A methodological approach to the evaluation of the effectiveness of innovative projects

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Abstract. Ensuring the sustainable development of the economy depends to a large extent on the implementation of the innovative model, in which the innovation infrastructure plays a key role. The growing number of technoparks in Ukraine has increased the requirements for economic substantiations for decision-making regarding the expediency of implementing their innovative projects. The search for appropriate methods and approaches to project evaluation has determined the actuality of the research topic. The article summarizes the methods of evaluating innovative projects, identifies their advantages and disadvantages. Besides, it reveals the features of the evaluation of innovative projects of technoparks. The novelty of the work is the proposed methodological approach to the evaluation of the efficiency of innovative technopark projects, which takes into account the specifics of the Ukrainian legislation. The methodological approach is based on the generally accepted performance indicators in the world: Net Present Value, Profitability Index, Internal Rate of Return, and Payback Period. Special accounts of technology parks, their participants, and joint ventures are a separate element in the calculation formulas. The application of the proposed methodological approach will accelerate the process of selection of innovative projects and their implementation, activation of innovative activities, and the sustainable development of the state. The proposed methodological approach is tested in the evaluation of the innovative project of the technopark of the E. O. Paton Electric Welding Institute and confirmed the effectiveness of its implementation.

1 Introduction

Ensuring the sustainable development of the economy depends to a large extent on the implementation of the innovation model, in which the innovation infrastructure plays a key role. It provides strong links between the subjects of innovation and, through the realization of its innovative potential, promotes the transfer of knowledge and diffusion of technologies.

An acceptable form for this is any structure that has been tried and tested in the world, and that allows concentrating financial and material resources on innovative development.

The most widespread concept is the technopark concept of development. According to world data, in the developed countries of the world technological innovations implemented within the framework of the specified concept provide almost 50% of efficiency of the market economy, and the share of the latest technologies, innovative products, new approaches in the organization of production and the sphere of services accounts for 80% of GDP growth [1].

The main idea of technoparks is the commercialization of scientific research, the production of which is brought to commercial structures. The combination of interests of developers and consumers caused an increase in the number of science and technology parks in Ukraine, which, in turn, increased the requirements for economic substantiations of decisions on the expediency of implementing innovative projects.

The search for appropriate methods and approaches to project evaluation, based on the current state of the Ukrainian economy, determined the actuality of the research topic.

The purpose of this article is to propose a methodological approach to the evaluation of the efficiency of innovative technopark projects, which will take into account the specifics of the Ukrainian legislation and accelerate the process of selecting the most effective innovative projects for implementation.

2 Analysis of main achievements

Key aspects of economic development are now reoriented in the world. Resources and innovations became key elements in achieving national goals [2].

Prospects for economic development through innovative infrastructure are reviewed in the works of many authors. The development of innovative infrastructure is linked to the implementation of startups

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[3-4], with foreign direct investments [5]. Some scientists focus on the aspects of innovation resource management [6] and argue that ensuring sustainable economic development presupposes the application of different ways of the engagement of stakeholders, which will influence the outcome of the process and the ensuring of sustainability. In an innovation-driven world, collaboration between men of science and business is a prerequisite for sustainable economic growth [7]. The study discusses how different types of collaboration influence the effectiveness of new product development (NPD) [8].

The effectiveness of economic innovation positively correlates with the stability of innovation activity. This means that innovation goals in economics and sustainability can be achieved simultaneously [9].

The study [10] presents the application of an economic-probabilistic model for conducting risk analysis in technological innovation projects. The model integrates risk and economic analysis through quantifying the value as well as the probability of cash flow deviations, which leads to an economic-probabilistic analysis of expected returns. The importance of risk analysis in technological innovation projects is also emphasized in this study. [11].

During the implementation of investment projects with the use of innovations, considerable difficulties appear [12], namely, the determination of project expenses and their planning, as well as the expediency of their effectiveness considering the influence of risk factors. It is proposed to predict and control the cost of a project and its predicted effectiveness at each stage of the project life cycle. At that, it is important to evaluate the possible efficiency of the fluctuation range, which characterizes the degree of stability of the project effectiveness evaluation.

