LIMITS OF USAGE OF COST-BENEFIT ANALYSIS BY EVALUATION OF PUBLIC PROJECTS

Lucie Sobotková

Abstract: *The article deals with the issue of evaluation of public projects which is based on the method of Cost-benefit analysis. The future social benefits and costs of public projects (financed especially from funds of the European Union) are evaluated by means of this method. We can practically meet the approach of set of social benefits and costs which arise from the assessment of present relevant economies. These economies are consequently predicted on the whole time of life cycle of the project. At the same time we simplify when we assign the present benefits to the particular years of lifetime of the project (we only respect the discount rate). This article proposes to involve the approach of system dynamics in the prediction. The system dynamics searches the reality as the system when the particular items of system are mutual influenced. The feed backs are raised when the result of the activity influences the original cause by return. The integration of the system dynamics into the evaluation of social benefits and costs could improve the prediction. Because the efficiency allocation of public resources is the aim of evaluation of public projects, the usage of system dynamics could support the process of allocation.*

Keywords: *Cost-benefit analysis, Methods of evaluation, Public projects, Simulation, System dynamics.*

***JEL Classification**: H43, R58.*

Introduction

Any human activities in private and public area as well are confronted with the fact of limited sources. This limitation relates to all of sources (financial, capital and human sources). Therefore it is important to evaluate their using. On the basis of the evaluation we can make the decision about the final allocation of sources that way in order to the result of the human effort brings the required solution. Nevertheless e.g. in the area of public sector may deal with the effort to support the development, assess the suitability of provided public services etc. with the aim to identify the territorial impacts of these activities.

We can use various methods and approaches for evaluation above mentioned activities. These methods are represented by cost minimization analysis (CMA), cost-effectiveness analysis (CEA), cost-utility analysis (CUA) and cost-benefit analysis (CBA). The evaluation of projects in the area of public sector is just most often linked to these methods. Firstly the attention will be paid to the method of CBA, which is recommended e.g. by the European Union to the evaluation of projects which call for the grants from the European Funds (see e.g. [2]). However, this method is often criticized by a lot of authors. These authors often stress the weaknesses and inaccuracy which this method produces. The aim of this article is not only to describe these weaknesses by its application. The steps which are using the theory of the system dynamics are suggested in the conclusion of this article. The theory of system dynamics may be the instrument for specification of criteria designed for the decision making about the realization of public projects.

1 Cost-Benefit analysis method

1.1 Characteristics of the method

The cost benefit analysis (CBA) represents the practical way of evaluation of suitability, especially of public projects. This method evaluates from the point of view of the long term projects and the point of view of wide of their impact (we can insert the impact on the specific groups of inhabitants, chosen industries or relevant regions, cf. e.g. [9]). This analysis becomes an instrument in the hands of government. The aim of this analysis is to support the decision making process about the realization of public projects. Namely, the ensuring the efficiency by usage of public sources is the aim of the analysis. The essential decision-making criterion is based on the principle according to which the benefits of the project have to exceed the costs expended on the project. Benefits and costs are expressed in financial units. This fact enables to compare the projects with different time of life cycles. We can include the factor of time in the analysis in the discount form.

The decision on the choice of suitable variant of project should be determinated on the basis of difference between benefits and costs (accordingly on the basis of the net present value) or on the basis of the benefit-cost ratio. Then it has to stand:

$$PV(B) > PV(C) \tag{1}$$

or

$$NPV > 0 \tag{2}$$

whereas:

PV – present value,
B – benefits,
C – costs,
NPV – net present value.

In the case of the benefit-cost ratio the project (variant of project) is accepted under these conditions:

$$PV(B) \,/\, PV(C) > 1 \tag{3}$$

It is possible to set the rank of projects (variants of project) on the basis of result of the net present value or the benefit-cost ratio. After, we can choose the project (variant) with the highest calculated value for the realization.

