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EVALUATION OF INVESTMENT RISKS IN CBA WITH MONTE CARLO METHOD

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Abstract

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Investment decisions are at the core of any development strategy. Economic growth and welfare depend on productive capital, infrastructure, human capital, knowledge, total factor productivity and the quality of institutions. Decision-making process on the selection of suitable projects in the public sector is in some aspects more difficult than in the private sector. Evaluating projects on the basis of their financial profitability, where the basic parameter is the value of the potential profit, can be misleading in these cases. One of the basic objectives of the allocation of public resources is respecting of the 3E principle (Economy, Effectiveness, Efficiency) in their whole life cycle. The life cycle of the investment projects consists of four main phases. The first pre-investment phase is very important for decision-making process whether to accept or reject a public project for its realization. A well-designed feasibility study as well as cost-benefit analysis (CBA) in this phase are important assumptions for future success of the project. A future financial and economical CF which represent the fundamental basis for calculation of economic effectiveness indicators are formed and modelled in these documents. This paper deals with the possibility to calculate the financial and economic efficiency of the public investment projects more accurately by simulation methods used.

Keywords: Public projects, EU funds, CBA, efficiency, education infrastructure, Monte Carlo simulation

INTRODUCTION

There have not been any records of improvement in economic situation of the Czech Republic recently. What is more the decrease of GDP in 2012 was recorded and it still continues in current year. Among others the unstable political situation, increase of VAT rates, small (or none) growth of salaries, growing unemployment rate and continuous reduction of state investments as well as stimulus are the main negative factors. Deep cuts in public investment into transport infrastructure development and problems with drawing EU funds (e.g. errors in coordination and management, troubles with corruption) (Country report, 2013) represent particularly negative factors for construction industry.

Unstable political situation still remains the main risk of prognoses. Planned reforms carry on fighting with continuous postponements and mainly with frequent changes in key elements. Government collapse in June 2013 led to dissolution of the Parliament and announcing premature elections for October 2013. Meanwhile the president appointed a new government but it did not get necessary parliamentary support and governed as government in resignation. Therefore this government had no necessary authorisation for example to negotiate within EU about funds for new programme period. October premature elections did not bring any significant result to traditional government parties and establishing of the new government therefore remains one big question mark. The most probable variant is continuing the current government in resignation to the following year. Therefore there is now a great issue – the approval of 2014 state budget. If there will be no general agreement about the budget, provisional budget system will come into effect and certainly it would not help economic situation any further (Country report, 2013).

Unpredictable economic policy and absence of stable government with clear vision still afflicts Czech atmosphere. Although there is low confidence in economics, prognoses of Czech National Bank and Ministry of Finance are quite optimistic (1.3 to 2.1% GDP growth in 2014). Those predictions are also base for state budget plan and its deficit. It is not sure if government has enough time to approve state budget for the next year. Impending budget provisory which tend to be long-term can cause threat to government investment, utilization of EU funds and decline of GDP by about 1% (Country report, 2013).

Investment decisions are at the core of any development strategy. Economic growth and welfare depends on productive capital, infrastructure, human capital, knowledge, total factor productivity and the quality of institutions. All of these development constituents implied – to some extent – making the difficult decision to sink economic resources now, in the hope of future benefits, betting on the distant and uncertain future horizon (Guide to CBA, 2008).

One of the basic objectives of the allocation of public resources is the respecting of the 3E principle (Economy, Effectiveness, Efficiency) in their whole life cycle. Economy refers to the efforts to minimalize especially financial resources. In the context of criteria of effectiveness the ability to produce the desired benefit is required. Efficiency indicates the use of such resources, which tend to achieve maximum volume and quality of products (Ochrana, Jan, Vítek, 2010).

Decision-making process on the selection of suitable projects in public sector is in some aspects more difficult than in the private sector. Evaluating projects on the basis of their financial profitability, where the basic parameter is the value of the potential profit, can be misleading in these cases. public sector has to evaluate projects from two aspects, both from the perspective of direct financial impact of the project on the evaluated entity (financial profitability) and in a relatively large scale in terms of the objectives of national economic policy aimed at raising the standard of living at all levels of society (economic profitability). Decision on the project selection is based on the priorities that the society has.

The public sector, sometimes referred to as the state sector or the government sector, is a part of the economy concerned with providing basic government services which represent the production, delivery and allocation of goods and services by and for the government or its citizens, whether national, regional or local/municipal.

The composition of the public sector varies by country, but it mostly includes police and military services, public infrastructure, primary education, healthcare etc. The public sector might provide services that non-payer cannot be excluded from (such as street lighting), services which benefit all the society rather than just the individual who uses the service (such as public education), and services that encourage equal opportunities.

