**ECONOMIC RISKS FOR PROJECT MANAGEMENT – A MONTE CARLO SIMULATION APPROACH**

Paul Pașcu, Eusebiu Toader

“Ștefan cel Mare” University of Suceava

paulp@usm.ro, eusebiu.toader@usm.ro

**Abstract:** *Monte Carlo simulation is a technique that includes several simulation techniques in which the analysis of the real phenomenon is replaced by the analysis of an artificial phenomenon, described by a model, by solving it generating for variables, random values. This paper explores the applications of Monte Carlo simulation for managing project risks.*

**Key words:** management risk, economic uncertainty, Monte Carlo method

JEL classification: D81, G32

**I. Introduction**

We live in a world of risks and every activity has a certain degree of risk, and the risk becomes an ordinary and inseparable partner of any activity, having direct and strong effects on the results of that activity. Every day the organizational structure of which we are part is directly or indirectly subject to various risks. These risks relate to our assets, to the partners we work with, to the environment in which we work.

The implementation of a risk management system therefore becomes an important objective for any organizational structure, as well as for an individual. Excessive caution leads to risks so not taking risks is a risk.

Can we counteract the negative effects of such random events, which appear whether we like it or not, whether we like it or not? Probably not entirely, but we can certainly alleviate them. The risk management and the risk manager are obligatory for a successful activity in business and, especially, within the organizational structures through projects, respectively of the management through projects. Improper risk management activity leads to significant financial, political, and even human losses.

The multitude and complexity of the tools developed by the market economy allows to cover any type of risk. Risk management is not an easy and cheap activity, these two parameters being at maximum levels. An environment with a growing complex risk, with a high degree of unpredictability, a complex insurance market with interdependencies between various organizational structures contributes to the difficulty of finding the right risk management solutions, corresponding to our requirements for success.

The increasing use of information technology in risk management has led to the development of integrated intelligent systems, adaptive in risk management, which can make decisions in real time, leading to minimizing the negative effects of risk and monitoring residual risks, with optimization positive effects. Given the above, it can be said that “The biggest risk is that there is no risk.” If there is a risk, using risk management, it can be controlled, but if there is no obvious risk, there will certainly be hidden risks, which will be harder to control. Risk is not to be taken lightly. The risk can lead to great opportunities for those who know how to use it. The goal is to know the risk and use it for our success.

The solution is not to avoid risk altogether, which is impossible, but to avoid unintelligible risks and control them, and to monitor and use the remaining risks for success.

**II. Elements of risk management**

Risk management is defined as the management of uncertain events, in the goal of success (figure 1). Risk management is characterized by the totality of methods and means by which the risk is managed to meet the objectives described in the technical event, social, human, or political analysis, with uncertainty as a major basis for risk factors.

Risk management uses the following three fundamental components: assessment risk planning, risk response planning, risk monitoring and control:

* Risk assessment requires a systematic search for risk factors within the event to be held.
* Risk response planning involves identifying each risk, depending on the type and its severity for the event under review, and finding an appropriate response strategy for each case separately. Response strategies contain changes in responsibilities within the framework of the event, the means of communication between the components, the modification of the purposes of the event or the specifications that affect the established results.
* Risk monitoring and control aims at implementing response strategies and monitoring the effects that these changes may have on the event under review. Strategies however, risk control measures must be adjusted according to the effects they produce, taking care of all of them the parties involved in the event agree to these changes.

**RISKS**

More or less serious

More or less known

Easier or harder to avoid

**Figure 1. General risk classification**

The event to be analysed is treated as a separate project, because any successful modern activity, as a component of a project, is approached as a separate project, with project management methodology, with rigor and flexibility necessary for success.

The follow-up, step by step, of each event is considered component of the project, respectively of the subproject, of the activity, of the action, starting with using the basics and approaching sophisticated elements as much as is necessary for each specific project.

Risk management strategies and procedures apply on a case - by - case basis each organizational structure, depending on its profile and the events to be held.

The first step in developing the best strategy is to evaluate the current business environment.

Using quantitative and qualitative methods, the assessment includes both the examination of financial risks and operational ones. Financial risks are credit, interest rate and exchange rate risks foreign exchange, liquidity, and reinvestment. Operational risks include personnel, technological, distribution, policy, and regulation.

