SIMULATION IN PROJECT RISK MANAGEMENT

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Abstract. *The article describes the Monte-Carlo simulation method for project risk management. The method includes a sensitivity analysis and simulation experiments. The simulation of parameters is performed with the MS Excel software and "EVA - risk analysis" software application on a sample investment project for an office building construction.*

Key words: *Project risk assessment, Monte-Carlo method, simulation modeling.*

There are quantitative and qualitative methods of investment projects risk assessment. Qualitative assessment is a simpler though less accurate and reliable method while quantitative methods are used if the volume of information and indicators are sufficient to identify the likelihood or impact of risk [1]. In practice, both methods are used. The Monte Carlo simulation is a quantitative method.

Let us consider the use of the Monte Carlo method on a sample investment project "Construction of an administrative business building" by the "LuxGarant" LLP. The project involves construction of an office building to offer rent in the future for the recovery of project investments. The project cost is KzT290 247 000 with duration of nine months. The objective is to evaluate the risks of the project.

The Monte Carlo method is conducted in MS Excel environment using the "EVA - risk analysis" add-ons, a product of «EMF Plus". This software application is necessary for carrying out simulation calculations of the investment project profitability, needed for the following reasons: implementation of repetitive simulation experiments, significant simplification of the simulations results processing and a graphical presentation of the results [2, 3].

In the first stage a sensitivity analysis is carried out. Figures 1 and 2 show the first steps of the sensitivity analysis by the EVA application - initial data input and parameters selection.

