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О МЕТОДАХ СРАВНЕНИЯ ИНВЕСТИЦИОННЫХ ПРОЕКТОВ В РАКЕТНО-КОСМИЧЕСКОЙ ОТРАСЛИ

ABOUT METHODS OF COMPARISON OF INVESTMENT PROJECTS IN THE ROCKET AND SPACE INDUSTRY

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Управленческие решения относительно целесообразности реализации инвестиционных проектов необходимо принимать на основе всех пяти видов факторов - социальных, технологических, экологических, экономических, политических. В статье проанализированы возможности обоснованного расчета финансового потока и коэффициента дисконтирования, используемых для оценки экономической эффективности. Введены такие динамические показатели инвестиционных проектов, как чистая текущая стоимость *NPV*, внутренняя норма доходности *IRR*, дисконтированный срок окупаемости *DPP*. Проведен их расчет для простейшего инвестиционного проекта. Итоги сравнительного анализа трех характеристик инвестиционного проекта таковы. Область применимости *NPV* и *DPP* - период стабильности экономической ситуации, причем требование стабильности касается как микроэкономической, так и макроэкономической сфер, поскольку речь идет о возможности применения определенного значения коэффициента дисконтирования *q*. Область применимости *IRR* шире, так как речь идет не об определенном значении *q*, а выделении интервала значений коэффициента дисконтирования, в котором инвестиционный проект экономически выгоден. С точки зрения теории устойчивости целесообразно вычислять все три характеристики *NPV*, *IRR* и *DPP*, затем сопоставлять выводы, сделанные на основе значений этих характеристик. Управленческие решения относительно возможности и целесообразности реализации инвестиционных проектов необходимо принимать на основе тех или

Management decisions regarding the expediency of implementing investment projects must be made on the basis of all five types of factors - social, technological, environmental, economic, political. The article analyzes the possibilities of a reasonable calculation of the financial flow and the discount factor used to assess economic efficiency. Such dynamic indicators of investment projects as net present value NPV, internal rate of return IRR, discounted payback period DPP are introduced. They were calculated for the simplest investment project. The results of a comparative analysis of the three characteristics of the investment project are as follows. The area of applicability of NPV and DPP is the period of stability of the economic situation, and the requirement of stability applies to both microeconomic and macroeconomic spheres, since we are talking about the possibility of applying a certain value of the discount factor q. The area of applicability of IRR is wider, since we are not talking about a certain value of q, but the allocation of the interval of values of the discount coefficient, in which the investment project is economically profitable. From the point of view of stability theory, it is advisable to calculate all three characteristics NPV, IRR and DPP, and then compare the conclusions drawn on the basis of the values of these characteristics. Management decisions regarding the possibility and expediency of implementing investment projects must be made on the basis of certain expert technologies, relying on the experience and intuition of experts. In a typical innovation process, 13 stages are identified. They are united in three stages, the transition from one of them to the next is usually associated with a change of ownership. It is shown that the introduction of innovation at the final иных экспертных технологий, опираясь на опыт и интуицию экспертов. В типовом инновационном процессе выделены 13 этапов. Они объединены в три стадии, переход от одной из них к следующей обычно связан со сменой собственника. Показано, что внедрение новшества на заключительной стадии переходит в реализацию инвестиционного проекта, что оправдывает использование термина "инновационно-инвестиционный процесс", часто используемого в ракетно-космической отрасли. Полученные результаты позволяют повысить обоснованность выводов об экономической эффективности инвестиционных проектов. Необходимы соответствующие изменения в преподавании экономических и управленческих дисциплин, позволяющие побудить обучающихся избегать неоправданно широкого бездумного применения рассмотренных показателей экономической эффективности инвестиционных проектов

stage turns into the implementation of an investment project, which justifies the use of the term "innovation-investment process", which is often used in the rocket and space industry. The results obtained make it possible to increase the validity of conclusions about the economic efficiency of investment projects. Appropriate changes are needed in the teaching of economic and managerial disciplines to encourage students to avoid the unreasonably wide thoughtless application of the considered indicators of the economic efficiency of investment projects

