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IMPLEMENTATION OF MONTE CARLO SIMULATION IN INVESTMENT DECISION MAKING

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Abstract: The aim of the paper is to point out to the risk analysis as an integral part of the evaluation of economic efficiency of investment projects. Traditional and probabilistic approaches of evaluation of projects efficiency are briefly characterized. The focus is taken on probabilistic tools, specifically on Monte Carlo simulation. Monte Carlo simulation utilization is demonstrated on a specific example from the economic practise. Businesses, in order to maintain their existence and ensure long-term effective development, must continuously invest into reconstruction and development of their technological base. Given that these investment projects significantly affect the future development of the company, it is important to assess their economic effectiveness in terms of profitability, liquidity and risk. Since the current business environment is developing dynamically and becomes uncertain, risk analysis shall receive in this process greater importance.

1 Introduction

Businesses, in order to maintain their existence and ensure long-term effective development, must continuously invest into reconstruction and development of their technological base. Given that these investment projects significantly affect the future development of the company, it is important to assess their economic effectiveness in terms of profitability, liquidity and risk. Since the current business environment is developing dynamically and becomes uncertain, risk analysis shall receive in this process greater importance.

2 Approaches to evaluation of investment projects

The traditional approach to evaluation of investment projects is based on financial criteria that the risk and uncertainty associated with the project either do not respected at all or only indirectly. Non-respecting of risk is associated with static criteria such as profitability and payback period of the project. Indirect integration of risk and uncertainty is associated with dynamic criteria such as net present value, index of present value, internal rate of return or discounted payback period. In this case, compliance of risk is implemented through a risk premium, which forms a part of the discount rate of the project.

The following facts can be considered as shortcomings of this approach [1], [5]:

- This is a single-scenario approach because cash flows of the investment project under consideration are based on a single, usually the most likely development of internal and external factors affecting cash receipts and cash expenditures of the project during its economic lifetime.
- Risk and uncertainty are taken into account only non-formalized as another aspect of the evaluation of investment projects.
- Optimism of managers who often underestimate the probability of an unfavourable development of individual risk factors affecting the results of the evaluated projects.

Shortcomings of the traditional approach to the evaluation of investment projects can be somewhat weaken by a sensitivity analysis. The substantial increase in quality of investment decision making in terms of respect of risk and uncertainty can be provided by probabilistic approaches, specifically scenarios and simulations. Monte Carlo simulation belongs to the most significant simulation models. It is used when there are more risk factors, usually of continuous nature. Its essence lies in generation of a large number of scenarios (hundreds to ten-thousands) and calculation of criteria for each scenario.

The main reason for using a Monte Carlo simulation is the quantification of the probability distribution for the overall project risk [4], [7]. On the basis of this distribution can be stated the expected value of project risks and how probably this value will be in the range of our interest [3], [8].

This method has also some drawbacks. These include high labour intensity and complexity especially when determining the probability distribution of risk factors and

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respect of their dependence. The greatest deficiency is considered the fact that the key risk factors that influence the most the results of the risk analysis are often based on an assessment of the present and past unpredictable. This can lead at the simulation to so called tunnelling effect and thus decrease the sensitivity of the search of new risk factors [2], [6].

3 Application of Monte Carlo simulation of concrete investment project

Risk analysis based on Monte Carlo simulation is applied on the project, which is aimed to expand the production of sanitary products. Its aim is to select such production equipment, which enables to achieve the required production volume and react flexibly to changes of market requirements in production assortment.

3.1 Economic evaluation of investment project

Economic evaluation of investment project precedes the risk analysis which is based on the most likely scenario. It is processed using a financial model created in MS Excel. The financial model includes:

- *Input data* for determination of cash flows of the project and monitored financial criteria (such as investment costs, production volume, selling price, material consumption, energy consumption, repair and maintenance costs, personnel costs etc.).
- *Cash flows of the project* which take into account the construction period and the operation period of the production equipment. The construction period of the project is set at two months. The economic lifetime of the project is identified with the depreciation period of production equipment, i.e. estimated for a period of six years.
- *Financial criteria* for evaluation of the economic efficiency of the project are net present value (NPV), index of present value (IP) and discounted payback period (DPB), and criteria for risk analysis is net present value.

Calculated values of the above mentioned financial criteria are indicated in Table 1.

Table 1 Financial criteria of the project

Indicator	Unit	Value
NPV	EUR	2,282,800
IP	coefficient	1.69
DPB	year	3.48

From Table 1 it clearly results that the investment project is economically efficient. However, despite positive values of financial criteria, it is probable that the real development of input variables of the investment project can deviate from the considered most probable values. For this reason a risk analysis of the considered investment project processed.

