

TRANSPORT SYSTEM COSTS IN CONTEXT OF COST-BENEFIT ANALYSIS

ИЗДЕРЖКИ ТРАНСПОРТНОЙ СИСТЕМЫ В КОНТЕКСТЕ АНАЛИЗА ИЗДЕРЖЕК И ДОХОДОВ

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Abstract: *The paper deals with the problems of transport system costs. It is focused on transport infrastructure projects and their appraisal. First it presents cost-benefit analysis as a suitable tool for the appraisal, describes its principles and appraisal process. Afterwards it concentrates on impacts of transport infrastructure projects and defines selected appraising criteria that are used for these projects.*

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KEYWORDS: COST-BENEFIT ANALYSIS, TRANSPORT SYSTEM, TRANSPORT PROJECTS, TRANSPORT INFRASTRUCTURE

1 Introduction

Cost-benefit analysis (CBA) has its fundamentals in theoretical framework of microeconomics and theory of social solution. It is application of these theories on practical problems of public sector, not only transport sector but also other sectors, e.g. health service, energetics and environmental protection. This paper is focused on CBA of transport projects.

Transport projects must be judged from the point of view of their feasibility, viability but also necessary financial flows. CBA brings enlargement of information value about a given project from the multi-criterion point of view, when benefits on one hand and costs on the other hand are judged in complex conception. Only on the basis of complete sum of information it is possible to make final decision about particular transport project.

Some of the basic principles of transport CBA we can generally summarize as follows:

- it should be judged costs and benefits of all influenced groups,
- some effects can be transferred from one group to the other or they can cancel one another in total analysis,
- total social impact is calculated as a sum of impacts on individuals,
- future costs, benefits and forecasts shouldn't be underrated – it is especially important for the stage of demand appraisal,
- initial point of the appraisal is individuals' willingness to pay for benefits – based on studies of time and safety value,
- adequate evaluation of cost and benefit items,
- money is the basic unit (though other units can be used, as well),
- respect for discount and growth rates of prices in the course of the time.

2 Heart of the appraisal

Investments in transport infrastructure influence many sides – supranational, national and local authorities, transport operators and users. Investments influence life quality of people, whose economic, social or environmental life qualities can be changed as a result of investment in transport infrastructure.

The main perspective of transport (transport infrastructure) projects appraisal by way of socio-economic CBA is social perspective. This is the perspective that takes into account all important effects regardless of the fact, who is affected by them. Relevant considerations involve:

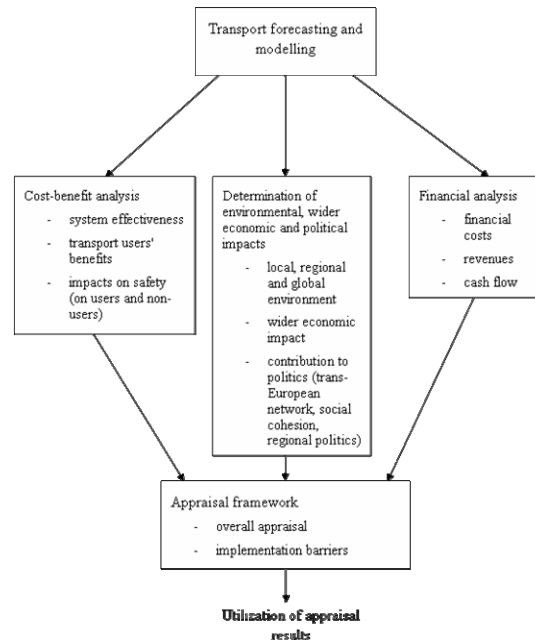
- total economic, social and environmental effect of the project,
- scheme of profits and losses,
- financial viability of the project,
- feasibility of the project and identification of implementation risks.

For “social” appraisal of the projects it is suitable to use general approach including in its core CBA elements, which can

be evaluated financially with sufficient addition of environmental impacts, wider economic impacts and further impacts (e.g. political aspects). The purpose of such approach is to take into account CBA and wider economic, environmental and political indicators together, i.e. in a cohesive way, with the aim to get a complex appraising analysis.

