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SENSITIVITY ANALYSIS OF INDICATORS OF INVESTMENT PROJECTS EFFICIENCY IN ECONOMIC SPACE OF A REGION

The effectiveness of the implementation of investment projects in economic space of a region depends on many factors, particularly social and economic, political, ecological conditions in regions that together constitute meso-economic risks, and affect significantly the microeconomic risks. The sensitivity analysis of effectiveness indicators refers to analytical methods of risk assessment which are based on evaluation of factors' influencing investment project efficiency indicators, and also enable determination of critical variables (factors) exerting project realization and its effectiveness as per which the developer of the project has no unambiguous opinion.

Justification of choice of sensitivity method for analysis of investment project efficiency in economic space of a region is carried out highlighting the basic elements of algorithm analysis. The theoretical and methodological backgrounds of comparative analysis of various factors influencing investment project on the basis of project effectiveness indicator is investigated.

Thus, at the investment and operational phases during sensitivity analysis of efficiency indicators the significance of the certain variables used for assessing of investment project efficiency may lead to inaccuracy of certain indicators on investments efficiency.

Changing of the particular factors can occur for various reasons, for example, changes in cash flows may be caused by changed prices for goods and services, general economic changes, regional trends etc. Therefore, this method is intended for determination of sensitivity of efficiency of the investment project to the changes in various factors, which originates from existing methods of evaluation. It should be stressed that the objective of sensitivity analysis is not the calculation of a risk, but study of the changes effect on the indicators of investment project efficiency in economic space of a region.

The author proposed definition of the sensitivity coefficient of the investment project during identification of the critical variables for each explanatory factor. The notion of explicable variable is defined by application of evaluation method of project efficiency, the explanatory variables indicate these variables included in the algorithm of evaluation method for investment project efficiency, presume the following: dependent – variable which exists in the algorithm of the evaluation method of the investment project efficiency, which transformation directly depends on the level of independent variables change; independent – which change occurs due to direct changes in other variables.

Thus, the sensitivity analysis allows identification of the most significant indicators of the investment project sustainability. Despite certain advantages, the method has a big disadvantage, which is the lack of risk measurement. This method is a source of information for other more sophisticated methods of risk assessment and the indicators of investment projects efficiency. It should be admitted that the main disadvantages of sensitivity analysis of indicators of investment projects efficiency are the following: assumption of a constant level of remaining independent explanatory variables in the analysis of changes in certain independent explanatory variable; incompetence. Consequently, this method identifies risks, but does not measure them.

In this case, the sensitivity analysis of indicators of investment projects efficiency is characterized by: simplicity and ease of implementation; risk detection, which indicates the areas for deeper analysis, such as identification of variables; attention to the efficiency of the project;

the possibility to apply its results in other methods of risk analysis; it provides a possibility to present all the curves of sensitivity in one schedule, which would simplify a direct comparison of risks, based on the different independent explanatory variables; the possibility of calculating the factor of safety. It is worth to note that at the meso level a region as an isolated unit of executive system forms the system infrastructure of the investment activities, which is an element of risk management, and affects on the investment risks of a region as a whole, and in the direction of a possible increase or decrease.

The substantiation of choice of analyzing method of sensitivity of investment project efficiency in the economic space of a region is conducted, highlighting the basic elements of algorithm analysis. The theoretical and methodological backgrounds of comparative analysis of various factors influencing investment project on the basis of project effectiveness indicator are investigated. The author proposed a notion of the sensitivity coefficient of the investment project by identification of critical variables for each explanatory variable.

Key words: sensitivity analysis, investment projects, risks, effectiveness, region.

Formulation of the problem. The effectiveness of the implementation of investment projects in the economic space of a region depends on many factors, particularly social and economic, political, ecological conditions of a regions that together constitute the meso-economic risks, makes a significant impact at the microeconomic risks. Analyzing exactly the regional risks and indicators of efficiency of investment projects for potential investors is an extremely important issue because there is a choice between competing regions, enterprises, projects, it means that there is the consideration of the influence of certain microeconomic risks. The actuality of timely and comprehensive identification and objective assessment of all possible risks influence on investment processes of a region determines the necessity for research into the causes and factors of the level of efficiency of investment projects. Therefore problematic aspects of the choice of the optimal method for the assessment of risks and ways to minimize them, the formation evaluation system of indicators of efficiency of investment projects in the economic space of a region are very acute and require urgent solutions, because the level of investment risks is one of the largest obstacle for the investment of resources into a regional economy.