Ключевые слова: ИНВЕСТИЦИОННЫЙ ПРОЕКТ, ЭФФЕКТИВНОСТЬ, ЭКОНОМИЧЕСКАЯ ОЦЕНКА, ЭКОНОМИКО-МАТЕМАТИЧЕСКИЕ МОДЕЛИ, УПРАВЛЕНИЕ, УСТОЙЧИВОСТЬ, ЧИСТАЯ ТЕКУЩАЯ СТОИМОСТЬ, ВНУТРЕННЯЯ НОРМА ДОХОДНОСТИ, ДИСКОНТИРОВАННЫЙ СРОК ОКУПАЕМОСТИ, ИННОВАЦИОННЫЙ ПРОЦЕСС

Keywords: INVESTMENT PROJECT, EFFICIENCY, ECONOMIC ESTIMATION, ECONOMIC AND MATHEMATICAL MODELS, MANAGEMENT, STABILITY, NET PRESENT VALUE, INTERNAL RATE OD RETURN, DISCOUNTED PAYBACK PERIOD, INNOVATION PROCESS

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Introduction

Investment management is one of the main areas of modern management (see, for example, [1]). An investment is an investment in a project. Funds can be financial, material, personnel, in the form of services, etc. Investors are those who make investments. The goals of investors may be different. In some cases, but by no means always, they seek to obtain precisely the economic effect. In the general case, investment decisions are made on the basis of the values of not one, but five groups of factors corresponding to the projects under consideration. We are talking about social, technological, environmental, economic, political groups of factors. This statement is especially important in the rocket and space industry, the problems of which are devoted to a number of works of the author of this article.

The main provisions of investment management formulated above reflect the point of view of the author [1]. There are other definitions of the considered area of management in the literature.

Sometimes resources are understood only as financial means, and the goal is reduced to making a profit. We cannot agree with such an extremely simplified point of view. For example, to implement projects in the rocket and space industry, it is necessary to attract not only one or another amount of money, but also material resources (machines, buildings, transport, etc.), intangible assets (results of research and development work , patents, etc.), the required number of skilled workers and managers, allocate sufficient time to complete the work on the project, etc. It is impossible today to allocate financial resources, and tomorrow to get a ready-made spacecraft of a new type. The failure of such expectations is reflected in the well-known parable: “It takes a woman nine months to bear a child. The financier asks: How long does it take nine women to bear one child? It is expected that in a month". Note that the attraction of resources does not mean that they are completely created at the expense of the investor's funds. They are attracted (they are allocated) in the required amount to complete the project, after which (or simultaneously) they are used to implement other projects.

With the receipt of profit is also not all clear. When trying to calculate the value of this financial and economic indicator, it becomes necessary to choose one of the many types of profit. So, production profit differs from the balance sheet used for taxation. You must select the time period for which the profit is calculated. on the basis of which a decision is made on the implementation of the project or on the choice of one project from several. Optimal solutions are determined by the planning horizon and may vary depending on its size. Finally, when making managerial decisions, the head of an economic unit takes into account, in addition to profit, the achievement of other goals, including the need for mandatory implementation of the state order, an increase in market share, an increase in the scientific and technical level of the enterprise, personnel development, etc. John Kenneth Galbraith (1908-2006), "major corporations are driven by the desire for security and expansion, not the pursuit of maximum profit" [2].

The article is devoted to the discussion of methods of analysis and comparison of investment projects in order to prepare management decisions. Let us consider two problem statements that can be solved by applying such methods. First, is the project profitable from an economic point of view? Second - which of the two projects is more profitable? This article is a continuation of [3]. This publication provides definitions and designations of the main characteristics of investment projects, we will not repeat them here.

Basic ideas of investment management

The historical analysis of methods for calculating the effectiveness of investments is given in the article [4]. Note that when applying a number of characteristics of investment projects, the term "efficiency" cannot be used in the sense accepted in economics as the ratio of economic effect to costs. These are characteristics such as internal rate of return and (discounted) payback period.