Public structural investments can be financed by public sources in full or partly with utilization of other possible financial sources:

- PPP projects,
- EU funds,
- grants,
- etc.

European Union (EU) uses structural EU funds and cohesion fund as tools for applying policy of economic and social cohesion in member states on regional level. Structural EU funds are divided into (depending on their focus):

- European Regional Development Fund (ERDF),
- European Social Fund (ESF).

Those funds represent big amount of potential financial sources for member states of EU. For example during programme period 2007–2013 there were allocated 26.69 billion EURO for the Czech Republic.

Operational programmes are intermediate stages between EU funds and the specific beneficiaries. There are 26 operational programmes in the Czech Republic divided into several chapters which can be represented by:

- municipalities,
- regions,
- ministries,
- entrepreneurs,
- non-profit organizations,
- schools,
- etc.

The Czech Republic was evaluated as the worst of EU members in area of effective utilization of EU funds during the passed period. Since its proportion on unexpended resources in the whole EU during last year was more than 60%. As actual Monthly Monitoring Report created by Czech Ministry of Regional Development displays there are still more than 50% of certified costs left to spend (Monthly Monitoring Report, 2014).

Considering above mentioned facts, current government has set the effective utilization of EU funds as its priority since there are not many other financial sources to recover Czech economy.

Aim of this paper is to prove that including Monte Carlo analysis for risk prediction into Cost Benefit Analysis can help to reach more accurate results in planning phases of investment projects. CBA is used as a main tool for evaluating public projects thus their profit is represented by public goods. Involving risk planning with probabilistic approach in CBA can increase effectiveness of utilization of financial sources including EU funds. In this case it can lower negative effect of risks such as wrong allocation of costs or refunding of grant.

Using Monte Carlo simulation for risk prediction can help to achieve approximation to real values and thus decrease variation of plan from reality.

MATERIALS AND METHODS

The output presented in this paper has been created with the use of CBA, risk analysis and Monte Carlo simulation.

CBA method should form the basis of a good appraisal and, on the other hand, of some issues that deserve particular attention. The scope of the feasibility section is to summarise the main input that should, ideally, be included, together with demand prognosis, options for consideration etc., before entering the financial and economic evaluation. In the area of Education and training infrastructure it is recommended to deal with critical factors investment and operating costs, the demographic dynamics in the catchment area and the success of the educational programmes (Guide to CBA, 2008).

Creating a simulation model completes the modelling and simulation process CBA. The CBA was created according to generally known technique of CBA analysis. The first level is a determination of the relevant financial and economic net cash flow (NCF) of the projects. It means that the following items should be known:

- total investment cost,
- operational revenues during lifetime of the project,
- operational costs during lifetime of the project,
- relevant measurable monetary benefits that relate to the focus of the project during its lifetime.

All of the mentioned items are liable to risks. Project risks are uncertainties that may have either a positive or negative influence on at least one of the project´s constraints (De Ceuster, 2010).

It is necessary to apply risk management to avoid undesirable results in both public and private projects. The aim is to maximalize project success and at the same time minimalize negative effects of risk factors. Risk management is systematic, coordinated and cyclic process which operates with uncertainties considering principles of continual improvement.

Risk analysis represents key part of this process. It consist of a set of rules how to handle a risk. Risk identification is the standardized process for identifying and characterization of the risks that may be present in the project. In further step it is necessary to quantify the effect of those risks and identify those essential ones which we should focus on. The most significant risks are quantified by their monetary value and financial impact. Several methods for evaluation of risks such as economic effectiveness indicators, decision tree analysis, statistical and probabilistic approaches are used for it.

The advances in technology also changed the possibilities how to analyze statistical data and develop simulation techniques. Modern statistical methods are used everywhere and they have become very important in the process control and simulation techniques like Monte Carlo (De Ceuster, 2010).

When there are several key risk factors that influence results of risk analysis and which have continuous character, it is appropriate to apply Monte Carlo simulation instead of plain scenario analysis. Creating a simulation model closes the modelling process and opens the space for using the model in simulations, which are actually the real objective of the whole modelling process. The first level is the insertion of input items into a simulation model and determining the costs (investment, operational). The second level of the economic simulations are experiments with different input variables, while using the principle of a sensitivity analysis. This procedure can be repeated in a number of simulation steps (Hlinica, Fotr, 2009).

RESULTS

Construction of buildings for education is a typical public investment project. The purpose of such projects is forming a financial profit; the project is evaluated particularly in the light of its social benefits. The evaluation is influenced by the investment costs, operational costs and also the number and quantity of benefits. The expected changes in these variables have been included in the assessment of projects using the Monte Carlo simulation and software Crystal ball respectively.