It is necessary to emphasize that environmental and further politically important impacts should be subject to proper forms of analysis. This analysis should, ideally, be quantitative. Where the quantitative analysis is not possible, qualitative analysis should be accomplished, based on expert estimate. The basis of the analysis should always be set as a part of information provided to decision makers. This information should form an input to the decision-making process, not an output of previous politically irreversible decisions.

Responsible decision makers then have the task to strike a proper balance between benefits for user and environmental and further impacts. The purpose of the appraisal is to provide relevant information as an input for the decision-making process. The scheme of the decision-making process is depicted in the figure 1.



Source: CBA, authors

Fig. 1 Complex scheme of the appraisal process

3 Transport infrastructure projects impacts

Some of the direct effects of transport infrastructure projects will affect transport users that use (or will use) transport system, and transport providers. Costs and time spent by transport users on transport from one place to another will be reduced, both for

passenger transport and freight transport. This cost reduction will probably result in a number of users' reactions – changes in routes, choice of transport kind and destinations. Proper evaluation of these demand changes is vitally important for the appraisal. [16]

The impacts on transport providers are relevant, as well, in the framework of investments (investment costs), operational costs and revenues – for infrastructure, transport means and service operation.

3.1 Value of time and safety

Investment projects that improve transport infrastructure result in travel time reductions (as a consequence of shorter routes and higher speed) and in reduction of traffic accidents and victims number (as a consequence of safer design standards) in comparison with the situation without the project. Values of time and safety are not generally available in the form of market prices because they are not marketable commodities in its core. That's why an alternative base for the evaluation of time and safety is necessary in the project appraisal.

Monetary value of travel time savings is one of the most important variables in CBA of transport infrastructure. Travel time savings represent a large share in total benefits of the project – numbers concerning latest experience of various EU's national governments and European investment bank find that typical share is 80 % [1]. Therefore:

- heightened attention is required by time value determination,
- where some doubt about proper value exists, it is necessary to accomplish sensitivity tests in order to find out the impact of time value change,
- consistency in the appraisal must be kept – it is necessary to use consistent time values within the group of projects that are compared (e.g. TINA projects) [2].

If infrastructure is improved, time savings arise, both in passenger and freight transport. In the framework of passenger transport, evident difference among business trip and trips for other purpose exists. Working time includes either trips for employer's enterprise or for own business in the case of private entrepreneurs. Non-working time includes all other kinds of trips. Generally, on that account there will be needful values for:

- working time savings [EUR/person-hour],
- non-working time savings [EUR/person-hour],
- time savings in freight transport [EUR/person-hour].

In the transport project appraisal, time values should be based on local values. Ideally, local values should be derived from local (or at least regional or national) data and from the results of transport market research and they should reflect willingness of individual user to pay for time savings [3, 4].

Nevertheless, if it is not possible to get reliable values based on willingness to pay, approximate estimates should be adopted.

For the purpose of providing a consistent set of **values for safety impacts** are necessary definitions for [5]: injuries seriousness, accidents seriousness and various cost items related to them. Relevant measures are [6]: costs in connection with an accident (EUR per one accident) and cost in connection with traffic accidents victims (EUR per one victim). Costs in connection with accidents and costs in connection with traffic accidents victims should be counted up in order to provide total costs of accidents within the network [7].

Costs in connection with an accident:

- material damage,
- police and fire services,
- insurance administration,
- legal and court costs.

Costs in connection with victims:

- treatment expenses and health care costs including administration,

- performance loss,
- human costs – smart money, grief, suffering.

3.2 Environmental impacts

Changes of transport system and final changes in the use of transport influence not only transport system participants but also those, who are exposed to the system and its emissions without being involved in it directly. Environmental impacts occur at the local, the regional and the global level (change of climate).

According to the theoretical principles of project management, projects should be designed in such way to balance any serious or dangerous effects by certain compensatory measures. As for environmental impacts, it is necessary to include costs of these measures in investment costs of the project [8]. Nevertheless, it is also necessary to report all remaining localized effects and ensure to be taken into account within the appraisal framework.

