused by the investment projects’ realization. Particular methods included in valuation approaches are based on common principles. The main principle of valuation approaches is to assess, what value particular non-profitable goods, events or processes have for the society. The value is in this case characterized as a rate of utility, which individuals (or the society as a whole) feels during the usage of valuated goods or at least in the case of possibility of the choice to use these goods. However the utility is hard to measure and quantify, that is the reason, why for the expression of the utility it is used the magnitude called Willingness to Pay (WTP) for an existence and possibility to use particular non-profitable goods. There exists the presumption that individuals will be able to express the maximal amount of money, which they are willing to sacrifice for possibility to use particular goods. The difference between the willingness to pay (the rate of utility that individuals feel during the utilization of the non-profit goods) and costs connected with the acquisition of these goods (the difference between the sum that the individual is willing to pay and the sum that he must to pay) is called the Consumer Surplus (CS).

In the case of decision making about the realization of particular variants of public investment projects it is judged the total change of the consumer surplus for the whole society. (Florio, 2002), (Edwards, 2000).

Methods based on the valuation approaches can be e.g. (Edwards, 2000):
- Expressed preference methods
- Revealed preference methods

Expressed preference methods

Expressed preference methods are based on the direct questioning of individuals, how much they evaluate monitored non-profit goods. Really these methods are directly focused on the creation of real demand curve of particular non-profit goods. This creation is allowed by various methods of direct questioning (contingent valuation method, contingent ranking and stated preferences methods).

Contingent valuation method is based on researches, in the frame that particular respondents are directly asked, how much they are willing to pay for possibility to pump the benefit from the utilization of non-profit goods, or what financial compensation they would require in the case of non-possibility of their utilization. Contingent valuation method consists in the assessment of willingness to pay (WTP) for possibility to use the non-profit goods or willingness to accept (WTA) the compensation in the case of non-possibility to use this non-profit goods. (Edwards, 2000), (Litman, 2005)

Contingent ranking and stated preferences methods are based on personal inter-views, when respondents choose between particular goods, from that each is de-scribed by many characteristics. One of these characteristics usually has the financial expression (price, costs and fees). In the case of Contingent ranking method the respondents are asked for expression of preferences by sorting of particular kinds of goods from the most preferred to less preferred. Each kind is described by several characteristics. And if one of characteristics is the price of particular goods, then it is possible to express the value that other characteristics have for the respondent. Stated preference
method is usually applied for the assessment of value of the territory intended for recreation. In the case of this method respondents are acquainted with two or more recreation areas. Each area is described by many characteristics, from that some have the financial expression (travel costs, entrance fee, etc.). Respondents are next asked for the expression of preferences, which of defined territory they prefer for leisure time activities. Analytics then evaluate how the preferences of respondents have changed with the change of particular characteristics expressed in monetary units. From this information they then define the value of each particular characteristics of the territory. (Florio, 2002), (Edwards, 2000)

**Revealed preference methods**

Revealed preference methods are focused on the definition of value of non-profit goods with the help of monitoring of amount of goods valued by market. It concerns about goods, which individuals acquire for possibility to use non-profit goods (e.g. petrol necessary for realization of the all-day trip outside). This information allows, with the help of statistical processes, the construction of the demand curve of specific non-profit goods. From this curve there are next defined changes in the consumer surplus caused by changes in offering of non-profit goods.

The travel cost method is used mainly for assessment of value of environmental goods. It uses costs caused by traveling of individuals to use non-profit goods for the purpose of expression their value. The value is derived from the price of market goods acquired by individuals. Really the travel costs caused by individuals for the purpose of achievement of valued goods express vertical “price” axe of the demand curve graph. These costs consist from two parts, material costs (the consumption of petrol, fares, entrance fees etc.) and the value of the travel time. These travel costs determine number of visits of the specific place (horizontal axe of the demand curve graph).

By the monitoring of visitors of the specific place and by questioning for information including their travel costs, the quantity of visits for the defined time period, or next important factors, it is next mapped the demand curve for the specific environmental goods. (Florio, 2002), (Edwards, 2000)

The hedonic pricing method starts from the hedonic pricing formula. It defines, that the price of the house is dependent on its next characteristics. Among these activities there are included e.g. environmental characteristics (the esthetic level of environment, where the house is situated, the level of noise in this location or the quality of air). And just these non-profit goods are appreciable by the hedonic method. The hedonic pricing method it is possible do divide into two phases. The first phase consists in the creation of the hedonic pricing function. In this case there are used statistical methods. With their help it is found, in what amount they are the differences in prices of houses dependent on the amount of environmental goods that inhabitants of those objects can use. The second phase is then focused on the creation of the own demand curve of the specific environmental goods. (Florio, 2002), (Edwards, 2000)

### 3. Possibilities of megaprojects impacts valuation

As mentioned at the beginning of the chapter 2, the main idea of the transport projects economic evaluation is based on the principles of the CBA (Cost-Benefit Analysis) approach and the WLC (the Whole Life Costs). (Korytárová, 2010)

In next chapters there are described the basic structure of possible impacts of the transport infrastructure megaprojects impacts and the approaches for the particular impacts evaluation using the software support in the Czech Republic. Information is completed by the simple case study of the megaproject in the north-east of the Czech Republic.

