

## SENSITIVITY ANALYSIS IN CAPITAL BUDGETING

Investments are one of the main factors of economic growth. In market economy, a crucial condition for sustained viability and development of enterprises is the efficiency of capital invested in projects. The decision to finance certain project is determined by the goals which the company has set to itself.

Development of the enterprise may be carried out in different directions. Some enterprises plan to develop and organize manufacturing of new products, while others purchase new equipment and thus want to reduce production costs; others are planning creation of a new sales structure. Despite the difference in development strategies, all of them have one common feature — almost every company represents an investment project or a set of them. It is necessary to create project, to analyze its strengths and weaknesses, to represent it to potential investors, to ensure its funding and effectively manage the process of its implementation. It means that there is no need to avoid risks. The main purpose is the ability to assess risk of the investment project and take measures to reduce its negative consequences.

*Project risks* — a set of risks which threaten the investment project or may reduce its efficiency (commercial, economic, fiscal, social, etc.) [1, p. 86].

Nowadays under conditions of global financial crisis the amount of investment project has reduced. Thus, investors are not absolutely sure that the project will bring benefits and profits in future.

Under such conditions occurs the necessity in such methods of risk estimation which will help to take into account risk at the stage of making and realisation of decisions. One of these methods is sensitivity analysis (SA). “SA shows to what extent the viability of a project is influenced by variations in major quantifiable variables” [2, p. 173].

Analytical sense of the method of risk assessment is as follows: the greater the range of fluctuations in the initial parameters (under which it is rated) of the project is, the less risky this project can be [3, p. 64 — 65].

To find out whether SA is effective for investment project or not, it is necessary to examine it in more details, to identify its purposes, advantages and disadvantages.

According to Pedro Belli et al, *sensitivity analysis* assesses risks by identifying the variables that most

influence a project’s net benefits and quantifying the extent of their influence. It consists of testing the effects of variations in selected cost and benefit variables on the project’s IRR or NPV [4, p. 85]. In general the algorithm of investment project risks analysis is presented in Figure 1.

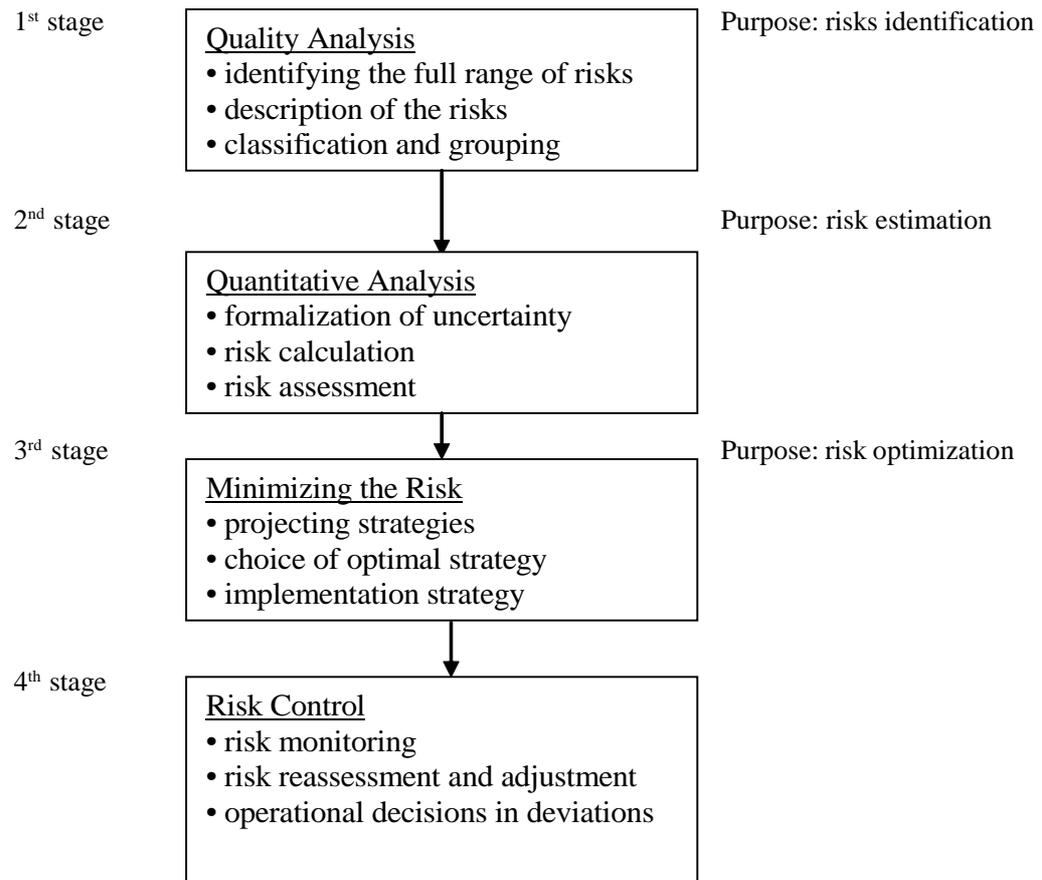
So, SA is one of the tools of quantity risk analysis and its purpose is to identify numerical values of the risk events and their consequences, make quantitative evaluation of risk, and establish a valid risk level in a particular situation [5, p. 34]. Quantitative assessment of the likelihood of some risks and their consequences allows us to find out the most probable according to their occurrence and magnitude value losses risks, which could be objects of the further analysis for making decision about the project feasibility [6, p. 490].

