SENSITIVITY ASSESSMENT MODELLING IN EUROPEAN FUNDED PROJECTS PROPOSED BY ROMANIAN COMPANIES

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Abstract: *The extension of the European Union with the last two "waves" of new members in 2004 and later in 2007 brought new opportunities for the countries in Eastern Europe, especially those linked with the usage of European funding to support public or private investments. It is obvious that "effective utilisation of EU support can foster the success of economic performance". Financing investment projects proposed by the SMEs can be realized through several financial programmes, especially those established under the European Regional Development Fund (ERDF). In order to be approved investment projects must comply with the requirements of the financing program especially those related to a proper realized Cost Benefit Analysis (CBA). A major emphasis within the CBA consists from sensitivity and risk assessment modelling.* Sensitivity analysis aims to identify those variables / risks that may impact during project development and operational period and may lead to failure of positive factors leading to significant change in the financial and economic profitability of the project. Sensitivity analysis used to measure consider identifying risk factors that have the greatest influence on the net present value in general*, and* in particular on EU-*funded* projects*,* the financial and economic rates from financial modelling to analyse cost-benefit analysis (*CBA) (including* rate gap financing for investment projects where required*)* and indicate their impact during project cycle reg. Sensitivity analysis can help identify poor design choices and can highlight the need to obtain further information on certain variables*. Regarding this, the current paper analysis the decision system and the proposed indicators within the sensitivity and risk assessment system which is used for selection of investment projects. The analysis is made using as a case study an investment project developed by Romanian companies. Both approaches of sensitivity analysis: deterministic and stochastic analysis, were tackled within the paper. As final conclusions of this paper we will demonstrate the theoretical and practical role of cost-benefit analysis – sensitivity and risk assessment to select the best applications that will be proposed for funding under the European grant programs.*

Keywords: Sensitivity analysis, Cost benefit analysis, OFAT, Risk analysis, European Regional Development Fund, Monte Carlo Simulation

JEL Codes: *G17, G21, F35, O16, H43, C63, C61*

1. Introduction

The extension of the European Union with the last two "waves" of new members in 2004 and later in 2007 brought new opportunities for the countries in Eastern Europe, especially those linked with the usage of European funding to support public or private investments. It is obvious that "effective utilisation of EU support can foster the success of economic performance".

Financing investment projects proposed by the SMEs can be realized through several financial programmes, especially those established under the European Regional Development Fund (ERDF). In order to be approved investment projects must comply with the requirements of the financing program especially those related to a proper realized Cost Benefit Analysis (CBA) as mentioned by the European Union(2008).

A major emphasis within the CBA consists from sensitivity and risk assessment modelling. Sensitivity analysis is considered one of the key elements in the risk assessment of investment projects, especially since is considered a keystone in evaluation of risks.

The definition of the sensitivity analysis as mentioned by Saltelli(2000) is that sensitivity analysis is "the study of how the variation in the output of a model (numerical or otherwise) can be apportioned, qualitatively or quantitatively, to different sources of variation".

Sensitivity analysis aims to identify those variables / risks that may impact during project development or in the project operational period and may lead to failure of positive factors leading to significant change in the financial and economic profitability of the project.

Sensitivity analysis is used to measure, consider and identify risk factors that have the greatest influence on the net present value in general, and in particular on EU-funded projects, the financial and economic rates from financial modelling to analyse cost-benefit analysis (CBA) (including rate gap financing for investment projects where required) and indicate their impact during project cycle. As mentioned above, within the context of cost benefit analysis a very important element is represented by the risk assessment.

The compulsory steps for risk evaluation of an investment are:

- Identification of the main risks
- Analysis of sensitivity
- Distribution of the probabilities of critical variables
- Risk analysis
- Evaluation of the acceptable risk
- Risk management

As observed above, the sensitivity analysis creates the basis for the risk analysis and helps identification of major risks, which must be taken into consideration by the beneficiaries, management authorities and target groups.

2. Sensitivity analysis modelling issues

The sensitivity analysis studies how the variation in the numerical results of a project can be attributed quantitatively to different sources of variation of input parameters (input) base. Thus, it provides check of the robustness of the numerical results of a project and, more specifically, highlights the major risks that may affect the whole project cycle, during implementation.