3.2 Risk analysis of investment project

Risk analysis using Monte Carlo simulation is carried out in the Crystal Ball system, which is an extension of MS Excel. The output variable is NPV whose base case is determined by the traditional approach (Table 1).

Risk factors of the project are determined using sensitivity analysis. They are followed in relation to the NPV at isolated changes of individual input variables by ± 10% from their most probable values. Twenty three risk factors have been considered. The results of the sensitivity analysis showed that the key risk factors include investment expenditures, sales price, material costs and production volume.

Uncertainty of individual risk factors is displayed using the normal distribution (risk factor is production volume), lognormal distribution (risk factor are investment costs) and Beta PERT distribution (risk factors are selling prices and material costs).

The probability distribution of selected risk factors of the investment project is illustrated in Figure 1.

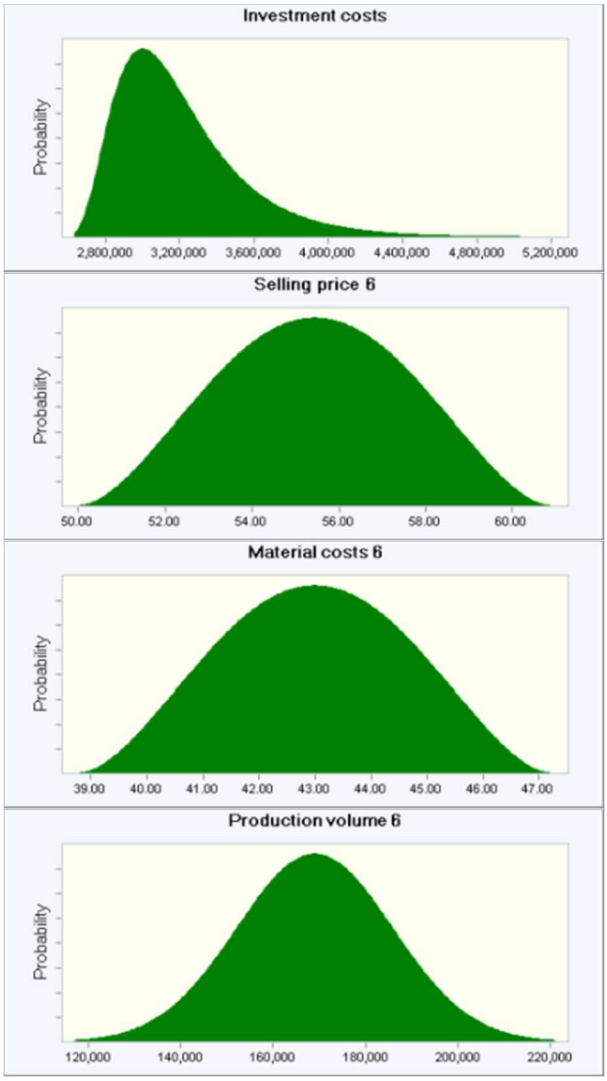

Figure 1 Probability distributions of selected risk factors

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The results of Monte Carlo simulations. The primary outputs of the Monte Carlo simulations are the probability distribution of NPV, statistical characteristics and percentiles (Figure 2).