As Colin Drury points out, “SA enables managers to assess how sensitive and responsive is NPV to changes in the variables which are used to calculate it” [7, p. 405]. NPV depends on a number of independent variables:

- sales volume;
- selling price;
- variable costs;
- initial outlay;
- investment costs and their components;
- interest on loans, the discount rate, etc. [8, p. 92].

Drury states, the approach requires that the NPVs are to be calculated under alternative assumptions to determine how sensitive they are to changing conditions [7, p. 405]. It means SA shows to what extent the viability of a project is influenced by variations in major quantifiable variables.

Due to the application of SA it is possible to indicate those variables to which NPV is most sensitive, and the extent to which these variables may change before the investment results in a negative NPV [7, p.406]. In other words, SA helps to find out why a project might fail. According to this, it is necessary to review any critical variables to assess whether there is a strong possibility of events occurrence leading to a negative NPV or not (Fig. 1). Besides, it is also important to pay attention to the controll of those variables that NPV is particularly sensitive to, once the decision has been taken to accept the investment [7, p. 405].



**Fig. 1. Algorithm of investment project risks analysis**

Three specific areas are normally considered when conducting SA:

*Aggregate costs and benefits.* Simple SA of variations effects in total project costs and total project benefits is often aimed to indicate the joint influence of underlying variables. However, in some special cases only this type of analysis does not assist judgments on the range of likely variation, or on the specific measures that might reduce project risks.

*Critical cost and benefit items.* SA is usually most effective if costs and benefits are subdivided into disaggregated in some detail. SA is best done in respect of individual parameters that are most critical to the project. Concerning the benefit side, detailed SA typically includes such parameters as output prices or tariff levels, unit cost savings, and expected rate of growth in demand for project outputs. Talking about the cost side, such analysis typically involves productivity coefficients and prices of major inputs. SA examines shadow prices used in the economic analysis.

*The effects of delays.* Such types of delay as delays in starting the project during the construction phase, and delays in reaching full capacity utilization (as in industrial projects) or in reaching full development (as in agricultural

projects) may occur in projects. Thus, it is important to include the relevant delay factors in sensitivity tests [4, p. 85].

Taking into account the data above, it is necessary to mention that SA helps to identify project risks and make quantitative evaluation of them. But it is obvious that any method and analysis of investment project has its own strength and weaknesses. SA advantages and disadvantages are considered in the next section.

There are some advantages of using SA in investment project. Firstly, “*it shows how significant any given input variable is in determining a project’s economic worth*” [9, p. 8 — 62]. It means that the analysis displays the range of possible outcomes for the range of input values, which shows decision makers the input values that would have an impact on the project and make it either “*a loser or a winner*” [9, p. 8 — 62].

Secondly, SA is an excellent technique to answer “what if” question (e.g. What if the value of X factor will change to N points?). “*Generating answers to «what if» question will help assess how well a proposal will stand up to scrutiny*” [9, p. 8 — 62].