The study [13] is devoted to the examination of the relationship between an emphasis on innovations and relative economic effectiveness. In economic effectiveness management, the main focus is on reducing revenue-related expenses. This implies, not necessarily, reduction in expenses and also the utilization of the revenue that can be derived from investing in innovations. A wide range of methods for the evaluation of innovative projects and the problems of evaluating their effectiveness are reviewed in the works of [14-17]. The authors propose an approach with the use of net present value (NPV).

3 Research methods and results

The main regulations on the creation and functioning of Ukrainian technoparks are given in the Law of Ukraine “On the Special Regime for Innovation Activity of Technology Parks”, No. 991-XIV from 16.07.1999 [18]. The importance of the development of their activity is also emphasized in the Draft Law of Ukraine “On Amendments to Some Legislative Acts of Ukraine on the Activity of Technology Parks”, No. 0943 from 29.08.2019 [19].

In comparison with regular investment projects, the implementation of innovations has its fundamental features:

a) a higher degree of unknown parameters of the project (predicted results, terms of development and implementation, costs, revenues), which significantly reduces the reliability of the preliminary financial assessment of the project. This requires additional selection criteria based on the collection of a large amount of necessary information. Therefore, in parallel there is a definition of what kind of information you need to get in order not to perform additional work, which will lead to an increase in project costs;

b) focus on long-term results, requires more stringent requirements for forecasting and for accounting for the time factor;

c) the need to attract highly qualified scientific specialists who often work part-time. This requires a detailed development of the stages of the project;

d) the possibility of terminating the implementation of the project without significant expenditure of material resources (as, for example, this happens in the manufacturing sector, where, as a result of the impossibility of further financing, all kinds of long-term construction projects emerge, etc.);

e) a high probability of obtaining results that were not expected, but have potential commercial attractiveness. This enables to rely on the rapid diffusion of the project and potentially high profits.

The basis for the work of technoparks is the implementation of innovative projects, each of which requires appropriate funding. An innovation project is inherently an investment project, which is carried out to implement STP in the production and social sphere. Therefore, the most important problem that arises when organizing work on financing innovative projects is to determine their attractiveness to investors.

When choosing the most attractive innovative project, technoparks evaluate their production, financial, and economic capabilities. The market situation is analyzed; production capacities and product range, administrative, management, and scientific-technical staff of the company are carefully viewed. At that, a variety of decision-making methods – from subjective to objective, from intuitive and empirical to accurate – are used. In practice, mixed decision-making methods that are on the border of intuition and science are often used, or they are a combination of both, and form heuristic methods and models.

Technical and economic analysis of evaluating an innovative project that uses the whole set of indicators found a wide application. The advantage of this method is that the project is evaluated from different sides and in much detail. But this requires a large amount of information, which is usually not sufficient.

The very essence of economic tasks presupposes the use of many criteria. However, the selected project evaluation criteria can be controversial, and the known mathematical calculation methods allow determining the optimum only for one objective function. The development of a model that meets all the criteria is still very problematic.

Often the methods used in the evaluation of innovative projects are theoretically less accurate, but in practice more acceptable.

One method is to simply compare the advantages and disadvantages of separate project variants or a few projects. The effectiveness of this method is enhanced by applying a systematic approach to evaluation, that is when each variant (project) is evaluated against the whole set of criteria. The result is a complete list of advantages (+) and disadvantages (–) that are more convenient to show in a matrix form. The choice of variants (projects) can be made by the exclusion method. This method is quite simple but far from accurate, so it can be used only for approximate analysis.

In more complex cases that require detailed analysis, a scoring system is usually used. It helps to evaluate each criterion of the variant (project) according to a certain number of points. A point scale is quite differentiated and allows to evaluate the similar parameters of different projects as well as the different parameters of the same project. In modern conditions, up to 30 project selection criteria are used in US firms. The selection is based on a system of scoring the proposed criteria considering the weighting factors of each of them.

