A Three-Phase Methodical Approach to Assessing the Effectiveness of Investment Projects In Oil and Gas Production

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Abstract—The article is devoted to the improvement of the methodological framework for evaluating the effectiveness of investments in oil and gas production. Particular attention is paid to the formation of cash flows, accounting for the time factor at various stages and stages of the life cycle of long-term investment projects in the oil and gas industry, which makes it possible to more reasonably evaluate their effectiveness under uncertainty and risk conditions. A new approach to the economic evaluation of investment efficiency has been developed, which combines the methods of differentiated accounting for the influence of the time factor at various stages of the life cycle of investment projects. It is proposed to carry out the division of the life cycle of investment projects for the development of oil and gas resources into three periods (phases): the period of investment expenditures (exploration, drilling), the payback period (rehabilitation) and the after payback (primary operational) period. For each period, it is envisaged to apply the relevant time factor accounting procedures and different discount rates, taking into account the risks of investing and cash flow generation.

Keywords—investment projects in oil and gas production, investment efficiency, cash flow formation, discount rates, time factor

I. INTRODUCTION

The development of oil and gas resources is a long and capital-intensive process. In the conditions of political instability, an acute shortage of investment resources, growing uncertainty and price volatility of oil and gas resources, a well-grounded evaluation of the effectiveness of investments is especially important. The urgency of this problem is aggravated by the depletion of traditional oil and gas fields and the need to develop hard-to-recover hydrocarbon reserves.

Therefore, an important task is to develop methodological approaches that would enable us to properly solve the problem of assessing the effectiveness of investments using modern advances in economics.

The purpose of the article is to develop a methodological approach to assessing the effectiveness of investment projects in the oil and gas industry to ensure a more accurate accounting of the time factor and the maximum consideration of the possible economic benefits and costs accompanying the investment activities in conditions of uncertainty and risk.

II. RELATED WORKS, RESEARCH AND PUBLICATIONS

Currently, when evaluating the effectiveness of investment projects, there is applied the method of discounting cash flows (DCF), founded by I. Fisher [1] and D. Keynes [2], and which is actively developed in the works of many foreign and domestic researchers. This method is based on the concept of accounting for changes in the value of money over time, and is influenced by numerous factors.

Recently, however, there are more and more publications in which the method of discounting cash flows has been reasonably criticized [3–8]. It is noted that the application of the discount procedure leads to a high depreciation of future cash flows. The value of a monetary unit decreases in geometric progression with time, and incomes grow only in arithmetic one. This leads to an outflow of financial resources from the real sector of the economy into the sphere of short-term, speculative financial operations and disrupts the normal process of reproduction of non-current assets in the real production sphere [7]. The use of the method of discounting cash flows in the traditional form leads to an underestimation of the results of evaluating the effectiveness of investments, especially projects relating to real production with the implementation period of 5-10 years or more.

To eliminate the drawbacks of discounting methods, V. Daskovsky and V. Kiselev [3-6] offer a two-phase method for evaluating the effectiveness of investments, the essence of which is to take into account the time factor by dividing the life cycle of an investment project into two phases. The first one is the period of investment costs (construction of the facility). Investment costs are accounted for the time of construction completion by replacing the traditional discounting procedure with a compounding procedure. The second phase is the period of operation of the facility. Investment costs are accounted for the end of the life of the facility using the compounding procedure.

In the publication [9] we noted that this was another extreme. The rate of increase in the value of cash flows during compounding is much higher and almost unlimited with an increase in the forecast period. That is, having got rid of the shortcomings of the discounting procedure, with this approach, the results of evaluating the effectiveness of investment projects will be clearly overestimated.