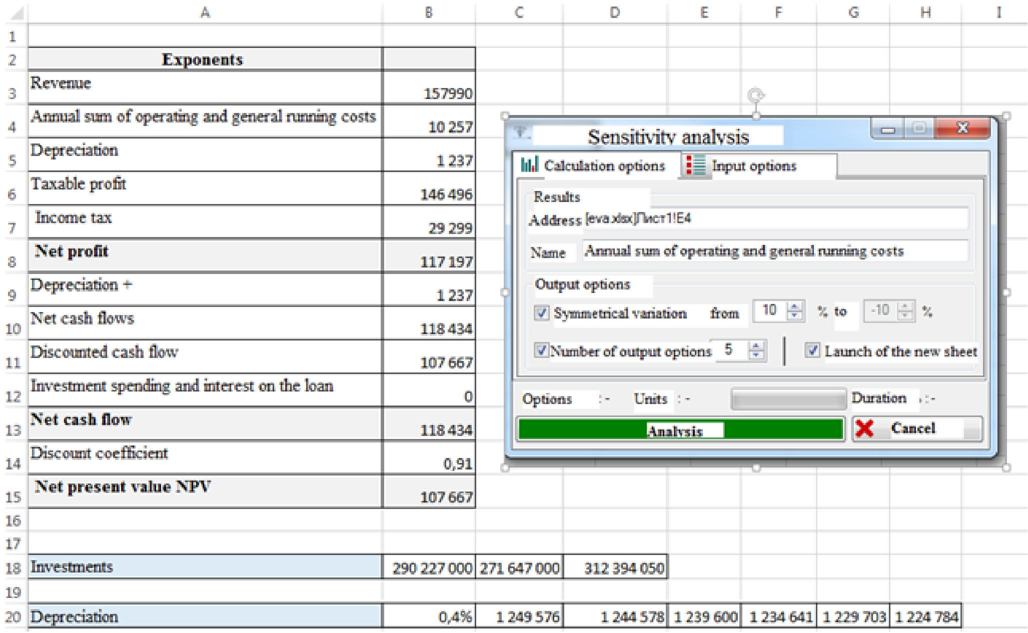


Fig. 1. Initial data input

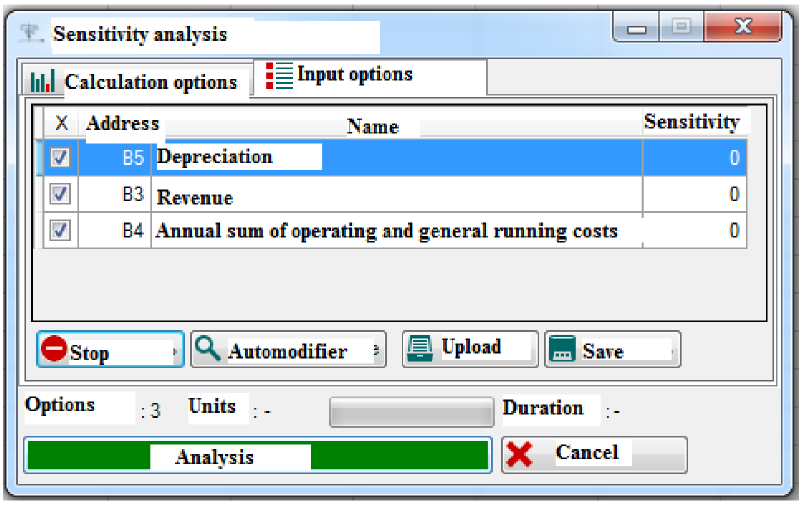


Fig. 2. Parameters input

The initial data are accepted as follows:

– a calculated break-even point of the project, in the form of net present value (NPV), at the level of 107 million tenge per year;

– main components affecting the NPV - average amount of revenue, amount of current and general expenses and depreciation amount;

– other components: discount rate, tax rates on property, land and profit are constant.

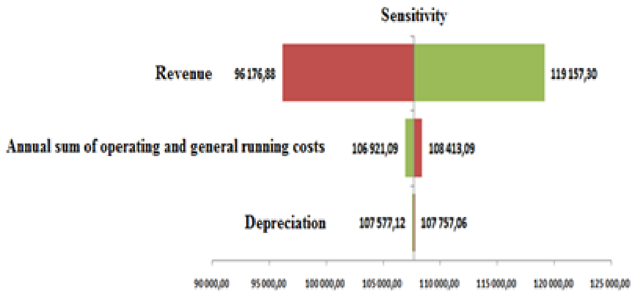
The purpose of sensitivity analysis is to find the level of impact of the changes in the original data of a model (project) on the totals (profitability, revenue and/or payback period - any of the chosen options). The sensitivity analysis is to identify the critical factors of the boundaries change, for example, a maximum possible reduction of the volume of sales or prices for the products, works or services for which the net present value (NPV) is positive. The wider the range of parameters in which performance indicators remain within acceptable levels, the greater the project safety margin, the better it is protected against fluctuations of various factors that influence upon the project results.

The sensitivity analysis algorithm is as follows:

- parameters of interest are chosen (automatically or manually);–
- the chosen parameters are changed alternately by reducing them for 10% and increasing by the same amount, then the final figure is recalculated and shown on the “Tornado chart”;
- if you change the parameters sequentially from -30% to + 30% in increments of 10%, the final schedule will be of the "spider" type.

Here are the two scenarios for analyzing the sensitivity of the project. In the first case, the range of the input parameters variation is -10% - +10%. In the second case, the range will be between -30% -+30%. By setting the required options/parameters, we obtain the following data shown on Figures 3 and 4.

Each bar shows how the final option changes when the corresponding input parameter is varied within its range (in this case, plus or minus 10 % and 30 %), and other input parameters remain equal to the base value. Longer bars correspond to the options with the greatest impact on the total and are always located at the top.

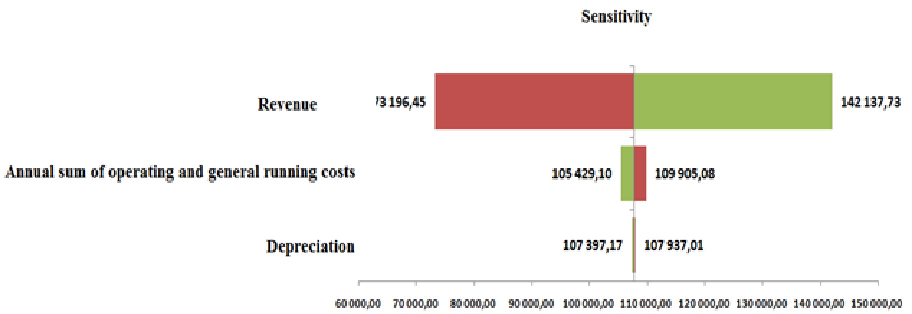


Summary analysis of possible total values options

Input options most affecting the total values

Range	Input option	Cell	Minimum			Maximum			Base value		Sensitivity
			Total		Option	Total		Option	Option	Total	
			Value	Change (%)	Value	Value	Change (%)	Value			
1	Revenue	83	96177	-10,67%	142191	119157	10,67%	173789	157990	107667	22980
2	Annual sum of operating and general	84	108413	0,69%	9232	106921	-0,69%	11283	10257	107667	1492
3	Depreciation	85	10777	0,08%	1113	107577	-0,08%	1361	1237	107667	180