The advantage of the scoring method is that it allows quantifying each criterion and to evaluate the project according to the total score. However, the real value of such conclusions depends on the accuracy of the scoring, intuitively determined. Therefore, in practice, during the decision-making process, besides the scoring system, the cost comparison method is used.

The cost comparison method has a more versatile application because the ultimate conclusion here is based on maximizing profit. The assessment is based on the comparison of investments and future cash inflows. This approach is particularly important when implementing strategic projects, and each innovative project is inherently strategic.

The estimation of the potential profitability of a project is a rather difficult task, but the need and importance of such a task is confirmed by international practice.

Under market conditions, financial and economic factors of attractiveness play a significant role. The greatest attention is paid to the indicators of the absolute efficiency of the projects, which make it possible to evaluate each innovative project separately without solving the problem of reallocation of resources between alternative variants. For technology parks, such an assessment is of particular importance. At the economic substantiation of the technopark project, the following indicators in its business plan are used: payback, net discounted cash inflow, internal rate of return.

Absolute efficiency is evaluated according to the following criteria of the movement of financial flows (expenses and incomes), accepted worldwide:

1) Net Present Value;
2) Profitability Index;
3) Internal Rate of Return;
4) Payback Period.

When evaluating innovative projects, the net present value indicator is one of the main ones. The essence of the method is to calculate the net present value (NPV), which is defined as the difference between the present value of future cash inflows and the present value of investment in the project:

$$NPV = \sum_{i=0}^{n} \frac{CI_i - In_i}{(1+d)^i} \tag{1}$$

where CI_i – annual cash inflows in the i-th year;
In_i – amount of investment in an innovative project in the i-th year;
d – discount rate;
n – project implementation time.

When forecasting annual cash inflows, it is necessary to take into account all their types – both production and non-production – which are related to the project implementation. First of all, it is net income and depreciation. However, if the proceeds are planned to be in the form of an equipment liquidation value or the release of a portion of current assets, they should be taken as income for the relevant periods. Therefore, for the ordinary enterprise the calculation of annual cash inflows will be made by the formula:

$$CI_i = NP_i + A_i + OI_i \tag{2}$$

where CI_i – net income in the i-th period;
A_i – depreciation in the i-th period;
OI_i – other cash inflows in the i-th period.

In such case formula (1) will take the following form:

$$NPV = \sum_{i=0}^{n} \frac{(NP_i + A_i + OI_i) - In_i}{(1+d)^i} \tag{3}$$

By formula (3) it is possible to evaluate any investment project. However, not every investment project is inherently innovative. After reading the Ukrainian legislation, it turned out that there are peculiarities of evaluating an innovative project by a technology park.

The Law of Ukraine “On the Special Regime of Innovative Activity of Technology Parks” [18] provides some privileges for technology parks. For the implementation of technology park projects, the state provides technology parks, their participants and joint ventures that implement technology park projects with targeted subsidies in the amount of import duties, calculated following the Customs Law of Ukraine, when new equipment and component parts, as well as materials that are not manufactured in Ukraine, are imported into Ukraine for the implementation of technology park projects.

These import duties are credited to the special accounts of technology parks, their participants and joint ventures. At that 50% of import duties are credited to the special accounts of the participants of the technology parks and joint ventures that are implementing technology parks projects, and the remaining 50% of import duties are credited to the special account of the governing body of a certain technology park. Besides, during the implementation of technology park projects technology parks, their participants and joint ventures are allowed to accelerate the depreciation of fixed assets involved in the project of the technology park, and the annual 20% rate of the accelerated depreciation of the fixed assets of groups 3 and 4 is set. At that, the depreciation of group 3 fixed assets involved in the technology park project is held until the carrying amount of the group is zero.