Analysis of recent research and publications. Theoretical and methodological principles of identification and analysis of the investment's risk aimed to minimize it were researched by a domestic and foreign scientists and, in particular: Vitlinsky V.V., Velykoivanenko H.I., Hamyduhlyn F.F., Balyant H.R., Butko M.P., Akimenko O.U., Murashko N.I., Hlibchuk V.M., Chorna M.V., Glukhova S.V., Sadykov M.A., Kolomic N.O., Dmytrenko E.V., Jaresko R.S., Pylypyak O.V., Shvets L.P., Zaharkevych N.P. etc. In the scientific literature analyses of the investment risks is a part of a comprehensive analysis of the investment projects and is an important component for passing decisions on choosing of the most appropriate for a number of alternative investment projects and solutions to avoid or minimize the risks of a specific project.

After a review of current scientific developments regarding theoretical and methodological principles of identification and evaluation of investment's risk it should be note the following:

1. Overview investment risks are interpreted as probability of unforeseen losses or failure to achieve certain benefits (financial, ecological, industrial, economic, social impact, etc.) under uncertainty of the investment activity. At the same time, and investment risk is:

– the potential failure to achieve the planned objectives of investment (in the form of income or social impact etc.) and the resulting as unforeseen loss of money and the cash losses or profits, but lower than it was planned before¹;

– a category which is generated by the investor's activities during the moment of passing of a decision concerning the implementation of a certain investment project through the specific objective reasons, such as uncertainty, conflict, lack of full information and the possibility of alternative choices, and may result in losses or receiving profits in the process of investment activity².

¹ Бутко, М.П., Акименко, О.Ю., Мурашко, М.І. (2009). *Інвестиційний менеджмент: теорія і практика*. Ніжин: ТОВ «Видавництво АспектПоліграф».

² Глібчук, В.М. (2011). *Оцінювання та регулювання інвестиційних ризиків машинобудівних підприємств*. Автореф. Дис. ... кандидата економічних наук: спеціальність 08.00.04. Львів.

2. Theoretical principles of risk management in terms of the risk genesis determine the components of the genesis of a risk of an investment project of an enterprise, namely:

1) clarify the prerequisites of risks arising by establishing preconditions in real time and space, which can lead to risk events;

2) the determining of risk forming factors that characterize the risk situation and may become its potential causes;

3) a description of possible risk situations, the onset of which may lead to negative event;

4) identifying negative event (consequence) of the certain type of risk and / or aggregate risks in relation to the object of study¹.

3. Group distribution of the methods of evaluation of investment risk based on the identification of the following¹⁻³:

– unformalized (qualitative) methods of assessment – analysis of investment sensitivity (the method of variation of parameters), scenario analysis of the project (the method of formalized description of uncertainty), simulation method (Monte-Carlo method) and method of correction for the risk discount factor. Qualitative risk analysis precedes their quantitative assessment, and involves the identification of all possible significant risks, the factors and conditions of risk arising are determined, their potential effects etc.;

– formal (quantitative) evaluation methods – statistical method, method of expert evaluations, the method of "decision tree", method of the appropriateness of the costs, method of analogs using, method of checking the resistance (calculation of critical points) and cash flow method. Quantitative analysis allows us to determine the causes, probability and sources of risk, simultaneously to assess the extent of their probable consequences;

– qualitative and quantitative (kVA dimer) – the method of expert evaluations and the formation of a risk profile or risk map.

