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Article

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SCENARIO ANALYSIS OF THE EXPECTED INTEGRAL ECONOMIC EFFECT FROM AN INNOVATIVE PROJECT

Abstract. *The purpose of the article is to analyse conceptual approaches to determining the financial feasibility of an innovative project and to develop a methodology for assessing the expected integral economic effect of an innovative project based on a set of performance indicators while ensuring the compatibility of the considered scenarios. Analysed are theoretical approaches to assessing the effectiveness of an innovative project in conditions of uncertainty. The features of evaluating the effectiveness of innovative projects are identified, and the need to assess the expected integral economic effect of socially significant innovative projects is substantiated. The indicators of efficiency and feasibility of evaluating an innovative project in the context of applicability in various economic conditions are critically studied. A set of indicators for evaluating the effectiveness of innovative projects has been determined based on the provisions of the integral approach, and these indicators have been systematised based on their relationship. The expected integral economic effect or possible damage from the implementation of an innovative project has been calculated. The expected integral effect of an innovative project with given intervals of probabilities for individual scenarios is calculated. An integrated methodology for assessing the integrated effectiveness of innovative projects is proposed, which combines quantitative and qualitative performance indicators, economic and non-economic effects. The key directions for the selection of effective innovative solutions in the presence of uncontrollable factors, taking into account a variety of indicators, have been determined. A methodology has been developed for evaluating effective innovative projects with a lack or absence of information about the conditions for their implementation and functioning. Methods have been developed for determining the best options for innovative projects based on the theory of multicriteria choice while ensuring the compatibility of the considered scenarios.*
Keywords: innovative project, assessment, expected integral effect, net present value.

Introduction. Today, there is no doubt about the need for innovative renewal of the economy. Innovation is important in terms of anticipating the tangible impact it will bring. If, as a result of the

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implementation of the innovative project (IP), there has been no significant renewal of the material and technical base, the receipt of additional income, then the project turns out to be ineffective. Therefore, the project assessment must be approached using all the methods at the disposal of the enterprise even at the stage of preliminary analysis and selection of projects in order to accurately represent what the result can be obtained. Evaluation of the effectiveness of an innovative project is an important element of scientific, technical and economic growth. Analysis of the positive and negative effect of an innovative project is inextricably linked with the development of production as a whole.

The problem of correctly calculating the effectiveness of innovative projects for the enterprise and Ukraine as a whole means a lot. There are a number of reasons for this. The Ukrainian economy is non-stationary, and this specificity of it significantly affects the methodology and result of efficiency assessment. A large innovative program should be implemented in Ukraine, since fixed assets, including equipment, are outdated and unacceptably worn out. An expert analysis of project efficiency calculations shows that the methodology used for these calculations needs to be improved, since in practice, the determination of estimates of the effectiveness of an innovative project is often based not on well-grounded theoretical propositions, but on various prejudices arising from "common sense". When choosing effective innovative projects, one should not rely on international analogues. A project that is effective in the West may not be effective in Ukraine. For example, a Ukrainian project that provides for large volumes of product sales in the external market may turn out to be ineffective due to the peculiarities of the Ukrainian economy. The task of assessing the expected integral economic effect of an innovative project is to choose the best project from a number of alternative ones. Often, trying to "stretch" the desired project, they form many alternative projects, where all others are worse, and good ones are not considered at all. No less "successfully" the idea is exploited - the effectiveness of projects is assessed, but some constraints are not checked (for example, the conditions for its financial feasibility). In this case, the obtained preliminary estimate in a number of cases may be significantly overestimated.

This has significantly influenced investors in the direction of investment decisions, which requires reliable methods for calculating the effectiveness of innovation. The investor has the right to know: what economic effect he has the right to expect from the project, how stable the obtained results are in relation to the inevitable deviations of the project implementation conditions from those adopted in the calculations, what financial risks await him in the investment process. These calculations are also necessary to attract shareholders and creditors. The meaning of assessing the expected integral economic effect of an innovative project is to obtain information that allows one to draw a conclusion about the feasibility (or inexpediency) of investment. The problem of choosing the best from alternative innovative projects is especially urgent. This problem is faced by both individual enterprises, investors, and regions (represented by government agencies) when forming their investment portfolios. The value of the assessment results equally depends on the completeness and reliability of the initial data and on the correctness of the methods used in the scenario analysis. It should be emphasized that the development of a number of scenarios is not carried out in order to select from the “typical” scenarios and use it to determine the effectiveness of the project, but to simultaneously take into account all possible scenarios and make a decision based on their totality. The fact is that participation in a project for a positive effect does not insure against losses, as well as refusal to participate. This means that in situations of uncertainty, a future project is considered effective if participating in it is better than abandoning it. There is a need to continue research in the field of improving the methodology for assessing the expected integral economic effect from the implementation of an innovative project based on the scenario analysis of the dashboard.

Literature Review. The economic literature offers many methods for assessing the effectiveness of innovative projects for an enterprise, but they are either general in nature or extremely highly specialized (Cigola and Peccati, 2005; Guerra et al., 2014; Magni, 2015). As you know, the success of a project is determined by the value of the economic effect obtained in the process of commercialization. In the foreign literature, there are recommendations to “separate investment decisions from financing decisions” and to evaluate the effectiveness of the project “as a whole”, making adjustments for the impact of the loan (Marchioni and Magni, 2018). Recommendations of this kind raise doubts even in Western economics, if only because when calculating the effectiveness of a project, it is necessary to assess its financial feasibility. In the Ukrainian economy - and this is one of its differences from the Western one - this approach is not appropriate. The fact is that in Western stock markets there are “strictly identical” conditions for raising loans (Magni, 2013; Nwogugu Michael, 2016). Therefore, they have little effect on the absolute and relative effectiveness of participation in the project, although there remains the task of determining the financial feasibility of the project. In Ukraine, the situation is completely different. Loan terms vary widely (at interest rates - sometimes many times, taking into account inflation). Therefore, the main thing is to assess the effectiveness of participation in the project - a different assessment for different subjects. In scientific sources, there are different opinions regarding the economic effect of innovation.