Therefore, for technology parks, annual cash inflows will be calculated by the formula which is somewhat different from formula (2):

$$CI_i = NP_i + A_i + SA(P)_i + SA(TP)_i + OI_i, \qquad (4)$$

where $SA(P)_i$ – funds that are credited to the special account of participants of technology parks and joint ventures that are implementing projects of technology parks in the *i*-th period;

$SA(TP)_i$ – funds that are credited to the special account of the governing body of a certain technology park in the *i*-th period.

NPV will be calculated by the following formula:

$$NPV = \sum_{i=0}^{n} \frac{(NP_i + A_i + SA(P)_i + SA(TP)_i + OI_i) - In_i}{(1+d)^i} \quad (5)$$

If the present value of future cash inflows from the project is higher than its original cost or discounted value over several years, then the project should be implemented, and vice versa, if the present cost is lower than the original cost, the project should be rejected because the investor will lose money from the implementation of this project. In other words, the net present value of the approved project should be zero or positive ($NPV \geq 0$) and the net present value of the rejected project should be negative ($NPV < 0$).

The profitability index (*Ip*) is a method that compares the present value of future incomes with initial investments, that is, it's the ratio of the present value of cash inflows to investments. This criterion characterizes income per unit of expenses. It is the best one when arranging independent projects to create an optimal portfolio in the case of a tight budget. In this case, projects with the highest profitability index should be preferred.

The profitability index is calculated by the formula:

$$Ip = \sum_{i=0}^{n} \frac{CI_i}{(1+d)^i} \div \sum_{i=0}^{n} \frac{In_i}{(1+d)^i} \qquad (6)$$

Taking into account formula (6), the profitability index of an innovative project, when executed by a technology park, will be calculated by the following formula:

$$Ip = \frac{\sum_{i=0}^{n} \frac{(NP_i + A_i + SA(P)_i + SA(TP)_i + OI_i)}{(1+d)^i}}{\sum_{i=0}^{n} \frac{In_i}{(1+d)^i}} \qquad (7)$$

The profitability index, in contrast to the net present value, is a relative value. In the numerator of formula (7) the value of income before the beginning of the innovation selling process is specified, and in the denominator the value of investments in innovations discounted before the beginning of the investment process is given. In other words, the two parts of the payment stream are compared: income and investment.

The profitability index is closely linked to the integral effect of implementing an innovative project that acts as a net present value (*NPV*). If $NPV > 0$, then $Ip > 1$ and the project is accepted. Conversely, if $NPV < 0$, then $Ip < 1$, and the project is considered ineffective.

Internal rate of return (*IRR*) is a very popular metric when evaluating the expediency of investing. It is the discount rate at which discounted income over a specified period of time is equated with innovative investments. In this case, the income and expenses of the innovation project are determined by bringing it to the estimated moment.

In other words, the internal rate of return characterizes the level of profitability of a certain innovation project through a discount rate, at which the future value of the income from innovation is brought to the present value of the investments.

Abroad, the calculation of the internal rate of return is often used as a first step in the quantitative analysis of investments. For further analysis innovative projects, in which the *IRR* is 15-20%, are chosen. The calculated *IRR* value is compared with the required rate of return for an investor. An innovative solution can be considered only when the *IRR* value is not less than the investor needs.

If the innovative project is fully financed by a bank loan, the *IRR* value indicates the upper limit of the permissible level of bank interest rate, the excess of which renders the project economically inefficient. If the project is financed from other sources, the lower IRR value corresponds to the cost of the advanced capital, which can be calculated as the arithmetic weighted average of the payments for the use of the advanced capital.

Practical use of this method is reduced to a successive iteration, by which the discount factor which will ensure equality $NPV = 0$ is found, or:

$$\sum_{i=0}^{n} \frac{CI_i - In_i}{(1+IRR)^i} = 0 \qquad (8)$$

For technology parks, formula (8) in view of formula (7) will have the following form:

$$\sum_{i=0}^{n} \frac{(NP_i + A_i + SA(P)_i + SA(TP)_i + OI_i)}{(1+IRR)^i} -$$

$$- \sum_{i=0}^{n} \frac{In_i}{(1+IRR)^i} = 0 \qquad (9)$$

Using the calculations (or tables), two discount rates are selected so that in the interval (d_1, d_2) the $NPV = f(d)$

function would change its value from "+" to "–" ($d_2 > d_1$). Thus, at this interval, there is a root of the equation $f(d) = 0$. To do this, use the formula:

$$IRR = d_1 + \frac{NPV(d_1)}{NPV(d_1) - NPV(d_2)} \cdot (d_2 - d_1) \quad (10)$$

where d_1 – value of the discount rate at which $f(d) > 0$;
d_2 – value of the discount rate at which $f(d) < 0$.

