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PROBABILISTIC AND STATISTICAL METHODS OF RISK ASSESSMENT OF INVESTMENT PROJECTS OF A REGION

Abstract
Objective: the article deals with the research of the peculiarities of the probabilistic and statistical methods of evaluation of investment project risks in the economic space of a region.
Methods: comparison, generalization, systemic analysis, theoretical cognition.
Results: the main advantage of probabilistic and statistical methods is that fact, that the measurement of risk is carried out using objective measures — standard deviation and coefficient of mutability. However, these methods have certain disadvantages, in particular the necessity of making a large number of assumptions and the difficulty of estimating the probability both as net cash flows, and individual scenarios.
Using the proposed approach to risk factor assessment in the evaluation of the effectiveness and feasibility of investment projects in a region, an investor can exercise an informed choice of the best of them. This will increase the degree of validity of the investment decision-making, reduce the probability of deterioration in the financial condition of the potential investor, and will improve the relationship between risk and expected return of investment projects in the economic space of a region.
Scientific novelty: the author proposed to apply a method of net present value, while make the calculations of the expected net present value, standard deviation, and shift factor during probabilistic and statistical estimation of the risks of investment project.
Practical significance: the conceptual basis of probabilistic and statistical estimation of the risks of investment project in a region are formed.
Keywords: Probabilistic and statistical methods; Investment projects; Risks; Region.

Formulation of the problem

Planning and implementation of investment projects in the economic space of a region is associated with the influence of various risk factors, the degree of influence of these factors had risen sharply during the financial and economic crisis and post-crisis period at the domestic economy. A modern economic risk has the following features: its totality, inclusiveness, therefore, economic risk refers to the fundamental definitions of modern economic theory and investment analysis. Based on general

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economic theory, system analysis, economic and mathematic methods and models, riskology has formed its own theoretical and methodological principles, summarized a powerful and flexible tool that finds more and more wide practical use in all spheres of economic and investment activities. In practice quantitative evaluation of risks of investment projects, which is determined by the absolute or relative size of financial losses that threaten the potential investor in case of occurrence of risk events has important role. At the same time, quantitative risk evaluation is objective, since it is based on a specific statistical basis.

Analysis of recent research and publications.

Theoretical and methodological bases of identification of investment risks in order to minimize them the following scientists investigated: D. A. Krasovskyi, O. P. Logvinova, R. Y. Mokrydin, R. V. Tuchyn, V. V. Tsarev, V. M. Glibchuk, Mayorova T. V., Gluschevskyy V. V., Kyrychenko O. A., A. Blanka, F. Nayta, A. Kayna etc. The research of the problems of quantitative assessment of economic risks devoted the work of: O. Yastremsky, N. Mashina, M. Sulima, A. Leschynskyy, N. Kravchuk, I. Ivchenko, A. Kaminskyy, O. V. Pylypyak, L. P. Shvets, N. P. Zakharkevich etc. After analyzing the scientific research according to theoretical and methodological bases of identification of investment risks and peculiarities of quantitative analysis application it is worth to mention the following:

In the scientific literature, probabilistic and statistical methods (probabilistic risk analysis PRA) are based on an extended evaluation of critical cash flows that is carried out using sensitivity analysis. These methods mitigates the main drawback of sensitivity analysis — its deterministic character.

O. V. Pylypyak, L. P. Shvets, N. P. Zakharkevich note that the statistic and probabilistic method of risk assessment based on analysis of fluctuations of the estimated parameter over a specified period. The income, gross profit, net present value or net cash flow are used as such estimated notions in investment analysis. The use of statistic and probabilistic method can be carried out in two directions: with the use of the probabilistic assessments; without taking into account probabilistic estimates [1, P. 236].

Probabilistic and statistical approaches to risk assessment involve the use of criteria such characteristics of positive random variables (magnitude of damage), as: mathematical expectation; dispersion; average deviation; coefficient of variation (standard relative deviation, which is defined as the standard deviation, divided into mathematical expectation, that is, the standard deviation, expressed in fractions of the mathematical expectation); a linear combination of mathematical expectation and standard deviation; the mathematical expectation of the loss function, etc [2].