1.2 The basic evolutional stages of the method

The evolution of the CBA is mainly linked with the requirement of so called the efficiency in government. This concept especially begins to enforce in the phase after the World War II. Prest and Turvey [9] describe that this method started to invoke in the United States over the 20th century. Stepwise, the method is deepened and the principles are codified. According to Adler and Posner [1] the modern concept of the CBA is the result of three historical evolutionary phases. In the historical concept we can see the first at the turn of 19th and 20th century when the idea of usage of expertise in public administration on the scientific basis is established. The main phase of practical usage of CBA relates to strengthening the influence of central government of the USA in other countries during the 20th century. The method is especially linked with the programme the New Deal which in the United States in 1936 initiated the usage of the CBA. In this stage the Congress instructed to agencies to weight the costs and benefits of projects related to flood-protection actions. The popularity of this method begins to grow from these times. The third phase relates to the enforcement of modern concept of the welfare economics. This situation relates to 1950s and 1960s when the U. S. government and other countries found the technical support for application of this analysis. In this period the techniques for evaluation of investments developed by private sector diffuse to the public sector. Pearce, Atkinson and Mourato [8] remark that in this period the method of the CBA especially struggles in the area of environmental policy, transport or health care. Furthermore, e.g. the OECD struggles for its distribution in terms of economic analyses which facilitate the decision -making process.

In the following years the principles of the CBA become a part of other additional analyses. E.g. presently we can meet this method in valuation of required by the European Union for the Applications Form to obtain the grants from the EU Funds. The method of the CBA is the part of the Feasibility Study which is required e.g. in applications for financing from Regional Operational Programmes when the relevant the Regional Council of Cohesion Regions.

1.3 Limits of the Cost-Benefit Analysis Method

The method of CBA was often the subject of criticism over the years. The criticism was pointed at the philosophic-moral aspect, theoretical principles or practical application. Adler and Posner [1] mention that many of research workers in the area of law, but also economics and philosophy refer to poor moral foundation of evaluation and assessment in the area of natural sources or human life and other hardly valuable products. The relevancy of obtaining information for further decision making is very low. In addition, it is argue against according to economic point of view that the CBA does not allow the comprehensive and consequent ranking of projects because we are in the area of normative economics. Therefore, the results cannot be always neutral and scientifically well-founded.

The European Commision [2] refers to other limitations. The CBA is used in the area of social sciences which are not the exact sciences. These sciences are based on the approximations, working hypotheses or certain simplifications. The reason relates to the often lack of data, limitation set by the used methods of assessment etc.

We can meet in the case of the method of CBA the quite a number of critical reservations which relate to the theoretical foundation and its application as well. Pearce, Atkinson and Mourato [8] attend to limited usage of the CBA in the theoretical level where the CBA is based on the neoclassical economics of welfare especially linked to the Pareto approach. Pareto principle says that made changes are successful only in the case if nobody suffers the loss of welfare and at least one person improves (the Pareto improvement). However, the Pareto principle cannot evaluate in the certain situation the fruitfulness of the changes. Therefore the CBA uses as the theoretical basis the Kaldor-Hicks compensation principle as well. The aim of this principle is to overcome the limits of Pareto approach. The compensation principle moves towards the evaluation the policy as fruitfulness when the subjects, which increased the level of their welfare, will compensate those subjects, which lost a part of their welfare in consequence of realization of the policy. Nevertheless, it was achieve of the certain improvement compared to previous conditions.

In relation with the CBA more critical acceptances occur pointing the theoretical fixation. E.g. Prest and Turvey [9] set four basic critical questions:

- Which costs and which benefits are to be included?

- How are they to be valued?
- At what interest rate are they to be discounted?
- What are the relevant constraints?

The first question refers the determination of subjects which will directly be injured and determination of benefits and costs which will come into the analysis. Vodáková [17] e.g. mentions that the impacts of projects affect a wide range of subjects (beneficiaries). Therefore, it is important to decide which subject will be included into the analysis as the relevant beneficiary and which subject will not be included. It is the normative approach again when the decision on appropriate beneficiaries (the choice of the suitable deciding criterion for their determination) can influence the output of the analysis.