The payback period (T) is one of the most common indicators of evaluating the effectiveness of investments in an innovative project. In contrast to the indicators used in domestic practice, the payback period of capital investments is not based on profit but cash flow, bringing investment into innovation and cash flow to its original value.

In a market economy investing is closely linked with significant risk and the longer the payback period, the greater this risk. Market conditions and prices can change significantly during this time. This is especially true for industries with high tempo of STP, when the emergence of new technologies or products is rapidly devaluing previous investments.

The payback period is used when there is no certainty that an innovative project will be implemented and so the owner of funds does not risk entrusting the investment for a long period of time.

The payback period of the project is determined according to preliminary calculations of net cash inflows (CI) and net present value (NPV):

$$T = p + NPV_p / CI_{p+1}, \quad (11)$$

where p – last year when $NPV < 0$;
NPV_p – net present value in the p-th year (without sign "–");
CI_{p+1} – value of net cash inflows in the (p + 1) year;

International practice has established that the payback period of the innovation must not exceed five years, which should be accepted in the calculations.

It's worth to say that during the analysis of alternative projects, the considered criteria may contradict each other, that is, a project which is acceptable by one criterion may be rejected by another.

In case of contradiction, it is recommended to take the net present value criterion as the basis.

Having considered the basic methods of the evaluation of innovative projects by a technopark, let's use them in practice. The technology park of the E. O. Paton Electric Welding Institute is in the first turn preparing for the implementation of an innovative project on the creation of new technology and equipment for semi-automatic welding, which presupposes the production of new lightweight panels for space and rocket, aeronautical, shipbuilding and other industries. The term of the implementation of this innovative project is 5 years.

All necessary data for the calculation is given in Table 1.

It is estimated that the investment in the project will amount to 80 million UAH and will be made before the project implementation is started. Capital investment will be done in the form of equipment belonging to the third group of fixed assets. For the implementation of the project, they anticipate the procurement of component parts and materials not produced in Ukraine with their average import duty amounting to 2% of anticipated current expenses.

Table 1. Results of the implementation of the innovative project by the technopark, thousand UAH

Indicators	**Years**				
	1	*2*	*3*	*4*	*5*
Sales revenue	51680	52160	57600	58720	60400
Current expenses	35700	36600	37500	40200	40650
Depreciation	16000	16000	16000	16000	16000
Residual value of equipment (at the end of the year)	64000	48000	32000	16000	0
Taxable income	15980	15560	20100	18520	19750
Income tax	2876,4	2800,8	3618	3333,6	3555
Net income	13103,6	12759,2	16482	15186,4	16195
Special account funds (total)	714	732	750	804	813
Special account funds of technopark participants	357	366	375	402	406,5
Special account funds of the governing body of the technopark	357	366	375	402	406,5
Net cash inflows	29817,6	29491,2	33232	31990,4	33008

When determining net discounted income and net present value, the technopark management proceeds from a 15% rate on an alternative bank deposit. The results of the calculation of these indicators are given in Table 2.