Education field is facing lack of public sources and lowering number of students. This situation leads to optimisations and consolidation of some subjects. Supporting element for this area are represented by EU funds (Country report, 2013).

Investment projects from education infrastructure area were used as a subject of analysis. All of the case studies are comparable since they are situated in the same region and financed by combination of public sources and EU funds. They are covered by Regional Operational Programme NUTS II – South-East and are included in priority axis 3 Sustainable development of towns, cities and rural settlements.

Mathematical models of object of risk analysis in MS Excel for each case study were created as the first step of the Monte Carlo simulation. Significant part of these models was formed by projects cash flows during the whole considerated period. This period of 20 years included investment and operational periods.

All of the main input variables were subject to sensitivity analysis. Sensitivity analysis can indicate which parameter values are reasonable to be used in the simulation model. The sensitivity indicators were indicators of economic effectiveness – financial and economic net present values (FNPV, ENPV). Sensitivity analysis is used to determine how "sensitive" the model is to changes in the parameter value of the model and to changes in the structure of the model. By showing how the model behaviour responds to changes in parameter values, sensitivity analysis is a useful tool in modeling building as well as in modeling evaluation. Sensitivity analysis helps to build confidence in the model by studying the uncertainties that are often associated with parameters in models (Breierova, Choudhari, 2001; Hnilica, Fotr, 2009).

Sensitivity analysis resulted in set of three key input variables (assumptions) which are highly unsure and influence the outcome of case studies significantly:

- investment costs,
- income from grants,
- income from public sources.

Probability distribution of sensitivity analysis to found key variables based on the survey parametres were set. Thus defined key variables were entered into the Monte Carlo simulation. The basic idea of this simulation is that working with certain probability distribution of key variables ultimately informs us about what is the probability of achieving project results, including identification, how much the key variables threaten the outcome of the project (FNPV, ENPV). Their explanatory power is much stronger compared to the previous procedures. Moreover, it is possible to model various links between key variables and track of their combined influence on the outcome (Breierova, Choudhari, 2001; Hnilica, Fotr, 2009).

Within economic applications in general the following distributions are used:

- triangle distribution,
- BetaPERT distribution,
- normal distribution.

Normal distribution is used to display symmetric risk factors by characteristics of mean and standard deviation. Approximately 68% of value of risk factor fall into interval of mean +/– standard deviation (Fotr, Švecová).

The equation of the normal distribution is given by the following formula:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}, \quad (1)$$

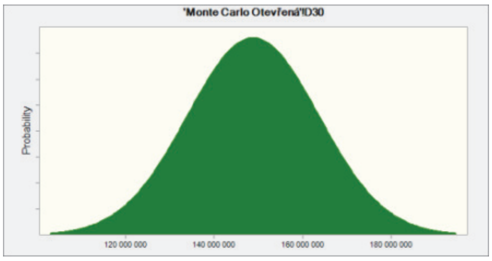
where

μ....... mean or expected value, real number

σ....... standard deviation, positive number (De Ceuster, 2010).

Characteristics of key variables were set individually to each project considering actual conditions. A case study of investment project Elementary School Otevrena was chosen as an example of input and output of Monte Carlo simulation in software Crystal ball. Figure below shows an example of probability distribution of investment costs. In this case normal distribution was chosen.

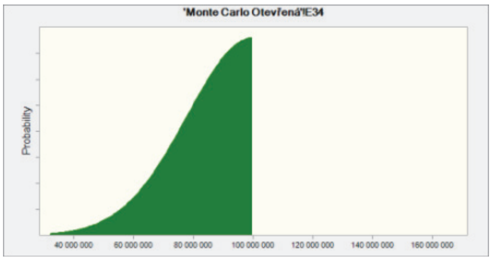
It is necessary to consider that long-term trends in investment costs can vary up to 10% from expected value e.g. due to change of technologies, auxiliary works during construction, inflation, change of legislation and many others.



1: *Normal distribution of investment costs*

I: *Parameters of Normal distribution of investments costs in Crystal ball software*

Assumption: Investment costs	
Normal distribution with parameters:	
Mean	159, 571, 332
Std. Dev.	15, 957, 133



2: *Normal distribution of income from grants with restrictions from right*

II: *Parameters of Normal distribution of incomes from grants in Crystal ball software*

Assumption: Income from grants	
Normal distribution with parameters:	
Mean	100, 000, 000
Std. Dev.	22, 000, 000

Normal distribution of income from grants had to be restricted from the right according to rules of maximal value of financial support.

