THE USV ANNALS OF ECONOMICS AND PUBLIC ADMINISTRATION | VOLUME 23, ISSUE 1(37), 2023

ECONOMIC RISKS FOR PROJECT MANAGEMENT – A MONTE CARLO SIMULATION APPROACH

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Received 29 March 2023; Accepted 15 June 2023

Abstract:

Monte Carlo simulation is an approach 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 examines the utilization of Monte Carlo simulation in project risk management.

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

JEL classification: D81, G32

I. INTRODUCTION

We reside in a world characterized by risks, and every undertaking carries a certain level of risk. Risk becomes an inherent and inseparable companion to any activity, exerting direct and substantial influence on its outcomes. Each day, the organizational structures in which we participate are subject, either directly or indirectly, to a variety of risks. These risks encompass our assets, our collaborative partners, and the work environment itself.

Consequently, the implementation of a risk management system emerges as a crucial objective for both individuals and organizational entities. It is important to note that excessive caution can engender risks, thus refraining from taking risks inherently poses a risk itself.

Can we counterbalance the adverse effects of unpredictable events, which arise irrespective of our preferences? Perhaps not entirely, but we can certainly mitigate them. Risk management and the role of a risk manager are indispensable for fostering successful business activities, particularly within project-oriented organizational frameworks. Inadequate risk management practices may result in significant financial, political, and even human losses (Blom, Stroeve, de Jong, 2006)

The market economy has yielded a multitude of complex tools designed to address various types of risks. However, risk management is a challenging and costly endeavor, with both parameters operating at maximum levels.

The increasing integration of information technology into risk management has given rise to the development of intelligent and adaptive systems capable of real-time decision-making. These systems aid in minimizing the adverse impacts of risks and monitoring residual risks, thereby optimizing positive outcomes (Platon, Constantinescu, 2014). Considering the aforementioned, it can be said that "the greatest risk is the absence of risk." When risks are identified and managed through risk management practices, they can be controlled. Conversely, when risks are not readily apparent, hidden risks are likely to be present, making control more challenging. Risk should never be taken lightly. It can present significant opportunities for those who know how to leverage it.

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 encompasses the management of uncertain events with the ultimate objective of achieving success (Figure 1). It is characterized by a comprehensive set of methods and measures employed to handle risks and achieve the objectives outlined in the analysis of technical, social, human, or political factors, all rooted in uncertainty as a fundamental basis for risk elements.

The practice of risk management revolves around three core components: risk analysis, risk management planning, and risk supervision (Brandimarte, 2014):

1. Risk assessment involves systematically identifying and examining risk factors associated with the event in question.
2. Risk response planning entails the identification of each risk, considering its type and severity within the context of the event being evaluated, and devising appropriate response strategies for each individual case. These response strategies may encompass alterations in responsibilities within the event framework, communication methods between involved parties, modifications to event goals or specifications that impact desired outcomes.
3. Risk monitoring and control aim to implement the response strategies and monitor the resultant effects on the event under review. It is essential to regularly assess the impact of these changes and adjust risk control measures accordingly. All parties involved in the event should be engaged and in agreement with the implemented changes.

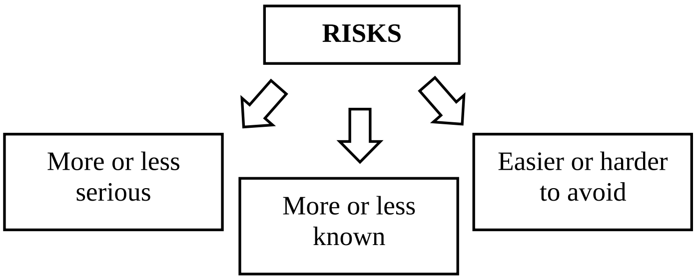

Figure no. 1. General risk classification

Source: Brandimarte, P. (2014) *Handbook in Monte Carlo Simulation: applications in engineering, risk management and economics*, Wiley, USA

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 (Kwak, Ingall, 2007).

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 (Hammond, Sun, 2004):

- 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, analyzing 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. Another alternative method is to utilize risk maps, which visually depict the causes and consequences of each risk, employing Monte Carlo modeling. Monte Carlo modeling, a probabilistic technique, enables the analysis of various scenarios by incorporating random variables to simulate possible outcomes. 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, decisions are made based on the analysis of several scenarios. Each variable that makes up the scenario will be given multiple values, sometimes even thousands, so that they cover each individual scenario. Most of the time, decision makers make decisions by analyzing each scenario separately. Monte Carlo simulation helps the decision maker by providing a wide palette of scenarios from which to choose the one that is probabilistically closest to the actual situation. Typically, one starts with a baseline estimate, where the most likely assumptions are entered for each factor to arrive at the most likely outcome.