Sensitivity analysis (or post-optimality analysis) is used to determine how the optimal solution is affected by changes, within specified ranges.

- Sensitivity analysis is important to the manager who must operate in a dynamic environment with imprecise estimates of the coefficients.
- Sensitivity analysis allows him to ask certain what-if questions about the problem.

The sensitivity analysis can be classified in two categories: the deterministic approach and the stochastic approach.

Deterministic sensitivity analysis assumes, that basic economic parameters results from a known interval (in larger sizes: a compact set) and quantifies the equilibrium outcome variable spread. In other words, the deterministic sensitivity analysis can be implemented based on a numerical formula step by step. The deterministic sensitivity analysis presumes that the ordered set of basic parameters is an element of a given subset of all possible choices of parameters. It tries to determine upper and lower limits of appropriate subset of the economic results of the project.

Stochastic sensitivity analysis treats the vector of parameters as a stochastic variable with a given distribution, putting economic balance model in stochastic variable. It aims to calculate the first moments of these variables, indicating the robustness of the results change. The stochastic sensitivity analysis should be implemented by a Monte Carlo algorithm or Gauss Quadrature.

Sensitivity analysis can involve more or less balance calculations, so usually there is a compromise between accuracy and time calculation. This is already true regarding the comparison between stochastic and deterministic approach that the stochastic approach is more relevant for the case of multidimensional sensitivity analysis.

A good sensitivity analysis should conduct analysis on the full range of probable values of the key parameters and their interactions, in order to assess the impacts of changes in key parameters.

Sensitivity analysis: aims to identify the project's critical variables. This is done by letting the project variables vary according to a given percentage change and observing the subsequent variations in both financial and economic performance indicators.

The main steps in order to perform a proper sensitivity analysis are presented as:

- Quantification of the factors of uncertainty in each input (Wikipedia, 2013).
- Identification of the model output which is supposed to be analysed as mentioned in the above mentioned study: "the target of interest should ideally have a direct relation to the problem tackled by the model".
- Simulation of the proposed model for a large a number of times, depending "by the method of choice and the input uncertainty" (Sacks, 1989).
- Calculation of the sensitivity using the resulting number outputs.

In some cases this procedure will be repeated, until it is obtained a proper sensitivity analysis. This is common especially when dealing with high-dimensional analysis where the user has to screen out unimportant variables before performing a full global sensitivity analysis(Saltelli, 2000).

The most common model for sensitivity analysis is the one-factor-at- a-time model also known as OFAT or OAT(Czitrom, 1999). This model supposes:

- Moving one input variable at a time while the others are kept at their baseline (nominal) values in the first stage,
- The second stage consists in returning the variable to its nominal value, and later repeating for each of the other inputs in the same way (Czitrom, 1999).

As mentioned by Ascough et all (2005) there are different ways of classifying sensitivity analysis methods: such as mathematical, statistical (or probabilistic), and graphical (Frey and Patil, 2002). Alternatively, the sensitivity methods can be classified as screening, local, and global (Ascough et all, 2005).

When using the OFAT model the sensitivity is determined by measuring the changes in the output and comparing them with the input data. This model is preferred by analysts since it is very easy to establish and later to analyze its results. However this model it is not effective in cases when are dealt with simultaneous changes in input variables. But this model is still preferred as mentioned by Saltelli and Annoni(2010) since it helps the analyst to determine immediately which factor caused the failure of the model.

Usually when this happens the analysts are turning to local methods (Griensven et all, 2006), screening (Campolongo et all, 2007), regression analysis, scatter plots, Gaussian or Monte Carlo filtering(Frey,and Patil, 2002 or Saltelli, 2008).

In case of failure of OFAT methods, Frey and Patil(2002) and Yoe, C. (2012) suggest using Monte Carlo simulation methods since they “can be used to generate multiple values of each model input and corresponding output”, and later a “least squares regression method can be used to fit a standardized first or second level equation to the data obtained from the original model” (Yoe, 2012)

3. **Case study – usage of sensitivity analysis in EU funded projects**

In general, the feasibility of investment projects is based on IRR and NPV criteria. Moreover, for EU-funded projects is necessary to realize a CBA, including many other criteria that confer viability of the project, such as gap financing, socio-economic impacts, regional strategy, environmental protection, so on(Droj, L. and Droj, G., 2012). Therefore, in the economic analysis of projects there are certain aspects of project feasibility which may require sensitivity and risk analysis. Sensitivity analysis estimates the effects on achievement of project objectives when certain assumptions materialize or not(European Union , 2008).