Methods for analyzing investment projects are considered in detail in a number of monographs (see primarily [5, 6]), including those on decision theory [7–9]. The most fundamental monograph (1300 pages) on this topic was prepared by P.L. Vilensky, V.N. Livshits and S.A. Smolyak [10].

In mathematical modeling of investment projects, such concepts as financial flow and discount factor (or factors) are used. Let's discuss them.

We will consider time as discrete, with a step of 1. The transition to continuous time does not cause mathematical difficulties. However, the results are summarized discretely, once a year, quarter or month.

Let us recall the main concepts and notation introduced in [3], which is continued by the present paper.

Let discrete moments of time be used when modeling an investment project, for which, without loss of generality, we can take the numbers 0, 1, 2, 3, ...,*k*, where 0 corresponds to the beginning of the project implementation, and k is the planning horizon (the length of the planning interval). Under financialthe flow of an investment project is understood as a sequence of numbers a(0), a(1), a(2), ..., a(k), ..., where a(t) is an assessment of the results of the project according to the results of the time interval with the number t, i.e. the difference between receipts and payments (expenses) from the moment (t - 1) to the moment t (the balance for the interval with the number t), and a(0) is a negative number and is equal to the initial investments (i.e. investments at the moment 0) with a sign minus.

There are two significantly different tasks for evaluating the effectiveness of an investment project - when the project is already completed (we analyze the past - according to completed projects) and when it continues or begins. In the first case, you can use current prices, in the second - prices at the moment the project started (or at that moment between the past and the future, at which the known history of the project ends and its future begins). To calculate the net present value and other indicators of the effectiveness of investment projects, the financial flow must be measured in comparable prices, excluding the effect of inflation (changes in the purchasing power of funds). For past time points, the transition to comparable prices is carried out using inflation indices known to the researcher and current prices at the corresponding time points.

A number of our works [11, 12] are devoted to the problems of inflation calculations. These problems are analyzed in most detail in chapter 4 of our textbook "Econometrics" (4th edition) [13, p.198 - 274]. We emphasize that the values of inflation indices are determined not only by prices, but also by the consumer basket used. Such a basket should correspond to the set of goods and services that is used in the implementation of the project. According to it, calculations should be made for completed (fully or partially) investment projects. Industry-specific and related to the entire national economy inflation indices can be found in the materials of Rosstat. However, their applicability to the analysis of a particular investment project must be carefully justified.

Practice shows that a reasonable forecast of inflation indices for the future is impossible. Therefore, it remains to carry out calculations in prices at the initial moment of time. This recommendation is based on the assumption that the ratio of prices for goods and services used in the project is stable. Such stability can be disrupted by various innovations in the area of economic practice to which the investment project under consideration belongs.

Sometimes they ask whether depreciation should be included in payments when calculating the cash flow? If the investment project is carried out entirely at the expense of the investor's financial investments, then the answer is no, because otherwise a double count will occur. In other words, the depreciation expense has already been paid out of the initial investment. If, in addition to financial resources, material resources and intangible assets are involved, the labor of employees and managers is used, then the corresponding costs must be reimbursed during the implementation of the project.

Unlike financial flows determined by the microeconomic situation in the implementation of an investment project, the situation in the economy as a whole affects the discount coefficients, i.e. they should be considered macroeconomic. This can be seen from the methods of their practical calculation. For example, it is natural to determine the value of the discount factor by comparing the economic effect of an investment project with the effect of investing initial financial resources in a bank deposit. We are talking about the so-called "price of capital", determined by bank interest on the equity and borrowed capital that will be used in the implementation of the project. It is clear that the dynamics of these percentages depends on the macroeconomic dynamics. In particular, they believe that the discount factor should be higher than the refinancing rate of the Central Bank of the Russian Federation.

Table 1.