#### 3.1. Impacts of megaprojects in transport infrastructure

In the area of transport infrastructure projects realization it is possible to describe many kinds of impacts, which can be characterized from particular point of view. For purposes of better orientation in all kind of impacts arising due to infrastructure projects realization it is possible do define several categories. Most important categories are presented in Table 1.
### Categories of impacts in the area of transport infrastructure projects

<table>
<thead>
<tr>
<th>Categories of impacts in the area of transport infrastructure projects</th>
<th>Description of category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs connected with means of transport</td>
<td>Fixed costs connected with the ownership of mean of transport, variable costs for the mean of transport operation</td>
</tr>
<tr>
<td>Transportation time</td>
<td>Value of time used for transport</td>
</tr>
<tr>
<td>Car accidents</td>
<td>Costs connected with car accidents including costs held by society</td>
</tr>
<tr>
<td>Construction and facilities of roads</td>
<td>Value of constructions including facilities and operation costs not covered with user payments</td>
</tr>
<tr>
<td>Value of built up area</td>
<td>Value of land intended for construction of the road</td>
</tr>
<tr>
<td>Air pollution</td>
<td>Costs connected with air pollution by emissions of polluting gases from motor means of transport</td>
</tr>
<tr>
<td>Noise</td>
<td>Costs connected with pollution of air by noise emissions</td>
</tr>
<tr>
<td>Water pollution</td>
<td>Water pollution and hydrologic impacts caused by transport accessories and cars</td>
</tr>
<tr>
<td>Consumption of resources</td>
<td>External costs connected with the consumption of non-renewable resources, mainly petroleum</td>
</tr>
<tr>
<td>Way of territory usage</td>
<td>External costs resulting from car oriented development and opportunity benefits connected with more efficient utilization of land</td>
</tr>
<tr>
<td>Waste liquidation</td>
<td>External costs connected with disposal of waste connected with automobile transport</td>
</tr>
<tr>
<td>Transport services</td>
<td>Costs for providing of transport services, e.g. traffic police, public lighting, emergency services for car accidents etc.</td>
</tr>
<tr>
<td>Transport diversity</td>
<td>Value of possibility to use variable transportation system with transport possibilities also for people not using cars for transport</td>
</tr>
<tr>
<td>Barrier effect</td>
<td>Limitation and decreasing of comfort of other parts of public transport mainly due to new wide highways</td>
</tr>
</tbody>
</table>

In the next chapter it will be described the most important possibility for economic efficiency assessment, which is intended for valuation of projects and megaprojects in the transport infrastructure.

#### 3.2. Specific applications – HDM-4 Model

Very complex approach to evaluation of investment projects in the transport infrastructure is the HDM-4 model. Model had been developed during years from 1993 to 2000 at University of Birmingham with the financial support of World Bank. HDM-4 model (Highway Development and Management) is focused on evaluation of investment projects in the area of transport infrastructure, mainly projects of highways. It concerns about complex software tool for analyses of roads and highways and investment decision making in this area.

The evaluation of the economic efficiency of constructions of roads and highways in the territory of the Czech Republic is nowadays based on the Implementing guidelines for evaluation of efficiency of road and highway constructions in investment intentions issued by Ministry of Transport of the Czech Republic. The Czech System for Evaluation of Roads is in principle based on the HDM-4 model completed with information calibrated for the Czech Republic territory. Main criteria for evaluation of efficiency of these projects are Net Present Value (NPV), Internal Rate of Return (IRR) and the Cost Profitability (BCR).
The essential principle of economic efficiency of transport infrastructure project evaluation is based on the CBA (Cost-Benefit Analysis). There are compared all relevant socio-economic benefits and costs respecting the time value of money. The calculation formula for evaluation of roads and highways consists from following groups of impacts:

- Costs for infrastructure
- Users’ costs
- Other cost
- Next external costs

Costs for infrastructure include mainly investment costs for the construction realization and costs for maintenance and repairs. Users’ costs involve mainly costs connected with the operation of vehicles, e.g. fuels, tires wear; repairs and maintenance of vehicles and other costs of trucks (wages of drivers, insurance, depreciation and overhead costs).