As Boot T. V. noted, using the statistical method based on the calculation of dispersion, standard deviation and coefficient of variation it is possible to assess the development of the regional economy. However, statistical methods do not provide estimates of the development in conditions of limited information [3, P. 6].

Setting the objective.

The purpose of this article is a theoretical and methodological research of the conceptual foundations of probability and statistical (probabilistic risk analysis PRA) risk assessment of investment project in a region. The objective of this research will be based on the selection of the features of applying the method of net present value, simultaneously the calculations of expected net present value, standard deviation, and shift factor.

The basic material of research

In probabilistic and statistical methods net cash flows are determined probabilistically, it means that there is a definition of several possible options, and assignment a certain probability of occurrence, which allows to measure a risk using statistical measures of dispersion [4–9]. Thus, these methods are based on probability and static measurement of risk, as well as on defining a risk as the possible deviation from the expected values, in this case — from the result of the implementation of the investment project in the economic space of a region, which is measured using different evaluation methods of efficiency of investment projects. The risk of the investment project can be determined by measuring the dispersion of possible outcomes around this central value, which in the concept of risk an expected value is.

In relation to the economic objectives the methods of probability theory are reduced to the determination

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of the probability values of the events and the choice of possible events to the most desirable scenario, based on the highest values of mathematical expectation, which is equal to the absolute value of this event, and multiplied by the probability of its occurrence. The degree of risk is measured by two indicators: the average expected value and fluctuations of its possible outcomes [9, P. 31–32].

The dispersion of a random variable and standard deviation that are the measures of dispersion of random variable around the average value, often used as indicators of risk associated with certain investment project. The higher values of dispersion, the higher are the risk. As a risk measure in the framework of probabilistic and statistical methods, coefficient of mutability is also applied, which is a relative measure that allows to compare the risks of several investment projects. Thus, conducting probability and statistical estimation of risks of investment project in a region should be based on relevant conceptual aspects (Fig. 1).

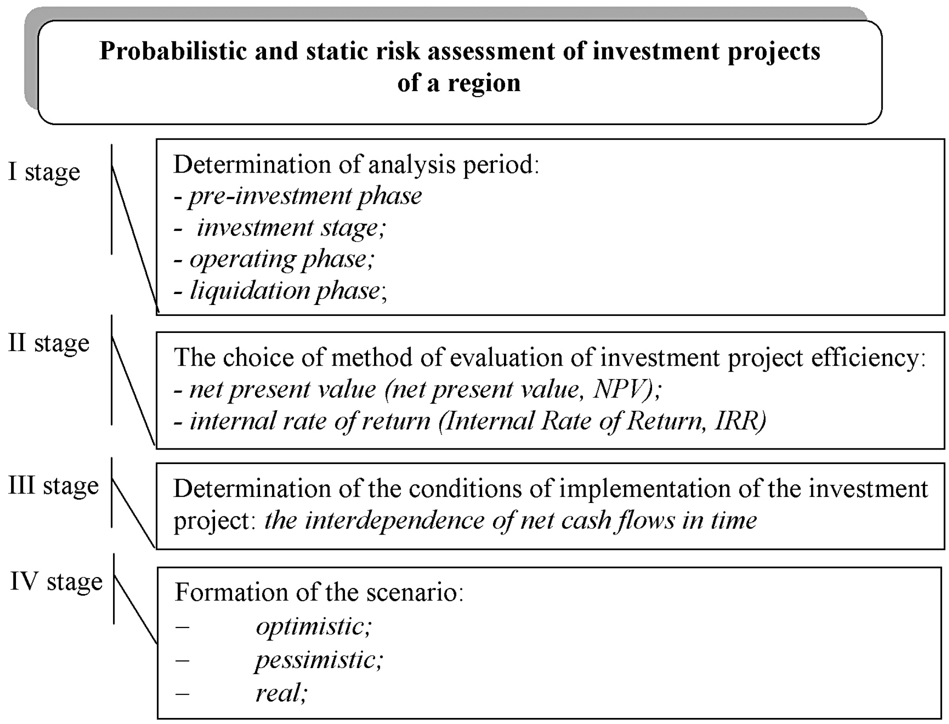

Figure 1. Conceptual basics of probability and statistical estimation of investment project risks in a region