Statistical data from Monthly Monitoring Report of Ministry of Regional Development confirms poor effectiveness in utilization of EU funds. Considering this, standard deviation of income from grants is quite high.

After defining all key variables and their characteristics it is necessary to determine forecasts (outcome of projects) and run a simulation. In our case 100, 000 simulation steps for NPV with 5% discount rate at 95% confidence level were modelled.

It is obvious that due to high number of simulation results, they cannot be represented as characteristics of individual scenarios. Results cover the whole collection of scenarios by statistical data. Value of risk of projects is qualified by expected value, variation, standard deviation, graphical probabilistic distributions of chosen criteria, sensitivity charts etc. (Hlinica, Fotr, 2009).

III: *Parameters of NPV of investment project*

FORECAST:	
Summary	
Entire range is from ....to	–108, 466, 578 93, 065, 900
Base case is	24, 045, 204
After 100, 000 trials, the std. error of the mean is	72, 996
Statistics:	
Trials	100, 000
Base Case	24, 045, 204
Mean	2, 033, 390
Median	3, 062, 486
Mode	---
Standard Deviation	23, 083, 507
Variance	532, 848, 281, 730, 485
Skewness	–0.2752
Kurtosis	3.06
Coeff. of Variability	11.35
Minimum	–108, 466, 578
Maximum	93, 065, 900
Range Width	201, 532, 477
Mean Std. Error	72, 996

IV: *Confrontation of achieved results in the case study Elementary School Otevrena*

Source of input data	NPV in CZK
Plan – ROP NUTS II - application	25 247 464
Plan – using Monte Carlo simulation	2 033 390
Real costs – final monitoring report ROP NUTS II	–4 515 262

DISCUSSION

Considering aim of this paper, it was necessary to compare achieved results with presumptions and real figures. As was mentioned before data from ROP NUTS II were used as a basis. Data from applications represents a plan which is obligatory created by CBA modelling. Same data was subject to Monte Carlo analysis including risk and sensitivity analysis, adding probabilistic approach. Final monitoring reports of ROP NUTS II served as a source for real figures of key variables.

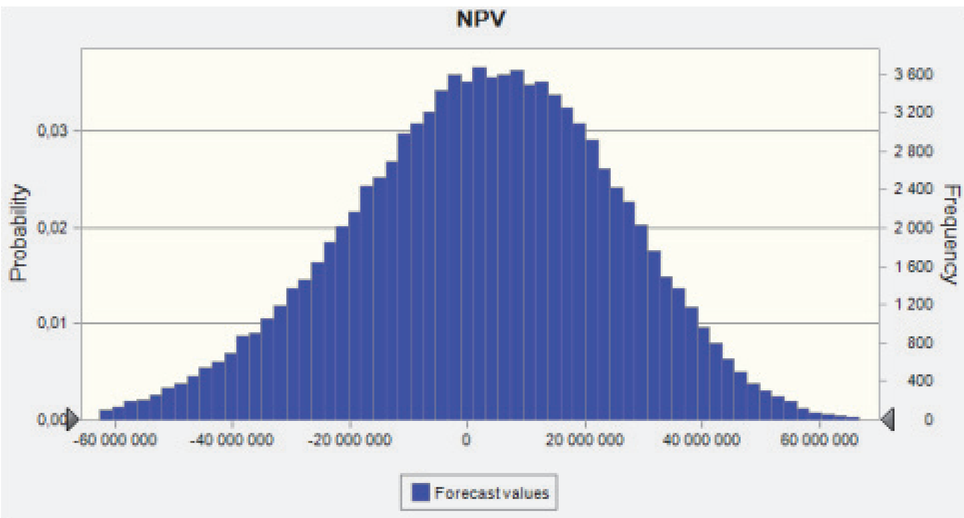
Variation between plain CBA planning and CBA planning with Monte Carlo simulation is quite distinctive. This difference is caused by including key risk factors in appropriate mathematical values and statistical characteristics. For example supposed high level of standard deviation was proved as reasonable since it helped to receive more accurate estimation of NPV.

During sensitivity analysis of income from grants data from following table was used as sum for priority axe 3 where all of the studied projects pertained.

There are big differences in effectiveness of utilization of allocated sources between particular areas of intervention. This fact was proved when analysing results for each project – variations in estimation of NPV.

It is obvious that CBA planning with Monte Carlo simulation was more accurate in comparison of real figures. Although both planned NPVs pertained into the first confidence interval of NPV, results from the Monte Carlo simulation were much closer to real costs.