Other costs consist from three parts, the valuation of time of passengers, the value of time during transport of goods and losses from car accidents.

Other external costs represent external impacts of the traffic on the projects surroundings, mainly environment. There are calculated losses from traffic noise and air pollution caused by the traffic.

All analyses realized in the HDM-4 model are dependent on relevant inputs. The basic input is information about present state and future development in traffic for zero and investment variant. Zero variant represent the variant “without project”, investment variant supposes realization of the evaluated project. Based on information about the traffic flow, its intensity, its structure and changes due to the project realization it is possible to determine the differences between variants and using suitable methods to derive net benefits or costs coming out from the project realization and operation. Those valuated benefits and costs are next compared in the frame of valuation criteria (NPV, IRR, BCR) according that it is possible to recommend the project for the realization or the rejection.

4. Case study

Case study consists in brief description of the outputs of the economic analysis of big project realized in the northwest of the Czech Republic. From technical point of view it concerns about big city bypass including spinal road and several supplementary roads. The project should be connected mainly with big savings in the environmental area, because most of the traffic will be transferred from the city center outside the city.

The economic analysis is carried out with the comparison of the base case (zero option) and project case (investment option) in the discounted total costs connected with the project. Costs taken into account are:

- costs of investor (maintenance and construction of the road)
- vehicle operation costs
- travel time costs
- costs for car accidents
- costs for pollution of environment

The most important inputs into the project analysis are information about the traffic flows in particular related areas and their changes. Next very important data come out from the Czech legislation and express unit values of particular costs intended for the next project evaluation. Input data are processed within the HDM-4 Model and outputs of the model are interpreted in order to decide about the project realization. The main tools for the decision making are discounted cash flows and Net Present Value, Internal Rate of Return and Profitability Index.

Values of discounted costs for particular variants related to total costs of the base case are summarized in the table 2.
<table>
<thead>
<tr>
<th>Kind of Costs</th>
<th>Base Case (B)</th>
<th>Project Case (P)</th>
<th>Difference (B - P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs of Investor</td>
<td>0,48 %</td>
<td>3,88 %</td>
<td>-3,40 %</td>
</tr>
<tr>
<td>Vehicle Operation Costs</td>
<td>33,33 %</td>
<td>34,18 %</td>
<td>-0,84 %</td>
</tr>
<tr>
<td>Travel Time Costs</td>
<td>44,30 %</td>
<td>40,64 %</td>
<td>3,66 %</td>
</tr>
<tr>
<td>Costs for Car Accidents</td>
<td>2,80 %</td>
<td>2,55 %</td>
<td>0,25 %</td>
</tr>
<tr>
<td>Environmental Costs</td>
<td>19,09 %</td>
<td>17,86 %</td>
<td>1,23 %</td>
</tr>
<tr>
<td><strong>Total Costs</strong></td>
<td><strong>100,00 %</strong></td>
<td><strong>99,12 %</strong></td>
<td><strong>0,88 %</strong></td>
</tr>
</tbody>
</table>

From the table 2 is evident that the project analysis has very interesting results with significant impacts on the project surroundings.

**Total socio-economic costs**

Comparing total costs the base case (zero option) and total costs of the project case (investment option) provides the result proving good intention to carry out the project. Respecting all costs connected with the project it is possible to see the cost saving 0.88% from the total discounted costs of the zero option and the Net Present Value of the project is positive.

**Particular costs**

The project option brings bigger costs for investor connected with the investment (the construction and the investment), also vehicle operation costs are bigger in the case of the project option. Other socio-economic costs, costs connected with the travel time, costs for car accidents and environmental costs are lower in the case of the project variant. In those cases it possible to expect quite interesting cost savings.

5. Conclusions

Further research in the area of the transport megaprojects impact evaluation will be oriented on the determination and next evaluation of other socio-economic costs and benefit not covered by HDM-4 model. The inspiration can be taken from the Table 1, where the important socio-economic impacts of the transport infrastructure projects are described. As an example of the next development of the research could serve for instance the software application called eCBA, which has been developed in the Czech Republic mainly for reason of evaluation of projects asking for financial resources of European Union, mainly from the Structural funds through Regional Operational Programs. Beside common financial analysis of revenues, costs, incomes and expenditures this application is able to evaluate many (approx. 60) socio-economic benefic often connected with the realization and the operation of public investment projects. This evaluation is in most case based on the above-mentioned willingness to pay principle.
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