4. Risk analysis is carried out mainly on pre-investment phase, while they are found in the investment phase and project closure phase. Such temporal remoteness of risks occurrence from the time of the analysis leads to the following consequences: certain risks may not be taken into account at the stage of identification; some identified risks can be assessed accurately due to changes in the external environment of the project; making amendments into the project; the evaluation of individual risks may change due to the obtaining of more information about it². This is a reason why there is a necessity for a systematic and comprehensive analysis of risks and the effectiveness of investment projects in the implementation of the tools of controlling and monitoring for the investment risks, both at the level of the investor and the regional authorities, since the latter one is the most interested in reducing regional risks at all stages of the life cycle of the investment project and, accordingly, improving the investment attractiveness of a region.

Based on the analysis of recent researches and publications of conceptual provisions concerning the identification and evaluation of the investment risks of the projects, it is worth to note that calculation and a clear understanding of project effectiveness indicators to the specific conditions of the economic space of a region is necessary for a potential investor in the planning phase when he decide the basic parameters of a project with the lowest cost-financial, time and other resources that are necessary. Therefore it is necessary to study the peculiarities of analyses of sensitivity of indicators of efficiency of the investment project, i.e. the determination of the level of impact on the financial indicators of individual regional factors, that may be changed.

Determination of the objective. This article is aimed to justify of method choice of sensitivity analysis (sensitivity analysis) of effectiveness of the investment project efficiency in the economic space of a region, that is, theoretical and methodological research of a comparative analysis of the influence of various factors on the investment project on the fundamental indicator of project effectiveness.

The basic material of research. The sensitivity analysis of indicators of the effectiveness relates to analytical methods of risk assessment that is based on the evaluation of the influence of the factors of the investment project on the change of the effective indicators, and also allows you to determine critical variables (factors) that significantly affect on the opportunity for project realization and its

¹ Яресько, Р.С. (2016). *Ризик-менеджмент інвестиційних проектів енергетичних підприємств*. Автореферат Дис. ... кандидата економічних наук: спеціальність 08.00.04. Київ.

³ Вітлінський, В.В., Великоіваненко, Г.І. (2004). *Ризикологія в економіці та підприємстві*. Київ: КНЕУ.

² Баянт, Г.Р. (2006). *Кредитування інвестиційних проектів в умовах становлення та розвитку ринкових відносин*. Автореферат Дис. ... кандидата економічних наук: спеціальність 08.04.01. Тернопіль.

effectiveness with respect to which the developer of the project has no unequivocal thought. A relative influence of the researched factors on the outcome indicators of a project are determined due to a relative sensitivity analysis and critical factors of the project are identified and set of measures to prevent their negative impact is developed. The absolute sensitivity analysis involves provides a definition of the numerical values of the deviations of the effective indicators, due to changes in the initial parameters of the variables.

Sensitivity analysis of the effective indicators is one of the most prominent, easy to use and allows you to determine these parameters that are the most risky for this investment project. Its essence is the assessment of the impact of the basic initial parameters of real investment project on the efficiency endpoints, such as internal rate of return¹.

In modern scientific literature in general sensitivity analysis has the following stages²:

1. Definition of the fundamental indicator of effectiveness (internal rate of return or net present value).
2. Choice of the factors of uncertainty of the investment project.
3. Setting the nominal and limit values of the factors defined in the previous stage.
4. Calculation of fundamental indicator for all selected limit values of uncertain factors.
5. Construction of a schedule of the sensitivity to all uncertain factors ("Spider Graph").

Thus, among several investment projects it is necessary to choose that one, which has the smallest coefficient of elasticity, and therefore the interval between the potential fluctuations in the future is less and the risk is less as well. Sensitivity analysis is one of the most common methods of evaluating of the investment projects, but it has disadvantages which include: the inability to refine the probability of alternatives implementation; it does not take into consideration all possible circumstances; the sensitivity between different factors can not always be compared directly; the factors are not mutually independent and can change at the same time³.

The method of sensitivity analyzes allows to investigate the consequence made by a change of a certain parameters on the resulting figure, which can be an indicator of the overall project (NPV, IRR, PI, payback period) as well as annual indicator of a result of project activity (net profit, gross income). The basic condition for improving the sensitivity analysis, which is based on the indicator of NPV is taking into consideration a discount rate, which does not involve the risk premium and statement that during this certain period only one independent variable can changes. As a rule, the limits of variation of the parameters are not more than 10-15% and should match the level of possible fluctuations in the real market situation. The coefficient (parameter) of elasticity is an important indicator characterizing the degree of sensitivity of a resulting indicator compared with the variable parameter. It shows the ratio of interest rate of changes of a resulting indicator to the interest parameter, which varies. The higher the certain indicator, the greater impact on the resulting indicator has a parameter that varies.