In probability and statistical estimation of risk of investment projects t is necessary to apply the method of net present value, while calculations of NPV are treated as random variables, for which it is possible to set the probability of their display. Based on this expected net present value E (NPV) is calculated, which is the absolute decisive criterion for a certain investment project. If the value of E (NPV) is greater than or equal to zero, then the project is effective. The scale of the risk associated with this project is defined by the standard deviation value <<Eqn0001.eps>> (NPV) and coefficient of mutability C (NPV), calculated on its basis, thus the lower is the value, the lower is the risks. Relative overwhelming criterion, based on the proposed statistic value, is based on maximizing the value of E (NPV) and minimize standard deviation. However, investment projects with a high expected value and are also characterized by higher values of dispersion, and it leads to the fact that additional indicator, which will identify the risk, which falls per unit of expected value, is required for unambiguous assessment. Coefficient of mutability executes this function. Among the considered options project, which has the lowest coefficient C (NPV) is the best.

To evaluate expected value and risk of the investment project it is necessary to set the probability distribution for the explanatory variables that determine the amount

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of net cash flows. For each explanatory variable, it is necessary to set the probability distribution of the formation of its certain size at a certain expected level. This distribution can be established on the following basis: research that are conducted with the aim of obtaining an experimental data; theoretical distributions, which correspond to the researched case; heuristic methods that use experience, intuition and subjective opinions of experts [5].

Time to time in practice, despite the lack of data with respect to the probability distribution, a certain simplification is using, which mainly leads to the definition of the possible states for each accepted explanatory variable, and to determining the probability of its receipt. Calculation of the NPV for three different scenarios: optimistic, pessimistic and most realistic (average), the probability of which it is possible to determine, for example, as: 0.50 — for the most real and 0.25 for optimistic and pessimistic, can be an example. However, the application of limitation to three main scenarios (optimistic, realistic and pessimistic) are burdened by serious disadvantages. Only a few separate variants of the project are taken into account and it is assumed that the uncertain variables are correlated (all variables have in the same time the best and worst values).

The application of probabilistic and statistical methods is a display of the interdependence between subsequent net cash flows. If the cash flows that will take place in subsequent years are independent (i.e., NCF received in year t does not affect on the values of the net cash flow in the next year (t + 1)), then the risks of an investment project is represented by variance and standard deviation. If, instead, the net cash flow in year t depends on the cash flow in the previous period (t — 1), in this case, calculation of the covariance of net cash flows is required.

In probabilistic understanding dispersed risk assessment is to evaluate several possible levels of flows of financial resources for each period, as well as in determining the probability of their realization with the aim of establishing the expected balance of these flows (NCF). If we assume that the cash flows of this investment project are independent, then the sum of probability of their display determines the probability of a certain balance of these flows — net cash flows. The combination of possible cash flows forms the following scenarios for which the metrics NVP are calculated. This determines the expected net present value, dispersion of random variables, standard deviation, and coefficient of variation. Therefore, it is proposed the following algorithm to calculate the expected value of NVP of the investment project in the economic space of a region (tab. 1).

In the process of determining of semi-dispersion risk alternately should be calculated the following: half-dispersion of net present value, half- variation and the coefficient of half- deviations (table. 1).

Standard semi- deviations is an absolute measure of risk, which can be used as a criterion during the absolute evaluation. As a relative criterion, it may be applied, when the comparable projects are characterized by similar expected values. Otherwise, coefficient of half- deviations can be used as a relative measure of risk.

