

Chosen Techniques of Construction Risk Analysis

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Abstract

The paper presents some issues related to analysis of construction investment profitability, including detailed approach to probability methods related to risk analysis and management. The analysis was performed with the use of Net Present Method (NPV), considering influence of variables on profitability of the investment. Statistic calculations were carried out with the use of Monte Carlo method and the Crystal Ball computer software. Results of the research leading to simulation NPV value, are shown on a diagram, described by a probability distribution and additionally enriched by Tornado analysis. Conclusions from the paper describe very useful tools for analysis of construction investment profitability.

Keywords: risk management, risk assessment, Monte Carlo simulation

1. Introduction

Available publications treating about problems connected with risk assessment of investment projects divide them into five groups (see Figure 1) (Ostrowska, 2002). These methods can be used in specific conditions, depending on a planning phase of the investment and availability of connected data.

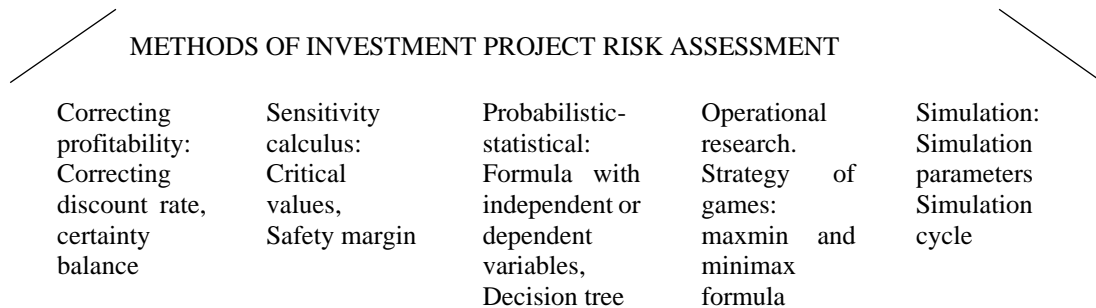


Figure 1: Methods of investment risk assessment

At the stage of preliminary assessment of an investment project e.g. during prefeasibility study, can be used method of correcting investment project profitability, mainly by correcting discount rate and certainty balance. Correcting investment project profitability is done through changing discount rate depending on potential risk. The higher is risk, the higher discount rate should be applied. Received under these conditions value of NPV will be decreased, or even become negative, what may lead to rejecting the whole investment.

Correcting investment project profitability through changing discount rate consists in correcting cash flows streams. Correcting cash flows streams is done by using mentioned above rates i.e. discount rate free of risk and discount rate under risk conditions. The higher risk is, the lower the index becomes, what influences values of cash flows.

Assessment of risk on the initial assessment of investment project can be carried out by sensitivity analysis. Methods of investment project sensitivity analysis on varying values of factors influencing NPV allow establishing, which factor has the most crucial impact on the NPV value. Defining factors, having the strongest impact on project profitability, simplifies more detailed analysis of project threats and describes which factors are “critical” for the project. It means specifying most important among a number of factors. To the sensitivity analysis methods also belongs profitability threshold method, especially applicable in projects connected with industry. This method allows describing, which groups of project costs have the major influence on its profitability. Another group of investment risk assessment methods is can be used during both, during predecision phase in prefeasibility study, and on the later stages in feasibility study. First of these methods (variance as a measure of risk) is used with assumption that balance of cash flows connected with the investment are independent. Expected value of cash flow balance is analyzed and after discounting, calculated expected net present value. Calculation in following steps gives variance of net present value and standard deviation.

As a result of the analysis, a variability factor of net present value is calculated, expressed by quotient of net present value standard deviation to expected net present value. Obviously amount of risk falling to unit of expected net present value should be minimized for the success of the project. Variety of this method is a description of semivariance as a measure of risk. This method is based on assumption that in the project profitability risk analysis most disturbing are negative cash flows. Therefore, for these cash flows semivariance of net present value is calculated as well as semistandard deviation of net present value and deducts semivariant net present value factor.

Another analysis from the probabilistic and statistical group is a method of decision tree. It consists in presenting cash flows and their probability in the form of decision chart. For every decision path can be defined value of net present value (NPV) and its probability. On that basis expected value of NPV can be determined.