Dynamics of the refinancing rate of the Central Bank of the Russian Federation (in %)

date	Bid	date	Bid	date	Bid
2019.07.26	7.25	2021.03.19	4.5	2022.02.28	20.0
2019.09.06	7.0	2021.04.23	5.0	2022.04.08	17.0
2019.10.25	6.5	2021.06.11	5.5	2022.04.29	14.0
2019.12.14	6.25	2021.07.23	6.5	2022.05.26	11.0
2020.02.07	6.0	2021.09.10	6.75	2022.06.10	9.5
2020.04.24	5.5	2021.10.22	7.5	2022.07.22	8.0
2020.06.19	4.5	2021.12.17	8.5	2022.09.17	7.5
2020.07.24	4.25	2022.02.11	9.5	-	-

How to determine the discount factor? You can use one or another method of expert assessments [14 - 18]. A special case of expert evaluation is a reference to the value adopted in a particular organization.

Sometimes it is recommended to use to determine q formula

$$1 + q = (1 + a)I(1 + R)(1)$$

or its analogue with the replacement of the product by the sum. Here (1 + a) is the discount factor in the absence of inflation and risk, I is the inflation index (not used when using fixed prices), R is the risk adjustment. However, the values of the multipliers cannot be reasonably determined.

If the financial flow and the discount factor are given, then various static ones are introduced (i.e. for$q$= 0) and dynamic performance indicators of investment projects (for q > 0). Of these, we consider three dynamic estimates.

Net present value, as you know, is determined by the formula

$$\mathrm{NPV} = \mathrm{NPV}(q) = a(0) + \frac{a(1)}{1+q} + \frac{a(2)}{(1+q)^2} + \frac{a(3)}{(1+q)^3} + \dots + \frac{a(k)}{(1+q)^k}. (2)$$

The characteristic NPV (from Net Present Value - English) is sometimes called net present value. However, NPV can also be a negative number, and the situation when the income turns out to be negative does not correspond to the traditions of using Russian words. Another name for the NPV characteristic is the reduced value of the cash flow [4]. There are other translations of the term under consideration, the discussion of which we do not consider it useful to give here.

Since it is difficult to justify the choice of one or another value of the discount factor, there is a desire to find out whether the valueNRV is positive (that is, the investment project will be economically profitable) for all possible values of this coefficient in a particular situation. Consider the net present value as a function of the discount factor (with a fixed planning horizon and the same financial flow. The considered function NPV(q) is continuous and, as a rule, positive at q = 0. Therefore, it is also positive at a certain interval (0 , q0), where q0 is the root of the equation

$$NPV(q)=0 \quad (3)$$

Equation (3), generally speaking, can have several roots. There are corresponding examples in the literature [5, 6, 10]. However, as stated in [3], "the dynamics of the financial flow is usually described by a typical dependence, which is characterized by a negative value at the initial moment, then also negative values, corresponding, for example, to the design and construction of an object in which investments are made, followed by a transition to growth , reaching positive values and then reaching a fairly long plateau, at the end of the implementation interval, the project ends, for example, with disposal. It has been established that in the case when the financial flow is described by the specified typical dependence, the solution of equation (3) is the only one. This equation can have several roots when the implementation of the project includes several stages, for example, associated with the sequential construction of a number of facilities. Then the financial flow is described by a dependence with several sections of negative dynamics in the balance of receipts and payments, since at the beginning of the construction of the next project, payments increase sharply, while receipts remain at the achieved level.

under the internal rate of return*IRR*(from Internal Rate of Return - English). understand the smallest (positive) root of equation (3). If the discount factor is less than IRR, i.e. q < IRR, then the net present value is positive, NPV(q) > 0, i.e. investment project is economically profitable. In practice, quite often a significant uncertainty in the discount factor is combined with the certainty that all possible values of the discount factor are less than the internal rate of return, i.e. fulfillment of the inequality q < IRR. Then we can conclude that the investment project is economically profitable, and use this conclusion when making management decisions. At the same time, the value of the net present value remains uncertain, but there is confidence that this value is positive.

Since all terms of the net present value, except for the first*a*(0), tend to 0 with an unlimited growth of the discount factor, then the internal rate of return exists for any investment project.