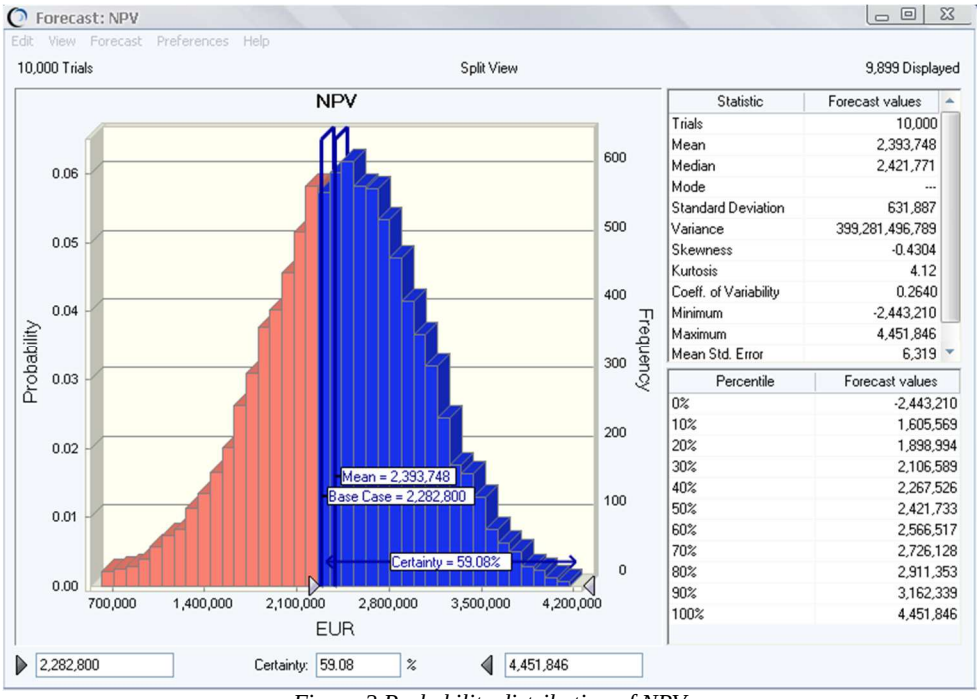

Figure 2 Probability distribution of NPV

Based on the values of statistical characteristics it is possible to mention the following conclusions. Mean value of NPV is by EUR 110,948 higher than the NPV calculated by traditional approach. With the probability of 95% the NPV of the project is expected in the range from EUR (- 2,443,210) to EUR 4,451,846. The probability that the NPV of the project shall exceed the most probable scenario is 59.08%, which means that lower values than EUR 2,282,800 shall be achieved with a probability of 100% - 59.08% = 40.92%. NPV probability distribution is approximately symmetrical; skew has a negative value, indicating that it is slightly inclined to the left, towards lower NPV. Given that the probability distribution of NPV is approximately symmetrical, variability characteristics of standard deviation, variance and coefficient of variation represent appropriate measure of risk of the project in relation to the NPV.

Another important output of the simulation is a sensitivity graph of NPV (Figure 3). It provides information about contributions of selected risk factors to the overall risk of the project in relation to the NPV, in both, graphical and numerical form.

It is evident from Figure 3 that the most important risk factor is the investment costs that contribute to the risk of the project by 36.5%. Another important factor is the selling price in year 4 of the project operation, whose contribution to the risk is 9.0%. The selling price is a risk factor monitored in time series.

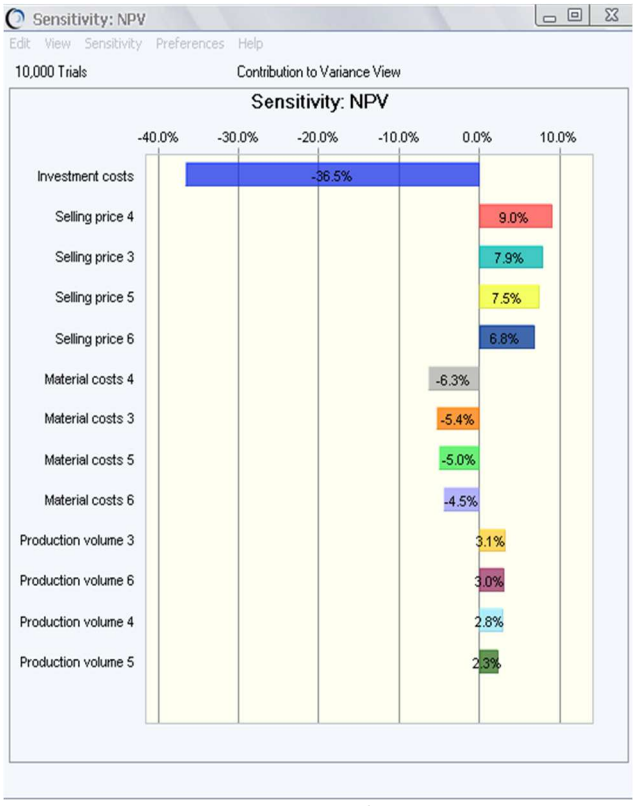

Figure 3 Sensitivity of NPV chart

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Thus, its cumulative contribution to the risk of the project for the period from the third until the sixth year of operation is 31.2%. The amount of contribution of risk factors material costs and production volume circulates by respective years in range from 2.3% to 6.3%. In both cases, these are also risk factors monitored in time series. Attention should be paid to material costs for which the cumulative contribute to the risk of the project amounts to 21.2%. In order to reduce the risk of this project it is appropriate to focus attention on the first three risk factors.

Conclusions

The paper presents a probabilistic approach to evaluation of the investment project, which complements the indicators of traditional approach by thorough risk analysis. From an economic point of view, the assessed project is effective. The risk of the project is further analysed using Monte Carlo simulations. Based on simulation results it can be concluded that the project bears a low risk. However, application of Monte Carlo simulation is not a one-time event. The simulation should be repeated always when changes in the development of the analysed risk factors of the project have been detected, or when new risk factors have been identified.

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