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RISK QUANTIFICATION APPROCHES TO THE ASSESMENT OF ECONOMIC EFFICIENCY OF INVESTMENTS

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Abstract. *In order to increase the quality of investment decision making in a company it is important, regarding economic efficiency evaluation of investments, to pay more and more attention to risk quantification. In this case, the risk is primarily related to the cash flow of investment being assessed. Its reflection in the final value of the given economic criterion – net present value – can be estimated by different approaches. With the direct risk evaluation, the evaluation basis is the determination of the cash flow probability of investment by applying statistical characteristics such as the method of standard deviation and the diffusion and variation coefficient. In economic practice the process of taking risk into account is usually performed indirectly. It is simpler and it mainly comprises the methods of discount rate adjustment, the determination of risk classes, the method of certainty coefficient or that of real options. The mentioned approaches to risk quantification have their specifications, which are described in the paper.*

Key words: *Investment, Risk, Cash Flow, Discount Rate, Coefficient of Probability, Real Options*

1. INTRODUCTION

The risk estimate represents an indispensable feature of the proper investment decision-making. It is particularly important in the case of the investments launching new products or those made into corporate research and development. In the process of investment decision-making, the risk theory includes several more or less difficult mathematical and statistical tools and methods designed for risk exploration and measurement. Their practical application in the companies overcomes a variety of knowledge, information, and administrative barriers. One of the reasons is that the company managers are not

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used to dealing with the business risk because, in the centrally managed economy, this issue is solved by the state. However, in the market economy, under conditions of economic and financial independence of companies, the situation is completely different – investment risk falls directly on the company owners, managers, and also employees.

Although some risk quantification methods are not feasible for some companies due to various reasons, it is essential for companies to use at least rough estimate of the risk, take it into account and thus improve their investment decision-making process. It is crucial to realize that it is better to make at least a subjective estimate of the risk than not to estimate at all.

The method of incorporating the risk into evaluation of the investment's economic efficiency depends, to a certain extent, on the selected assessment criterion. If the growth of market value represents the goal of the company, then the net present value or economic value added by investment are suitable criteria for the given investment assessment and selection. For determination of the given criteria the following two key inputs are necessary: investment cash flows and discount rate.

The risk is primarily connected with cash flow of investment being assessed; its reflection in the final value of the given economic criterion can be performed directly or indirectly. In the following part of the paper the risk is applied to the economic criterion of the net present value.

2. DIRECT CONSIDERATION OF RISK

The risk quantification is based on the determination of probability of investment cash flows. The probability that individual income or capital expenditure of investment will happen in the future can be defined by a percentage representing a possibility of its occurrence. Probability can be determined:
objectively on the basis of previous cash flows data (especially in case of repeated investments), subjectively on the basis of professional estimate with respect to the potential deviations caused by various factors (prices, costs, taxes, and alike).

Subsequently, the so-called average expected value of cash flows is determined, identifying the level of income of individual variants and also the level of their probability. However, it does not identify the distribution of individual incomes around this mean, so it fails to determine the investment risk, because the same expected average investment income may be related to various risks.

For the complete determination of the investment risk level it is indispensable to compare the deviations of individual income from the average expected value. The project with higher deviation is more risky. Each deviation has different probability; therefore, it is necessary to determine the average level of deviations from the average expected value. For this purpose there are following statistical characteristics: the method of standard deviation, the variance, and the coefficient of variation.

The most appropriate statistical characteristic is the method of standard deviation, i.e. an absolute rate of risk. It is calculated by means of the root of income variance. The variance of income is determined as a sum of products of deviations square roots of individual incomes from the average income and the probability rate of these incomes. To compare the risk of projects with significantly different average values of incomes it is recommended to use a coefficient of variation, i.e. the relative measure of risk rate, which represents a ratio of standard deviation and the average expected investment income.

The calculation of the net present value variance is given as an example. The calculation is to be made in the following steps: [5, p.192-195]

1. Calculation of net present value taking into account a probability of income at various variants,
2. calculation of net present value variation, in which it is necessary to take into account whether incomes during life time are:
   - independent, i.e. income in the respective years does not show any systematic dependence, then the total net present value variance is equal to the sum of discounted annual variances of incomes, or

$$\sigma_{NPV}^2 = \sum_{n=1}^{N} \frac{\sigma_n^2}{(1+r_f)^{2n}} \tag{1}$$

   - dependent on each other, i.e. income in the following years is predetermined by income in the first year, then the total variance

$$\sigma_{NPV}^2 = \left[\sum_{n=1}^{N} \frac{\sigma_n}{(1+r_f)^{n}} \right]^2 \tag{2}$$

Where: σ^2_{NPV} – total variance of net present value,
σ^2_n – variance of income in the year n,
r_f – risk-free required return rate (expressed by a decimal number),
N – investment life time
n – respective years of investment life time.

3. Selection of investment taking into consideration the risk. The investment with lower variance, i.e. the lower risk, is more advantageous.

3. INDIRECT CONSIDERATION OF RISK

In economic practice the process of taking the risk into account is usually performed indirectly. It is simpler than the direct method and it occurs in the following forms: adjustment of discount rate, determination of risk classes, and method of certainty coefficient.

