The Role of Risk Analysis in Determining Investment Cash-flow

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1. Introduction

Corporate management demand increases to support strategic decisions and use scientific tools and methods to model uncertainties, thus creating connection between decisions and their expected consequences. To word it in another way corporations want to bear the risk of their decisions consciously to maximize their profit.

This is the reason for risk analysis and risk management being a very current topic in corporate practice, as sharpening competition increases the significance of everyday activity related uncertainties, revealing risks and quantifying their impact and based on the results of the analysis to realize risk mitigation action.

The available specialized literature comprises an abundance source of different tools and methods to carry out risk analysis. After studying the above mentioned, however I experienced that their use is difficult, as their language is rather difficult to understand for practicing professionals, and they rarely use an example for demonstration. To put it in another way the methods recommended in specialized literature are generally not user friendly. Based on realizing all this, my aim is primarily not to scientifically classify the methods in professional literature, or proposing to further develop them, but to give a theoretically well grounded risk analysis, which is easy to use in corporate practice, to base management decision on.

For me this was important, when I prepared the analysis, so to manage uncertainties of investment realization for my workplace called MATÁV Rt., and to develop a method based on procedures have known from professional literature, and partly based on new elements, which is possible to integrate to the business activities of the company without larger scale difficulties. Therefore, however I intend to have a general approach with my proposals, in several parts I make reference also to specialties of telecom investments.

As a consequence of the above, the aim of the present study is not the scientific clarification of the concepts related to the topic, however, I still feel it is indispensable to shortly define at least the concept of risk and uncertainty, as this may highly foster better understanding of my further study parts.

Before touching upon this it is worth mentioning that all activities have related risks as well. So this way we may speak about e.g. IT, security, financial, technical, legal,
economic etc. risks. In my study I am going to detail further the economic and more specifically the risks and uncertainties related to corporate investment analysis. This topic has rich literature background, where several approaches can be found. We have to differentiate also the aspects of economic risk in terms of mathematical, economic and legal concept. Among these I would like to depict the mathematical concept of risk – with regard to my topic selection, which in case of professional literature investments are approached by the measuring of a typical profitability index change (deviation). In order to understand the concept of risk concept of probability is also to be interpreted. In terms of risk analysis we have to consider mathematical and statistical interpretations, and according to these concepts the probability is the limiting value of relative frequency of regularly repeated events, around which relative probabilities fluctuate.

Another approach is that risk is a situation when an event has a certain probability to occur, so this means the number of possible future events is greater than the actually realized ones, but certain probability values can be attributed to the events. This way in theory the risk of any investment can fully be expressed with each possible output and determining their probabilities. However in practice this is quite difficult, or next to impossible. For this reason we use deviation as the indicator of risk to demonstrate the versatility of possible outputs.

The very same approach defines uncertainty, that the possible output situations are unknown, or if the possible situations are known but we do not know their occurrence probability. This means that uncertainty and risk are two different concepts as, opposed to uncertainty, because in case of risks the possible outcome probabilities can be estimated.

In agreement with the above concepts I keep using them in my study. In the first module of the next chapter of my study –after identifying the factors of risk we evaluate them within an expert workshop first as defining impact factors (outputs), and then with the appropriate scale transformation estimations are carried out for the evaluation of certain outputs. The results received in this process can be used also during the investment economic and financial analysis as well. The exact value of investment cash-flow certain elements however – even with very careful preparation – is not known for certainty.