Let us now discuss the dynamics of the net present value as a function of the planning horizon *k*(see formula (2) above). For k = 0, the value of this function is negative. If the financial flow is described by the above typical dependence, then as k increases, the net present value may first decrease, but then it begins to increase and at some point crosses the abscissa axis, i.e. goes from negative to positive. This moment is called the discounted payback period DPP (from Discounted payback period - English). Find a natural number k such that NPV(k - 1) <0 and NPV(k) > 0 and set DPP = k. Sometimes it is recommended to carry out linear interpolation for a more accurate calculation of DPP. Then the value of this characteristic is not a natural number.

Unlike net present value and internal rate of return, a discounted payback period does not exist for all investment projects, but only for those for which

NPV(k) > 0 for some k. If this condition is not met, then the investment project will never pay off. The decision on the expediency of its implementation can be made on the basis of social, technological, environmental, political factors, but not on the basis of economic ones.

We will proceed to a further discussion of the characteristics of investment projects after considering the simplest situation.

Analysis of the simplest investment project

In the simplest case, the investment project is described as follows. First, the investor invests in the project *A* monetary units, and then every year for k years receives an income in the amount of B monetary units. In this case, the financial flow looks like this: a(0) = (-A), a(1)= a(2) = ... = a(k) = B.

Let's find the main characteristics of this investment project: net present value, internal rate of return, payback period. Let the discount factor be equal to$q$.

Then the net present value is

$$\mathrm{NPV} = \mathrm{NPV}(A, B, q) = -A + \frac{B}{1+q} + \frac{B}{(1+q)^2} + \dots + \frac{B}{(1+q)^k}. \quad (4)$$

Because the

$$\mathrm{NPV} = \mathrm{NPV}(A, B, q, k) = -A + \frac{B}{1+q}\left(1 + \frac{1}{1+q} + \dots + \frac{1}{(1+q)^{k-1}}\right), \quad (5)$$

then we use the formula for the sum of a geometric progression

$$1 + a + a^2 + \dots + a^n = \frac{1-a^{n+1}}{1-a} \quad (6)$$

at$a \neq 1$,in which we put

$$a = \frac{1}{1+q}, n = k - 1. \quad (7)$$

Hence,

$$\mathrm{NPV}(A, B, q, k) = -A + \frac{B}{1+q}\left(\frac{1-\frac{1}{(1+q)^k}}{1-\frac{1}{1+q}}\right) = -A + \frac{B}{q}\left(1 - \frac{1}{(1+q)^k}\right). \quad (8)$$

From the obtained equality it follows, in particular, that always

$$\mathrm{NPV}(A, B, q, k) < -A + \frac{B}{q}. \quad (9)$$

Thus, at

$$-A+\frac{B}{q}\leq 0,\frac{B}{q}\leq A,\mathrm{Aq}\geq B \quad (10)$$

The investor's investment will never pay off. If

$$-A+\frac{B}{q}>0, \quad \text{(eleven)}$$

then they will pay off with a sufficiently long duration of the project, i.e. at

$$-A+\frac{B}{q}>\frac{1}{(1+q)^{k}} \quad (12)$$

those. at

$$k>\frac{\ln q-\ln(B-\mathrm{Aq})}{\ln(1+q)}. \quad (13)$$

The right side of the last inequality gives the value of the discounted payback period.

In static methods for evaluating investment projects, discounting is not carried out, i.e. believe q= 0, then a = 1 and

$$N(A,B,0,k)=-A+\mathrm{kB}. \quad (14)$$

The project will pay off

$$-A+\mathrm{kB}\geq 0,k\geq\frac{A}{B}. \quad (15)$$

Obviously, in dynamic methods (i.e., with positive$q$) the inequality

$$N(A,B,q,k)<N(A,B,0,k), \quad (16)$$

those. the net present value is always less than with static methods. The discounted payback period is always longer than the A/B payback period calculated using static methods.