3.1 Complying with risk by means of the discount rate adjustment

The discount rate adjustment is based on the fact that the higher the investment risk is, the higher required return rate is to be selected for the calculation of net present value. As a consequence of a higher discount rate, the present value of investment cash flows and the entire net present value of investment variant are declining.

The amount of discount rate depends on whether it is represented only by the costs of equity capital or the costs of total capital.

Equity capital costs mean required return, which the owners expect for their investment to the company. The amount depends on the risk of entrepreneurial activity of the company, while the following is true: the more risky entrepreneurial activity of the company is, the higher return is required by the owners and thus, the costs of equity capital are higher.

Specification of the equity capital costs is based on a sum of risk-free return rate and risk premium. If a company risk premium is zero, then the equity capital costs equals the risk-free return rate, which is generally considered to be a return of Treasury bills.

It is necessary to always specify a risk premium in actual projects. By means of the risk premium, it is possible to eliminate potential deviations in estimated values of the investment project income and costs during the time of its life.

The approaches to the risk premium specification based on the capital market data are of little use in our conditions, so that the expert approaches come into consideration, modular patterns being one of them. They are characterized by creating risk premium as a sum of several items. Then equity capital costs specification algorithm may be written as the following equation:

$$COE = r_f + r_1 + r_2 + \ldots + r_n \tag{3}$$

Where: COE – own equity cost in %,
r_f – risk-free return rate in %,
r_1 – n - others risk premiums in %.

This approach is represented by, for instance, INFA model or the complex modular pattern.

The total capital costs of the project are calculated as weighted arithmetic average of the equity capital and of the borrowed capital. The equation of the calculation of the weight average cost of capital – a model WACC is as follows:

$$WACC = w_1 \times Cc_1 + w_2 \times Cc_2 + \ldots + w_n \times Cc_n = \sum_{i=1}^{n} w_i \times Cc_i \tag{4}$$

Where: $WACC$ – weight average cost of capital in %,
w_i – per cent proportion of i-kind of capital (expressed by a decimal number),
Cci – cost of i-kind of capital in %,
n – number of kinds of capital.

The method for calculation of the net present value at the risk-adjusted discount rate can be expressed according to the following relation:

$$NPV_R = \sum_{n=1}^{N} \bar{I} \times \frac{1}{(1+r_R)^n} - \overline{CE} \tag{5}$$

Where: NPV_R – net present value taking into account the risk,
$\bar{I}$ – average income in respective years of the life time, taking into account a probability of various variants of income,
rR – discount rate (required return rate) taking into account the risk,
$\overline{CE}$ – average capital expenditure, taking into account a probability of capital expenditures.

Different modifications of equation for the average cost of capital calculation based on the number of sources and a manner of their weight calculation as well as on variously defined and calculated cost of capital exist in a theory and practice.

3.2 Determination of risk classes

The discount rate of the investment project may be identified with the average capital cost of the company only if the project risk rate is approximately the same as the risk of business activity of the company (the project represents a certain copy of the whole company) or if the manner of funding does not excessively influence the capital structure of the company, on which the company's cost of the capital are based on.

In other situations, it is necessary to adjust the cost of the capital. No exact approach exists for increasing or decreasing of company's costs. The method applied in economic practice is based on investment project classification into certain categories with different discount rates. In the simplest situation, the projects are classified into three categories, and these are: [1]

- low risk projects – discount rate corresponds to the company's cost of the capital by 1% up to 3%,
- average risk projects – discount rate corresponds to the company's cost of the capital,
- high risk projects – discount rate is higher than the company's by 2% to 5%.

More detailed investment projects classification according to the risk rate is specified in Table 1.

Table 1 Relation of discount rate to the type of project

Project Category	Discount rate (%)
1. Production equipment renewal	8
2. Cost decrease by means of well-established technology	10
3. Actual production program extension	12
4. New products establishment	15
5. Projects off the focus of the company	20

Source: own elaboration according to [5]

To determine the project discount rate according to the table above means to asses the project nature in an expert way and to classify it to the one of the categories specified.

3.3 Complying with the risk by means of the probability coefficient

The coefficient of probability approach is based on investment project cash flow adjustment. It expresses a degree of assurance that the cash flow will occurs. The coefficient values determined by analysts range from 0 to 1 and the higher they are, the more secure the estimated cash flows are.

Respecting certainty coefficient it can be expressed with net present value as follows:

$$NPV_k = \sum_{n=1}^{N} I_n \times c_{In} \times \frac{1}{(1+r_f)^n} - CE \times c_{CE} \tag{6}$$

Where: NPV_k – net present value respecting certainty coefficient,
c_{In} – certainty coefficient of income in respective years,
c_{CE} – certainty coefficient of capital expenditure.

When considering the risk, some theoreticians regard the coefficient of probability approach as more conceptual and more appropriate than the discount rate adjustment. The reasons for such preference are: [4]

- They divide the amortized value of the money from the risk; first, the risk is eliminated then the certainty coefficients are discounted by risk-free interest rate
- They enable adjustment of the cash flows separately regarding risks in each individual year to the time of the investment project life

The disadvantage of this method lies in the fact that there is no reliable method for determination of certainty coefficients values for the given periods.

