MONTE CARLO SIMULATION – RISK ANALYSIS TOOL OF INVESTMENT PROJECTS

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Abstract

The paper highlights the Monte Carlo simulation as a tool that allows a deeper understanding of risk assessment of the investment project while improving the process decision on its acceptance or rejection.

Key words: Simulation, investment, decision making, risk, efficiency.

INTRODUCTION

In theory and practice, there are several approaches to take account of risks in evaluating the economic efficiency of investment projects that are different in manner and scope of its evaluation. Traditional approach of evaluation is based on single-scenario approach whereby cash flows from the investment project under consideration are based on a single, usually the most likely development of factors that affect cash receipts and cash expenditures of the project during its economic lifetime. At the same time the most likely scenario is usually the optimistic variant. The risk associated with the project is not respected either at all or only indirectly. Disregard for the risk is related to static criteria such as average profitability and payback period of the project. Indirect integration of risk is linked to dynamic criteria such as net present value (NPV), index of present value, internal rate of return or discounted payback period. In this case, respect for risk is implemented through a risk premium, which forms a part of the discount rate of the project. Probabilistic approach of evaluation is based on a larger number of scenarios, while consistently respecting risk and uncertainty, increasing the quality level of an investment decision. The main representatives of this approach are scenarios and simulations [1], [2]. Simulation methods are based on the Monte Carlo method, or Latin Hypercube.

MONTE CARLO SIMULATION

Monte Carlo simulation is applied mainly in financial management and investment decisions. It is used when there are more risk factors, usually of continuous character. Its essence lies in generation of a large number of scenarios (hundreds to ten hundreds) and calculation of criteria values for each scenario. Objectivity of results depends on objectivity of the estimated input data, as well as the number of completed repetitions. Monte Carlo simulation is performed in five steps.

1. **Creation of financial model** of an investment project is implemented in Microsoft Excel. The financial model is being developed throughout the economic lifetime of the investment project and includes calculation of results of project management, cash flows and financial criteria (net present value, index of present value, internal rate of return and discounted payback period) by which the assessment of the investment project is being performed. At creation of financial model the level of its details should be considered. It is influenced by the purpose of the model, i.e. to which questions should the outputs of the simulation provide answers. Before the actual creation of a financial model, it is advised to graphically display mutual connection between its components. For this purpose, it is appropriate to use cognitive (thought) maps and influence diagrams.

2. **Identification of key risk factors**, i.e. factors which are of high uncertainties, and the simulation outputs are very sensitive to their changes. A useful tool in the selection of key risk factors is *a sensitivity analysis* that detects impacts of isolated changes of individual risk factors (e.g. production volume, selling price of products, cost of materials, etc.) on the selected financial criterion of the project (e.g. net present value, index of present value and etc.), while all other factors remain at estimated values. Graphic display of sensitivity analysis can be carried out using a spider chart or tornado chart.

3. **Determination of probability distributions of key risk factors.** Probability distributions for *discrete risk factors*, i.e. factors with a small number of values have a table form, for *continuous risk factors* the type of probability distribution is selected by its parameters. Determination of the distribution is problematic. When there are available historical data about a risk factor (e.g. about sale, exchange rates, etc.) the approximation of some theoretical distribution can be used to its determination. Otherwise, it is necessary to rely on the knowledge and experience of experts from areas that concern the individual risk factors. Basic

types of continuous theoretical probability distributions are illustrated in Figure 1.