The risks should be described in as much detail as possible, considering issues such as:

* causal factors and consequences.
* setting the time frame on which the strategy is carried out;
* correlation with other risks, with a particular focus on influencing methods and, most importantly, with the observation of negative correlations between certain risks, which thus represent “natural hedges” for each other.
* current risk reduction strategies and their current degree of effectiveness.
* statistical data or assessments of the impact of risk on financial performance, prepared by experts.

The process involves a combination of collecting historical data, reviewing documents, analysing the information about the organizational, technological, and cultural structures that go into the constitution of the business. There are several ways to formalize the results of the process of identifying risk. A simple method is to create tables, in which each line represents a certain risk, and risk information should be organized in columns. An alternative method is to draw up certain risk maps, which graphically illustrate the causes and consequences of each risk, using a Monte-Carlo modelling. Following further classifications, managers may decide which risks require the most attention.

Strategic risks require a more detailed analysis model. Patterns represent uncertainty associated with each strategic risk factor, which shows how and what is the degree of weighted influence.

These models can be entirely quantitative, based strictly on numerical data, or entirely qualitative, relying almost entirely on accumulated experience. In either case, the goal is evaluation of the probability of distribution for each factor. Models that use both inputs quantitative as well as qualitative, offers the greatest potential for risk modelling, at which the structure organizational / company could be exposed.

**III. The Monte Carlo model**

In project management, the decision is usually about an investment. When combined, all separate tests create a probability distribution or risk assessment for a particular investment or event. When investors use the Monte Carlo method, they are compared to different levels of risk tolerance. This can help stakeholders decide whether to continue with an investment.

When using the Carlo model, a user changes the value of several variables to determine the potential impact on the decision being evaluated. In Monte Carlo modelling, the analyst conducts several studies (sometimes even thousands) to determine all possible outcomes and the likelihood of them occurring. Most estimates start with a base case. By entering the highest probability hypothesis for each factor, an analyst can get the result with the highest probability. However, making any decision based on a base case is problematic, and creating a single-result forecast is insufficient because it says nothing about other possible values that might arise.

Most estimates start with a base case. By entering the highest probability hypothesis for each factor, an analyst can get the result with the highest probability. However, making any decision based on a base case is problematic, and creating a single-result forecast is insufficient because it says nothing about other possible values that might arise.

It also says nothing about the real chance that the future real value will be anything other than the prediction of the base case. It is impossible to protect against a negative occurrence if the determinants and probabilities of these events are not calculated in advance.

A Monte Carlo simulation approach involves:

1. Identification of input variables. Input variables (inputs) can be divided into three categories:

* decision variables. Examples: production volume, investment volume, promotional budget etc.
* variables known in advance, but over which we have no power decision. Examples: credit interest rate, income tax, yield equipment etc.
* variables subject to uncertainty or randomness (whose values cannot be accurately determined in advance). These are the sources of risk project. Examples: inflation rate, RON/Euro exchange rate, future exchange rate of hares, monthly expenditure volume, number of customers, number of faults that occurred in a month, etc.

2. Defining the distributions of random variables. Monte simulation results Carlo depends a lot on the correct definition of the distribution random inputs. To achieve this, we can start from:

* historical data on the previous behaviour of that variable, if they exist;
* the opinion of specialists.

3. Defining the output variables (outputs) whose study we are interested in. For example: turnover, profit, cash flow, net worth updated, repair costs, etc. Output variables depend on input variables. E.g.:

* profit depends on sales and expenses.
* repair costs depend on the number of failures and the cost of repairing a malfunction, etc.

Consequence: output variables are also random variables.

4. Simulation of the behaviour of the output variables, with the help of a

specialized simulation program. This step involves automatic generation,

on the computer, a very large number of values (also called "tests" or “Iterations”) of the system input variables.

5. Analysis and interpretation of simulation results.

The art of developing a suitable Monte Carlo model is to determine the correct constraints for each variable and the correct relationship between the variables. For example, because portfolio diversification is based on the correlation between assets, any model developed to create the expected portfolio values must include the correlation between investments.

**IV. Creating the model**

There are many random number generators on the market. The two most common tools for designing and running Monte Carlo models are @Risk and Crystal Ball. Both can be used as spreadsheet supplements and allow random sampling to be incorporated into established spreadsheet templates.

In Monte Carlo analysis, a random number generator chooses a random value for each variable within the limits set by the model. In a normal distribution, all occurrences are evenly distributed around the mean. The media is the most likely event. Natural phenomena, people's heights and inflation are some examples of inputs that are normally distributed. Then produce a probability distribution for all possible outcomes. To choose the correct distribution for a variable, you need to understand each of the possible distributions available. For example, the most common is a normal distribution, also known as a bell curve.