Hereto, these subjects (beneficiaries) are able to be specified, the next question appears which is related to their utility. The question is, if we can aggregate the individual curves of utility into the one utility function, or how the social function reflects the interests of all individuals. This social function is a certain consensus.

The next critical point according to the point of view of the comparison of benefits and costs relates to the probability of occurring of partial benefits and costs. While the probability of realization of future expenditures of the project is high, the probability of realization of partial benefits can move quite arbitrarily. The benefits of the projects are rather illusory. If we compare the various alternatives, we can claim the alternative with the highest "net profit" cannot be the best solution at the same time (cf. e.g. [3]). This consists in the completeness of involvement of all benefits and costs into the analysis. Sen [12] notes that the CBA is the method of maximization, but it is not the optimization method. According to this point of view it is not important to compare all of available alternates and to choose the optimal solution. According to the principle of maximization the solution is sufficient if the decision-maker chooses the alternative which is not worse than the other compared variant.

Close to the solution of the question of assessment of social benefits highly depends on the used technics of their valuation. At monetization of partial benefits (and costs as well) we can use the direct assessment on the basis of market price in the case, that the market of the product exists. Sieber [14] points out that we cannot use this technique in the case of a lot of benefits and costs of public projects. The projects create the effects which is possible to designate as public goods and services. If we cannot set the market price than we can use following possibilities:

- Analogical markets,
- shadow prices.

In the case of usage of analogical markets we can try to assess the effect by means of the derivation from the price of other asset for which the market exists. This possibility has the condition that the logical relation exists between the both of goods, e.g. we can evaluate the level of noise in the municipality by means of difference of market prices of real estates in the relative noiseless area and in the area with noise pollution.

The shadow price is according to Sieber [14] one of the possibilities to evaluate the good which does not pass through the market. The principle of shadow prices consists in the existence of opportunity costs of production or consumption of valuated commodity. Nevertheless, we expect if we do not obtain the valuated benefit instead of it we consume the other product or service. The saved costs for this product represent the price of valuated benefit. The valuation of increasing of road safety by means of decreasing of costs for healing wounds caused by traffic accident is the suitable example.

The usage of non-market evaluation methods is based on the using the approach of willingness to pay or willingness to accept (for details see e.g. [8]). The increment of individual welfare can be valued by the maximum amount which the individual is willing to forego to reach the change. In the case of decreasing of the individual welfare we can use the amount which the individual requires as the compensation to accept this decreasing. In principle, we can measure four basic variants (according to [7]):

- Willingness to pay to secure a benefit,
- willingness to accept to forego a benefit,
- willingness to pay to prevent a loss,
- willingness to accept to tolerate a loss.

Although, both of technics are essentially based on the same idea, they can provide different evaluation of attained benefits (or losses). This reality was in many times empirically confirmed. The difference among the results is especially evident in the case of the revealed preference method (for details see e.g. [8]).

The choice of the used discount rate can influence the resulting decision. Many public projects are long-run character. Then it is important by the valuation of benefits and costs to take into account the time factor. The question consists in the choice of the height of the discount rate which is suitable for evaluating of public projects. The European Commission [2] recommends to use in the case of so called cohesion countries the social discount rate 5.5 %. The Commission sets in other countries this rate in value 3.5 %. Further, e.g. Kubíček and Vítek [4] deal with the issue of the social discount rate. They refer to the absence of favorable methods for set the social discount rate for long-term projects. With increasing of the discount rate we will rather prefer the short-termed projects. These authors suggest two possible methods for the set of the social discount rate (for evaluation of social benefits of public projects). They recommend in both of cases to choose different height of discount rate during the lifetime of valuated projects. In the long run the height of the discount rate should be decreasing.