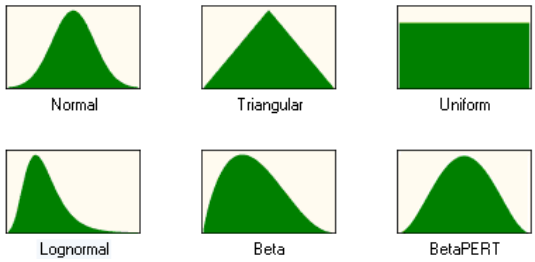

Fig. 1 Basic types of continuous theoretical probability distributions

4. **Determination of statistical dependence of risk factors.** There are two forms of statistical dependence. *Paired dependency* is a relationship between two factors in the same period, e.g. dependence of demand on selling price. *Time dependency* is a dependency of the same risk factor at two time periods. An example of time dependency is a dependence of a new product sales in coming years after its entry to the market. Respect of statistical dependence of risk factors is expressed by a correlation coefficient, which can take values from (-1) to 1, where:
   - 0 means that the risks are independent,
   - 1 means that the risks are fully dependent in a positive sense, therefore to a high value of one risk corresponds a high value of the second risk,
   - (-1) means full dependence in a negative sense, therefore to a high value of one risk corresponds a low value of a second risk,
   - intervals between (-1) and 0, or 0 and 1 mean a strengths of dependence [5]

5. **Simulation process** takes place by means of the selected software. It is advisable to use Microsoft Excel together with some add-ins, for example Crystal Ball (Oracle), Risk Simulator (Real Consulting), @Risk (Palisade Corporation) and others. The results of Monte Carlo simulations take on graphical form via the probability distribution of selected financial criteria and numerical form through statistical characteristics such as variance, standard deviation, variation coefficient, etc..
   Monte Carlo simulation outputs from the Crystal Ball system are shown in Figure 2. These are the primary simulation outputs such as probability distribution of net present value and statistical characteristics of this distribution.

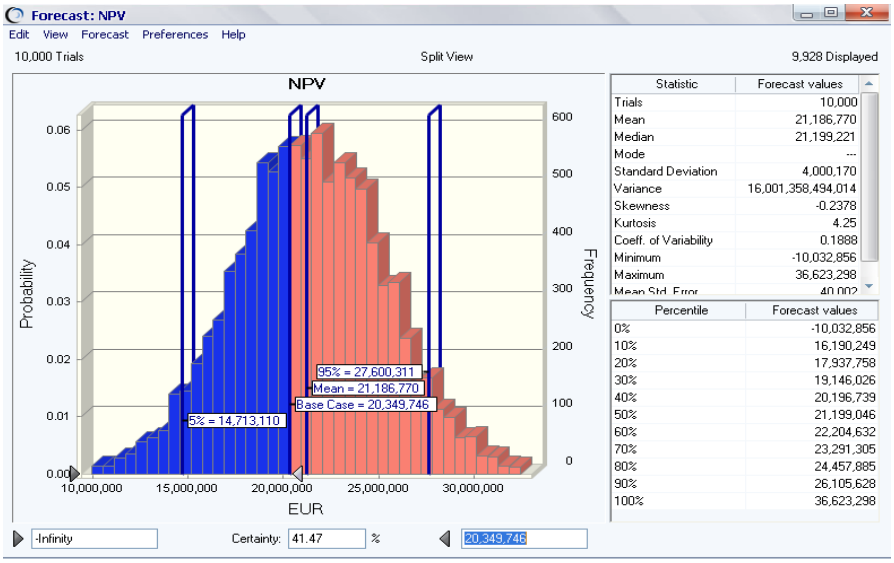

Fig. 2 Example of primary outputs of Monte Carlo simulation from Crystal Ball system

The main reason for using a Monte Carlo simulation is the quantification of the probability distribution for the overall project risk. Based on this distribution can be stated the expected value of project risk and how probably this value will be in the range of our interest. Therefore, it allows a deeper understanding of the risk of the assessed investment project, leading to improvement of the decision making process about its acceptance or rejection.

The Monte Carlo method has also some drawbacks. These include high labour intensity and complexity especially when determining the probability distribution of risk factors and 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 [3].

CONCLUSION

Risk is an integral part of economic efficiency evaluation of investment projects. The scope and extent of taking into account a risk depends primarily on the nature of the business environment and investment project. The principle is that the more dynamic and more uncertain the business environment is, thereby the importance of considering the risk is growing. On the contrary, for projects that will operate in a relatively stable environment, it is possible to limit the scope and extent of risk consideration. Taking account of the risk is the most important factor in investment projects aimed at mass production, projects introducing new products to market and investments into corporate research and development. In contrast, the risk can be neglected at small scale projects with short life time.

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