2 Dr. György Andor: Beruházási döntések számítógépes támogatása [Computer support of investment decisions] (PhD) study Budapest, 1998 pp. 6, 10 [1]
3 The concept of probability and its description are detailed in Alkalmazott statisztika [Applied statistics] I. University handout (Editor Dr. Szabó, Gábor Csaba) Műegyetemi Kiadó Budapest 1993 pp. 95-103[4]
Therefore, when determining the volume of certain factors we inevitably make estimation mistakes². In this case our aim can only be to generate input data with the appropriate method (e.g. brainstorming and expert workshops), and these – with the use of the appropriate model (e.g. Monte-Carlo simulation model) – can be used to develop certain scenarios for quantifying the impacts of uncertainty impact, so that the consequences of unexpected events influencing the investment can already be considered during the decision making. According to this interpretation I also agree with, a Monte Carlo simulation primary use is the quantifying of risk factors influencing the cash-flow volume after their identification during the lifetime of the investment (mean value and standard deviation calculation). The third chapter of the study details the questions of Monte-Carlo simulation use in practice. However it is a disadvantage of simulation use that it does not consider the continuous changes of the dynamic environment surrounding the decision makers, so it does not make it possible to perform dynamic optimization. Real option can be used to prevent the above, and this depicts management dynamic investment opportunities with the concept of option price, and on the other hand the parameters necessary for the study and the evaluation models for options referring to real assets. Therefore in chapter 4 I give abundant theoretic background to evaluate the real option and then present some proposals to use this method in practice. In chapter 5 of the study the recommended method testing is presented via an example, and according to the consequences of experiences I give recommendations for the direction of further development.

2. **Aim of the study**

According to the questions posed in the introduction the aim of the study is to develop an easy to use complex approach during practical work including the following:

- Rethinking and defining the risk analysis and management processes of investment projects;
- Identifying risk factors related to the investment project realization and developing a new method for the selection of critical factors;
• Monte-Carlo Simulation model use to quantify the previously selected critical risk factors;
• Using the results of simulation determining the value of real option and preparing a proposal with the use of Monte-Carlo simulation;
• Testing the recommended method in a practical example, interpreting the results received;
• Proposal for the direction of further development.

I developed the structure of the study according to the above chain of thoughts. Firstly I am presenting the risk analysis and management process most important steps as I picture them. The basis for further study is this suggested methodology flowchart according to the introduction.

3. Specialized literature summary

The risk analysis has two separable areas:

- Descriptive analysis of the risks,\(^6\)
- Methods about risk impact quantifying

In both areas, but especially related to the quantifying different methods are developed and their common aim is to consider the uncertainty impact of investment realization. Also in the area of quantifying there are practically two separable fields:

- Risk examination in a static environment
- Optimizing risks of the dynamic environment

From among static environment risk analysis methods the practically most significant one is sensitivity analysis\(^7\) and using the Monte-Carlo simulation process. During the sensitivity analysis it is analyzed what extent the changes of the certain risk factor occurrence values influence the impact factor that serves as the basis for analysis (e.g. cash-flow from continuous operation, or the yield of the investment)

The sensitivity analysis disregards:

\(^6\) In corporate practice mostly textual analysis is common.

\(^7\) Dr. Mihály Görög: Bevezetés a projekt menedzsmentbe [Introduction to project management] Aula Kiadó Budapest, 1993. pp. 294
The possible correlations and function relations among risk variables,
the risk variable occurrence probability.

The above mentioned disadvantages of the sensitivity analysis are avoided by the Monte-Carlo simulation, and during the modeling the stochastic relations of the variables are also performed. One of the pioneers of the simulation model was David Hertz, who presented the steps of constructing the simulation model considered classic today\(^8\).

The disadvantage of simulation models in addition to model construction difficulties is that it does not consider the optimization opportunities of dynamic investment environments. Several methods were developed\(^9\) to determine this during the past decades, out of which in addition to mentioning the methodology— due to its practical significance – I am presenting the use of option price theory in detail in my study. The option price theory was developed to evaluate the future price development of securities present in the financial markets, but later on it was also applicable on the real asset market with defining the appropriate analogies\(^10\). The theoretic background of the application is created by several excellent works. There are only less analytic solutions to evaluate option tasks, and out of them the European type call and put option evaluation method is the Black-Scholes formula.\(^11\) For most of the evaluation however only the so called numerical methods can be applied. Out of these the binomial tree method, which is capable of evaluating American type options was by Cox, Ross and Rubinstein published.\(^12\). In addition to this further numerical methods are also known such as the Monte-Carlo simulation an the so called „Finite difference” methods.\(^13\)