Semi variance and standard semi- deviations, as in the case with dispersed risk, should be calculated on the basis of less aggregated initial data that is at least pragmatic. In making investment decisions in practice disperse risk is taking into consideration. This follows from the fact that the distribution of the probability of occurrence of positive and negative deviations is mostly symmetrical. That is why semi variance may be equal to half of the variance, and therefore the application of these two methods can give similar results. If the distribution is not symmetric, then semi variance is less than dispersion, and with the growth of this difference the risk perceived in a negative vision is also decreased.

Table 1. – Algorithm of the expected value of NVP of the investment project in the economic space of a region calculation

No.	Indicator	The formula for calculating	Interpretation
1	2	3	4
1	Net present value $E(NPV)$	$E(NPV)=\sum_{i=1}^{n} p_i \cdot NPV_i$	$E(NPV)$ — the expected value, NPV, p_i – the probability of the i-scenario, NPV_i — value of NPV i-scenario

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1	2	3	4
2	Dispersion	$V(NPV)=\sum_{i=1}^{n} p_i \cdot [NPV_i - E(NPV)]^2$	$V(NPV)$ — dispersion NPV, $E(NPV)$ — the expected value NPV, p_i — the probability of the i-scenario, NPV_i — value NPV i-scenario
3	Standard deviation of dispersion	$\sigma(NPV)=\sqrt{V(NPV)}$	$\sigma(NPV)$ — standart deviation of net present value, $V(NPV)$ — dispersion NPV
4	Coefficient of variation of net present value $C(NPV)$	$C(NPV)=\frac{\sigma(NPV)}{E(NPV)}$	$C(NPV)$ — coefficient of variation, $\sigma(NPV)$ — standart deviation of net present value, $E(NPV)$ — the expected value NPV
5	The semi dispersion of the net present value	$V(NPV)_{sem}=\sum_{i=1}^{n} p_i \cdot h_i^2$	$V(NPV)_{sem}$ — semi dispersion NPV, p_i — the probability of the i-scenario, h_i — factor that dependents on the sign of the deviation
6	$h_i=\begin{cases} 0 \leftrightarrow NPV_i \geq E(NPV) \\ NPV_i - E(NPV) \leftrightarrow NPV_i < E(NPV) \end{cases}$		
7	Semi deviation of standard value NPV	$\sigma(NPV)_{sem}=\sqrt{V(NPV)_{sem}}$	$\sigma(NPV)_{sem}$ — standart semi deviation of net present value, $V(NPV)_{sem}$ — semi dispersion NPV
8	Coefficient of half-variation	$C(NPV)=\frac{\sigma(NPV)_{sem}}{E(NPV)_{sem}}$	$C(NPV)_{sem}$ — semi coefficient of variation, $\sigma(NPV)_{sem}$ — standart semi deviation of net present value, $E(NPV)_{sem}$ — expected half –value NPV

According to O.V. Pylypyak, standard deviation (standard deviation), average absolute deviation, variance and semi variance are the common absolute measures assess of the risk level of real investment. These indicators are based on deviations of individual values of random index from the average value. Application of the indicators average standard deviations, variance and semi variance allows to quantify the risk of several projects, or several variants of one project. More over the lowest risk will be that project, which would have the minimal the value of these indicators, because for this project the dispersion of a random variable around its average value will be the smallest [1, P. 240–241].

Dispersion and semi dispersion are the main probabilistic and statistical methods of risk assessment that are applied in these cases when the financial flows of the following years are independent. If the cash flows (NCF) in year t are dependent on cash flow for the previous period (t — 1), then the method of covariance is used for the risk assess. This method is associated with a conditional probability of net cash flows. That is, if in year t = 1 and i-net cash flows (NCF), as well as the corresponding indicators of the probability p_{1i}, in year t = 2 are j-net cash flow (NCF_{2j}) and the corresponding indicators of the probability p_{2j}, simultaneously this probability is conditional and is based on the formula:

$$p_{2j}\left(NCF_{2j} / NCF_{1j}\right)=\frac{p(NCF_{1j} \wedge NCF_{2j})}{p_{1i}(NCF_{1i})} \quad (1)$$

where p_{2j} $(NCF_{2j} | NCF_{1i})$ — the probability net cash flows NCF_{2j} under condition that there was a previous display of net cash flows, NCF_{1i}, p_{2j} $(NCF_{1i} \wedge NCF_{2j})$ — the probability of obtaining of net cash flows NCF_{1i} in year t = 1 and NCF_{2j} in year t = 2, or their simultaneous display.