Thirdly, SA is universal for the project. Thus, it can be used for any measure of the project worth.

Calculation technique of the investment project critical points [8, p.93].

Critical Point	Formula for calculating
Break-even annual sales	$Q_{BE} = \frac{IC - DFM4(r, n)}{(P - VC)(1 - tax)FM4(r, n)} + \frac{FC}{P - VC}$
Break-even unit price	$P_{BE} = \frac{IC - FM4(r, n)[D - (1 - tax)FC]}{Q * FM4(r, n)(1 - tax)} + VC$
Break-even variable costs per unit of production	$VC_{BE} = p_i - \frac{IC - FM4(r, n)[D - (1 - tax) * FC]}{Q * FM4(r, n)(1 - tax)}$
Breakeven annual fixed costs	$FC_{BE} = \frac{Q * (p_i - VC)(1 - tax) + D}{(1 - tax)} - \frac{IC}{(1 - tax)FM4}$
Maximum permissible value of the initial investment costs	$IC_{BE} = ([Q(p_i - VC) - FC](1 - tax) + D)FM4$
Maximum income tax rate	$tax_{max} = 1 - \frac{IC - D * FM4(r, n)}{([Q(p_i - VC) - FC]FM4(r, n))}$
Payback period of investment project	$PP = \frac{IC}{[Q(p_i - VC) - FC](1 - tax) + D}$

And the last but not the least, this type of analysis can be used when there is not enough time, recourses and information that is necessary for more detailed and sophisticated techniques [9, p. 8 — 63].

Moving on, SA is quite simple for practical application, but it has significant disadvantages. The main drawback is that SA does not take into account the probabilities of events occurrence [4, p. 87]. In other words it does not contain “any explicit probabilistic measure of risk exposure” [9, p. 8 — 63]. In this case information has limited usage because it is unknown whether this or that event is highly probable or highly unlikely. In the last case, it can be argued that information is useless for practical purposes.

The next disadvantage is that SA “does not take into account the correlation among the variables” [4, p. 88]. So, during this analysis the influence of each separate variable on the resulting value is considered. However, in practice, all variables affect the results of the project and at the same time impair or improve NPV resulting value (Tab. 1).

Finally, the practice of varying the values sensitive variables by some arbitrary percentage may cover most of the distribution for some variables, and only a fraction for others [4, p. 87].

Method of SA combines both significant

shortcomings and such advantages as theoretical transparency, simple calculations, the economic-mathematical naturalness and visibility of their interpretation and is quite simple in its methodology.

As it has been mentioned SA of investment project is used to assess the impact of any parameter of the project on its results under the condition that other parameters remain unchanged.

The techniques of SA conduction are as follows:

- Calculation of initial data;
- Calculation of critical points of investment project (the most secure setting in which the break-even level of production is achieved);
- Calculation of the sensitive margin of the factors (it shows the percentage may reduce the index under review to save the project from the losses zone);
- Ranking project indexes in terms of their impact on NPV [10].

SA helps to evaluate the effect of various parameters on the baseline index of the project (NPV). The next model of NVP dependence on external and internal indicators is used:

$$NVP = (Q p_i - VCQ - FC - tax + D) * FM4(r, n) - IC, \quad (1)$$

where  $Q$  — annual sales;  $D$  — value of annual depreciation;  $tax$  — annual value of profit tax;  $IC$  — initial investment outlay.

Having found out these indicators, we pass to the calculation of the investment project critical points and their sensitive margin (SM) (Tab. 1).

The next step is calculation of IRR:

$$NPV_{(IRR)} = \sum_{i=1}^n \frac{CF_i}{(1+r)^i} - IC = 0 \quad (2)$$

After it sensitive margin of project indexes is calculated [8, p.93]:

$SM_Q = \frac{Q - Q_{BE}}{Q} * 100\% ;$
$SM_{P_i} = \frac{P_i - P_{BE}}{P_i} * 100\% ;$
$SM_{VC} = \frac{VC_{BE} - VC}{VC} * 100\% ;$
$SM_{FC} = \frac{FC_{BE} - FC}{FC} * 100\% ;$
$SM_{IC} = \frac{IC_{BE} - IC}{IC} * 100\% ;$
$SM_{tax} = \frac{tax_{max} - tax}{tax} * 100\% ;$
$SM_n = \frac{n - PP}{n} * 100\% ;$
$SM_r = \frac{IRR - r}{r} * 100\% .$

The lower value of SM is, the more vulnerable to the negative impact of external and internal factors the investment project is. It means the project which is represented by financial indexes with low values of sensitive margin has the higher degree of risk [8, p. 95].