3.3 Wider economic impacts

Transport networks play a key role in economic development of countries and regions, which is the reason for financial resources allocation in transport investments through ISPA and international financial institutions (IFI).

Roles of a project in economic restructuring of regional and local economic systems in connection with wider economic impacts of transport investments include:

- in industry – incentive for local production/loss of local production; some sectors can profit or fail as a result of increased access to the market/increased competition,
- in financial economy and trade – incentive for local business activities/decrease of local business activity,
- incentive for tourism/decrease of tourism; incoming tourism can increase with improved access, while residents have tendency to travel at longer distance during their holiday,
- impact on regional balance of payments; net impact on the value of export minus import,
- on the labour market – incentive for local employment/losses in local employment; it can include the whole effect of improved access and economic changes in employment, in connection with working age population,
- on the market of land and real estates – incentive for new development/change in schemes of land use; it can include relocation of activities towards places close to transport connections and high quality junctions; possible consequences on car dependence and sustainable development.

3.4 Further political impacts

Governments (central and regional) invest in transport not only due to expected profit in the sphere of economic efficiency and mobility but also due to the fact that the investment is expected to have positive socio-economic effects on spheres of their political interest.

Further political impacts that should be taken into consideration in CBA:

- land use – whether the project promotes plans of the use of a particular industrial or agricultural sphere, housing, national parks/national preserve or if it contradicts them,
- transport networks,
- controversial questions of social politics and social cohesion,
- pricing,
- participation of private sector,

- international character of the project.

4 Selected appraising criteria

4.1 Cost-benefit ratio

Cost-benefit ratio (relation 1) represents the ratio of all benefits of an investment project and all costs that will be required by realization of the project [9, 10].

$$(1) \quad NKV = \frac{N_b}{K_b}$$

where NKV is cost-benefit ratio, N_b - total value of all components that creates project benefit [EUR], K_b - total value of all project costs [EUR].

In case the appraised projects haven't the same duration of construction or lifespan, it is necessary to recalculate determined values to the same basis. That means, to express what benefit the project would have to a chosen year [11].

Without accomplishment of the above mentioned recalculation an alternative that would realize higher benefits in absolute numbers but during a longer time could be chosen. We can get further comparative base through the recalculation - relative benefits of the appraised project within the span of the unified period.

It is also necessary to take into consideration the development on financial markets and the development of the economy, which determines gross domestic product. Investment projects can calculate on anticipated inflation rate and determine expected costs on project realization on its basis [12]. However, in most cases projections concerning the development of the economy are not fulfilled. It is necessary to analyse the situation, when funds could be invested in a different way than in transport infrastructure, possibly to analyse particular alternatives with consideration of various interest rates. It is therefore necessary to consider discount rate.

If we want to get current benefit of the project, we must discount future incomes (relation 2) [13]:

$$(2) \quad N_{b,i} = f \times N_i \quad [\text{EUR}]$$

$$(3) \quad f = (1 + p)^{b-t_{a,i}}$$

where $N_{b,i}$ is present value of benefits of the investment i [EUR], f - discount factor, N_i - original (non-discountable) value of investment benefit [EUR], p - discount rate, t_b - base year for discounting, $t_{a,i}$ - year that investment benefit is discounted at.

If constant investment benefit is expected for the whole period of service life, the calculation will be accomplished according to the relation 4 [13]:

$$(4) \quad N_{b,j} = f \times B \times N_j \quad [\text{EUR}]$$

$$(5) \quad B = \frac{1 - (1 + p)^t}{p}$$

where $N_{b,j}$ is present value of benefits of the investment j [EUR], f - discount factor considering the time difference between the beginning of operation and the base year that investment is evaluated to, B - capitalization factor, N_j - value of average benefit of the project in the year j [EUR], t - number of years with constant benefit of the investment.