So, in the work (Yang, Kum Khiong et al., 1993), the features of the economic effect of an innovation project and its impact on the development of the enterprise as a whole are considered. In the study (Wiesemann et al., 2010; Maravas and Pantouvakis, 2018), the types of effects from innovation activity and their relationship are considered, and the theoretical justification for calculating the total effect of the enterprise from the project is presented. Birger, 1980 proposed a method for calculating the economic effect of the use of innovations by reducing the cost of production of an enterprise, increasing sales, saving resources and recycling production waste. The article (Brem and Radziwon, 2017) is devoted to the analysis and generalization of theoretical studies of such concepts as "the effectiveness of innovation" and "the effect of an innovative project." The process of increasing the duration of the maturity stage at the stage of commercialization is discussed in the works (Borgonovo et al., 2010; Gordon, 2009; Leyman and Vanhoucke, 2017). Magni, 2010 proposes to extend the maturity stage of an innovation project by lengthening the decline point in the life cycle. However, in their article, Cappa et al., 2016 show that the recession stage can begin prematurely at any stage of the life cycle under the influence of many external factors beyond the control of the enterprise, and predicting the onset of this stage is a rather difficult process. At the same time, according to studies (Helfat and Quinn, 2006; Lööf and Heshmati, 2003), the starting point and duration of the commercialization stage depend on the initial stage of the life cycle of an innovative project - the stage of its development. And, accordingly, the duration of this stage affects the value of the economic effect of the implemented innovative project as a function of time due to the change in the period of use of this project (Mohamed and McCowan, 2001).

It can be seen from the analysis that scientists in their works (Foster and Mitra, 2003; Moshe and Kroll, 2017; Nwogugu Michael, 2016; Sewastjanow and Dymowa, 2008; Prokop et al., 2017) reveal the content, describe the constituent parts and propose methods calculating the economic effect from the introduction of an innovative project at the enterprise. For the Ukrainian industry, which has significant features, there is no universal methodology for assessing the expected integral economic effect from an innovative project. The dynamic aspect of the magnitude of the economic effect in the commercialization of industrial innovations is ignored. Evaluation of innovative projects is carried out, as a rule, either from an economic point of view or from a social point of view; there is no comprehensive methodology for evaluating from a systemic standpoint, taking into account the entire range of possible consequences. The issue of the composition of assessment indicators, reflecting the complexity of the effectiveness of innovative projects, has not been resolved.

Methodology and research methods. To determine the integral effectiveness of innovative projects, it is necessary to establish and substantiate a system of indicators, on the basis of which the integral assessment will be carried out. Many enterprises consider obtaining quantitative integral assessments too complicated process and in some cases develop their own system of innovative metrics, which to the greatest extent takes into account the specifics of the enterprise and the specifics of the management tasks being solved.

One of the indicators of the IP break-even limit for a certain step of the calculation period is the break-even level. The break-even level $Y_n^{Б}$ at step *n* is the ratio of the break-even sales (production) to the project at this stage. Break-even is the sales volume at which the net profit becomes equal to zero. The calculation of the break-even level is based on the assumption that the volume of production is equal to the volume of sales. When determining this indicator, it is assumed that at step n: the volume of production is equal to the volume of sales; the amount of revenue changes in proportion to the volume of sales; income from non-sales activities and expenses for the same activities do not depend on sales volumes; total operating costs, allocated to conditionally fixed and conditionally variable, change in proportion to the volume of production. The calculation of the break-even level $(Y_n^{Б})$ is carried out according to the formula 1.

$$Y_n^{Б} = \frac{CC_n - VC_n - DC_n}{N_n^{Г} - VC_n} \qquad (1)$$

where – $N_n^{Г}$ the amount of revenue; CC_n – full current production costs; VC_n – is the conditionally variable part of the total current production costs; DC_n – income from non-sales activities minus expenses for these activities.

If the project provides for the production of several types of products, formula 1 is also used. In this case, prices and costs are taken into account without VAT. The project is sustainable if the break-even level does not exceed 0.6-0.7. The approach of the break-even level to 1 (100%) indicates the insufficient stability of the project to fluctuations in demand for products. Allowable values of the break-even level at each step do not guarantee project efficiency. High values of the break-even level are not considered at all stages as a sign of project failure. For example, at the stage of mastering new production facilities or during the overhaul of expensive high-performance equipment, they can exceed 100%. When determining *NPV* for each scenario, the discount rate is taken as risk-free. The financial feasibility of the project is checked. The initial information about the factors of uncertainty is the form of the probabilities of individual scenarios or intervals of variation of these probabilities. The risk of project failure is estimated - the total probability of scenarios in which the conditions of the project's financial feasibility are violated. The risk of project inefficiency is estimated - the total probability of scenarios in which the integral effect (*NPV*) becomes negative. Possible damage from the implementation of the project in case of its inefficiency is estimated. Based on the indicators of individual scenarios, generalizing indicators of the project's effectiveness are determined, taking into account uncertainties (Pasqual et al., 2013).

