# Techniques and Simulation Models in Risk Management

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**ABSTRACT**
*In the present paper, the scientific approach of the research starts from the theoretical framework of the simulation concept and then continues in the setting of the practical reality, thus providing simulation models for a broad range of inherent risks specific to any organization and simulation of those models, using the informatics instrument @Risk (Palisade). The reason behind this research lies in the need for simulation models that will allow the person in charge with decision taking inside the field of risk management to adopt new corporate strategies which will answer their current needs. The results of the research are represented by two simulation models specific to risk management. The first model follows the net profit simulation as well as simulating the impact that could be generated by a series of inherent risk factors such as losing some important colleagues, a drop in selling prices, a drop in sales volume, retrofitting, and so on. The second simulation model is associated to the IT field, through the analysis of 10 informatics threats, in order to evaluate the potential financial loss.*

**KEYWORDS:** *Monte Carlo simulation method, risk management, simulation*

**JEL CLASSIFICATION:** *C15, G17, M21*

## INTRODUCTION

The simulation models in the process of risk management can represent important sources of information for the decision maker of an organization, both from the perspective of defining a new investment strategy, but as well from the perspective of adopting new corporate strategies (the development of new business opportunities, the implementation of new inspections that will ensure adequate protection of the organization's assets). The planning of a strategy or optimizing the latter at the organizational level is based on an analysis of the internal and external risk factors and as well on their accomplishment probability. Rouse & Boff (2005) considered that simulation has the potential to support strategic thinking in a new direction. In the author's vision, strategic analysis executed in the traditional manner can be enriched with new experiments obtained by anticipating the future, thus allowing the identification of new features that will allow the decision maker the selection of certain solutions before investing in their development.

Using simulation in the business environment allows the evaluation of the impact of risk factors, provides valuable information to decision makers in questions such as:

- How close are we to achieve a desired rate of return for an investment?

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- How different are the results of two strategies (a strategy based on implementing the risk management and a strategy without the implementation of this process)?
- What impact would have, for example, the loss of a major customer, the emergence of a new competitor on the market, a drop in selling prices on the profit?

The answer to these questions is not based on deterministic models, in which events are known with certainty.

The main objective of this paper is to present simulation models specific to the risk field and the actual simulation of these models with the informatics tool @ Risk (Palisade, 2012). In order to achieve this goal, we will use a mixed research methodology, on one hand, a positive research with deductive character, which will follow the review of specialist literature, the delimitation of simulation conceptual framework in risk management, and on the other hand, a research with practical character that will follow the design of simulation models in the specified field and their simulation and interpretation of their results.

## 1. LITERATURE REVIEW

### Conceptual framework of the simulation in the risk management

In literature, the definition of the concept of simulation varies depending on the area of application, but the purpose of this process is to optimize the performance of the system/process analysis. In a general context, simulation is defined as an "imitation of the functionality of a process/system from the real world over time" (Banks, Carson, Nelson, Nicol, 2001).

Schiefer, Roth, Suntinger & Schatten (2007) defines this concept as being “a computer experiment using a simplified model of an operating system in the framework of its evolution over time aimed at better understanding and improving it."

The list of definitions can continue, but in our opinion, based on the study conducted on this concept in the literature, simulation is based on a ***model*** that will integrate all the variables and the characteristics of the influencing factors, as well as the correlations that are established between them, thus enabling the representation of the actual behavior of the modeled system, through a significant number of iterations. Estimation of the value of the input parameters can be assessed based on historical data rated with some degree of uncertainty, which will be represented by using ***probability distributions***. We note that there are two basic characteristics associated with the concept of simulation***: simulation model and probability distributions***.

Pidd (2004) classifies the simulation models according to their behavior in deterministic models and stochastic models. Deterministic models have predictable behavior because they rely on a set of data values known with certainty. In contrast, stochastic models have less predictable behavior, because the input values are known only with a certain probability.

In the business environment, the Monte Carlo simulation method is the optimal solution for analyzing stochastic models or risk conditions, its applicability is recognized in areas such as: decision support at management level, production, finance, investment, online sales, project management, and so on. This way we present, acting as an example, a number of simulation models.