The next issue relates to the choice of criteria for decision-making on the realization of the policy or the project. The decision on the suitable variant of the policy or the project can be made on the basis of differences (also on the basis of the net present value) or the quotient of benefits and costs. However, Pearce, Atkinson and Mourato [8] refer that the choice of the decision criterion can affect the choice of resulting variants (the difference or the rate of benefits and costs). Nevertheless, it is not possible to set which of the criteria gives reliable results and to the better support of the decision.

2 Limits during application of the Cost-Benefit Analysis as a tool for evaluation of public projects

Beside the above describing limits of the method of the CBA we can meet other limits linking to a practical application. These limits can affect the final decision on the evaluated project. In this case the access of the evaluator is the source of constrain, e.g. Marešová [5] designates the author of the analysis as the significant factor. We can commit many mistakes in particular steps of the CBA. The author describes the example of error of the evaluator who can monitor the subjects by unequal ways in terms of projects. We can pay higher attention to some subjects (their benefits or costs) than others.

As it was mentioned above, the European Union requires at the application for financing of projects from the Funds to create the Feasibility Study. The CBA is a part of this study. This study is oriented at a comprehensive describing all of realization aspects of investment including their taking into an account in financial flows. The CBA is focused on the resulting effects of the project, on all of subjects and on the valuation of meaningfulness (cf. [15]). The project is evaluated by the criteria, which are contained in the Feasibility Study. These criteria should be clearly identified by their content, by their task in the system, by determination of the way of their measurement and determination of "transformation" of measured and assessed values into the integrated scoring scale, or, eventually, it must determine the conditions of acceptability or unacceptability of the project (for details see e.g. [6]).

In the methodical materials (see e.g. [11]), and in the projects studies (see e.g. [10]) the evaluated benefits are predicted and assessed for the appointed durability life of projects. We can mention as an example the Feasibility Study "Bicycle Path Bezpráví – Choceň" (The project of the bicycle path between two concrete municipalities in the Czech Republic) [10], where the benefits are evaluated in the form of time savings (saved time of employees and students which can use the bicycle path during the commuting to the job or to the school) or costs savings (savings of travelling expenses for buses or cars if they use the bicycle path instead of these vehicles). The savings are counted on the basis of expected usage of the bicycle path. The next criteria (e.g. reduction of air pollution or noise pollution) are only enumerated (considering their difficult quantification – see [10]). As indicated above, the method of the CBA is not understood as the optimization method. Therefore, we can the quantified benefits of the project regarded as sufficient. Further, this article deals with the way of criteria of saving applied in the method. The time savings are related to the users of the bicycle path. The number of users is estimated on the basis of the real population in the region and on the basis of the estimate of the number of potential users from the inhabitants. This estimate of users is taken as constant throughout the lifetime of the project. We come to the question whether this chosen approach is fully suitable (also whether with respect to the previous mentioned notice, it is really the question of the correct application of method or the fault of the method).

3 System dynamics as a tool for the limit restriction in the use of the Cost-Benefit Analysis

We use the above mentioned project of the bicycle path for the evaluation of limits of the application the CBA. As was mentioned above, the project of the bicycle path is evaluated according to the criteria of impacts of the project on the region and its inhabitants. The benefits entering the CBA are expressed by means of savings of time and savings of costs beside the unused the bus or the car as transport vehicles. Thus, these benefits have the direct connection with the project. The probability of the realization of these savings is not valuated in this study. Because the CBA in a principle does not value the probability of realization of benefits, their application is accepted in this sense.