4. Methods applied

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\(^8\) B. Hertz: Risk Analysis in Capital Investment  Harvard – Business Review 42 (January – February) 1964 pp.95-106
\(^9\) One of the methods is the so called dynamic programming, and its wider spread practical application is the decision trees
\(^12\) J.C Cox, S.A.Ross és M.Rubinstein: Option Pricing: A Simplified Approach Journal of Economics 7 (October, 1979)
\(^13\) The detailed description of the above methods can be found at : C.Hull:Options,Futures and other Derivatives, Securities Prentice-Hall New Yersey, 1993 pp. 329-362.
The nature of investments means that the task to be solved is always different, so as the data generated during the previous investments can not be used again for the evaluation of new investments. This also influenced the method suggested in my study – as the methods recommended in specialized literature– which may be suitable to quantify the impacts of uncertainties of the investment – based on having past (historical) data and the ability to use them. This may rarely happen in practice. Therefore during developing my proposal I preferred the method of expert estimation, and with their professional use primarily the missing data for the simulation model can be generated with high level of reliability.

4.1 Identifying risk factors, selecting critical risk factors

In the first phased of the research work I developed and independent model, to apply the risk factors threatening the realization of the given investment task, and to select the critical risk factors out of them. The method is based on „brainstorming” well known from professional literature. The essence of the procedure is that all relevant experts for the given task participate the process. The „brainstorming” is led by a speaker, who presents the certain steps of the process and takes care to interpret the content of certain tasks and realization method the same way. As a result of this procedure the critical risk factors are presented in a chart form.

4.2 Monte-Carlo simulation to quantify critical factors of risk

During the developing of the simulation model I primarily rely on the expert estimates. Within the framework of this the following were identified:

- The probability variables consisting the elements of the model,
- The forms of probability distribution functions describing the possible outcomes’ probability.

I also reach back to expert estimates when investigating the correlation, direction and closeness of variables. I use the American Decisioneering INC. developed Crystal Ball software to run simulation model.

4.3 Real Option
In order to determine the value of the option to check if the Black-Scholes differential calculus is applicable (the selected stochastic factor follows a random walking process) I use the series test well known from statistics and the chi-square statistical test\textsuperscript{14}.

In order to calculate the value of the option I use the macros mentioned in specialized literature recommended by T.A.Luehrman algorithm\textsuperscript{15} in Microsoft Excel and the previously mentioned software Crystal Ball.

5. Theses (research work results)

5.1 Thesis

I prepared a flowchart determining 4 steps of the investment risk analysis process\textsuperscript{16} according to the following:

- Exploration of risk factors,
- Grouping risk factors,
- Analysis of the identified risk factors,
- Developing the appropriate risk management strategy based on the results.

The flowchart includes – the definition of interactions among certain steps and also the including of continuous feedback. As a result of this independent modules are created to realize the first three steps of the process, and these can also be used together or independently due to the interfaces developed. Attention needs to be called specifically to the fact that the flowchart focuses not only on the decision preparation phase, but also on realization, and as an input data the results of decision-preparation analyses are used. (I have previously carried out also project risk analysis for the realization of the investment, however it is not part of the present dissertation.)

5.2 Thesis

I developed an independent method to identify risk factors and to select the critical risk factors.\textsuperscript{17}

\textsuperscript{15} Timothy A: Luerhman: Investment Opportunities as Real Option: Getting Started on the Numbers Harward Business Review pp. 51-67 (July-August, 1998.)
The recommended method is based on „brainstorming” well known from specialized literature and consists of the following steps:

- Exploring risk factors,
- Discussing the factors explored,
- Narrowing the factors revealed based on the debate (only the ones received full consensus can stay),
- Estimating the so remaining risk factor’s occurrence probability on an ordinal scale of 1-5, (probability scale)
- Selecting the impact factors the identified risk factors may have an impact on,
- Estimating the impact volume (compared to the value before risk analysis) on the 1-5 ordinal scale, (impact scale)
- Presenting the results received on the probability-impact matrix,
- Selecting the critical risk factors with a pre-defined formula based on the matrix.