Winston (2000) proposes two models for modeling financial situations. The first model involves the development of an investment to build a new simulation and the prediction of the evolution of the elements of financial statements. For each forecasted period, estimates will be made on the sales volume, the production costs, as well as capital expenditures using the normal distribution or the number of competitors with the help of the discrete distribution. The input variables of this model are the selling price, the unitary cost, the sales volume, the production expenditures composed out of direct material expenses, cost of salary and indirect costs of production. The second model proposed by the author is an evaluation model of the dividends which relies on estimating the growth index of the contained elements in the financial situations (account of profit and loss, balance), using the Pert distribution. The dividends can be evaluated by using evaluation methods applied to the expected flow of dividends.

Jones (2004) has developed a simulation model to maximize the profit per product, based on estimated costs and selling prices. The author believes that the main influencing factors in the model are the cost of production, the price of sales and the advertising expenses.

Hullet (2004) proposes a sales analysis model based on the following factors: marketing budget, organization prices and competition prices. The author chooses a triangular probability as the probability of price competition distribution. Through this exercise, the author tries to find an answer to the question: Will competitors prices fall to compensate for an increase in the marketing campaign or for a drop in organization prices? How well does the model justify reality?

The second model of the author analyzes the NPV and IRR for an investment strategy in the development of a new product. The determinant factors of the model are: the income, the percentage growth of revenues, the cost of goods sold, percentage growth of costs, the investment value.

Conrad (2005) proposes a model for analyzing uncertainty in investments regarding information security, using Monte Carlo simulation. Model parameters are based on the probability of intrusion, investment cost and expected losses in case of an attack at the information security level. The author uses a Poisson-type distribution associated to the annual rate of intrusion when there is no investment in information security.

## 2. RESEARCH RESULTS

### Simulation models specific to risk management

The theoretical elements presented earlier will act as basis for the practical examples which we will describe further in this paper. Even though the risks are present at the level of all the organizational activities and processes, the simulation models that will follow do not wish to be exhaustive. The actual simulation has been executed with the informatics tool @Risk (Palisade, 2003).

**Financial model**

The proposed simulation model starts from the model of the profit and loss account, and the determining factors that are subject to the simulation are: the turnover, raw material costs, staff costs, other operating expenses and interest income. To the 5 key factors, we have associated triangular probability distributions (see equation 1) with 3 distinct values (minimum value, most likely and maximum) as can be seen in figure no. 1:

$$\text{Turnover} = \text{RiskTriang}(25000,60000,100000) \quad (1)$$

The end purpose is represented by the net profit analysis through the key factors simulation.

| | A | B | D | E | F | G | H |
|---|---|---|---|---|---|---|---|
| 1 | **Profit and Loss Account** | | | | | | |
| 2 | | | | | | | |
| 3 | **Profit and Loss Account Items** | **Value** | | **Input Parameters** | **Minimum** | **Most Likely** | **Maximum** |
| 4 | **Turnover** | 61666.67 | | Turnover | 25000 | 60000 | 100000 |
| 5 | Income Cost of Production in Progress | 0.00 | | Raw Materials | 10000 | 40000 | 75000 |
| 6 | Productive Entity for Own | 0.00 | | Staff Costs | 0 | 2500 | 5000 |
| 7 | Other Operating Income | 0.00 | | Other Operating Expense | 500 | 5000 | 10000 |
| 8 | **OPERATING INCOME** | 61666.67 | | Interest income | 0 | 5000 | 10000 |
| 9 | Raw Materials | 41666.67 | | | | | |
| 10 | Staff Costs | 2500.00 | | | | | |
| 11 | Other Operating Expenses | 5166.67 | | | | | |
| 12 | **OPERATING EXPENSES** | 49333.33 | | | | | |
| 13 | **OPERATING PROFIT** | 12333.33 | | | | | |
| 26 | **Extraordinary profit** | 0.00 | | | | | |
| 27 | **GROSS PROFIT** | 17333.33 | | | | | |
| 28 | **INCOME TAX** | 2773.33 | | | | | |
| 29 | **NET PROFIT** | 14560.00 | | | | | |
| 30 | ***Profit Margin*** | 23.61% | | | | | |

**Figure.1 Model of simulation of the profit and loss account**
*Source:* author's calculation

The simulation process was based on a number of 1000 iterations, and the result of the simulation is represented in the figure no. 2, through a normal and a cumulative histogram. Analyzing this data we can observe that the amplitude of the simulated values is of 97.086 lei, with a minimum value of -34.094 lei and a maximum value of 62.952 lei. From the statistical data, an average value of the net profit is of 14.599 lei with a standard deviation of 17.161 lei.