In the case of making strategic decisions in investment planning analysis in predecision phase with large number of uncertain factors, a method of investment strategic analysis. As a result, client obtains a possibility of being aware of effects of individual variants of investment decisions. Strategy of games with respect to selection of variants (uncertainty scenarios) of investment project is based on criterion: rational, maxmax, maxmin and minimax.

Another group of methods used in investment project assessment analysis on the predecision and decision phase are simulation methods. These methods most frequently are based on Monte Carlo Method. Simulation methods are most useful when appropriate set of data is available in order to properly define probability distributions of factors influencing profitability of planned investment project. As a result it is possible to obtain probability distribution of net present value index (NPV). Result of simulations are not

binding in decision making process, but can give very important information aiding the process oriented on increase of project economical outcome.

2. Monte Carlo simulation

Generally speaking, simulation is a process leading to a solution of different issues (i.e. economic), by repeating random trials multiple times. Simulation method, used in assessment of investment projects, consists in a process of calculating measure of project's profitability multiple times (i.e. net present value – NPV), according to defined model of randomly generated values of variables, influencing this measure (Jaworski , 1999). Method using Monte Carlo simulation is a risk analysis technique, in which probable future investment events are being simulated in order to obtain most probable values like NPV of whole project.

Introducing simulation techniques in risk estimating give an opportunity to test the influence of many input variables on economical profitability of a project. As opposed to sensitivity analysis in which variables are treated separately, in simulation analysis all variables can be calculated simultaneously, also taking under consideration mutual correlations.

In simulation models correlations between variables are very important and have to be defined properly. Variables are given relevant probability distributions, with respect to analogical experience from other projects treated as historical data (Crystal Ball,2002). Defining hypothetical probability distribution is a very difficult and complex process in simulation, because too much subjectivity may lead to false results. Therefore in a process of defining probability distributions of variables it is very important to make good use of knowledge of experienced experts and management personnel of the company.

In classic analysis of scenarios only three levels of variables are taken into consideration – optimistic, realistic and pessimistic. They represent only few points on a curve of all possible values possible to occur. It is clear, that this method gives a very rough project risk assessment. Complex view on future effects of investment gives proper simulation of risk, which results may fundamentally change previous assessment of a project. Crucial issue in developing simulation model is collecting large number of data related to the project such as: expenditures, production and price of products, costs of production, dues and obligations, interest rates, tax rated etc (Rogowski, 2004).

In the following part of the paper authors presented an example of office building profitability analysis. The analysis was carried out with use of computer software – Crystal Ball. As the first step is necessary to define simulation parameters such as number of iterations or certainty range, after which the simulation ends. For the purposes of this example number of iterations was set to ten thousand. In the Table 1 below, breakdown of costs in EUR has been presented.

Table 1: Breakdown of costs example

Id.	Element	Cost
1.	Purchase of building plot	503365
2.	Ground and foundation works	108000
3.	Shell and core works	375000
4.	Finishing works	1152000
5.	Interior sanitary installations	104000
6.	Interior electric installations	412000
7.	Heating and ventilation/ Air-condition	664000

8.	Exterior wires	12000
9.	Road works and greenery	15000
10.	Special equipment / technology	113000
11.	Construction project	8000
12.	Other:	12000
13.	General expenses	78000
14.	Non-production costs	87000
15.	Salaries	102400
	Total [EUR]	3745765

Next stage of simulation model preparation is to fit properly probability distributions into data. Cells highlighted in grey were given relevant probability distributions. Below are presented two examples of variables and their probability distributions.

Simulation model after applying probability distributions for variables, description of simulation methods and setting proper number of iterations, can be then simulated. In the presented example of constructing and then renting office building, following values were distinguished as being crucial for investment assessment:

- Income during individual years of building exploitation,
- NPV of the investment during exploitation,
- Return period of the investment,
- NPV of the whole life cycle of the investment.