After conversion we get an example of determining the probability of display in year t = 1 and in year t = 2 of net cash flows NCF_{1i} і NCF_{2j}:

$$p(NCF_{1i} \wedge NCF_{2j}) = p_{1i}(NCF_{1i}) \cdot p_{2j}(NCF_{2j} / NCF_{1i}) \quad (2)$$

After determining the conditional probabilities for data net cash flows, using examples from independent

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flows of NCF, NPV values are calculated for all possible combination of flows, NCF, and further — statistical measures of risk: the expected net present value, standard deviation, and coefficient of variation. The covariance, i. e., which determines the relationship between the following net cash flows can be calculated on the basis of the following example:

$$\operatorname{cov}(NCF_1\ NCF_2) = \\ = \sum_{j=1}^{n} p_j \cdot [NCF_{1i} - E(NPV_1)] \cdot [NCF_{2j} - E(NPV_2)]. \quad (3)$$

where: cov (NCF_1, NCF_2) — covariance between the net cash flows in the first and second year of the investment project.

Covariance is a category, which characterizes the total change for two random variables, in particular if it is equal to zero: (cov = 0), than the net cash flows are independent; more than zero (cov > 0), than the flows NCF are positively interdependent; less than zero (cov < 0), than the net cash flows are negatively interdependent.

However, in the scientific literature the relative indicators of variation, characterizing the degree of risk per unit of return (profitability), and therefore can serve for comparison of different projects from the point of view of risk, are more common than the absolute indicators in the practice of risk assessment of real investment, are. The scientists emphasize the quadratic coefficient of variations and the quadratic level variation [1, P. 242–243; 4].

By means of coefficient of variation it is possible to compare the fluctuations of the features expressed in different units of measurement. The coefficient of variation can vary from 0 to 1. The greater the variation coefficient is, the stronger the vibrations will be. The more vibrations are, the higher the risk will be. When you select the best solutions it is advisable to use the rule of optimum fluctuation result, the essence of which is the following: you may choose a decision from all possible decisions, in which the probability of winning and losing for the same risk investments have a small gap, i. e., the smallest value of the average quadratic deviation and variation [5, P. 138; 10, P. 70; 11, P. 24–25].

As already noted, the investment is profitable when the expected cost E (NPV) will be positive. The standard deviation shows the level of deviation between average future value and net present value (plus, minus) from a certain expected value NVP. The coefficient of mutability defines the amount of risk per 1 unit E (NPV). In this case, the criterion for risk assessment is the maximization of expected value and minimization of standard deviation and variance. The main drawback of this method (risk of dispersion) is a uniform interpretation of all possible deviations, both positive and negative, as identical risk objects. Then, as the positive deviation is a useful for the investor, contrary to the unwanted negative. The semi variance is a level of risk and it is understood as a negative deviation from the expected net present value.

Conclusions

Thus, the main advantage of probabilistic and statistical methods is that fact, that the measurement of risk is carried out using objective measures — standard deviation and coefficient of mutability. However, these methods have certain disadvantages, in particular the necessity of making a large number of assumptions and the difficulty of estimating the probability both as net cash flows, and individual scenarios.

Using the proposed approach to risk factor assessment in the evaluation of the effectiveness and feasibility of investment projects in a region, an investor can exercise an informed choice of the best of them. This will increase the degree of validity of the investment decision-making, reduce the probability of deterioration in the financial condition of the potential investor, and will improve the relationship between risk and expected return of investment projects in the economic space of a region.

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