In addition, a baseline forecast does not provide insight into the likelihood that the actual future value will differ from the forecasted outcome.

Without pre-calculating the determining factors and probabilities associated with these events, it is impossible to protect ourselves against the occurrence of negative aspects. To effectively manage risks, it is essential to utilize techniques such as Monte Carlo modeling, which considers various scenarios and their associated probabilities.

This approach allows stakeholders to assess the spectrum of potential results and make informed choices based on a comprehensive understanding of risks and their potential impacts (Armaghani, Mahdiyar, Hasanipanah, 2016).

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.

To develop a correct scenario based on Monte Carlo simulation, the constraints that each model variable can take must be correctly identified (Armaghani, Mahdiyar, Hasanipanah, 2016).

IV. CREATING THE MODEL

Among the most popular tools used to design and run Monte Carlo models are Crystal Ball, @Risk, and Simul8 software. These types of applications may be integrated into existing Excel spreadsheets, also using randomization generators to make our work as easy as possible. Most of the time, economic phenomena, such as inflation, can take values in the form of a standard normal distribution, known as the Gaussian Curve or Bell, because the density graph looks like a bell. It is also found under the name of the 65-95-99 rule.

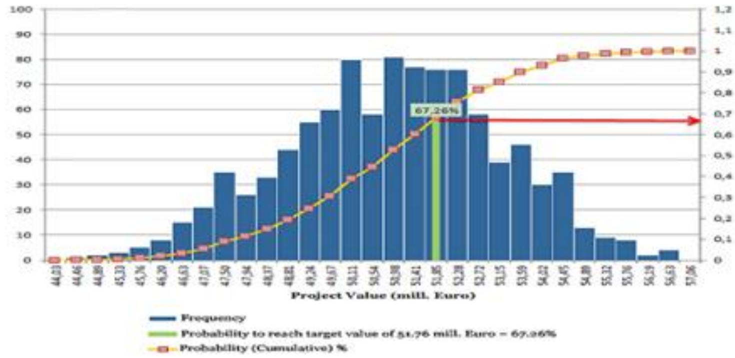

Figure no. 2. Monte Carlo Simulations Scenario

Source: Platon, V., Constantinescu, A. (2014) *Monte Carlo Method in Risk Analysis for Investment Projects,* Procedia Economics and Finance, Elsevier

It is also possible to perform this simulation in Microsoft Excel. By analyzing historical price data, we can identify two essential elements in financial market trading: by random variables and constant values. This analysis helps us to determine the variance, deviation and standard deviation, as well as the variation of the prices thus being able to do a Monte Carlo simulation.

$$DIR = ln\frac{PD}{EDP}$$

where:

DIR = daily interval return

PD = preceding day

EDP = end-of-day price

To calculate the average daily yield, standard deviation, and variance entries, we can utilize VAR.P, STDEV.P, AVERAGE, functions applied to the complete resulting series. The *trend* can then be determined as follows: The trend is equal to:

$$Trend = \mathrm{MDR} - \frac{Variance}{2}$$

where:

MDR (Daily Return) = The average daily return is calculated by using Excel's function AVERAGE. In the same way, the variance is obtained by periodic daily return's series using Excel VAR.P function.

$$\mathrm{RV} = \sigma \times \mathrm{NORM.S.INV\ (RAND\ ())}$$

In this context:

σ represents the standard deviation, which is calculated using STDEV.P function from Excel, for a series of regular daily returns. NORM.S.INV () and RAND are also Excel functions.

For calculating the price of the following day, we will use the next equation:

$$\mathrm{NDP} = \mathrm{TP} \times e\wedge^{(\mathrm{trend} + \mathrm{RV})}$$

where:

- The *trend* represents the deviation, which is a constant directional movement;
- *RV* represents the random value obtained from the simulation, which incorporates market volatility;
- TP (*Today's Price)* represents the price of the current day;
- NDR represent Next Day's Price.

Applying the equation in this way, we will find the price for the next day, as long as we know the price of the previous day and the trend. Of course, certain catastrophic events, a war or a major earthquake can alter our data and model.

V. CONCLUSIONS

Through this article we aimed to demonstrate that the use of Monte Carlo simulations should not only be addressed to professionals in the financial-banking environment, but also to simple employees who have access to technology and who know how to use Microsoft Excel. Of course, with such an approach, one should start from some simpler models, with a limited number of variables, so that later the model becomes more sophisticated and simulates the real economic world as realistically as possible.

And of course, when we have a risk associated with an investment within an organization, this risk also correlates with the risk associated with the respective decision-maker, with his individual appetite for risk.

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