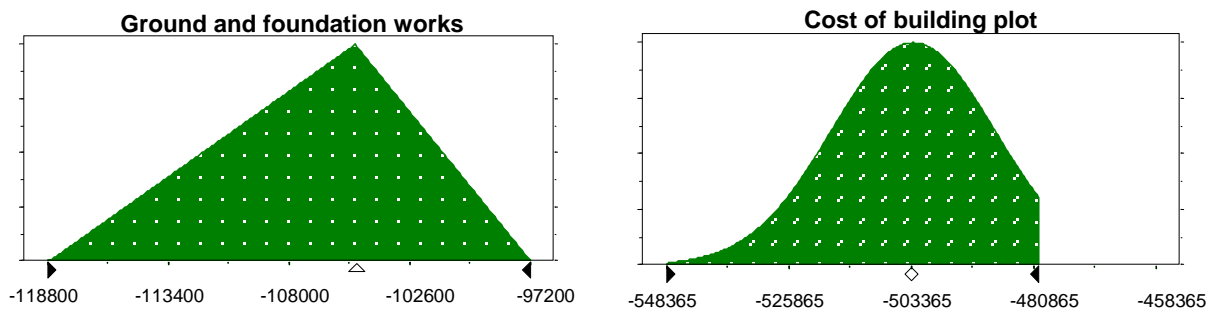


Figure 2: Examples of variables and their probability distributions

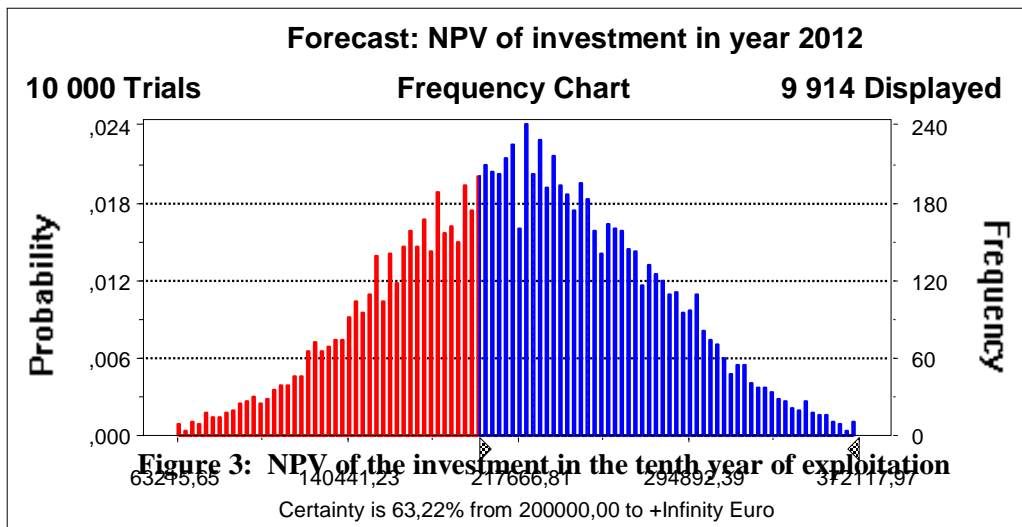
For the assessment of mentioned above factors' variability, several values has been given probability distributions, indicated in the table as grey cells (Table 2).

Table 2: Values of probability distribution example

	2003 – 1st half 2004	2 nd half 2004	2005	2006	2007	2008	2009	2010	2011	2012
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% of space rented	0%	20%	60%	75%	90%	95%	95%	95%	95%	95%
Discount rate	0%	5,60%	5,60%	5,60%	5,50%	5,50%	5,30%	4,90%	4,90%	5,00%
Renovation, repair, modernisation	0	32 500	65 000	65 000	65 000	65 000	65 000	65 000	65 000	65 000
Income per l m ²	0	16,0	16,0	16,0	17,0	17,0	17,0	18,0	18,0	18,0
Balance	-3745765	41951	354934	433939	540351	543398	520967	540727	515469	487195
NPV		-3703814	-3348880	-2914940	-2374589	-1831191	-1310223	-769496	-254026	233168,5

Simulation analysis has proven, that NPV becomes positive not before year 2012. As presented on the diagram (Figure 3), showing expected result of NPV in the year 2012, whole range of values is positive. It means that when established in the simulation model events occur, in the year 2012 client will have a certain profit from the investment. The Crystal Ball program offers an option of defining range for which a probability will be calculated. For example, client would like to know what is a probability of obtaining result of 200 000 Euro and more. After defining it on the diagram, the result is that the probability is 63,22%. Client in an easy way get very important information allowing more detailed prognosis on investment profitability.