However, according to O.V. Pylypyak and other, there are no standards for acceptable degree of variation in the results, and therefore a very subjective factor for the results interpreting is includes. The authors propose to distribute into the groups the types of the determined form of sensitivity analysis of project risks as follows: single-factor and multifactor analysis. In case of single-factor analysis only one variable can vary, then under the multifactor analysis there can be a very significant amount of such variables, which complicates the procedure of analysis and practically makes impossible the clear presentation of the results⁴.

Thus, at the investment and operational phases during the sensitivity analysis of efficiency indicators of the significance of the separate variables that are used for assess of the effectiveness of the investment project the deviations from the accepted values, which leads to inaccuracy of the certain indicators of investments efficiency can take place.

¹ Вітлінський, В.В., Великоіваненко, Г.І. (2004). *Ризикологія в економіці та підприємстві*. Київ: КНЕУ.

² Вітлінський, В.В., Великоіваненко, Г.І. (2004). *Ризикологія в економіці та підприємстві*. Київ: КНЕУ; Хамидуллин, Ф.Ф. (2012). Оценка рисков инвестиционных проектов в системе ЖКХ: количественный аспект. *Проблемы современной экономики, вып. 1 (41)*, 318-321; Вітлінський, В.В., Великоіваненко, Г.І. (2004). *Ризикологія в економіці та підприємстві*. Київ: КНЕУ.

³ Хамидуллин, Ф.Ф. (2012). Оценка рисков инвестиционных проектов в системе ЖКХ: количественный аспект. *Проблемы современной экономики, вып. 1 (41)*, 318-321.

⁴ Пилип'як, О.В. (2015). Практичні аспекти застосування методу чутливості для оцінки рівня проектного ризику. *Університетські наукові записки, вип. 1*, 365-378.

Changing of the particular factors can occur for various reasons, for example, changes in cash flows may be caused by changes in the prices for goods and services, general economic changes, regional trends etc. Therefore, this method is intended for determination of sensitivity of efficiency of the investment project to the changes in various variables, which is expressed using the measures that are derived from established methods of evaluation. It should be noted that the objective of the sensitivity analysis isn't the calculation of the risk, but a research of the effect of the changes in adopted in the analysis factors on the indicators of investment project efficiency in the economic space of a region.

Thus sensitivity analysis of indicators of efficiency of investment projects in the economic space of a region should be based on the next conceptual aspects (Fig. 1).