The improvement of predicative abilities rather relates to the access of evaluator to express future benefits (and costs as well) of the project. All savings are, as was above mentioned, related to the real number of the inhabitants in region. The number of potential users is set according to the estimation. This number is essentially valid for the moment of the creation of the Feasibility Study. It is predicated in unchanged form (only with taking into account of the time factor in the form of discounting) for the next year of the estimated life cycle of the project. We can denominate this approach as static. We only reflect the one-way causality between the usage of the bicycle path and the mentioned savings. We can set the question whether we can expect the change in the number of users of the bicycle path in the relation to its usage (e.g. worsening of the bicycle path condition) or in the relation to the other factors which will influence the attitude of users to its utilization (e.g. the growth of a price of bus tickets or growth of a price of fuel). These causalities express simultaneously in reality. Moreover, we can perceive so called feedbacks as well when the result of the certain process influences the initial causal factors (e.g. the worsening condition of bicycle path due to increasing interest in its utilization can discourage a part of potential users). Thereby, we come to the so called system thinking which also enables to us to perceive relations among events which are distant in space and time (for details see e.g. [13], [16]). We designate the scientific approach utilizing the system thinking for modelling of complex structures of the world as the so called system dynamics. And this approach is already used in this paper for supplementation of the CBA. We use the above mentioned project of the bicycle path and we simulate numbers of users and their reached savings. We can try to improve the evaluation of the project.

3.1 Dynamic model of the bicycle path project

The dynamic model was constructed in this paper for introducing the system dynamics as a possible and suitable instrument for the elimination of the limits along with the application of the CBA method. This model enables to predict the users of the bicycle path and the savings of the users. The model is created in a graphical form which uses the causal loop diagrams and the stock and flow diagrams. This graphical form enables to search the structure of the model and to perceive the linkages among the particular components of the drawing system. The model describes the above mentioned project "Bicycle Path Bezpráví – Choceň" and the model is based on information of the Feasibility Study of the evaluated project. This study was submitted in 2008 to the Regional Council of NUTS II North-East. This project fulfilled the required evaluating criteria and was approved on the basis of this study. The realization of the project took place in 2009 and 2010 and was co-financed from the European Regional Development Fund and from the Regional Operational Programme NUTS II North-East.

The impact on local community is evaluated by means of following groups of inhabitants:

- Employees which commute now or they are going to commute in future to work,
- students of secondary and primary schools,
- inhabitants of all age categories which commute to the Offices and to other services to catchment municipalities Ústí nad Orlicí, Brandýs nad Orlicí and Choceň,
- families with children and tourists of all age categories seeking the sport activities and cycle touring,
- specific groups of inhabitants – disabled people with reduced mobility.

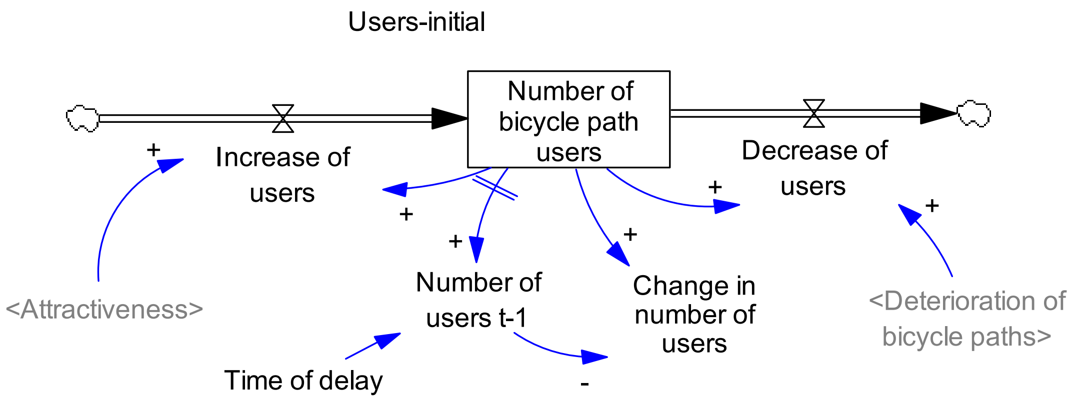
The following data of the Feasibility Study are taken as the input into the model. The group of employed people was only chosen for purposes of this paper. According to the

Study the 40 % of employees (also 1 387 persons) commute to work. The Study supposes that this target group will regularly use the bicycle path (however, just the half of these persons will use the bicycle path according to this Study). The searched employees save time (thanks to flexibility of the bike as the means of transport without necessity to wait for the bus service; moreover, according to the Study the frequencies of bus service are weak). The savings for bus ticket or costs related to the car are in the Study considered as well. However, we will not take into account these savings in the dynamical model with respect to focusing of this article. The time saving is evaluated by means of the average value of one hour in the Study (one hour is assessed as an average net wage per one working hour in the month). The saving amount is 100 CZK per hour. Furthermore, the Study operates with 253 working days in a year and the usage of bicycle path only in 30 % of cases. The annual amount of savings is estimated at 2.6 mil. CZK in the Study. This value is used within whole lifecycle of project (expressed in the form of the present value).