Net Discounted Income *(NDI)* (other names – *Net Present Value (NPV),* integrated effect). The Net Present Value is an estimate of the present value of the future income stream. It is defined as the sum of the current effects for the entire calculation period, reduced to the initial step, or as the excess of the integral results over the integral costs. One of the indicators used to compare different projects and choose the best one is the expected cumulative effect *(NPVee).* The integral economic effect (net present value) is defined as the sum of the economic effects for the accounting period, discounted by the beginning of the first step. In other words, the net present value characterizes the excess of the discounted inflow of funds over the discounted outflow of funds for the calculation period. Methods for determining the expected effect indicator depend on the available information on the uncertainty of the project implementation conditions. In case of possible uncertainty for each scenario, the probability of its implementation is known (specified). It can be determined expertly (Robison et al., 2015). The probable description of the conditions for the implementation of the project is justified when the efficiency of the project is due to the uncertainty of the processes of operation and depreciation of fixed assets, the uncertainty of changes in the market related to IP from suppliers, buyers, creditors, debtors who participate in the formation of cash flows; market volatility, the emergence of new competitors, possible fluctuations in financial results and financial stability related to the project (Silva et al., 2018).

Depending on the object of assessment, economic efficiency reflects the ratio of the costs and effect of the project to the goals and interests of the participants in monetary form. The effectiveness of an innovative project is a category that reflects the compliance of the project that generates this investment project with the goals and interests of its participants. The effectiveness of the project as a whole is assessed in order to determine the potential attractiveness of the project for potential participants and to find sources of funding. In the case when there is a finite number of scenarios and their probabilities are given, the expected integral effect *(NPV_{ee})* of IP is calculated using the mathematical expectation formula 2.

$$NPV_{ee} = \sum_k NPV_k \times P_k \tag{2}$$

where NPV_k – is the integral effect of *NPV* at k-scenarios; P_k – the likelihood of this scenario. The risk of project inefficiency P_e and the average damage from the IP implementation in the event of its inefficiency Y_e are determined by formula 3.

$$P_e = \sum_k P_k \tag{3}$$

$$Y_e = \frac{\sum_k NPV_k \times P_k}{P_e} \tag{4}$$

where the summation is carried out only for those scenarios k for which the integral effects NPV_k are negative.

The mathematical expectation *NPV* of the project is calculated using formula 5.

$$NPV_{ee} = \sum_n \frac{Mt_n \times (1-p)^n}{(1+r)^n} - CI = \sum_n \frac{(FV_n - B_n) \times (1-p)^n}{(1+r)^n} - CI \tag{5}$$

From formula 5 it can be seen that the multi-temporal effects Mt_n, provided under normal conditions, that is, in the absence of a force majeure event, are reduced to the base period using the coefficient $(1-p)^n/(1+r)^n$ which does not coincide with the usual discount coefficient $1/(1+r)^n$. In order for the usual discounting without taking into account risk factors, and the calculation taking into account these factors, give the same result, it is necessary that a different value r_p be taken as the discount rate:

$$1 + r_p = (1+r)/(1-p) \tag{6}$$

Hence we obtain that

$$r_p = (p+r)/(1-p) \tag{7}$$

For small values of probability *p*, this formula takes the form: $r_p = p + r$ confirming that in this situation, taking into account the risk is reduced to calculating *NPV* under normal conditions, but with the discount rate r_p which exceeds the risk-free *r* by the value of the risk premium reflecting the conditional the probability of termination of the project *p* within a year *n* In the case when any information about the probability of scenarios is absent (it is only known that they are positive and add up to 1, the calculation of the expected integral effect *(NPV_{ee})* is carried out according to formula 8.

$$NPV_{ee} = \lambda \times NPV_{max} + (1-\lambda) \times NPV_{min} \tag{8}$$

where NPV_{max} and NPV_{min} are the largest and smallest integral *NPV* effect for the considered scenarios; λ – is a special standard for accounting for the uncertainty of the effect, reflecting the system of preferences of the enterprise in conditions of uncertainty. When determining the expected integral economic effect λ, it is recommended to take it at the level of 0.3.

In the presence of additional restrictions on the probabilities of individual scenarios p_n, the calculation of the expected integral effect is performed according to formula 8.

$$NPV_{ee} = \lambda \times \max_{P_1,P_2,\dots} \sum_k (NPV_k \times P_k) + \left[(1-\lambda) \times \min_{P_1,P_2,\dots} \sum_k (NPV_k \times P_k)\right] \quad (9)$$

where NPV_k – is the integral effect of *NPV* for *k* scenarios, the maximum and minimum are calculated for all admissible combinations of the probabilities of individual scenarios at given intervals of their change.

The integral effects of scenarios NPV_k and the expected effect NPV_{ee} depend on the value of the discount rate *r*. The premium *g* for the risk of non-receipt of income envisaged by the main project scenario is determined from the condition of equality between the expected project effect $NPV_{ee}(r)$, calculated at the risk-free discount rate *r* and the effect of the main scenario $NPV_{ms}(r + \mathrm{g})$, calculated at the discount rate $(r + \mathrm{g})$ including an adjustment for risk g.