We have proposed a fundamentally new approach and a corresponding model for evaluating the effectiveness of investment projects, and it is to use the positive aspects of traditional methods and methods that take into account the time factor, that is, discounting and compounding methods [9]. It is proposed to divide the life cycle of any investment project into two, as in [3, 5–6], and into three periods: the period of investment costs (construction), the payback period and the after payback period (main operational). For each period there should be applied: appropriate procedures for taking into account the time factor, various points in time at which the cash flows are brought, different discount rates that take into account the specific risks and rates of income for each period [9].

However, the proposed model is made for the most general investment conditions and does not take into account the specifics of the implementation of investment projects in oil and gas production, where there are significant features of the implementation of long-term investment projects, the formation of cash flows, specific risks in production of various types of hydrocarbons (oil, natural gas from traditional fields, shale gas). Therefore, the article proposes an adaptation of the approach highlighted in [9], taking into account the specific conditions for the implementation of investment projects in the oil and gas industry.

III. Suggested Methodical Approach

As already noted, over the past decade a considerable amount of researches has appeared, highlighting the shortcomings of cash flow discounting methods. One of the most important is a significant underestimation of the real effectiveness of investment projects when applying the discounting procedure.

Indeed, the method of discounting significantly depreciates the value of future cash flows, and it is especially acute when the forecast period exceeds 5-10 years. That is, the application of the discounting procedure leads to the fact that the present value of cash flows becomes insignificant in 7-10 years, and, as a result, a high degree of depreciation of cash flows results in the rejection of long-term projects.

In order to eliminate the drawbacks of discounting methods, V. Daskovsky and V. Kiselev propose [3–6 and others] a two-phase method in a series of publications, the essence of which is to take into account the time factor by dividing the investment project life cycle into two phases (the period of investment costs (construction of the facility) and the period of its operation) and the replacement of the traditional procedure of discounting by the compounding procedure.

But carrying out simple calculations made it possible to establish that, when applying the compounding procedure, the cost of cash flows increases by 61% in five years, and in two years - up to 95%, that is, almost doubles. At the same time, the growth rate of the cost of cash flows during compounding is much higher and almost unlimited with an increase in the forecast period. That is, having got rid of the shortcomings of the discounting procedure, with such an approach to the use of financial mathematics, the results of evaluating the effectiveness of investment projects will be unequivocally overestimated.

In addition, when evaluating the effectiveness of large-scale projects, especially those relating to the development of mineral deposits, solving environmental and social problems, it is necessary to pay attention to the fact that such projects may lead to useful results in related fields of activity, forming both positive and negative externalities (external effects) [10, p.94-95].

Considering the above, for the economic evaluation of innovation and investment projects in the oil and gas industry we suggest using the following model:

$$NPV = \left[\sum_{t=t_c}^{PP} \frac{(NP_t + D_t)}{(1+r_t)^t} + \sum_{t_e=PP+1}^{Tc} \frac{(NPd_t + NPr_t(1+r_b)^{Tc-t_e} + D_t)}{(1+r_{pr})^t} \right] k_i \cdot k_d -$$
$$- \left[\sum_{t_{IC}=0}^{T_{IC}} I_{t_{IC}} (1+r_b)^{T_{IC}-t_{IC}} + \sum_{t_e=t_c}^{T_C} \frac{I_{t_e}}{(1+r_b)^{t_e}} \right] \qquad (1)$$

where

NPV is the net present value of the economic benefits and costs from the implementation of the innovation and investment project for the period of its life cycle;

NP_t is net profit as a result of the implementation of the investment project for the period *t*;

NPd_t is net distributed profit as a result of the implementation of the investment project for the period *t*;

NPr_t is net retained profit due to the implementation of investment project for the period *t*;

D_t is depreciation for the period *t*;

$I_{t_{IC}}$ are investment costs of an investment project during the period of exploration, well drilling and field development in the *t*[th] year;