All the above mentioned data will be used in this article as input data into the dynamic model as well. The introducing of the possibility of utilization of the dynamic model by the application of the CBA is the aim of this paper. Therefore, the model is simplified in a such way that a discount rate is not used in the model. Furthermore, the model estimates the certain lifetime of the bicycle path. However, we can expect that the real lifetime of the bicycle path will be longer. The possibility to let the discount rate relates to the paper of Kubíček and Vítek [4] which suggest using the social discount rate approaching to the zero in the limit.

The dynamic model for the evaluation of benefits of the bicycle path is shown in the Figure 1. This model displays only the time savings of users of the bicycle path.

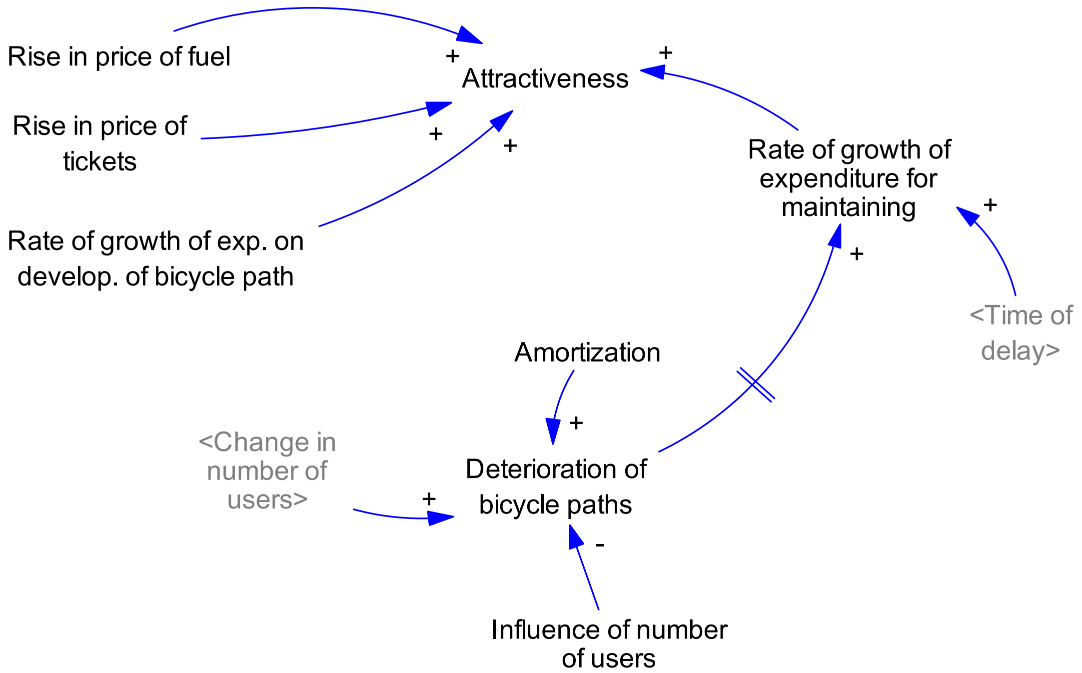
Fig. 1: Model of users of bicycle path



Source: Author

The model supposes that the number of users of the bicycle path is influenced by two basic factors which the Attractiveness of the bicycle path and worsening of the bicycle path. The construction of these two coefficients is displayed in the Figure 2.