$$NPV_{ee}(r) = NPV_{ms}(r + \mathrm{g}) \quad (10)$$

In this case, the average losses from non-receipt of incomes provided for by the main scenario under unfavourable scenarios are covered by the average gain from obtaining higher incomes under favourable scenarios. The amount of the premium g depends on which scenario is accepted as the main one. In the absence of information about the possibility of individual scenarios, to simplify the assessment of effectiveness, it is recommended to use moderately pessimistic rather than average estimates of costs and benefits in this scenario, that is, focus on a reduced risk premium. The *NPV* indicator reflects the forecast assessment of changes in the economic potential of the participants in the investment process. This assessment method is good in that it has sufficient stability under various combinations of initial conditions, allowing in all cases to find a rational solution, answering the question of whether the analysed investment mechanism contributes to the profitability of innovations Scenario analysis involves the construction, in addition to the baseline, of two more scenarios based on optimistic and pessimistic forecasts. The development of several scenarios for the implementation of the project is carried out not in order to choose the most preferable from the scenarios and determine the effectiveness of the project by it, but to simultaneously take into account all possible scenarios and make a decision based on their totality. The proposed approach to assessing the effectiveness of an innovative project includes calculating complex indicators of the effectiveness of an innovative project for various scenarios and the integral economic effect of the project, taking into account various scenarios. The scenario method is based on the formation of a multi-variant forecast of the dynamics of the external environment and ensures that the simultaneous influence of changes in risk factors is taken into account.

The scenario method involves the description of the entire set of possible conditions for the implementation of an innovative project (in the form of scenarios) and the corresponding costs, results and performance indicators. As possible options, it is advisable to construct at least three scenarios: pessimistic, optimistic and the most probable (realistic, or average *(NPV middle)).* If the probabilities of the occurrence of a particular event reflected in the scenario are known, then the expected integral effect of the innovative project is calculated using the mathematical expectation formula.

$$NPV\ middle\ = \sum NPVi \times Pi \quad (11)$$

where *NPVi* – is the integral effect in the implementation of the *i-th* scenario, p_i – is the probability of this scenario. In this case, the risk of project inefficiency *(Re)* is estimated as the total probability of those scenarios *(k)* in which the expected project efficiency *(NPV)* becomes negative: $Re = \sum R\kappa$. In cases where there is no information about the probability of individual scenarios, a minimax approach is used, in particular, the so-called criterion of optimism-pessimism.

$$NPV\ middle\ = \lambda \times NPVmax + (1 - \lambda) \times NPVmin \quad (12)$$

λ – a special standard to take into account the effect of uncertainty (it is recommended to take it at the level of 0.3), λ=0 means a pessimistic assessment of the effectiveness of an innovative project under the worst possible scenario.

Results. The development of Ukraine is impossible without intensive innovative development of enterprises. Innovations, representing investments in the development and implementation of new technologies, business organization schemes are characterized by certain risks inherent in innovation processes. This is manifested in the specifics of evaluating innovative projects. Uncertainty refers to the incompleteness and inaccuracy of information about the internal characteristics and external conditions of the project. Uncertainty is objective and does not depend on the attitude of one or another participant in innovation to the project. Risk means the possibility of unfavourable situations for the project or for one or more participants in its implementation. Therefore, "risk" is a subjective concept. For example, the possibility of raising the tax rate (say, on property) is a risk for the investor, but not for the budget. The risk is not necessarily probabilistic, but in many cases, it is. Probabilistic risk perceptions are based either on the participants 'statistically stable information about the frequency of occurrence of scenarios, or on the participants' personal ideas about the possibility of adverse situations and their frequency. Therefore, the methods for evaluating innovative projects in conditions of probabilistic risk and uncertainty should be different. Although in both cases, for project evaluation, it is advisable to define a similar characteristic – a non-deterministic analogue of NPV – an indicator of expected efficiency (let us denote it as *Iee*). Moreover, the project is effective if *Iee ≥ 0* and ineffective if *Iee <0*. If it is necessary to make an optimal choice from several alternative potentially realizable projects, preference should be given to a project with a maximum *Iee> 0*. In connection with the definition of the *Iee* indicator and its practical use, it is advisable to pay attention to the errors of a recommendatory nature that are widespread in this regard. Thus, *Iee* should be calculated using the formula for determining *NPV*. Only to account for uncertainty and risk, the *NPV* discount rate should be increased (added to the risk-free discount rate "risk premium" corresponding to the project's risk class). There are many controversial issues related to the metrics used to measure performance. Indeed, (Cigola and Peccati, 2005) for alternative projects the main criterion indicator of efficiency is *NPV*. The more NPV of real investments during the calculation period, the more their owner receives. Therefore, to assess the effect of an innovative project and compare the effectiveness of alternative projects, *NPV* is the main indicator. The rest of the performance indicators should not contradict him. Projects are not always alternative. In addition to evaluating efficiency, there is a task of checking the correctness of calculations, in which all indicators are involved. But *NPV* remains mainstream. It is no coincidence that in a number of foreign publications there is a paragraph under the title "Why is *NPV* a correct criterion than *IRR* or *PI*?" (Robison et al., 2015).

We believe that it is not worth comparing the *NPV* of the efficiency of projects of different duration. This requires some other indicators. Of course, with an increase in the duration of a project, the level of uncertainty of its indicators increases, in most cases it is perceived as an additional minus of a long-term project. Replacing *NPV* with any other measure of this provision will not make it easier. During the billing period after the end of project 1 (or 2), new investments are possible. Then, in order to choose between projects 1 and 2, it is necessary to know the *NPV* of these investments. Thus, in all cases, the choice must be made based on the *NPV* values of the options. To determine these values, it is important to know the investment conditions.