The dynamic environment in which any organization operates nowadays has lead us to the analysis of some risk factors that can diminish the end result. To this goal, the risk factors shown in the figure no 3 have been analyzed, for which there have been specified the following characteristics: the impact (percentage of the turnover, for example for the risk factor of losing important clients, we chose 50%*turnover), Likelihood of the risk factor, frequency occurence chosen as a key factor of the simulation modeled through a binomial probability (Frequency occurrence = RiskBinom (1,20%)) and updated impact (The Impact* frequency occurence).

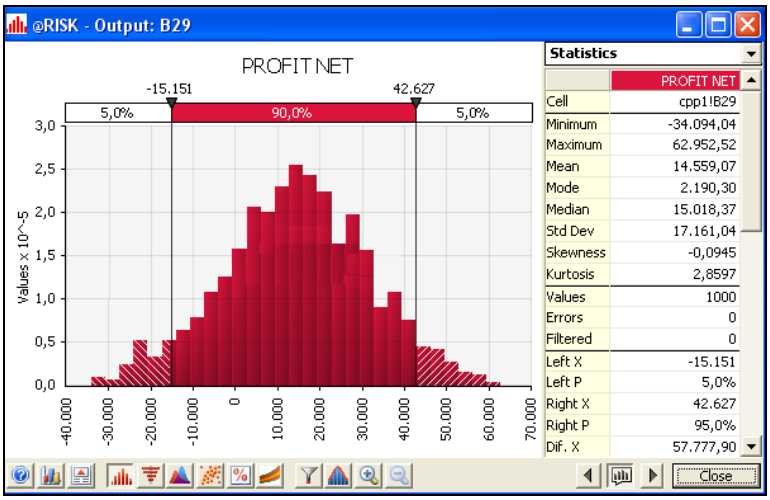


**Figure 2. The results of the simulation of the profit**
*Source:* author's calculation

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 32 | ***Risk Factors*** | ***Impact*** | ***Likelihood*** | ***Frequency Occurrence*** | ***Update Impact*** |
| 33 | Loss of important customers | 30000 | 20% | 0 | 0 |
| 34 | Lower selling prices | 18500 | 30% | 0 | 0 |
| 35 | Lower sales volume | 12500 | 40% | 0 | 0 |
| 36 | Departure of key personnelui cheie | 12500 | 50% | 1 | 12500 |
| 37 | Reingeniering | 9250 | 20% | 0 | 0 |
| 38 | Price increases from suppliers | 3000 | 20% | 1 | 3000 |
| 39 | Hiring qualified staff, training | 4300 | 50% | 1 | 4300 |
| 40 | **Total RISC** | 90050 | | | 19800 |

**Figure 3. Model of simulation for risk factors associated to turnover**
*Source*: author's calculation

This total updated impact value related to the 7 risk factors actually represents an additional cost that will lead to the decrease of net profits. The simulations results for this model, based on 1000 iterations, are represented in the figure no. 4 and it can be observed that for 90% of the cases the updated impact value for the specific risk factors varies from 3.000 to 64.000 lei.

Thus a correct assessment of the profit and loss account results can be viewed in the figure 5, where the situation is completely inverted, such that we leave from a profit situation and end up with a loss. We observe that the net profit, for 90% of the cases, will lie in the -49.000 to 26.920 interval and we record, for the current situation, a loss of 2.072 lei.