Investment costs discounting can be accomplished with the use of discount factor (relations 6 a 7) [1]:

$$(6) \quad K_{b,i} = f \times K_i \quad [\text{EUR}]$$

$$(7) \quad f = (1 + p)^{t_b - t_{a,i}}$$

where $K_{b,i}$ is present value of the cost item [EUR], f - discount factor, K_i - evaluation of cost items in the current year [EUR], p - discount rate, t_b - base year, $t_{a,i}$ - year that cost item is discounted at.

If information about cost distribution in the course of construction is not available, we suppose their uniform

distribution. The calculation of current costs is then accomplished according to the following relation 8 [1]:

$$(8) \quad K_b = f \times B \times K_j \quad [\text{EUR}]$$

$$(9) \quad B = \frac{1 - (1 + p)^t}{p}$$

where K_b is present value of investment costs [EUR], f - discount factor (between the moment of investment beginning and the base year), B - capitalization factor, K_j - value of average investment costs in the course of construction [EUR], t - construction duration.

The accomplished analysis shows how funds for construction are treated. For evaluation it is acquired present value of investment benefits and present value of project costs.

4.2 Cost-benefit difference

Another appraising criterion is cost-benefit difference. The criterion compares total discounted incomes following from the project with total discounted costs that must be invested in the project. The criterion refers to the base year and is determined by the relation 10 [14]:

$$(10) \quad NKD = N_b - K_b \quad [\text{EUR}]$$

where N_b means total current benefits of the project [EUR], K_b - total current costs of the project [EUR].

In case costs and benefits are determined in particular years, criterion value is calculated for every year with the use of capitalization coefficient according to the relation 11 [14]:

$$(11) \quad NKD_j = N_b \times \frac{1}{B} - K_b \times \frac{1}{B} \quad [\text{EUR}]$$

where NKD_j is annual cost-benefit difference [EUR], B - capitalization factor.

5 Results and discussion

The main part of CBA design is the estimate of users' benefits. The most important for economic side of many projects are user's benefits in the sense of time and money savings.

Three fundamental concepts that represent the basis of the user's benefit definition in transport CBA are generalized costs (GC), willingness to pay and consumer surplus (CS) [15]:

- generalized costs mean the amount of money representing total disutility or inconvenience of travelling between particular source (i) and destination (j) by means of particular kind of transport (m). Strictly speaking, they include all aspects of disutility including spent time, expenses and further aspects of inconvenience (in practise, these last are usually ignored),
- willingness to pay is the maximal amount of money that a consumer would be willing to pay to undertake a particular trip (this can be interpreted in the best way as maximal generalized costs that he is willing to pay to get from i to j),
- consumer surplus is defined as surplus of consumer's willingness to pay over current generalized costs of travelling from i to j .

For the travel market between i and j (for simplification we suppose existence of only one transport kind):

$$(12) \quad UP_{ij} = SP_{ij}^1 - SP_{ij}^0 \quad [\text{EUR}]$$

where UP - user's benefit [EUR], SP - consumer surplus [EUR], where 1 means the situation with the project and 0 the situation without the project.

Components of generalized costs will differ depending on transport kind. Users of public transport (bus, coach, railway and water) pay for the fare and spend time for the purpose of trips to their destinations. Users of passenger cars and lorries for own purpose (they give up time) pay charges for access to

infrastructure and pay also vehicle operating costs. That's why fundamental difference exists in reported user's benefits for different kinds of transport.

6 Conclusion

Transport infrastructure projects have a great impact on transport system and influence both transport users and subjects participating in its formation. These projects must be judged on the basis of multi-criterion comparison. It is difficult to apply free market competition because there are limited geographical conditions for transport constructions realization. Transport infrastructure represents a typical project realized in the public interest.

Another specific characterization of transport infrastructure investments is their long-term use and construction. It is therefore necessary to judge transport infrastructure projects mainly in the long run. The appraisal should be made with respect to public good, in particular.

Infrastructure projects can be generally judged on the basis of comparison between construction costs and construction positives that means through cost-benefit analysis. This analysis evaluates not only monetary impacts but also non-monetary ones, which is necessary in the case of such projects.

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