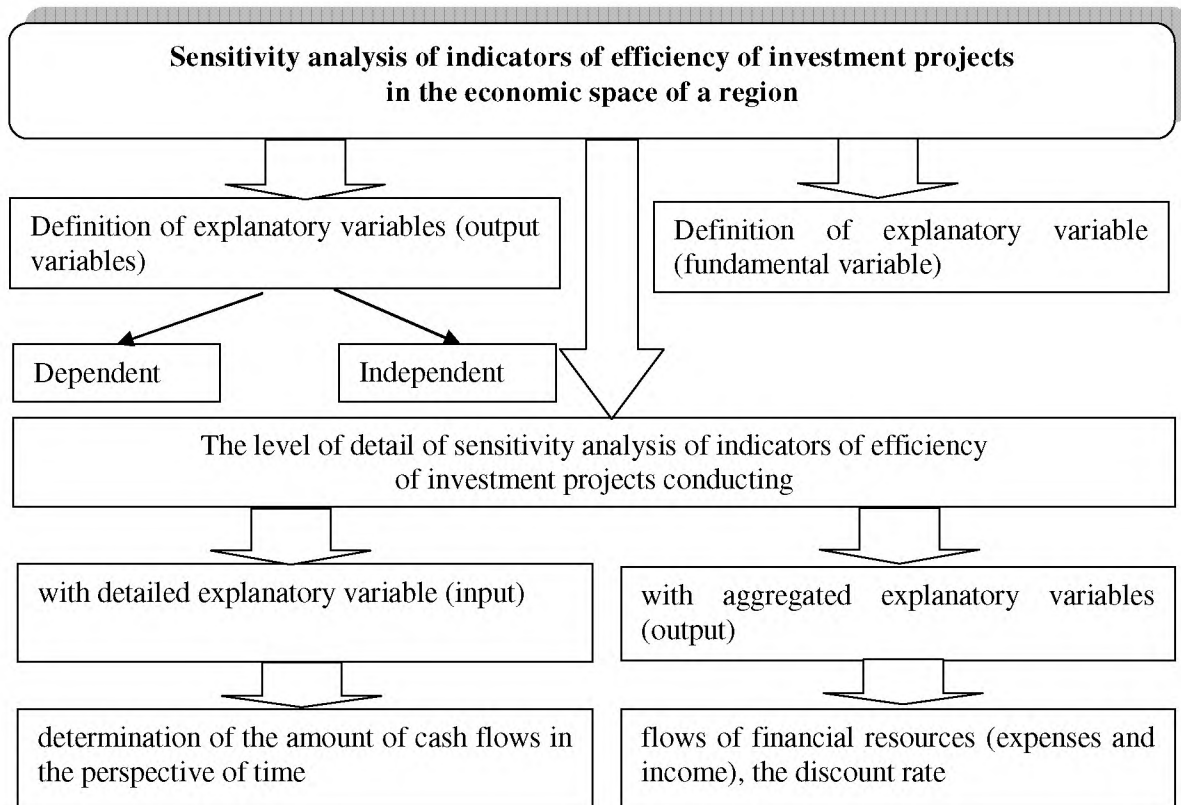


Fig. 1. The basic elements of the algorithm of sensitivity analysis of indicators of efficiency of investment projects in the economic space of a region

Definition of explicable variable caused by using of the method of evaluating the effectiveness of the project, and the explanatory variables indicate these variables that are in the algorithm of this method for evaluating the effectiveness of the investment project, including: dependent – variable, located in the algorithm of the method for evaluating the effectiveness of the investment project, which change is directly depends on the level of independent variables change; independent – which change occurs due to direct changes in other variables.

The sensitivity analysis in the simplest version allows to investigate the effect of interest deviations of the specific explanatory variables on the explicable variable. Generally, it is well-known that currently only one explanatory variable is changing, and others are still on the same basic level. If sensitivity analysis is carried out on individual explanatory variables, than changing of one independent variable may change multiple dependent variables. Sometimes sensitivity analysis provides simultaneous change of two or more independent explanatory variables. The research of the impact of changes in two independent variables (eg, discount rate and investment costs) on the explicable variable (such as index NVP), provided under conditions that all other variables remain constant, gives reasons to obtain two-dimensional matrix, which is a combination of potential for making choices investigated explanatory variables. This allows us to identify the steps and actions related to the desired change of one of these variables, while other is changing, in order to keep the effectiveness of investments project.

Since the aim of the sensitivity analysis is to identify the important factors, so-called critical variables, that can the most seriously impact on the project and to verify the impact of successive (single) changes of these factors on the results of a project. In theory of an experiment the sensitivity analysis is called as single analysis. The factors that are varying during the process of sensitivity analyzing are classified as follows: factors influencing on the volume of revenues of the project; factors affecting on the amount of project costs. Thus, using this approach the factors that have the greatest impact on the final result of investment are determines. This is achieved by changing the value of one of the fundamental variables and calculation of NPV of a project. In particular, as the scholars Chorna M.V. and others offer to calculate the value of the coefficient of the risk level thus¹.

$$CRL = 1 - \frac{NPV_1}{NPV_0} \quad (1)$$

where CRL is a coefficient of risk in fractions of a unit; NPV_1 is a value of NPV changes in conditions specified factor by 1%; NPV_0 is a basic values of NPV.