It is debatable to say that the higher the profitability index, the more efficient the project is (Silva et al., 2018). If we take into account the position of the owner and recognize the best the project that brings the owner the greatest income, then the choice of the most effective of the alternative projects should be carried out at the maximum *NPV*. If projects are selected on a different basis, for example, specific discounted income for each invested UAH (also discounted), the selection criterion will be different. In this case, the owner's income from the chosen project will not be the largest possible. This often leads to errors when evaluating projects – incorrect determination of the internal rate of return (IRR). A project is considered financially sustainable if, in all scenarios, it is efficient and financially implemented, and the negative consequences are eliminated by organizational measures. To assess the stability and effectiveness of IP in conditions of uncertainty, the following methods should be used: aggregate stability assessment; calculation of break-even levels; Lagrange method; assessment of the expected IP effect, taking into account the quantitative characteristics of the uncertainty. All methods, except for the first one, provide for the development of scenarios for the implementation of the project in possible or dangerous conditions and the assessment of the consequences of the implementation of such scenarios. This allows the design to include measures to prevent or redistribute losses (Birger, 1980).

A project is considered stable in relation to possible changes in parameters if, for all considered scenarios, *NPV* is positive and financial feasibility is ensured. If in any of the considered scenarios at least one of the specified conditions is not met, then the project is unstable. In this case, a more detailed analysis of the boundaries of possible fluctuations of the corresponding parameter is carried out and the upper limit of these fluctuations is refined. If, after such a refinement, the project is assessed as unstable, then in the absence of additional information, the project is rejected, and if information is available, the stability is checked by other methods. When assessing sustainability, an investor can develop his own, acceptable for him, scenarios.

The degree of stability of the project in relation to possible changes in the conditions of its implementation is characterized by indicators of the break-even boundaries and the limiting values of the project parameters (production volumes, the price of products). Indicators are used to assess the impact of a possible change in project parameters on its feasibility. However, they themselves do not relate to IP performance indicators, their calculation does not replace the calculation of integral performance indicators (NPV, discount investment profitability index, *IRR* (Guerra et al., 2014; Sorenson and Lavelle, 2008). *IRR* is the discount rate at which NPV=0. This thesis was analysed in detail in (Birger, 1980). The *IRR* method is no worse as a means of assessing the effectiveness of the *NPV* method. The higher the *IRR*, the higher the project efficiency. This statement contradicts the results of comparing projects by their *NPV* values. *IRR* of a project is its refinancing (reinvestment) rate. Indeed, it is unlikely that a bank will adjust its deposit interest rate at which the project's profit will be reinvested, depending on the risk associated with the project and, therefore, what its discount rate is (Robison et al., 2015). The interest on the bank's deposit depends on other factors.

The *IRR* of a wholly self-financed project is the maximum lending interest rate at which a wholly leveraged project is effective. It is not always so. Although you can specify the conditions when this position will be correct. These conditions are as follows: the loan is provided for the entire period of the project, and the cash inflows received from the project are invested in a deposit, and the deposit rate coincides with the credit; interest on the loan does not deduct taxable income. In the Ukrainian economy, none of these three conditions are met. Therefore, one should not look for a connection between *IRR* and the maximum lending rate at which the project is still effective, especially in the case when it is financed from borrowed funds only partially.

It is believed that in order to provide a loan for a project, its IRR must exceed the lending interest rate (Yang Kum Khiong et al., 1993). The ability to pay off and service a loan depends on its conditions, size and, of course, on the project itself. In order to prove the possibility of loan repayment, the investor must show that: if there is a loan, the project is financially feasible; *NPV* of the investor's participation in the project remains positive and large enough does not provide for difficulties in returning and servicing the loan (expert assessment). Thus, the *IRR* value does not play any role here.

Statement: the shorter the payback period, the more effective the project is difficult to comment on. Indeed, it often happens that, among alternative projects, the largest NPV is not the project with the shortest payback period (possibly with the longest) (Wiesemann et al., 2010). The main thing is that there should be a maximum and positive integral effect over the life cycle of the project *(NPV> 0),* which is equivalent to the condition *Pp ≤ P*. In other words, it was not possible to find a deterministic or correlation relationship between the value of the payback period and *NPV* of alternative projects. Often there are errors in the economic content of the indicators used. Payback period (P_p) – the time for which the operating accounting profit accumulated in the project will be equal to the initial investment; the sooner this happens, the better the project. In fact, not everything may be so at all because of the loss of profit that was not taken into account when calculating the accounting profit. For example, if from the lease of a building used in a project to a third-party client, an income can be obtained that is higher than for a project with a building.

It allows calculate the IP break-even level for 5 years according to the following data: revenue from IP sales – UAH 117 million; full costs – UAH 45 million; including: variable costs – UAH 24 million; fixed costs – UAH 21 million. Using formula 1, the break-even level would be:

$$Y_n^{Б} = \frac{CC_n - VC_n - DC_n}{N_n^{Г} - VC_n} = \frac{45-24}{117-24} = 0,23$$

Based on the results of our calculations, the break-even level does not exceed the established limits 0,23<0,6<0,7.

The project can be considered sustainable. The next method for assessing the effectiveness of *IP* is the parameter variation method (Borgonovo et al., 2010). Let us estimate the maximum integral level of the volume of product sales for the above project. This solution complements and clarifies the calculation of the break-even boundaries. To determine revenue, notional variable costs and taxes proportional to revenue are multiplied at each step by a common factor λ .

Investment and conditionally fixed production costs, taxes not related to revenue, remain unchanged, after which the multiplier is selected so that *NPV* turns to zero or *IRR* becomes equal to the discount rate (12% per year). The chosen multiplier is IP. For the calculation, we use the formula 5.