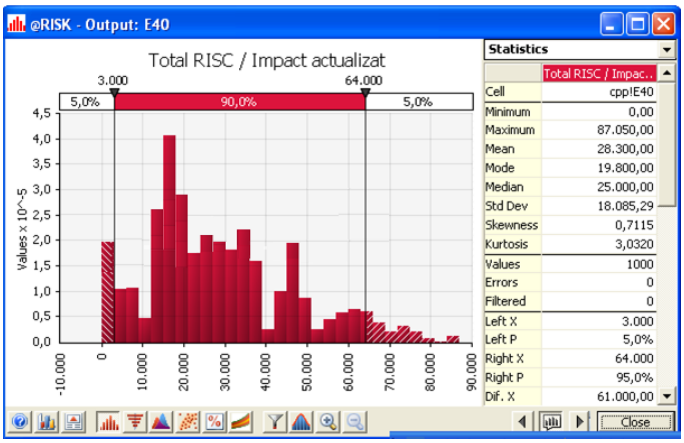


**Figure 4. The results of the simulation for risk factors associated to the turnover**

*Source:* author's calculation

| | A | B | C |
|---|---|---|---|
| 1 | **Profit and Loss Account** | | |
| 2 | | | |
| 3 | **Profit and Loss Account Items** | **Value** | **Value with Risk** |
| 4 | **Turnover** | 61666.67 | 41866.67 |
| 5 | Income Cost of Production in Progress | 0.00 | 0.00 |
| 6 | Productive Entity for Own | 0.00 | 0.00 |
| 7 | Other Operating Income | 0.00 | 0.00 |
| 8 | **OPERATING INCOME** | 61666.67 | 41866.67 |
| 9 | Raw Materials | 41666.67 | 41666.67 |
| 10 | Staff Costs | 2500.00 | 2500.00 |
| 11 | Other Operating Expenses | 5166.67 | 5166.67 |
| 12 | **OPERATING EXPENSES** | 49333.33 | 49333.33 |
| 13 | **OPERATING PROFIT** | 12333.33 | -7466.67 |
| 26 | **Extraordinary profit** | 0.00 | 0.00 |
| 27 | **GROSS PROFIT** | 17333.33 | -2466.67 |
| 28 | **INCOME TAX** | 2773.33 | -394.67 |
| 29 | **NET PROFIT** | 14560.00 | -2072.00 |
| 30 | ***Profit Margin*** | 23.61% | -4.95% |

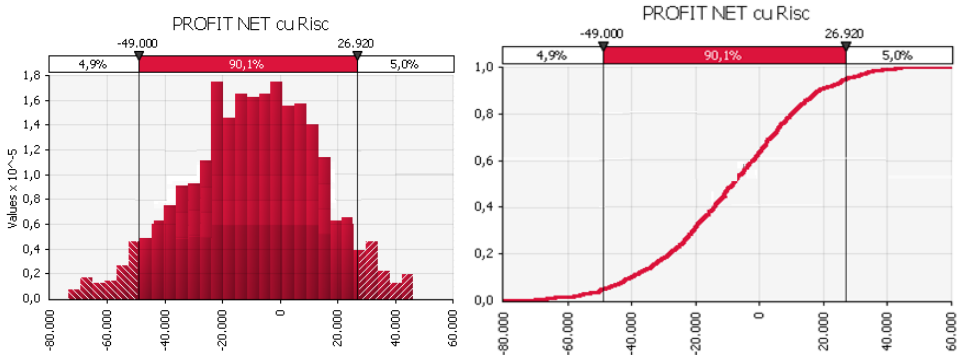


**Figure 5. Simulation of the net profit taking into account the analyzed risk factors**

*Source:* author's calculation

**IT model**

The informatics environment specific to a knowledge based society determined us to design a simulation model for the most frequent IT threats. Thus, 10 types of threats were analyzed (figure 6), for which the following influence factors were specified: the impact value and the likelihood, assessed according to historical data, frequency occurence chosen as a key factor of the simulation modeled through a binomial probability (Frequency occurence=RiskBinom(1,20%)) and updated impact (The Impact* frequency occurence).