Analyzing the percentage change of particular explanatory variables, it is advisable to separate the relevant variables, potential deviations, which will have the greatest impact on the level of effectiveness of investment project in the economic environment of a region. Identification of these explanatory variables indicates the areas that require additional and thorough analysis, that respectively need to identify the critical factors that have the greatest impact on the efficiency of investment project in the economic environment of a region. Critical variables can be determined by the research of elasticity of the efficiency of investments, which gives the ground to suggest about a change of a level of explanatory variable (eg, index NVP), if the value of apparent independent explanatory variable will changes on 1%, and the remaining independent explanatory variables would remain the same level.

Aimed to identify the critical variables for each explanatory variable a sensitivity coefficient, i.e. the slope of the curve of sensitivity with different values of the independent variable should be set. Example for calculation the value of the sensitivity coefficient is as follows:

$$WW_{NPV} = \frac{\frac{NPV_i - NPV_b}{NPV_b}}{\frac{ZN_i - ZN_b}{ZN_b}} \quad (2)$$

where NPV^i is the NPV value for the i-value of the variable Z; NPV^b – base value for NPV; ZN^i is i-value of the independent variable ($ZN^i = ZN^b \pm 0,01ZN^b$); ZN^b is base the value of the variable Z.

Sensitivity coefficient provides the information about a level of percent of the changes explanatory variable (e.g., NPV) accounts for 1% change of independent explanatory variable ZN. The value of the sensitivity coefficient is a constant value in the case, when the dependence of explanatory variable (NPV) from the independent explanatory variable is linear for each value of the independent explanatory variable. Independent explanatory variables that are linearly change net cash flows predominantly linearly affect on the change in the NPV. In that order, the independent explanatory variables lead to changes in the discount rate (the cost of private or foreign capital), or influence on multiple dependent variables, and, as a rule, are the result of other than linear, changes in the explanatory variable (nonlinear dependence).

If the sensitivity coefficient value for the researched independent variable is zero, then this change has no impact on the analyzed investment project in the economic space of a region. A high absolute value of sensitivity coefficient informs about the large impact of the independent explanatory variable. Those explanatory variables, whose change by 1% leads to a change in NPV by 1% or more, are critical.

The sensitivity analysis allows to assess the value of this independent variable for which the investment project is profitable, in accordance with the criterion, that relies on a particular method of performance evaluation, e.g.: $NPV = 0$. Such values of independent variables are treated as limit values

¹ Чорна, М.В., Глухова, С.В. (2010). *Формування ефективної інвестиційної політики підприємства*. Харків: ФО-П Шейніна О.В.

(threshold). Comparison of the ultimate independent variables with basic values can be applied in the determination of safety factors for each independent variable. The safety coefficient allows you to determine how this variable can be changed without losing profitability of the investment project.

The sensitivity analysis can be used in the decision-making process within the absolute estimation of efficiency of investments in the economic space of a region. Thus, this method doesn't determine directly the level of risk, however, it allows to complete the methods of evaluation of investment projects using determining the limit values and factor of safety. Sensitivity analysis can also be used as a criterion for comparison of risk relative in evaluating investment projects in the economic space of a region.

Conclusions. Thus, the sensitivity analysis allows to determine the most significant indicators from the point of view of sustainability of the investment project, despite certain advantages, given the great disadvantage, which is the lack of risk measurement, this method is a source of information for other more sophisticated methods of risk assessment and the indicators of efficiency of investment projects. It should be noted that the main disadvantages of sensitivity analysis of indicators of efficiency of investment projects are: the assumption of a constant level of remaining independent explanatory variables in the analysis of changes in certain independent explanatory variable; incompetence, that's why this method identifies risks, but does not measure them.

In this case, the sensitivity analysis of indicators of efficiency of investment projects is characterized by: simplicity and ease of implementation; function of risk detection, that indicates the areas that should be the subject of deeper analysis such as identification of variables that are most likely, paying attention to the efficiency of the project; the possibility of using its results in other methods of risk analysis; the opportunity to present all the curves of sensitivity on one schedule, that can simplify a direct comparison of risks, based on the different independent explanatory variables; the possibility of calculating the factor of safety. It is worth to note that at the meso level a region as an isolated unit of executive system forms the system infrastructure of the investment activities, which is an element of risk management, and affects on the investment risks of a region as a whole, and in the direction of a possible increase or decrease.

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