In order to test the usage of sensitivity analysis in EU funded projects, we selected a proposed infrastructure investment project and we created the sensitivity analysis model based on OFAT and Monte Carlo simulation.

The test company intended to access European funding to co-finance its infrastructure investments. The company is a market leader in its field of activity: plastic manufacturing and intends to increase its production capacity and to improve its competitive advantages on the Romanian market. In order to realize this an ambitious investment programme was started to build a new production facility and to increase the quality of their products.

Considering the selected test company, the procedure which was followed to conduct a sensitivity analysis (Ascough et all, 2005) included the following steps:

A. identification of variables

B. elimination of deterministically dependent variables

C. elasticity analysis
D. choice of critical variables

The variables were identified based on the specific conditions of the investment proposed and were varied one at a time, while keeping the other parameters constant (European Union, 2008). The "*Guidance On The Methodology For Carrying Out Cost-Benefit Analysis - Working Document No. 4*"(European Commission, 2006) suggests "considering as "critical" those variables for which a 1% variation (positive or negative) gives rise to a corresponding variation of 5% in the NPV's base value". In case of failure of establishing initial variables, different criteria can, however, be adopted.

Arbitrarily chosen percentage changes are not necessarily consistent with the variables' potential variability. The calculation of the switching values can reveal interesting information, by indicating what percentage change in the variables would make the NPV (economic or financial) equal to zero. (European Commission, 2006)

In order to determine the risk level and to establish the mechanisms to manage them the risk matrix was developed. The first step in developing a risk matrix was to determine risk factors, their weight and their level of appreciation. Table no. 1 Establishing risk factors is presenting how the risk factors were established and how were weighted.

Table 1: Establishing risk factors

RISK FACTORS	RISK WEIGHT	Level of appreciation (Ni)		
(Fi)	(Pi)	N1	N2	N3
Internal Risk F1	P1 - 60 %	Low impact	Medium impact	High impact
Economical Risk F2	P2 - 15 %	Low vulnerability	Medium vulnerability	High vulnerability
Social Risks F3	P3 - 15 %	Low impact	Medium impact	High impact
Political Risk F4	P4 - 10 %	Low vulnerability	Medium vulnerability	High vulnerability

Source: Data processed by author

Next we determined the level of risk and total risk score for risk assessment based on the information.

The total value of the risk is established based on the following algorithm:

$P_t = \sum_{i=1}^{n} N_i \times P_i$ where

N_i represent the level of the risk for each criteria and

P_i the weight

The risks where classify in 3 category :

- Low risk between 1 and 1.7
- Medium risk 1,71 -2,2
- High risk 2.21 -3,1

Having regarded that the improper performance of the works, schedule failure and increasing the value of the investment are economically manifested in the form of increased investment value we determined the sensitivity analysis for the following indicators:

- Increase of inflation
- • Wage growth
- • Increased demand
- • Increased investment price

A sensitivity analysis result by changing in key variables and evaluated on a scale from -3% to +3%. In the following table we present the result for the internal rate of return on equity in case of changes for the above mentioned indicators:

Table 2: Sensitivity analysis IRR

	-3	-2	-1		+1	+2	+3
Parameters	**IRR**	**IRR**	**IRR**	**IRR**	**IRR**	**IRR**	**IRR**
Increase of inflation	5,50	5,22	4,94	4,65	4,35	4,05	3,74
Wage growth	4,75	4,71	4,68	4,65	4,61	4,58	4,55
Increased demand	-1,21	0,45	2,5	4,65	6,88	8,92	10,76
Increased investment price	5,21	5,02	4,83	4,65	4,46	4,28	4,11

Source: Data processed by author

The values obtained for the net present value and internal rate of return on equity is used to construct the graph of sensitivity will be presented in the figures below, the methodology for its realization was also presented by Van Hauwermeiren M, Vose D. și Vanden Bossche S. (2012) . The sensitivity analysis was later generated with a specialized software: ModelRISK – VoseSoftware. In the figure no.1 Sensitivity analysis IRR we present how different variables are influencing the IRR.