Table 2. Calculation of net present value of the innovation project, thousand UAH

Indicators	**Years**					
	0	*1*	*2*	*3*	*4*	*5*
Net cash inflows	-80000	29817,6	29491,2	33232	31990,4	33008
Discount factor	1	1/1,15	1/1,323	1/1,521	1/1,749	1/2,0114
Net discounted cash inflow	-80000	25928,4	22299,6	21850,6	18290,6	16410,8
Net present value	-80000	-54071,6	-31772,0	-9921,4	8369,2	24780,0

Performing calculations, special attention should be paid to two points: the order of depreciation and the presence of special accounts, which play a significant role in determining net cash inflows. As far as the technopark invests in equipment belonging to the third group of fixed assets, then, as mentioned above, depreciation will be carried out at an increased rate – 20% until the carrying value of zero is reached. Therefore, during the implementation of this innovative project, the annual depreciation will amount to 80/5=16 million UAH. Besides, as a result of the targeted state subsidy on the amount of import duty on component parts and materials that are not produced in Ukraine, two special accounts will be created: the account of technopark participants and the account of the governing body of the technopark. Following formula (4) the funds on these accounts will also be included in the calculation of net cash inflows, besides depreciation and net income.

Thus, this innovative project is profitable because its net present value is greater than zero: $NPV = 24780{,}0>0$. Let's find other indicators that are necessary for evaluating the innovative project of the technopark.

The profitability index can be found by formula (7):

$$Ip = (25928{,}4 + 22299{,}6 + 21850{,}6 + 18290{,}6 + \\ + 16410{,}8) / 80000 = 1{,}31$$

Using formula (9) we find that in the interval (27%, 28%) the function f(d) changes the sign:

$$d_1 = 27\% \qquad f(d_1) = 274{,}5$$

$$d_2 = 28\% \qquad f(d_2) = -1334{,}8$$

Therefore, the root of the equation exists on this very segment. By formula (10) we find the internal rate of return:

$$IRR = 27 + \frac{274{,}5}{274{,}5+1313{,}8} \cdot (28 - 27) = 27{,}16\ (\%)$$

In order to calculate the payback period, it should be noted that net present value changes its sign from "–" to "+" between the 3rd and 4th years, therefore, using formula (11) we get:

$$T = 3 + 9921{,}4 / 18290{,}6 = 3 + 0{,}54 = 3{,}54 \text{ (years)}$$

Let's analyze the obtained results: net present value is positive and amounts to UAH 24780,0. Thus, the innovative project is effective and needs implementation; profitability index is greater than one ($Ip = 1{,}31 > 1$), what confirms the conclusion about the effectiveness of the project; internal rate of return is 27,16%. It is higher than the alternative bank deposit interest rate (15%). Therefore, the project is effective; the innovative project is long-term, as it will pay off in 3,54 years.

These calculations give grounds to claim that the innovative project of the technopark of the E. O. Paton Electric Welding Institute is effective and can be accepted for implementation.

4 Conclusions

Methods of the evaluation of innovative projects of technoparks are here generalized. All of them are aimed at making the right decisions on the choice of this or that innovative project and calculating the economic effectiveness of its implementation. However, the evaluation methods related to absolute efficiency have one major drawback: the calculation of its components is based on the legislation of Ukraine, which, at present, often changes as to technoparks.

As a result of the scientific research, a methodological approach to the evaluation of the effectiveness of innovative projects has been proposed, which takes into account the specifics of the Ukrainian legislation in the provision of certain privileges for technology parks. A separate element in the proposed calculation formulas is the special accounts of technology parks, their participants, and joint ventures.

The application of the proposed methodological approach to the evaluation of innovative projects of technoparks will accelerate the process of selection of innovative projects and their implementation by technoparks, will facilitate the activation of innovative activities and the formation of sustainable innovation culture of Ukraine, what, in its turn, will contribute to the sustainable development of the state.

The proposed methodological approach is tested in the evaluation of an innovative project on the creation of new technology and equipment for semi-automatic welding. The innovation project is a priority for the implementation by the technopark of the E. O. Paton Electric Welding Institute. It also presupposes the production of new lightweight panels for space and rocket, aeronautical, shipbuilding and other industries. The calculations carried out in this scientific study give grounds to state that the innovative project of the technopark of the E. O. Paton Electric Welding Institute is effective and can be accepted for implementation. This confirms the effectiveness of the use of the methodological approach proposed in the article.

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