Fig. 2: Model of factors influencing the number of users of bicycle path



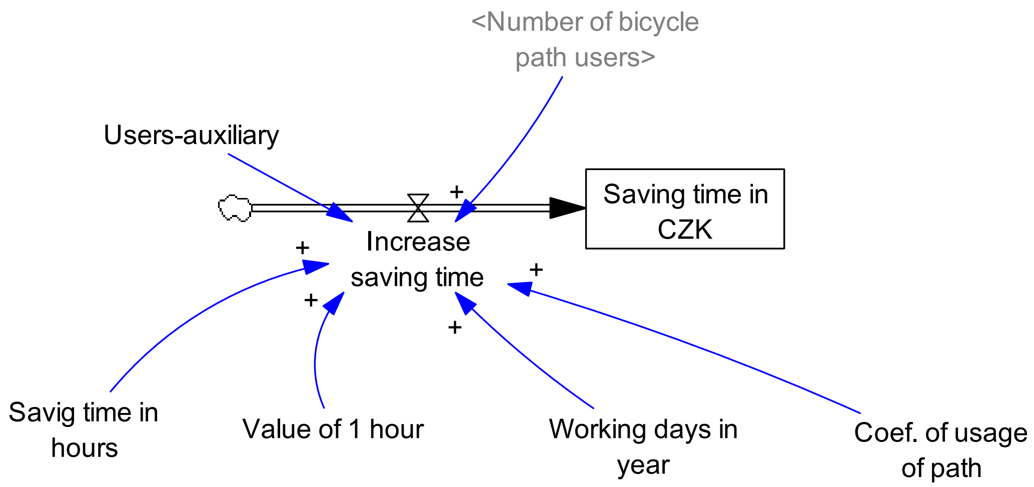
Source: Author

The coefficient of attractiveness of the model consists of four partial factors in this case. The number of users of the bicycle path will grow if prices of fuel will grow, prices of bus tickets will grow and expenditure for maintaining and development will grow as well. Nevertheless, the expenditure for maintaining and development of the bicycle path are realized with an annual delay.

Also the supposed coefficient of this model which expresses the deterioration of the bicycle path depends mainly on the number of users. This dependence between the growth of users and the relevant deterioration of the path is not linear. We suppose that the rate of deterioration of the bicycle path will grow faster than growth of number of users. The next factor which decreases the number of users of the bicycle path is the rate of an amortization. For simplification is considered that the amortization will express after five years since the introducing.

The last model already summarizes the reached time savings. The calculation procedure of the savings is displayed in the Figure 3 (according to the calculation procedure used in the Feasibility Study). We can expect that on the basis of the approach of the system dynamics, the limiting linear approach to the determination of the time savings will be replaced with the new values according to the simulation of the dynamic model.