Monte Carlo simulation provided valuable results for planning (mean of NPV, standard deviation, etc.). In all case studies under examination, real costs fitted into first confidence interval of NPV. In most cases mean of NPV simulated by Monte Carlo method was much closer to real numbers in comparison NPV planned only by CBA.

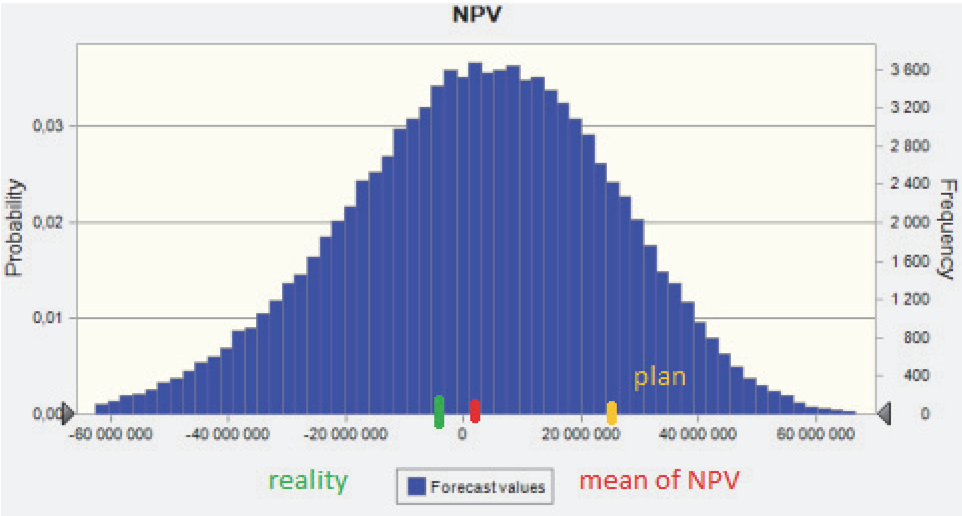


3: *Probabilistic distribution of NPV*

V: *Data about utilization of financial sources ROP NUTS II – South-East (EU + national sources)*

Priority axes/ Areas of intervention	Total allocation for 2007–2013	Requested applications	Project with approved decision/ contract	Total pay out to recipients (including deposit)	Sources in total applications from Payment and certified authority	Certified costs submitted to European Commission (including returns)
	mil. CZK	%*	%*	%*	%*	%*
3.1	2 507.10	102	78,2	59.5	57.8	33.7
3.2	1464.9	358	137.2	108.9	108.1	102.8
3.3	1487	401	64.8	50.3	50.2	50.2
3.4	1264.2	200.8	163.8	138.1	135.5	96.7
3	**6723.1**	**242.5**	**104.2**	**83**	**81.7**	**64.3**

* from total allocation
Source: Monthly Monitoring Report_2013_12



4: *Confrontation of achieved results of case study Otevrena*

VI: *Basic confidence intervals of normal distribution*

Confidence interval	Probability (%)
$\mu - \sigma \leq x \geq \mu + \sigma$	68.2
$\mu - 2\sigma \leq x \geq \mu + 2\sigma$	95.4
$\mu - 3\sigma \leq x \geq \mu + 3\sigma$	99.7

Source: De Ceuster, 2010

Linking CBA analysis to Monte Carlo simulation is currently developing quite fast. The Monte Carlo simulation method has been included in the conventional analytical methods of decision-making management in the Western countries and penetrated into the economic and technical fields (*Daoyuan, 2010*).

CONCLUSION

Decision-making process in the area of investment plans is very difficult. Thus all of the projects are not isolated from external environment it is necessary to pay attention to the influence of all factors. They are called uncertainties which can be both positive and negative.

Due to connection of economical (NPV, IRR), mathematical (probability, simulation) and management methods (risk management, planning) it is possible to eliminate threats or what is more try to avoid them in advance. In context of development of information technologies, simulation software is widely used in planning process. Results have to be necessarily evaluated considering knowledge from all related spheres.

According to current difficult political and economical situation, effective planning and risk considering start to be more important in both public and private sector. One of the main actual problems in the Czech Republic is ineffective utilization of financial sources from EU funds. In this area CBA analysis is used for evaluation of potential projects. In grant applications, risks are only named but not evaluated. Employing proper quality and quantity risk analysis leads to more accurate results. More exact approach to planning could lower risk of returns of EU grants, bad allocation of costs etc. Effective utilization of EU funds is one of the main tools to recover economy by increased investment activity.

Including Monte Carlo simulation for risk prediction into CBA analysis can help to achieve approximation to real values and thus decrease in variation of plan from reality. Those who are able to predict and react to critical situations in time can protect their interests better.

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