Internal rate of return *IRR* is a solution (with respect to q) to the equation

$$\mathrm{NPV}(A,B,q,k)=-A+\frac{B}{q}\left(1-\frac{1}{(1+q)^{k}}\right)=0.(17)$$

If the duration of the project is long enough ($k\to\infty$), then the second term in brackets can be neglected and IRR can be found from the condition

$$-A+\frac{B}{\mathrm{IRR}}=0,\mathrm{IRR}=\frac{B}{A}.(18)$$

Areas of applicability of the main characteristics of investment projects

Article [3] found that the net present value *NPV* can reasonably be used only for short-term (in terms of payback period) projects, during the implementation of which the economic situation does not change, i.e. the financial flow remains fixed, the elements of which are the differences between receipts and payments for successive time intervals. The reasons for a possible change in the financial flow may be technological and managerial innovations (including changes in legislation and regulatory and technical documentation).

Of great importance are the problems of the beginning and end of the period during which the financial flow is analyzed.

The problem of the beginning is connected with the choice of the reporting point from which the implementation of the investment process begins. Usually, the development of an investment project begins earlier than the official start on the basis of preliminary developments, culminating in the adoption of a management decision to start the implementation of this project. Expenses for preliminary developments, as a rule, are classified as expenses for exploratory research and are not included in the costs of an investment project, since they are paid, for example, from the fund for the development of new technology. Obviously, this practice reduces the costs of the investment project, although by an insignificant amount compared to the costs after the start of the project. However, it is difficult to take into account the preliminary costs, since, for example, it would be necessary to include in them part of the costs of vocational training of specialists,

The issue of the end is more important. Its appearance is determined by the fact that the choice of the end of the project is difficult to justify. Often this moment is determined by the volitional decision of the decision makers. At the same time, the results of the project implementation often continue to be used even after the official end of the project. These are, for example, buildings constructed during the course of the project, or technological equipment created or purchased for use in the course of the project. Usually, limiting the planning horizon leads to an underestimation of the economic effect. If we increase this horizon, then the net present value*NPV*will increase. However, the opposite effect is also possible if the costs of terminating the project and disposal of waste and equipment are significant, but the corresponding work is not included in the investment project. For example, projects for the creation of nuclear power plants often do not include the costs of disposing of spent nuclear materials. They leave the problem of disposal for the future, while methods for solving this problem have not been developed to date.

Much more difficult is the problem of choosing a reasonable choice of the discount factor. This problem does not refer to the sectoral, but to the macroeconomic level, i.e. at the level of the state and even the world economy as a whole. Many difficulties were noted above in this article and in [3], so we will not discuss them in detail here.

When analyzing completed projects or the initial part (consisting of periods completed to date) of current projects, discounted factors can be estimated (if the necessary information is available). Note that they obviously vary from period to period.

To analyze the future development of the project, it is necessary to accept certain hypotheses about the values of the discount coefficients. One of these hypotheses is the assumption that the discount coefficients, although they change, differ little from some average value q. Thus, the situation is described using the errorΔq determining discount factors, i.e. for all future periods, such coefficients lie in the interval$(q - \Delta q; q + \Delta q)$.Discount factor uncertainty leads to uncertainty$\Delta \mathrm{NPV}(q)$net present value NPV(q). In other words, the real value of NPV lies in the interval$(\mathrm{NPV}(q) - \Delta \mathrm{NPV}(q); \mathrm{NPV}(q) + \Delta \mathrm{NPV}(q))$.

Uncertainty$\Delta \mathrm{NPV}(q)$ can be found on the basis of interval data statistics approaches detailed in [8, 9, 19–23]. Calculation methods$\Delta \mathrm{NPV}(q)$obtained in [24 - 26]. The final article of this series is the work [27].

The rules for obtaining conclusions based on the calculations performed must be changed compared to the classical situation, when the discount factor is constant. So if the interval$(\mathrm{NPV}(q) - \Delta \mathrm{NPV}(q); \mathrm{NPV}(q) + \Delta \mathrm{NPV}(q))$ is located completely to the right of 0, then the project is certainly profitable. If this interval lies completely to the left of 0, then the project is unprofitable from an economic point of view. If $\mathrm{NPV}\,(q) - \Delta\mathrm{NPV}(q) < 0; \mathrm{NPV}(q) + \Delta\mathrm{NPV}(q) > 0$, then we have uncertainty - the project may turn out to be both profitable and unprofitable.