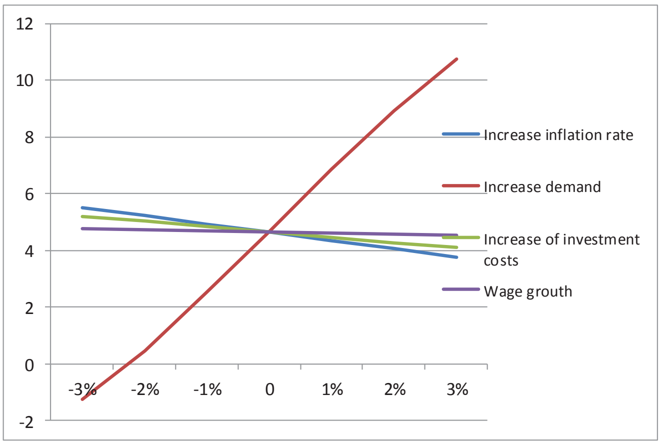

Figure 1: Sensitivity analysis IRR
Source: Data processed by author with ModelRISK – VoseSoftware

In the following table we present the result of the sensitivity analysis, on a scale from -3% to +3%, for the net present value:

Table 3: Sensitivity analysis NPV (table)

	-3	**-2**	**-1**		**+1**	**+2**	**+3**
Parameters	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**
Increase of inflation	393,8	241,9	+87	-181,3	-229	-388	-474
Wage growth	-140	-152	-175	-181,3	-185	-189	-195
Increased demand	-5133	-3567	-1846	-181,3	1767	3663	5620
Increased investment price	231,7	131	+31	-181,3	-208	-268	-368

Source: Data processed by author

The sensitivity analysis of NPV generated with a specialized software product: ModelRISK – VoseSoftware. In the figure no. 2 Sensitivity analysis NPV we present how different variables are influencing the NPV. As shown in the table and figures presented, the sensitivity analysis and the risk for financial analysis company retains the basic parameters of the project within the limits imposed by the donor.

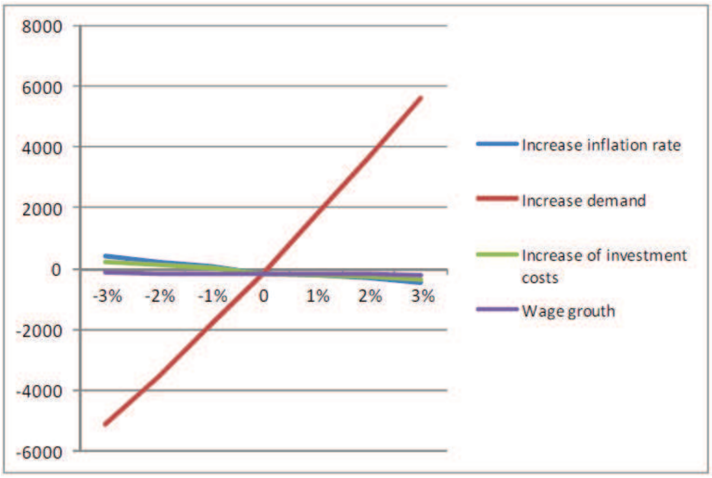

Figure 2: Sensitivity analysis NPV
Source: Data processed by author with ModelRISK – VoseSoftware

We also notice that the most prominent impact is in case of changing in the demand for the proposed services or products, which could be critical in case of a change up 2-3%, mainly because the cost of production is not changed: since the equipment used must operate continuous the energy costs and wages remain constant, only a larger fluctuation in demand will require personnel changes.