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 4 | ***Threats IT*** | ***Impact*** | ***Likelihood*** | ***Frecuency Occurrence*** | ***Risk done?*** | ***Update Impact*** |
| 5 | Unauthorized changes to syste | 2000 | 20% | 0 | No | 0 |
| 6 | Corruption of data due to malicious code (viruses, worms, etc.) | 300 | 30% | 0 | No | 0 |
| 7 | Leaking sensitive information system | 450 | 50% | 1 | Yes | 450 |
| 8 | Spam | 700 | 70% | 1 | Yes | 700 |
| 9 | Technical failures of network | 1500 | 20% | 0 | No | 0 |
| 10 | Failure infrastrctura | 1000 | 20% | 0 | No | 0 |
| 11 | Human Error | 750 | 40% | 0 | No | 0 |
| 12 | Copyright infringement | 240 | 40% | 0 | No | 0 |
| 13 | Network attacks or cracking type hacking | 1000 | 35% | 1 | Yes | 1000 |
| 14 | Attacks internal (employee dissatisfaction) | 2500 | 60% | 0 | No | 0 |
| 15 | **Total impact** | 10440 | | | | 2150 |

**Figure 6. Model of simulation of IT threats**
*Source:* author's calculation

The simulation was based on a number of 1000 iterations, and the result of the simulation is represented if the figure. Analyzing the first plot, we can notice that the impact generated by the 10 IT threats varies from 940 to 5.150 in a 90% confidence interval; the second one, also known as a Tornado plot, reveals in decreasing order the weights of each informatics threat (the variables).

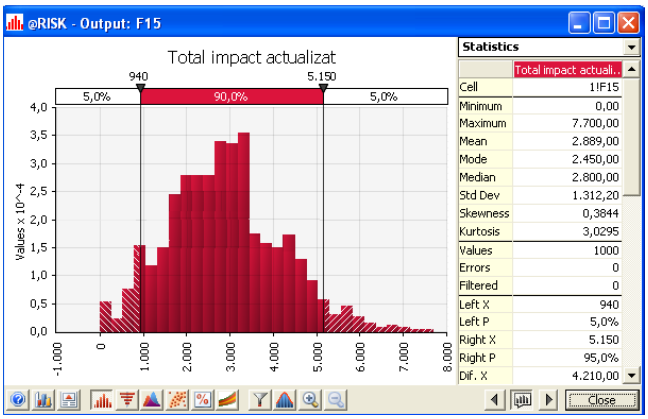


**Figure 7. Simulation of IT threats**
*Source*: author's calculation

## CONCLUSIONS

The risk analysis specific to any entity is a complex, dynamic process, interconnected to the economic and social processes and activities of the organization. From the simulation's perspective, the risk management process must integrate all variables and features of the key factors acting simultaneously on economic processes, in order to exhibit as realistically as possible the impact that these risk factors could generate.

The contribution of the research is focused on two dimensions: one theoretical and one practical. At a theoretical level we achieved an analysis of the state of knowledge in the field of simulation for the specific risks of the financial-economic activity of any organization. Based on the literature review characteristics that define the notion of simulation are specified and justified and also examples of implementation of Monte Carlo simulation method in the economic-financial (profit maximization model simulation, model uncertainty analysis investments, dividend valuation model, etc.) are given.

On a practical level, research has focused on the design of two simulation models, one associated with the financial sector and the second to the IT field, in order to analyze the impact of inherent risk factors.

The first simulation model aims at analyzing net profit by simulating key factors: turnover, raw material costs, staff costs, other operating expenses and interest income. The model is completed by the impact that risk factors could generate: the loss of major customers, a drop in selling prices, the decrease in sales volume, the departure of key personnel, the refurbishment, the increase in prices from suppliers and the hiring of qualified personnel, over the final outcome. The final results of the simulation provide valuable information for the decision factors, in order for them to adopt relevant strategies.

The second simulation model is based on analyzing 10 types of informatics threats in order to examine the financial loss that could occur, in the likelihood of these threats and the impact value.

The research does not offer an exhaustive approach of the field, so that future interest will continue this work started with the purpose of defining simulation models associated to the risk management concerning project development, information security risk management, risk management and so on. The simulation offers the decision factors a support and an instrument of analysis for the prediction of the examined risk factors, their cost and their impact over the financial results of the organization.

## ACKNOWLEDGEMENTS

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