As a result of the recommendation – even in the investment preparation, or realization phase – we may receive a clear picture of the sources of risks surrounding the investment. And with the help of the formula recommended in my dissertation we may select those which make it impossible or very difficult to meet the targets set. It is a strength of the recommended method that it is based on the collective wisdom of the expert participants, and therefore the results received may be considered quasi objective. Naturally the efficiency is greatly influenced by the composition of experts, therefore the aim shall be that at the brainstorming possibly all areas concerned shall be represented by highly experienced professionals. The above mentioned method can be partly an alternative solution in order to identify risk factors and to select critical factors as opposed to the sensitivity analysis mentioned at the beginning of the chapter, as this method also includes a „rough” impact analysis. The aim of both methods is to determine the critical factors, which have significant role in the yield indicator status that characterizes the given investment project, and this means that it works as a sort of filter for selecting critical factors. The difference between the two methods is that the above method makes the wide range and flexible application possible with the evaluation of the identified risk factors and presenting them on the five grade ordinal scale. So the method described can be used not only to select the critical factors influencing the cash-flow of investments, but also

17 Feket I: Kockázati tényezők gyűjtése és értékelése [Risk factors and their evaluation] Magyar Távközlés 2000/1 pp. 43-46
during solving entirely different tasks. Such tasks may include e.g. preparing risk maps, cooperation in the preparation of standards, developing a given corporate price structure etc.

5.3 Thesis

The second module covers the quantifying of uncertainties impacting future cash-flow of investments, that is the quantifying of estimation mistakes in the volume of more important factors determining the cash-flow. For this part I basically consider methods available in professional literature. The problem we encounter here as well is again the lack of available historical data. Therefore, I still rely on estimation methods.

Main steps of the structure of the Monte-Carlo simulation model:

- Selection of probability variables,
- Determining the range of the selected variables, determining the probability distribution functions, and examining if they have stochastic correlation, and if yes the estimation of the direction and closeness of this relation,
- Giving typical simulation parameters,
- Running simulation,
- Interpreting results received.

First we have to identify and evaluate the risk factors impacting the value of relevant factors of investment future cash-flow (market size, unit price, etc.) according to 5.2 (second module), which will be probability variables in the simulation model. The results of the first step are going to be the basis for the Monte-Carlo simulation model. After finishing first step I am suggesting to calculate the range of probability variables in the probability distribution function as follows: The range (so the highest and lowest value of the probability distribution) is calculated by using the smallest and largest difference found on the impact scale of 1-5 for each probability variable. The difference comes from the result of risk assessment activity detailed in 5.2.
The estimation of the stochastic relation (correlation) between the probability variables is according to the recommendations of the professional literature\(^\text{18}\) – with the use of beta probability distribution function’s chart.

### 5.4 Thesis

The third module is the evaluation of investments in a dynamic environment with the use of real option, and this includes the following steps:

- Selecting the appropriate factor the management is going to use as basis for decision optimization,
- Prove that the factor selected with the above method follows stochastic movement (Geometric Brown motion),
- Determining the parameters necessary to define option type and value,
- Calculating the value of the option,
- Interpretation of results.

#### 5.4.1 Thesis

In order to determine the project cash-flow the factor stochastically easy to model is to be found, and this determines the future cash-flow volume of the project, so this means their correlation is close to one. As in telecommunications (I am using the example of) we can not find a factor for which historic (several decades) of public and easy to access data is available, furthermore, telecom real assets have no active and liquid secondary market, therefore I recommend to use the net present value of the future cash-flow of the investment received with the Monte-Carlo simulation to evaluate the conditional claim. With this recommendation I continue the approach mentioned several times, and this means when lacking data I rely on expert estimates. This in a specific case means that with the recommended solution it is also possible to use this model in a branch – in spite of its limited use\(^\text{19}\) – to evaluate investment projects dynamic environment options with real option where no factor can be clearly identified (such as for instance the oil prices, metal prices, prices of raw minerals etc.), where the management decision is conditional depending on their temporal change, and for which

\(^{18}\) Dr. György Andor: Beruházási döntések számítógépes támogatása [Investment decision computation support] PhD Doktori (PhD) Értekezés Budapest, 1998.