To determine the *IP*, the proceeds that refer to *IP* and the variable part of costs – 24 million UAH are multiplied by λ and *NPV* is reduced to zero. Find the factor λ as an unknown variable in the equation, where *NPV = 0.*

$$\lambda = \frac{117\times\lambda - 24\times\lambda - 6}{(1+0,12)^5} - 65 = 0 \rightarrow \lambda = \frac{65\times(1+0,12)^5 + 6}{(117-24)} = 1,3$$

The calculation shows that in this example IP = 1.296. For a more accurate assessment, you need to determine the stability margin in the form of a difference:

$$\varphi = 1 - \lambda = 1 - 1,296 = -0,296$$

It is known from previous calculations that the internal rate of return *(IRR)* is less than the discount rate ; when calculating *NPV*, in which the amount of output investments is not discounted, the net discount income is less than zero $NPV < 0$ = –15,57 million UAH. These indicators negatively characterize the efficiency and financial feasibility of the project. However, the break-even level does not exceed the established limits with a large margin 0,23<0,6-0,7.

Comparing the margin of stability with the indicator of the break-even level, we see that reasoning about the stability of the IP based on the values of the break-even level may turn out to be unjustifiably optimistic (Cigola and Peccati, 2005). More accurate methods for assessing the effectiveness of IP in conditions of uncertainty include the method of calculating and assessing the expected effect of the project. This method allows you to calculate a generalized indicator of the effectiveness of the project - the expected integral effect (expected *NPV*). An integral effect is the combined effect of several actions.

If: *NPV>0,* then the project should be accepted; *NPV<0,* then the project should be rejected; *NPV=0*, then the innovative project is neither profitable nor unprofitable. The positive value of *NPV* shows how much the value of assets increases from the implementation of this project. Therefore, preference is given to the project with the highest *NPV.* The *NPV* method belongs to the category of absolute, which allows you to summarize the results for selected innovations to determine the *NPV* as a whole.

The calculation of the expected integral effect and average damage from the implementation of the project in case of its inefficiency is presented in Table 1.

Table 1. Expected integral economic effect or possible damage from the implementation of an innovative project

N scenario *k*	Integral effect at *k* scenario NPV_k, million UAH	Probability k of the scenario p_k	Expected integral effect NPV_{ee}, million UAH	Risk of ineffectiveness of the project P_e, million UAH	Average possible damage Y_e, million UAH
A	1	2	3	4	5
1	3,7	0,25	0,925		
2	3,5	0,3	1,05		
3	-0,7	0,15	-0,105	0,15	**-0,94**
4	2,7	0,2	0,54		
5	-1,3	0,1	-0,13	0,1	
Total	-	1	2,28	0,25	

Source: Calculated by the authors.

To simplify calculations, the average damage from the implementation of the project, provided that it is ineffective, will be taken through Y_e. It allows determine the expected integral effect by formula 2. To do this, we multiply the integral effect *NPV* for each scenario with the probabilities for each scenario and compare the numbers obtained. Thus, NPV_{ee} = 2,28 million UAH. Next, the risk of project inefficiency was calculated. It allows summarize the probability of scenarios for which the integral effects NPV_k are negative $P_e = 0{,}25$.

The average damage from the implementation of the project in case of its inefficiency is calculated by the formula 3. The sum of the expected integral effects for scenarios with negative integral effects is divided by the risk of project inefficiency $Y_e = -0{,}94$. The calculation shows that as a result of the operation of the project, the effect of the project is expected, taking into account the uncertainty, in the amount of 2,28 million UAH. At the same time, the possible damage in the worst-case scenarios is in the amount of 0,94 million UAH. Suppose that the process of object functioning is considered as discrete and starts from step 1. The object's service life is unlimited. The project is terminated at some step, if at this stage there is a sharp deterioration in the results of work. This is due to the appearance on the market of a cheap product – a substitute or force majeure. The probability that force majeure will occur at some step, provided that it was not at the previous steps, does not depend on the step number and is equal to *p*. In this case, the expected integral effect is determined as follows. The probability that no force majeure will occur at step 1 is *(1-p)*. According to the above data, the amount of income from individual entrepreneurs in 5 years of investment will be equal to UAH 117 million. The amount of expenses – UAH 30 million. Capital investments – UAH 65 million. Suppose that the probability of a cheaper substitute product appearing on the market during one calculation step (year) leads to a sharp deterioration in the IP implementation results. The probability of force majeure is 0.0101 (1.01%) per calculation step. The discount rate is set at 12% per annum. Under such conditions, the expected integral effect, will be:

$$NPVee = (117 – 30) \times (1 - 0{,}0101)5/(1 + 0{,}12)5 - 65 = – 18{,}08\ million\ UAH$$

Thus, the *NPV* of the project according to previously perfect calculations (baseline scenario) amounted to a negative value: –15,57 million UAH. The expected integral effect *NPV*, taking into account the probability of a force majeure event at 1.01% per one calculation step (year) during the investment period (5 years), again takes a negative value (–18,08 million UAH). This change occurred due to the lack of a margin of financial stability of the project. A small deviation in the predicted project implementation leads to an even more negative value.

Suppose that as a result of the IP operation, the maximum possible is predicted in the amount of 1,75 million UAH and the minimum possible in the amount of – 18,08 million UAH. It allows calculate the expected integral IP effect if the standard for accounting for the effect uncertainty is set at 0.3. The calculation of the expected integral effect is carried out according to the formula 5:

$$NPVee = 0{,}3 \times 1{,}75 + (1 – 0{,}3) \times (– 18{,}08) = - 12{,}131\ million\ UAH$$

The expected integral effect, taking into account the interval uncertainty, is negative, which indicates the likelihood of large losses from the sale of IP. The calculation of the expected integral effect from the project with given intervals of probabilities of individual scenarios is shown in Table 2.