I_{t_e} are investment costs of an investment project during the operation of an oil and gas field in the *t*[th] year;

k_i , k_d are, respectively, increasing or decreasing correction coefficients of externalities that may arise from third parties who are not direct participants in investment projects, as a result of a decrease or increase in destructive environmental impacts, improvement or deterioration of social conditions, etc. These coefficients can be determined according to the data given in [10, p.95-97];

r_b is the basic rate of return, which is defined as the average rate of return on foreign currency deposits in systemic banks of Ukraine at the time of the assessment;

r_{pr} is the discount rate, taking into account only the risks of investing in this project, enterprise or industry;

r_t is the total discount rate, taking into account the risks of investing in this project and the risks of freezing investment resources due to the possibility of alternative capital investment ($r_t = r_b + r_{pr}$);

t_{IC} is the current year of investment costs (geological and geophysical works, well drilling);

t_c is the year of commencement of cash flows and economic benefits;

t_{PP} is the current year of receipt of cash flows and economic benefits in the payback period, which varies within $t = t_c = 1, 2, ..., PP$;

t_e is the current year of receipt of cash flows and economic benefits after the payback period, which varies within $t_e = PP+1, 2, 3, ..., Tc$;

T_{IC} is the number of periods during which investments will be made before the introduction of the oil or gas field into operation;

PP is the payback period of the investment project, years;

Tc is the year of completion of the field development.

The criterion for choosing the best option among many possible options for implementing investment projects is the maximum value of *NPV* - the net present value of economic benefits and costs.

Let us characterize the peculiarities of the time factor, making investment expenses, generating cash flows and calculating them in each of the periods.

Any investment project is impossible without investment costs. As a rule, their implementation begins with a pre-investment phase, which consists in carrying out a set of geological and geophysical works, geological and economic assessment of hydrocarbon resources in prospective areas, a feasibility study for the development of a field, obtaining appropriate permits and approvals. For large projects, this phase can be long-term and costly. During this period, investment costs are frozen investments, the return on which will begin only with the start of operation of the oil and gas field. At the same time, we want to pay special attention to the fact that these investment expenses need to be compounded, and not to be discounted, as it is written in the existing "Methodological recommendations" [11]. It is also paid attention to the time of bringing investment costs, namely, before the start of commissioning of the object. The economic-mathematical model (1) in this part is constructed in such a way that it allows to take into account the fact that the farther in time the distant investment costs from the start of operation of the facility, the greater the loss from freezing investment $\left[\sum_{t_{IC}=0}^{T_{IC}} I_{t_{IC}} (1+r_b)^{T_{IC}-t_{IC}} \right]$.

As for the basic rate of return, which is used in compounding, in the world practice of investment analysis, it is most often accepted as the rate of return on the so-called "risk-free assets" - long-term government bonds with a maturity of 10 or more years, since this type of investment is considered the least risky.

Due to the unstable political and economic situation, constant changes in legislation, insufficient development of the market environment in the conditions of Ukraine,

investments in government bonds have no reason to be the least risky. Therefore, it is more expedient to use the basic income when investing in alternative assets that are the most accessible and require minimal management from the investor. Such assets are deposits for legal entities in freely convertible currencies that were established at the time of evaluating the effectiveness of an investment project in leading Ukrainian commercial banks [12, p.177]. The average income rate in 2018 for this financial instrument in Ukraine was about 3,7% [13].

Payback period is the period during which the cumulative amount of cash receipts from the implementation of the investment project equals the amount of the initial investment. A feature of this period is that the cash flows and economic benefits that an investor receives during this period, as a rule, are used to repay interest on attracted credit resources, to build up the necessary infrastructure at the field, to compensate for increased costs in the development of oil and gas fields and to bring technological, operational and economic indicators to the levels established by development projects, etc.

At this stage, it is advisable to use a full-fledged discounting procedure, with the cash flows brought in by the start of operation, since the cash flows received by the investor during this period can hardly be directed to the financial market or to other alternative projects. That is, the cash flow received is almost frozen. The discounting of cash flows in this period should be carried out at a full discount rate, taking into account the principle of alternative investments and the risks of investing in this investment project [9].