Consider the problem of comparing the economic efficiency of two investment projects. Let for the first project the real value *NPV* lies in the interval$(\mathrm{NPV}_1(q) - \Delta\mathrm{NPV}_1(q); \mathrm{NPV}_1(q) + \Delta\mathrm{NPV}_1(q))$, and for the second - in the interval$(\mathrm{NPV}_2(q) - \Delta\mathrm{NPV}_2(q); \mathrm{NPV}_2(q) + \Delta\mathrm{NPV}_2(q))$. If these intervals do not intersect, then the conclusion is unambiguous - that project is more profitable, in which the entire interval corresponding to it lies to the right of the interval for another project. If the intervals have a common part, then we have uncertainty - both the first and the second project can be more profitable. Similarly, you can parse the comparison of three or more investment projects.

In the presence of these uncertainties, it is natural to further evaluate and compare investment projects using expert methods [14–16], primarily based on the intuition of experts (our works [28–31] are devoted to the problems of intuition and its development).

However, in real economic practice, we do not always observe small deviations of the discount coefficient from some average value$q$. In such cases, the net present value NPV(q) is not a reliable basis for making informed management decisions, even taking into account the possibility of calculating its error$\Delta\mathrm{NPV}(q)$,because the errorΔq the discount factor is not small, which is required to apply the methods of [27]. If the errorΔq If the discount factor is large enough, then the direct numerical assessment of the error in the net present value is large, and therefore the uncertainty interval for this characteristic is long, which makes it impossible to obtain sound management decisions based on this characteristic.

Due to these shortcomings of the net current value *NPV* in practice, when preparing management decisions, it is much more often, as stated, for example, in a detailed article [4], that the internal rate of return IRR is used. This characteristic is based only on the internal data of the investment project, i.e. on the financial flow, and does not depend on the macroeconomic situation, which generates a discount factor unknown to the decision maker. If the IRR exceeds the maximum possible value of the discount factor in the situation under consideration, then the investment project will almost always turn out to be economically profitable. If the IRR is less than the expected value of the discount factor, then the project is not economically viable. In other cases, there is uncertainty - the project may turn out to be both profitable and, conversely, unprofitable.

Thus, conclusions based on *IRR* do not depend on the value of q, and therefore are stable with respect to a change in q. From the point of view of the theory of stability of conclusions in economic and mathematical models [32 - 36], this is a decisive argument in favor of the mass use of the internal rate of return. The disadvantage of IRR compared to NPV is the inability to estimate, at least approximately, the economic effect of the implementation of an investment project.

Such a characteristic as the discounted payback period *DPP* allows, to a certain extent, to remove the "problem of the end". If there is reason to believe that DPP falls into a period of microeconomic stability of the economic situation in which the investment project is being implemented, then, since the discount factor q is determined and the calculation of the discounted payback period of DPP as a function of q is correct, the project will pay off and there is reason to believe that its further sales will be profitable. If the discounted DPP payback period for the first project is less than the value of this characteristic for the second one, then this fact is an argument for choosing the first one for implementation. We emphasize

Let's summarize the comparative analysis of the three main characteristics of the investment project. Scope of applicability *NPV* and DPP - period of stability of the economic situation, and the requirement of stability applies to both microeconomic and macroeconomic spheres, since we are talking about the possibility of applying a certain value of the discount factor q. The area of applicability of IRR is wider, since we are not talking about a certain value of q, but the allocation of the interval of values of the discount coefficient, in which the investment project is economically profitable. From the point of view of the stability theory [32 - 36], it is expedient to calculate all three characteristics NPV, IRR and DPP, and then compare the conclusions drawn on the basis of the values of these characteristics. Management decisions regarding the possibility and expediency of implementing investment projects must be made on the basis of certain expert technologies [14–18], relying on the experience and intuition of experts [28–31].

Innovation and investment

Investment management and innovation management are usually considered separately [1]. However, the term "innovation-investment project" is also used, especially in the rocket and space industry in accordance with its specifics (see, for example, [37–43]). Let's discuss the relationship between innovation and investment.