Fig. 3: Model of the financial evaluation of the savings of time



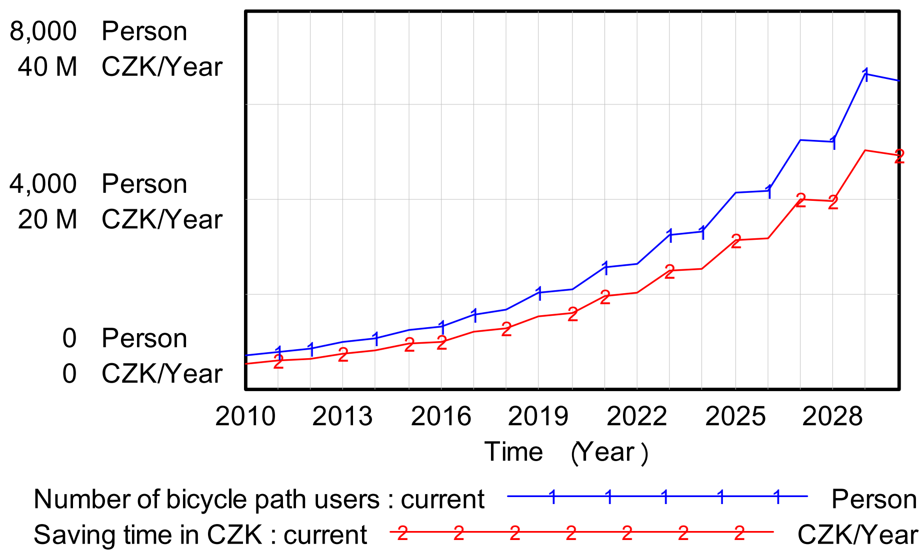
Source: Author

3.2 Simulation of dynamical model of usage of bicycle path

For assessment of savings of time in searched years the period of twenty years was chosen (this period represents the supposed lifetime of the bicycle path as it was set in the project). The Study considers that the benefits can be evaluated up from putting of the bicycle path into use (it means since 2010). The model was consequently simulated in the programme of Vensim PLE 5.1.

As it was mentioned above the input data were taken from the Feasibility Study. The result of simulation is shown in the Figure 4. This figure captures the number of users of the bicycle path within the tested horizon of twenty years and captures the achieved savings in the monetary expression. The indicator called "the saving time in CZK" is accordingly to the point of view the CBA very important one. The number of persons is observed as the auxiliary criterion in the figure.

Fig. 4: The simulation of the bicycle path users and their achieving time savings



Source: Author

The number of users of bicycle path will not be constant during the analyzed period (see the Figure 4 and the result of the simulation). We can compare with the Feasibility Study the situation which considers the constant number of users. This constant number of bicycle path users causes that the reached savings are constant throughout the lifecycle of the project as well (e.g. the Study enumerates the savings of commuting work forces as 7.532 mil. CZK). The input data from the Study were influenced partly by the growing attractiveness and partly by the supposed physical conditions. The number of users does not grow smoothly as we can see in the Figure 4. It is caused (in certain years) by predominated negative factors which decrease the number of users. Moreover, the savings proceed together with the number of users. The simulation of model displays that the social savings cannot always be constant throughout the lifecycle of the project. The usage of the system dynamics in the CBA enables to set the benefits (and costs) more precisely in both of evaluated situations. Even, it is possible in the specific situation when the negative factors that decrease the attractiveness outweigh the positive factors. We reach the limits in this approach by this procedure. Each model is dependent on the assumptions, on the input data and on the rate of simplification of reality. The accuracy of estimation depends on the precision of creator of model and the ability to record just the main linkages among the partial elements of the modeled system.

Conclusion

The economic evaluation of benefits and costs of public projects is required in certain cases (especially it is valid in the case of projects financed by the Funds of the European Union). The reason consists in the effort to support the efficient projects (also the projects with minimal costs and with maximum effects). The public projects should not bring the profit but their aim relates to the increasing of the social utility. Therefore, it is important to well-evaluate all of benefits. The evaluation of the suitability of projects (special projects which are financed by the Funds of the European Union) is done by the Feasibility Study. The CBA is usually the part of this Study.

The method of CBA is already used for evaluation of public projects for many years. However, many of authors highlight the weaknesses of this method in the theoretical foundation. They stress different simplifications linked to the assessment of the benefits and costs of public projects as well. On the other side, we can meet the plea, e.g. some warn of the fact that this method is not the optimization method. Therefore, the certain simplification of the searched reality is acceptable.

The article deals with limits of the CBA by its application. The real projects of the bicycle path were chosen for the documentation of these limits. The estimation of future benefits of project is the basic application limit. The system dynamics is used for overcoming these limits of the CBA. Because, the forecast of the evolution should provide the most faithful picture of the future situation of the world, the system dynamics recommends to look at the valuated object as at the system and notice the mutual causalities among the elements of this system. The model is the result of this approach. We can simulate this model and this simulation can precise our forecasts of the future benefits.

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Contact address

Ing. Lucie Sobotková, Ph.D.
University of Pardubice, Faculty of economic and administration, Institute of economic science
Studentská 84, 532 10 Pardubice, Czech Republic
Email: lucie.sobotkova@upce.cz
Phone number: +420 466 036 159

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