Table 4: Triangular distribution of the costs

	Initial Value	Low	High	Variation
Inflation Rate	1004798	90,00%	120,00%	101,03%
Wage raise	7960	90,00%	105,00%	102,22%
Decrease in Demand	1353815	99,00%	101,00%	100,02%
Price of Investment	1115181	97,00%	110,00%	108,41%
Total	**3481754**	**Total cost including risk**		**3586309,55**

Source: Data processed by author

Next we performed the Monte Carlo risk assessment for the sensitivity analysis above. The first scenario (moderate scenario) was developed assuming that the main types of project costs follows a triangular distribution where the minimum is 90% of the estimated costs of the reference year, while the maximum is 110% of the original cost estimates. Most probable values are estimated costs based on the reference year. The total cost simulation based on risk factors was processed with Monte Carlo method with ModelRISK – VoseSoftware. In the figure no. 3 Total cost simulation based on risk factors – Histogram plot and Spider Plot Modelation we present the results of cost simulation on two different graphics: histogram plot and Spider Plot.

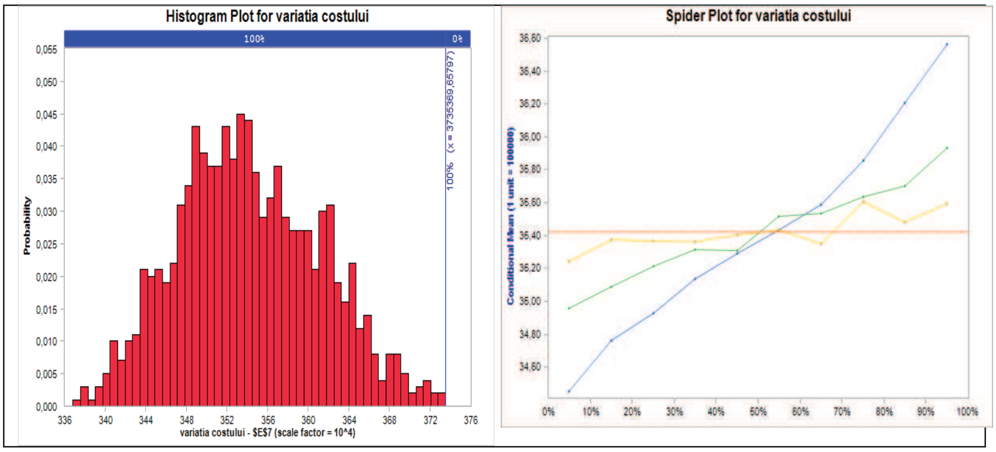

Figure 3: Total cost simulation based on risk factors – Histogram plot and Spider Plot Modelation
Source: Data processed by author with ModelRISK – VoseSoftware

As observed from the graphics and analysis presented above the biggest influence over the sensitivity analysis is realized by the demand factor, which can have a significant impact over the feasibility of an investment. Also this factor can cause significant changes over all other factors and in this context may prove improbable to function the OFAT method.

4. Conclusions

Financing investment projects proposed by the SMEs can be realized through several financial programmes, especially those established under the European Regional Development Fund (ERDF). In order to be approved investment projects must comply with the requirements of the financing program especially those related to a proper realized CBA. A major emphasis within the CBA consists from sensitivity and risk assessment modelling. Sensitivity analysis is considered one of the key elements in the risk assessment of investment projects, especially since is considered a keystone in evaluation of risks. The research within this paper focused on determining the factors which influence the sensitivity analysis of an investment project and to determine which method are appropriate to be used. Both approaches of sensitivity analysis: deterministic and stochastic analysis, were tackled within the paper, with a focus over OFAT and Monte Carlo simulation.
In conclusion the sensitivity analysis can be used successfully "to explore how the impacts of the options you are analysing would change in response to variations in key parameters and how they interact"(European Union, 2009). And in the same time sensitivity analysis can be considered particularly useful to pinpoint "which assumptions are appropriate candidates for additional data collection to narrow the degree of uncertainty in the results"(OMB, 2006). In this context the sensitivity

analysis can be considered the minimum necessary component of a quality risk assessment report. However, after the case study, a serious question raised over the efficient usage of the OFAT methodology in sensitivity analysis, since its unable to cope with the interferences between different variables. It seems that OFAT is mainly desirable to be used in the initial stages of the sensitivity analysis and selection of indicators. Later, in the analysis other methods should be used: especially local/global methods, screening, regression analysis, scatter plots and Gaussian or Monte Carlo filtering. But the methodology should be better adapted to the specific study subject: domain of study, data available, historical data available, software capacity, etc.

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