Innovation is understood as an introduced innovation (in the literature there are numerous detailed definitions, which are not necessary to analyze here). The path of innovation from the emergence of an idea to implementation (in the case of innovation in the material sphere - to industrial production) passes within the framework of the innovation process. In articles [44, 64], we identified 13 stages of the innovation process. Let's briefly discuss them.

1. Formation of an innovative idea.
2. F formation of a team of owners of an innovative project.
3. Protection of intellectual property through copyright or patent law.

4. Performing research work on the subject of an innovative project for the purpose of development of the original idea.

5. Development of a prototype.

Steps 1 - 5 are usually carried out by a team of original developers of an innovative idea, for example, employees of the technical department of the university. It is at stage 5 that the possibility of commercializing an innovative project becomes a significant factor in its movement along the development trajectory. There is a change of ownership - an innovative idea is transferred for further development to a small enterprise [45 - 56], sometimes specially organized for this purpose.

6.Marketing research.

The authors of innovations usually deal with scientific and technical issues. As a rule, they discuss the timing and cost of the transition to industrial production in their applications addressed to potential manufacturers. After creating a prototype (stage 5), field (and not just desk) marketing research is necessary [1], and marketing specialists should conduct them, of course, together with the authors of innovations.

7. Development of a business plan and performance evaluation.

Obviously, professionals in the field of organizational and economic support of innovative activity should be involved in the preparation of business plans.

8. Expertise.

When implementing many stages of the innovation process, various expert technologies are used. For their successful implementation, it is necessary to involve specialists in expert assessments.

Stages 6 - 8 are usually performed by employees of a small enterprise (specialists in marketing, business planning, expertise, etc.) together with the developers of stages 1 - 5. The goal of their work is to move from the original innovative idea to its development, allowing to propose this idea for industrial enterprises.

Stage 9. Transition to the stage of industrial production.

At this stage, the second change of ownership occurs - during the transition (from a small enterprise to a fairly large organization capable of mass production of innovative products. As suggested in [57, 58], this transition can be carried out by conducting an Internet auction. Stage 9 is organized by a small enterprise that has previously completed stages 5-8.

10. Preparation for implementation - development work and technological preparation of production.

11. Introduction and market entry.

12. Control after implementation (by the development team).

13. Evaluation of the effectiveness of the project.

We are talking about the short-term and long-term consequences of the project.

We see that the innovation process, as a rule, passes from the stage. At the first stage (stages 1 - 5), innovation is being developed - from an idea to a prototype. In the second (stages 6 - 9), the innovation is preparing for the transition to mass production in the third stage (stages 10 - 13). At each stage, an innovation is carried out by its own team of performers (owner). At the first stage, we are talking about innovation in the narrow sense (about the development of innovation). At the third stage, we observe a typical investment project. The second stage is transitional (preparation for the introduction of innovation). At the third stage, we observe a typical investment project. Therefore, projects aimed at the development and implementation of innovations, it is quite natural to call innovation and investment. They are often implemented in high-tech industries, in particular, in the aircraft building and rocket and space industries. Obviously, In modern conditions, the successful implementation of innovation and investment projects involves the use of systemic fuzzy interval mathematics [25, 59], artificial intelligence [16, 23, 60], digital economy [61–63].

Conclusion

Management decisions regarding the expediency of implementing investment projects must be made on the basis of all five types of factors - social, technological, environmental, economic, political. In [3] and this article, such indicators for assessing the economic efficiency of investment projects as the net present value *NPV*, internal rate of return IRR, discounted payback period DPP. Their areas of applicability and conclusions that can be drawn on the basis of these indicators are identified. It has been established that the main condition for their reasonable use is the stability of the microeconomic situation, and for NPV and DPP - also macroeconomic stability. An analysis of a typical innovation process showed that the introduction of innovation at the final stage turns into the implementation of an investment project, which justifies the use of the term "innovation-investment process".

The results obtained make it possible to increase the validity of conclusions about the economic efficiency of investment projects. Appropriate changes are needed in the teaching of economic and management disciplines to encourage students to avoid unreasonably wide thoughtless application of the considered indicators of the economic efficiency of investment projects.

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