\(^{19}\) Limited use partly means that the verification of the fact that the future cash-flow received with the simulation really follows an Ito process – is to be performed again and again in each case, and on the other hand – also considering practical usability factors – the verification process is not carried out for the entire distribution, but only for its mean value.
we have public data available for several decades to confirm in a reassuring manner that the temporal change of the given factor follows an Ito process.

5.4.2 Thesis

I recommend to perform the determination of one of the parameters necessary to define the option value, and this is volatility with Monte-Carlo simulation.\(^{20}\) I only found one reference in specialized literature\(^{21}\) for determining the value of volatility this way, and it remained on the level of idea. Consequently, the essence of my recommendation is to construct a new simulation model to determine the operational cash-flow volatility received with simulation (and in this case I can naturally prove with the previously mentioned statistical tests that the change in certain time intervals follows a stochastic process). I use the algorithm\(^{22}\) known from specialized literature to determine volatility. It is important to comment here that the operational cash-flow used as forecast in the previous simulation is going to be and assumption in the new model, and I am defining its value with statistical data received during the previous simulation (probability distribution function, mean value, standard deviation, range).

Advantages of the model recommended:

- Based on my recommendation – with carrying on the results of the previous simulation – the project cash-flow as volatility of time series is going to include the previously quantified risks. The result of simulation is going to be a distribution of volatility, and this includes the typical statistical values.
- Considering practical use features and accepting the loss of information, that from the data of distribution received this way in the future only the mean value is used (as a constant value in time) to determine the value of the option, and it enables us to also solve option tasks, where volatility is not constant in time.
- As also mentioned previously the value of volatility can be quite accurately received with the help of this method if no observation can be carried out as no data is available. Luerhman\(^{23}\) for instance recommends in these cases to use the stock index

\(^{20}\) Eurescom Project Extended Investment Analysis of Telecommunication Operator Strategies Deliverable 4 Heidelberg, 2000


\(^{23}\) Based on Luerhman’s previously referred article
status of the past 10 years, and calculate the volatility of time series from this and if we can feel that the risk of the future investment is similar to the stock index risk exposure, based on the value calculated this way we shall estimate volatility. However this seems to be feasible this way, but the question remains if we can confirm in a reassuring way that the stock index, or the risk of another suitable financial asset risk in time is comparable to the risk of the investment to be realized. With the method I am recommending no such analogy is to be searched, but the volatility extent can be determined from the data of the given investment.

6. Summary

The following may be considered as new findings of the dissertation:

- Defining the interfaces recommended for between certain steps of the investment project risk analysis and management process.
- Developing a method to identify risk factors, and to select critical risk factors.
- Developing a proposal to determine one of the parameters necessary to define the option value, and that is volatility with Monte-Carlo simulation.
- Developing a module system directly suitable for practical launch, where the certain modules can be used independently and also together.

Opportunities to step forward

- Composing the simulation model for an investment realized in several years and having significant impact on the initial cash-flow.
- Identifying stochastically easy to manage and model factors in the area of telecommunications for the evaluation of the option\(^\text{24}\), which result in conditional management decision direction with their temporal changes (correlation factor close to one!) and hence also impact a project future cash-flow present value.
- Extending the option evaluation for evaluating American and complex options. For such an option evaluation the binomial tree method is well applicable. Therefore its wide range use opportunity is to be examined.
- Examining the connection of risk analysis and game theory. This is important because the risk analysis presumes that there is only one enterprise in the world, and this enterprise endeavors to optimize its investments based on external and internal factors.

\(^{24}\) I considered this important in spite of the fact – as I put it down several times in my thesis – that the market for real assets is not efficient, and therefore the use of real option is limited.
internal information. In contrast, the game theory makes an effort to also analyze the expected reactions of possible competitors, and with consideration of these to define the optimal strategy. For this reason it would be worth including the risk analysis, and within that the results of the option calculation in the game theory, and with this step ensuring the development of an optional strategy for all competitors in the market regarding planned capacity. With my colleagues we mutually developed the theoretic basis for this, and it was also published on several forums. The theoretic basis is presently being converted into practice, however further serious efforts are still necessary to complete this process.

Budapest, December 14, 2000

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