The standard deviation of this probability is a statistic that indicates the probability that the actual result being estimated will be something other than the recalcitrant or most probable event. Assuming that the probability distribution is normally distributed, approximately 68% of the values will fall within a standard deviation of the mean, approximately 95% of the values will fall within two standard deviations and approximately 99.7% will fall within three deviations standard of the average.

This is known as the “68-95-99.7 rule” or “empirical rule”.

Chart, line chart

Description automatically generated

**Figure 2. Monte Carlo Simulations Scenario**

This simulation can be done in Excel as well. Two components intervene in the movement of the price of an asset: the drift, which is a constant directional movement, and a random entry, which represents the volatility of the market. By analysing historical price data, we can determine the deviation, standard deviation, variance, and average price movement of a security and these are the basics of a Monte Carlo simulation.

To design a possible price trajectory, use historical asset price data to generate a series of periodic daily returns using natural logarithm:

where:

PDR= periodic daily return

PD=previous day

PDP=price day’s price

Then we can use the AVERAGE, STDEV.P, and VAR.P functions for the entire resulting series to obtain the average daily yield, the standard deviation, and the variance entries, respectively. The drift is equal to:

where:

AverageDailyReturn=Produced from Excel’s AVERAGE function from periodic daily returns series, Variance=Produced from Excel’s VAR.P function from periodic daily returns series.

where:

*σ* = standard deviation, produced from Excel’s STDEV.P function from periodic daily returns series NORM.S.INV and RAND=Excel functions

The equation for the following day’s price is:

where: RV= random value

By repeating this calculation, a desired number of times, where each repetition represents a day, a simulation of the future price movement will be obtained. By generating an arbitrary number of simulations, one can assess the probability that the price will follow a certain trajectory.

**V. Conclusions**

Monte Carlo analyses are not only performed by finance professionals, but also by many other companies. It is a decision-making tool that assumes that each decision will have an impact on the overall risk.

Every individual and institution have a different risk tolerance. This makes it important to calculate the risk of any investment and compare it to the risk tolerance of the individual. The probability distributions produced by a Monte Carlo model create an image of risk. This image is an effective way to convey the results of others, such as superiors or potential investors. Today, very complex Monte Carlo models can be designed and executed by anyone with access to a personal computer.

**Bibliography**

1. Brandimarte, P. (2014) Handbook in Monte Carlo Simulation: applications in engineering, risk management and economics, Wiley, USA
2. Glasserman, P. (2016) Monte Carlo methods in financial engineering, *Stochasting Modellling an Applied Probabilities,* vol 53*,* Springer
3. Platon, V., Constantinescu, A. (2014) Monte Carlo Method in Risk Analysis for Investment Projects, *Procedia Economics and Finance,* Elsevier
4. Kwak, Y., Ingall, (2007) L. Exploring Monte Carlo Simulation Applications for Project Management, *Risk Manag*, vol 9, 44–57
5. Armaghani, D.J., Mahdiyar, A., Hasanipanah, M. *et al.* (2016) Risk Assessment and Prediction of Flyrock Distance by Combined Multiple Regression Analysis and Monte Carlo Simulation of Quarry Blasting, *Rock Mech Rock Eng*, vol 49, 3631–3641
6. Blom, H.A.P., Stroeve, S.H., de Jong, H.H. (2006) Safety Risk Assessment by Monte Carlo Simulation of Complex Safety Critical Operations, *Developments in Risk-based Approaches to Safety*, Springer
7. Hammond, P.J., Sun, Y. (2004). Monte Carlo simulation of macroeconomic risk with a continuum of agents: the symmetric case, *Assets, Beliefs, and Equilibria in Economic Dynamics*. *Studies in Economic Theory*, vol 18
8. Alekseeva, N., Antoshkova, N., Pupentsova, S. (2019). Application of the Monte-Carlo Simulation Method in Building and Energy Management Systems, *International Scientific Conference Energy Management of Municipal Facilities and Sustainable Energy Technologies,* *Advances in Intelligent Systems and Computing,* vol 983
9. Hammond, P.J., Sun, Y. (2008) Monte Carlo simulation of macroeconomic risk with a continuum of agents: the general case. *Economic Theory,* vol 36, 303–325