Fig.3. The sensitivity analysis results in EVA application. Scenario №1



Summary analysis of possible total values options

Input options most affecting the total values

Range	Input option	Cell	Minimum			Maximum			Base value		Sensitivity
			Total		Option	Total		Option	Option	Total	
			Value	Change (%)	Value	Value	Change (%)	Value			
1	Revenue	83	73196	-32,02%	11093	142138	32,02%	20588	157990	107667	68941
2	Annual sum of operating and general running costs	84	10990	2,08%	7180	105429	-2,08%	13335	10257	107667	4476
3	Depreciation	85	107937	0,25%	866	107397	-0,25	1608	1237	107667	540

Fig.4. The sensitivity analysis results in EVA application. Scenario №2

The calculations and graph show that which exactly initial parameters change withstand the project, while remaining cost-effective. If this is a wide range, the sensitivity of the project can be considered low, and the business plan in this case is affordable.

From the analysis we conclude that the NPV> 0 for any variation of the input variable parameters such as the average amount of revenue, amount of current and general expenses and amount of depreciation in the range -10 % / 10%. At the same time, amount of revenue influences upon the NPV most of all.

The next step is the Monte Carlo simulation which normally involves the model parameters with the greatest impact on the result found in a sensitivity analysis. The Monte Carlo method algorithm is as the following:

- a set of variable parameters (risk factors) is selected;
- the changes boundary and the laws of distribution of each of the factors is put;
- the correlation matrix for each other dependent factors is clarified;
- calculations are performed for a desired number of experiments (generally not less than 1000).

In the course of the simulation, a large number of the model implementations is carried out under the joint random variation of selected parameters. The distribution law is found possibly based on historical data of a selected value. The user specifies the number of implementations of the method, and limits of changes with distribution law of a respective random variable for each of a selected parameter. If the chosen parameters depend on each other, it is necessary to set the correlation coefficient between them. Analysis by the Monte Carlo method enables us to understand the degree of uncertainty of the analyzed final value (characterized, for example, with specified 90% confidence interval). Also, the user can focus on the values of his interest, setting them instead of the probability in the determination of interval.

Figure 5 shows a first step in the Monte Carlo simulation which is the input parameters, that is, the possible risks. In this case, it is possible to reduce the volume of sales, the cost per square meter, the boundary changes are set with the confidence interval at 90%, the normal and triangular distribution laws being chosen for each of the risk factors.

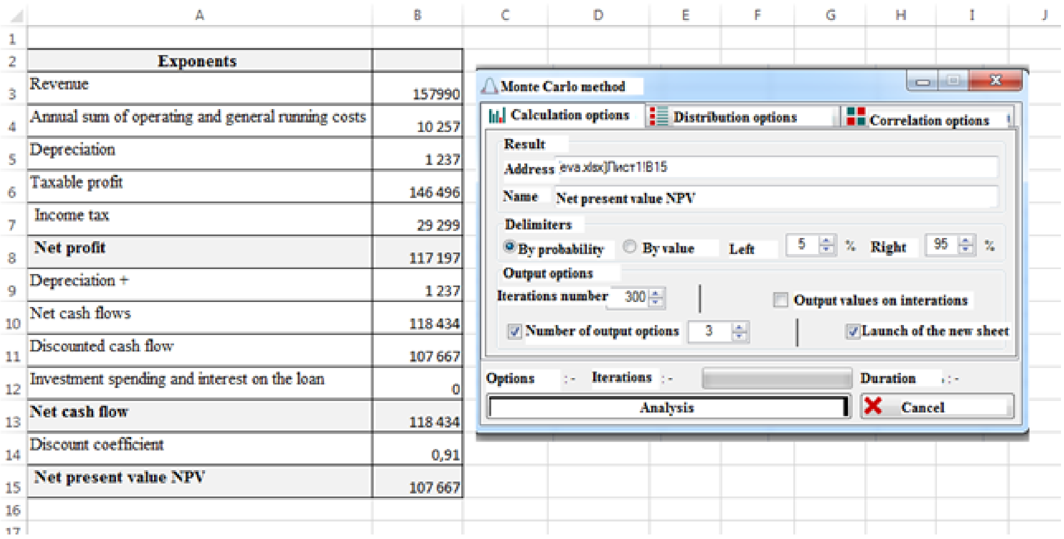
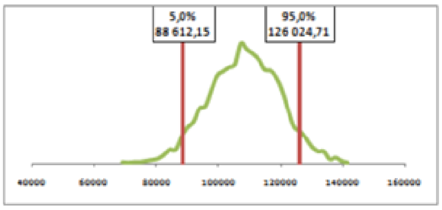