Table 2. Expected integral effect of an innovative project with given intervals of probabilities for individual scenarios

N scenario k	Integral effect for *k* scenario NPV_k, UAH million	The intervals of variation of the probability of realization *k* of the scenario p_k		Maximum integral effect, UAH million	Minimum integral effect, UAH million	Expected integral effect ***NPVee***, UAH million
A	1	2	3	4	5	6
1	3,7	from 0,25	to 0,15	0,925	0,555	0,666
2	3,5	from 0,3	to 0,35	1,05	1,225	1,1725
3	-0,7	from 0,15	to 0,2	-0,105	-0,14	-0,1295
4	2,7	from 0,2	to 0,2	0,54	0,54	0,54
5	-1,3	from 0,1	to 0,1	-0,13	-0,13	-0,13
Total	-	1	1	2,28	2,05	**2,119**

Source: Calculated by the authors.

The standard for taking into account the uncertainty of the effect, reflecting the subject's system of preferences in conditions of uncertainty, is taken equal to 0.3. The calculation of the expected integral effect is made according to formula 6. It allows calculate the maximum integral effect *NPV* with the best combination of probabilities. When calculating it, it is necessary to multiply the values of the integral effects at k of the scenario NPV_k by the corresponding values of the probabilities from the interval of their values, providing a greater expected effect. Summing up the results, the maximum possible integral effect:

$$NPVee, = 0{,}3 * 2{,}28 + (1 – 0{,}3) * 2{,}05 = 2{,}12\ million\ UAH$$

Thus, the positive value of the expected integral economic effect indicates the predicted effectiveness of the project. Formula 6 can be used to calculate the maximum and minimum possible values of the expected integral effect in the absence of specified intervals of probabilities for individual scenarios. This version of the calculation using formula 6 is advisable to apply if there is a possibility of complete exclusion of scenarios with positive or negative integral effects in the implementation of IP. The calculation of the expected integral effect from IP, subject to the availability of data on the capabilities of individual scenarios, is presented in Table 3.

Table 3. Expected integral effect of an innovative project, subject to the availability of data on the possibilities of individual scenarios

N scenario k	Integral effect for *k* scenario NPV_k, UAH million	The intervals of variation of the probability of realization *k* of the scenario p_k	Maximum integral effect, UAH million	Minimum integral effect, UAH million	Expected integral effect *NPVee*, UAH million
A	1	2	3	4	5
1	3,7	0,25	0,925		
2	3,5	0,3	1,05		**0,59**
3	-0,7	0,15		-0,105	
4	2,7	0,2	0,54		
5	-1,3	0,1		-0,13	
Total	-	1	2,515	-0,235	

Source: Calculated by the authors.

Thus, the positive value of the expected integral effect indicates the predicted effectiveness of the project under the assumption of a probability mutually exclusive of the implementation of opposite scenarios. Calculations of the expected project efficiency, considering uncertainty, show that the obtained values of the expected integral effect differ from the base integral effect *NPV* by values that take into account the possible development of the project scenario in comparison with the baseline scenario.

Each of the methods for calculating *NPVee* leads to different results for the same indicator – *NPVee*. The deviation of various results of innovative design depends on which directions of change in the baseline scenario are taken in the calculation, and the type of uncertainty is considered in the methodology used. The choice of the type of uncertainty and the direction of the scenarios depends on the specific conditions of investment and should be determined by the management for each specific case of the innovation project.

The desire to minimize risks by adjusting to the worst-case scenario can lead to unreasonably high costs and the creation of too large reserves in the event of a more favourable situation. In addition, many successful innovative projects will be rejected in this case. At λ = 1, the so-called criterion of optimism-pessimism turns into a criterion of extreme optimism, focusing on the best possible scenario, although the probability of its realization is usually not very high. In the paper (Yang, Kum Khiong et al., 1993) it is proposed to assess the effectiveness of the project "as a whole". However, this, in our opinion, is the very effectiveness of participation in the project, only for a hypothetical participant who carries out the entire project at his own expense and receives all the income from this project (net of taxes). In addition, we believe that calculating the effectiveness of a project as a whole is not a very serious matter. The calculation is done mainly in order to advertise the project, in order to attract investors and turn them from potential investors into real ones by providing information about the high efficiency of the project as a whole. Since nothing else can be calculated at this stage (at the next stage, a comprehensive analysis and performance assessment is still carried out for each participant, for his own capital). It is also necessary to adequately take into account all the costs of the project, that is, include the full value of its assets in terms of the amount of expenses incurred for their production (taking into account, if necessary, their revaluation). The main question here is not whether it is necessary to take the initial, replacement or residual value, but whether it is necessary to take into account the full amount of expenses, including past, or only their future value. It is not difficult to prove (see, for example, Lööf and Heshmati, 2003) that in order to decide whether the project should continue, only its future efficiency should be assessed, that is, only future costs and revenues should be taken into account. If assets already created earlier in the project implementation process allow for alternative use (for example, they can be sold), their opportunity cost should be added to the forthcoming expenses. Is it possible to evaluate the effectiveness of participation in the project, regardless of the measures to ensure the financial feasibility of this project. The essence of the error is as follows. In order for the project to be implemented from a financial standpoint, it is necessary that at each step of the calculation the organizer of the project has a sufficient amount of money to cover all costs. A situation is possible when at a certain stage (m) there is not enough money, but at the previous steps there would be an excess of money. This surplus (or part of it) can be deposited at the appropriate steps, and withdrawn from it at step (m) in order to compensate for the lack of funds. In this case, when determining efficiency, it is necessary to take into account additional outflows of money when placing them on a deposit and an additional inflow – when withdrawing from a deposit. The mistake is that these additional outflows and inflows are not counted. For some types of projects (for example, those with high liquidation costs), such errors can lead to a significant distortion of results.