3. Tornado analysis.

Tornado technique consists in analysis of selected probability variables included in the probability model, with respect to their influence on examined value. On diagram shown in Figure 4 variables are put in specific order: from the variable having the biggest influence on the value - "NPV of investment in year 2012", to variables having slight influence on that value. Number of variables shown on the diagram was limited to 15 most important. Bars on the right side of the vertical line mean shift of NPV to higher values (positive effect), and on the left side, shift to negative values. Every variable was described on both sides of the bars, by values of range in which it was calculated. On the horizontal axis, probable value of NPV is marked.

As an example, costs of finishing works were presumed on the level of 1,152,000 Euro. From the Tornado analysis shows that increase of this cost to 1,193,650 Euro will cause drop of the NPV in year 2012 to 179,926 Euro. Decrease of this cost to 1,110,350 Euro will result in increase of NPV to 265,567 Euro.

Tornado analysis for this example shows, that most important for final financial result measured by NPV, critical variables are cost of: finishing works, heating and ventilation system, air-condition and electric installation inside the building.

Being aware of Tornado analysis results, client obtains very important information about categories that should be treated with special attention. Keeping these costs on the assumed level, or even making them lower, will drastically increase profitability of the investment.

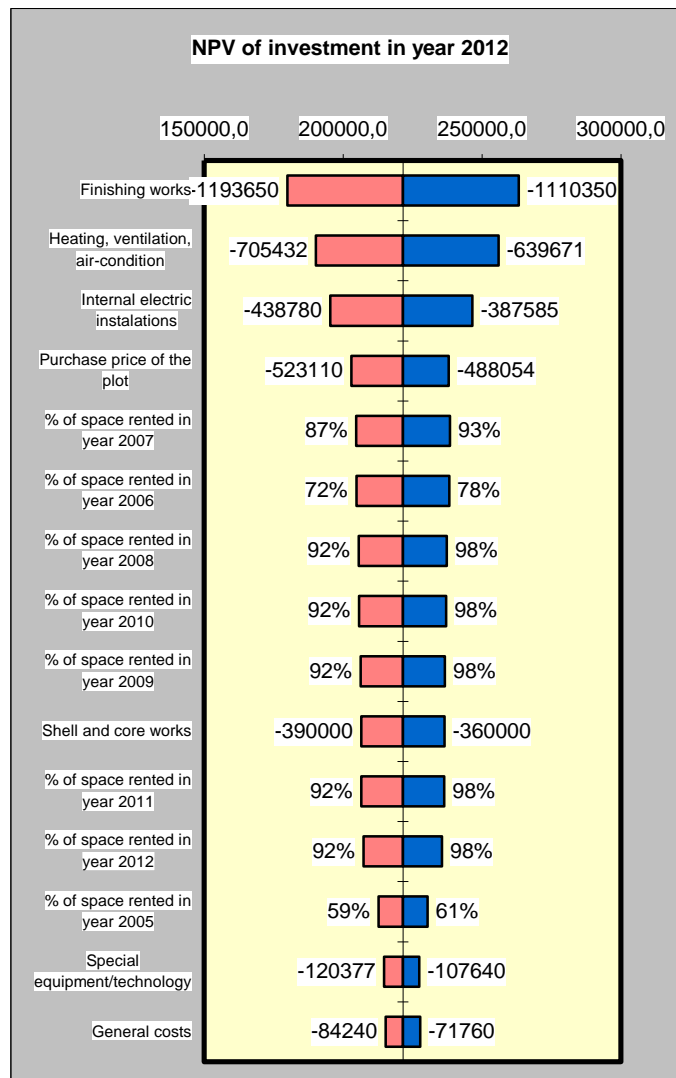


Figure 4: Diagram - Tornado Chart of the project

4. Conclusion

The paper presents various methods of investment projects' risk assessment. One of these methods is simulation analysis. Use of this method was presented on an example of office building planning, construction and exploitation. Presented example proved, that simulation analysis allows probability assessment of invested means return and points at factors that have major influence on the assessment. Method of investment projects' assessment shown in the paper is a very important element and aid in client's decision-making process and can be extremely valuable in many different types of project.

5. References

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