Fig. 5. Parameters input for the Monte Carlo simulation

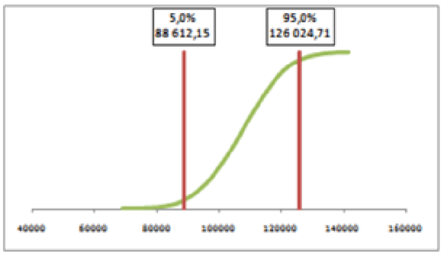
Figures 6 and 7 shows the results of the software simulation for Scenario №1.

The table of results displays information in percentage, percentage probability that the value of the forecast will be less than or equal to a given percentile.

Next, let us try another scenario - how the NPV would be changed at the end of the payback period, if its components - the volume and cost of leased area will change within the confidence interval of 5% -95%. Let us consider a situation in which the maximum amount of leasable area is set at the level of 1281 square meters, the cost per square meter at USD 54.6$ with an even method of distribution. Figures 7 shows the results of the software simulation for Scenario №2.

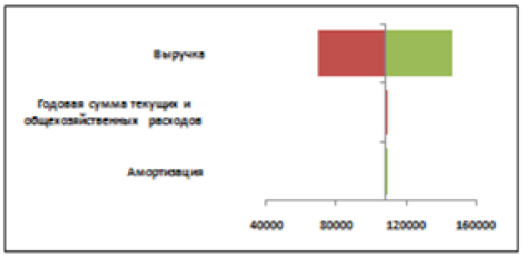


Summary statistics			
Minimum	69044	Left X	88612
Maximum	145629	Left P	5,00%
Average	107555	Right X	126025
Standard deviation	11366	Right P	95,00%
		Diff X	37412,55
		Diff P	90%



Percentiles			
5%	88612,15	50%	107650,95
10%	92958,88	55%	109044,80
15%	95631,66	60%	110593,22
20%	97844,27	65%	112032,40
25%	99739,39	70%	113773,29
30%	101431,1	75%	115464,89
35%	103141,9	80%	117247,04
40%	104929,9	85%	119304,05
45%	106339,8	90%	121747,30
50%	107651	95%	126024,71

Fig. 6. The results of the risk assessment by the Monte Carlo method. Scenario №1



Options impact		
Name	**Lower**	**Upper**
Revenue	68948	145684
Annual sum of operating and general running costs	108413	106921
Depreciation	107756	107578

Original options				
Address	**Name**	**Distribution**	**Options**	**Options**
83	Revenue	Normal	μ=157990,417; Ω=15799,042	157990
84	Annual sum of operating and general running costs	Even	a=9231,71; b=11283,201	10257
85	Depreciation	Triangle	a=1113,432; b=1360; m=1237,147	1237

Fig. 7. The results of the risk assessment by the Monte Carlo method. Scenario №1

Analysis by the Monte Carlo method shows that the minimal probability that the NPV of the project will be negative. This is possible only under a simultaneous deterioration of the risk factors. According to the distribution histogram, there is almost no likelihood that the NPV of the project would be negative.

Thus, assessment of the investment project risks for the construction of business buildings at different combinations of factors was conducted by using the Monte Carlo simulation method. As the research results show, the project is profitable, and the company's management is recommended to build this business building.

If the Monte Carlo method model is correct, it provides very reliable results, allowing insight into both the profitability of the project and its sustainability (sensitivity).

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