It is important to determine the total discount rate (r_t), which should take into account the facts as follows: which hydrocarbon field is subject to development, peculiarities of its geological structure, natural and geographical location conditions, depth, reservoir properties, etc.

Due to the shortcomings of the discounting procedure and the importance of reducing the multi-temporal effects, in many countries, at the level of government agencies, uniform discount rates are established in assessing the effectiveness of investments in the development of natural resources, environmental and social projects. For example, in France - 8%, in Italy - 5%, in Spain these rates are differentiated by industries, in Russia, when the cadastral valuation of mineral deposits is set, the discount rate is 10% [14].

We believe that taking into account the specific risks inherent in a single hydrocarbon field will still be more correct. Here, it is advisable to apply methodological approaches to determining discount rates, which are proposed in [12, 15].

Thus, when developing traditional oil and gas fields, it is necessary to take into account the specific risks that exist for a particular oil or gas field, namely: the amount of reserves, natural and geographical conditions of development and location of the field, the complexity of the geological structure, the mode of operation of the deposits, the production rate of wells, the permeability of the reservoir, oil viscosity, oil recovery factor, gas-emission method of operation, depth of deposit, water content, reservoir type, porosity, effective thickness, oil and gas saturation, the

content of sulfur, asphaltenes, resins, paraffins in oil, carbon dioxide, the content of hydrogen sulfide in the gas [12, p.191-199].

During the development of shale gas deposits, a methodical approach has been developed for determining discount rates, which allows to take into account the main risks inherent in particular shale plays where the project is being implemented [22, p.63-74].

After payback period is the period during which the investor will receive the main economic benefits from the implementation of the project on the development of an oil and gas field. In order to take into account the time factor, cash flows must be brought to the start of field exploitation by discounting.

However, it is mistaken to assume that the investor will immediately direct all received economic benefits to alternative real investment projects or the financial market, and therefore these cash receipts should be combined before the end of the operational period, as proposed in [3–5]. In our opinion, this approach is not entirely correct for the following reasons:

- first, only the net profit, its undistributed part can be directed to the financial market. Another part, distributed profit, is used for paying dividends, environmental and social goals, especially in our time, which is declared by the international community as an era of socially oriented economy;

- secondly, a part of implicit cash flows in the form of depreciation deductions should be used for their main purpose, that is, to maintain fixed assets in proper condition during operation and to renovate them after the end of their useful life [9, p.97].

Therefore, only a part of undistributed profit can be combined, as reflected in model (1). At the same time, bringing undistributed profit before the expiry of the deposit period should be carried out at the base rate of return (r_b).

In addition, it is necessary to take into account the risks of the project, applying the discount procedure. But we should use a special discount rate r_{pr}, taking into account only the risks of the project and does not include the base rate, which takes into account the loss of value due to the possibility of alternative capital investment.

In all periods, it is necessary to use real discount rates, that is, to take into account inflation using the Fisher formula [12, p.196]. It will also significantly reduce the impact of the compounding and discounting procedures on the cash flows. In addition, the final determination of discount rates should take into account the structure of assets and the terms of taxation.

It is also necessary to note that for any project during the payback period and the after payback period there is another part of the investment costs I_{t_e} that are incurred during the operation. It is advisable to apply the procedure of discounting at the basic rate of return for them.

IV. CONCLUSION AND FUTURE WORK

There is proposed a new approach to the economic evaluation of the effectiveness of investments in oil and gas

production, which allows to take into account differentially the process of obtaining economic benefits, as well as the influence of the time factor at various stages of development of oil and gas fields. The features of determining investment costs and cash flows at the main stages of exploration and development of oil and gas fields and the justification of discount rates are described. Further researches will be aimed at improving the methodological approaches to the definition and justification of numerous parameters that are necessary in assessing the effectiveness of investment projects in the oil and gas industry.

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