Finally, indexes of the project are ranked by the dependency on external and internal factors. Indexes which have the highest degree of influence on results of investment project take the highest position in this rank [6, p. 500].

SA considers the change of each variable of the project revealing the value of their critical values. In SA a separate effect of each of them on the resulting value is examined. It is advisable to use this method in conjunction with other methods of quantitative risk analysis of investment project at the stage of ranking factors by dependency of their influence on the result.

Due to SA such data could be determined, which have high level of impact on the project and could lead to negative results. Besides, this method allows to identify the strongest indexes which may compensate some risks.

Nevertheless, the impact of each project index on the result is examined separately. It means, in practice all variables affect the results of the project at the same time having positive or negative impact on the NPV.

In conclusion, according to Pike and Ho, "SA is the most frequently used formal risk measurement technique" [11]. It is popular because of its simple methodology, which boils down to the next steps:

- Calculation of initial data;
- Calculation of critical points of investment project;
- Calculation of the sensitive margin of the factors;
- Ranking project indexes in terms of their impact on NPV.

Even without undertaking relatively complex procedures which explicitly involve probabilities in sampling scenarios or interpretation of results, SA is a powerful and illuminating methodology. The simple approach to SA is easy to take, easy to understand, easy to communicate, and it is applicable to any model.

It is obvious that the biggest disadvantage is that this method is *univariate* [11]. It means that SA is oriented on changing only in one factor of the investment project. While, in real life, changes in one factor lead to changes in others.

Answering the main question, it is important to state that SA is very effective for the investigation of the project risks. But, SA can be used in conjunction with other methods of quantitative analysis to get the more reliable information about the risk of investment project.

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#### **Zhamoida O. A., Matsiuk M. S. Sensitivity Analysis in Capital Budgeting**

Nowadays because of unstable economical situation appears the necessity in such methods of risk estimation which will help to take into account risk at the stage of making and realisation of decisions. One of these methods is sensitivity analysis. Term “sensitivity analysis” is defined, the basic idea and purposes of sensitivity analysis are presented, advantages and disadvantages of this method are specified in the article.

*Key words:* sensitivity analysis (SA), investment project, risk, project risk, measure, methodology, net present value (NPV), internal rate of return (IRR).

#### **Жамойда О. А., Мацюк М. С. Використання аналізу чуттєвості під час розрахунку рентабельності капіталовкладень**

Сьогодні за умов нестабільної економічної ситуації в країні з’являється потреба в таких методах вимірювання ризиків, які дозволять урахувати будь-які відхилення на стадіях прийняття та реалізації інвестиційних рішень. Одним з таких методів є аналіз чуттєвості. У статті визначено поняття „аналіз чуттєвості”, розкрито його зміст та основні цілі, акцентовано увагу на недоліках та перевагах цього методу.

*Ключові слова:* аналіз чуттєвості, інвестиційний проект, ризик, інвестиційний ризик, методологія, чиста поточна вартість, внутрішня норма прибутку.

#### **Жамойда А. А., Мацюк М. С. Использование анализа чувствительности при расчете рентабельности капиталовложений**

Сегодня в условиях нестабильной экономической ситуации в стране возникает потребность в таких методах измерения рисков, которые позволят учесть любые отклонения на стадиях принятия и реализации инвестиционных решений. Одним из таких методов является анализ чувствительности. В статье определяется понятие «анализ чувствительности», рассматриваются его содержание и основные цели, акцентируется внимание на недостатках и преимуществах данного метода.

*Ключевые слова:* анализ чувствительности, инвестиционный проект, риск, инвестиционный риск, методология, чистая текущая стоимость, внутренняя норма доходности.

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