3.4 Complying with the risk by means of real options

In a dynamic and significantly insecure environment, the real options represent an alternative tool for complying with the risk in the investment projects economic efficiency assessment. The basic idea of the real options is based on the fact that the investment project value is affected not only by the factors determining standard project NPV but also by dynamics and the uncertainty rate of the environment, in which the project functions and by the investment project flexibility rate. In other words, the project NPV is also affected by possibilities (options) to leave, extend, and reduce as well as temporarily interrupt the investment project and the like in the future.

This method brings in dynamics into the standard NPV by the option value in the future and transforms it to the so called strategic NPV. It may be formally written in the following way:

$$\textit{Strategic NPV} = \textit{standard NPV} + \textit{real option value} \tag{7}$$

The use of the real options is therefore a sequential approach. In its first phase, the evaluation based on the discounted cash flows takes place while the second phase is reserved for the determination of the real option value based on the input values, which are the outputs from the first phase. The real options evaluation is based on the financial and real options analogy

The real options are a useful tool mainly in the situations when the use eliminates or weakens the failures and shortcomings of the investment projects valuation by means of discounted financial incomes. The biggest possibilities of use are by those investment projects, where NPV is close to zero without the valuation of their flexibility or when it occurs in not too high negative numbers. If the insecurity is trivial or the project NPV is highly positive, it is not necessary to use real options for investment project valuation. [1]

Considering the increase of dynamism and insecurity of the business environment, the significance of the real option increases and leads to the need for a deeper knowledge of their possibilities of use in investment decisions-making.

4. CONCLUSION

Apart from the above specified risk quantification methods, there are also other analytical methods in investment decision making, used for the specific recalculations of investment economic efficiency, such as sensitivity analysis, simulation analysis or decision trees.

Well-performed risk quantification in the investment project economic efficiency assessment increases the probability of success of the individual investment projects, leads to an advance calculated and for the company acceptable (not too high, not too low) risk undertaking and with the appropriate securing against possible failure; it thus decreases the threat of such failure, that would result in a negative impact on the company financial stability.

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REFERENCES

1. Fotr, J. – Souček, I.: *Podnikatelský záměr a investiční rozhodování*. 1. vyd. Praha: Grada Publishing, a.s., 2005. ISBN 80-247-0939-2.
2. Hurná, S. – Szombathyová, E.: *Benchmarking – cesta k dokonalosti v produktivite a kvalite*. Zborník prednášok z medzinárodnej konferencie ICAMS 98 a ASRTP 98, Vysoké Tatry, 8. – 11. 9. 1998, str. 612 – 615.
3. Kováč, J. –Szombathyová, E.*: Zvyšovanie produktivity montážnych systémov*. INTERCATHEDRA č. 22, Poľsko, Poznań 2006, str. 56 – 60. ISSN 1640-3622.
4. Janeková, J. - Fabianová, J.: *Integrácia rizika do hodnotenia efektívnosti investičných projektov*. In: Trendy v systémoch riadenia podnikov: 9. medzinárodná vedecká konferencia, Herľany, 26.-27. október 2006: Zborník príspevkov. Košice : TU, 2006. ISBN 80-8073-660-X.
5. Valach, J.: *Investiční rozhodování a dlouhodobé financování*. 2. prepracované vyd. Praha: Ekopress, s.r.o., 2006. ISBN 80-86929-01-9.
6. Cvetkovi S., Barac N., *"Optimal solution for organizing the logistics process of just-in-time concepcion"* Facta Universitatis, UNIVERSITY OF NIŠ 2004. ISSN 0354-2025 (153-159)
7. Predić B., *„MBO system of managing the productionin small and medium-size enterprises"* FACTA UNIVERSITATIS Series: Mechanical Engineering Vol.1, No 9, 2002, pp. 1187 - 1192

PRISTUP MERENJU RIZIKA U PROCENJIVANJU EKONOMSKE EFIKASNOSTI INVESTICIJA

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Da bi se povecao kvalitet donosenja odluka o investiranju u jednoj kompaniji, važno da se prilikom procenjivanja ekonomske efikasnosti investicija posveti velika paznja proceni rizika. U ovom slučaju, rizik je prvenstveno povezan sa protokom novca od investiranja koje se procenjuje. Njegov prikaz u poslednjoj proceni datog kriterijuma-prisutna vrednost na mreži-može da se dobije različitim pristupom. Kada se primenjuje direktna procena rizika, osnova je odredjivanje mogućnosti protoka novca od investiranja primenom statističkih karakteristika: metode standardne devijacije, difuzije i koeficijenta varijacije. U ekonomskoj praksi proces razmatranja rizika se često odvija indirektno. Jednostavnije je i najčešće se dešava uskladjivanjem stope popusta, odredjivanja klasa rizika, metode koeficijenta sigurnosti ili realnih opcija. Pomenuti pristupi proceni rizika imaju svoje karakteristike, koje su opisane u članku.

Ključne reči: *investiranje, rizik, dijagram toka, dikontne rate, koeficijent, realna opcija*