Therefore, for a correct assessment of efficiency, it is first necessary to generate a cash flow that provides a sufficient amount of money at each step of the calculation. Then, for a specific participant (this may be a firm organizing a project or budgets of various levels), determine its inflows and outflows from this cash flow, and then evaluate the effectiveness of its participation in the project.

Conclusions. Based on the study, the authors concluded that those innovative solutions based on the use of progressive accounting methods for assessing the effectiveness of innovations will be the most justified. The conducted research on the implementation of the developed integral methodology for assessing and selecting an innovative project confirmed the fact that the author's methodology provides an adequate and objective quantitative assessment of the effectiveness of financing business development projects. The proposed methodology makes it possible to select the optimal solution, to determine the generalized economic profitability of innovations in terms of financial returns from them, taking into account the time factor. The use of the methodology by companies in the process of substantiating a project's business plan increases the accuracy and objectivity of assessing the expected integral economic effect of an innovative project. The presented approach to assessing an innovative project and identifying the most desirable ways of its implementation allows us to solve the problem of choosing between a more effective and less risky project, which is most often faced by companies. The proposed integral indicator includes qualitative and quantitative performance criteria, as well as criteria for assessing risks in conditions of uncertainty.

Recommendations are given regarding the application of the scenario method for assessing the effectiveness of an innovative project based on probabilistic analysis, including the calculation of the integral indicator of the project, is determined based on the normalized values of the criteria for the effectiveness of the project for each scenario and the weight significance of these criteria for identifying risk groups of an innovative project in accordance with its industry affiliation , as well as determination of the weight of these groups. The proposed method for assessing alternative options for financing an innovative project is based on the use of the indicator of the net present value of the project. This method will allow the investor to fully take into account the costs and obtain an adequate value of the net present value indicator, to compare alternative options for financing the innovation process. Analysis of alternative options for project implementation volumes using an algorithm for enumerating project options will allow you to select an effective package of innovative projects in conditions of budgetary constraints and effectively distribute funds at the initial stage of its implementation. The proposed methodology for assessing the expected integral economic effect of an innovative project based on the scenario analysis of the dashboard provides an unambiguous answer on a quantitative assessment of the level of project efficiency in conditions of uncertainty and risk. On the basis of normalized indicators, uniform integral indicators for assessing the effectiveness of innovative project options for different scenarios were formed.

A distinctive feature of the proposed approach is its flexibility, which manifests itself in the ability to choose one or another optimality principle, vary the weights of performance criteria, and integrate the assessment of risks and uncertainties. This approach is advisable when applied both to the choice of one project from many alternative ones, and makes it possible to form an optimal innovative program with a small transformation. The conducted research on the implementation of the developed integral methodology for assessing and selecting an innovative project confirmed the fact that the author's methodology provides an adequate and objective quantitative assessment of the effectiveness of financing innovative projects. The proposed methodology makes it possible to select the optimal solution, to determine the generalized economic profitability of an innovative project in terms of financial returns, taking into account the time factor. Government structures that provide financial support for business using the proposed methodology among other accepted methods for analysing alternative projects significantly increase the likelihood of achieving the main goal – choosing the best, most appropriate for financing alternative from the various proposed options. The material presented in the article may be of interest to a wide range of readers involved in solving problems related to assessing the effectiveness of socially significant projects. These include the heads of business entities, developers of innovative projects, specialists in the field of strategic planning and management, researchers dealing with the problems of multi-criteria choice of investment decisions in the economy.

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Сценарний аналіз очікуваного інтегрального економічного ефекту від інноваційного проєкту

У статті узагальнено науково-методичні підходи до визначення ефективності впровадження інноваційних проєктів, а також запропоновано методологію оцінювання очікуваного інтегрального економічного ефекту від інноваційного проєкту за сукупністю показників ефективності при забезпеченні сумісності розглянутих сценаріїв. Проаналізовано концептуальні підходи до оцінювання ефективності інноваційного проєкту в умовах невизначеності і ризику. Виявлено особливості оцінювання ефективності інноваційних проєктів та обґрунтовано необхідність визначення очікуваного інтегрального економічного ефекту соціально значущих інноваційних проєктів. Критично вивчено показники ефективності й доцільності оцінювання інноваційного проєкту, а також їх економічну сутність і застосовність в різних економічних умовах. Визначено сукупність показників оцінювання ефективності інноваційних проєктів, виходячи з положень інтегрального підходу, і систематизовано ці показники на основі їх взаємозв'язків. Розраховано очікуваний інтегральний економічний ефект або можливий збиток від реалізації інноваційного проєкту. Розраховано очікуваний інтегральний ефект від інноваційного проєкту із заданими інтервалами ймовірностей в окремих сценаріях. Запропоновано інтегровану методику оцінювання комплексної ефективності інноваційних проєктів, що об'єднує кількісні та якісні показники ефективності, економічний і неекономічний ефекти. Визначено ключові напрямки вибору ефективних інноваційних рішень при наявності неконтрольованих факторів з урахуванням безлічі показників. Розроблено методологію оцінювання ефективних інноваційних проєктів при нестачі або відсутності інформації про умови їх реалізації та функціонування. Розроблено методи визначення кращих варіантів інноваційних проєктів на базі теорії багатокритеріального вибору при забезпеченні сумісності розглянутих сценаріїв.

Ключові слова: інноваційний проект, оцінка, очікуваний інтегральний ефект, чистий дисконтований дохід.