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Peculiarities of Investment Decision-making in the Oil and Gas Industry Aimed to Ensure Sustainable Growth of the Russian Economy

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ABSTRACT

A dynamic analysis of the composition and structure of the oil and gas sector of the Russian economy was carried out in the study, a relationship between cyclical fluctuations of the world economy and energy prices was analyzed, and trends in world market prices for energy were studied. The authors identified basic systematic risks and uncertainties affecting investment decision-making in the Russian oil and gas sector and studied the peculiarities of making investment decisions. The academic novelty of the study is to propose specific ways to improve the investment decision-making of the Russian oil and gas business entities in the context of high macroeconomic risks to ensure sustainable growth of the Russian economy. The results obtained in the framework of the present study may be implemented by enterprises of the oil and gas industry and will also be of interest to other business structures in risk management, which is especially relevant in the context of high economic and geopolitical uncertainty. The paper presents mathematical models and justifies the choice of parameters to evaluate the fields taking the uncertainty into account. The approaches to formation of the investment decision-making policy based on real options method are proposed.

Keywords: Oil and Gas Sector, Oil and Gas Investment Projects, Oil Quotations, Decision-Making Models, Real Options
JEL Classifications: E3, Q4

1. INTRODUCTION

Complex geopolitical situation in the world aimed at the isolation of the Russian Federation in the international economic environment leads to the need for qualified evaluation of possible implementation of investment projects in the face of increasing uncertainties and risks. In this regard, the urgency of objectives to improve the efficiency of managerial decisions plays a special role in ensuring economic growth in the sectors of Russia's economy, especially in the oil and gas sector as its locomotive.

Oil and gas, which mean so much in the world economy and especially in the economy of individual countries, are just commodities in the commodities market, which has its own characteristics. Accordingly, a fundamental factor that influences the price of oil and gas is the ratio of supply and demand (Analitik: Deystviya OPEK pereotsenivat ne sleduyet, n.d.). It is clear that the supply of oil and gas is dependent primarily on the level of their world production, while demand is dependent on the need of business entities in energy, i.e. from consumption.

Oil supply in the world market varies and is not constant (Figure 1). Other things being equal, the larger the volume of oil supply on the market, the lower its price.

It is obvious that the volume of oil extraction and production grows from year to year and will grow in the future, which in general should reduce oil quotations. During the period of 2015-2017, the volume of oil production could rise by 127 million tons (Feller, 1984).

The same can be said about the volume of gas production: They are not constant either (Figure 2), while their growth is even somewhat more stable. The exception is 2009, when there was a relatively sharp drop in natural gas production, which was due to the fall in gas demand from the industry influenced by global recessionary

Figure 1: Volumes of oil production, million tons (BP Statistical Review of World Energy 2016)

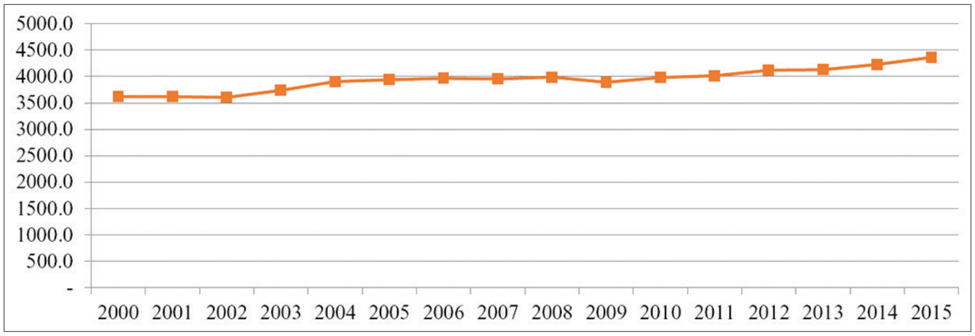
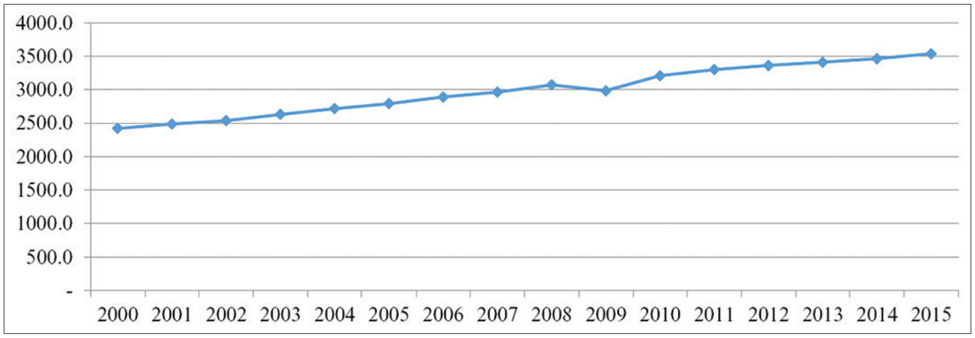


Figure 2: Volume of gas production, billion cubic meters (Giant Oil Field Found in Russia, n.d.)



trends (Current Trends in the Development of the World Economy and Dynamics of Global Commodity Markets, 2015).

The most significant factors influencing the oil and gas demand include the growth rate of industrial production in the world (Table 1), because the industry is a major consumer of oil and gas. Let's consider the relationship of oil quotations and the growth rate of industrial production.

In addition to the growth rate of industrial production, it is advisable to pay attention to another figure in the study of the dynamics of prices for oil and gas – the growth rate of global gross domestic product (GDP) (Figure 3).

Growth rates of global GDP are correlated with changes in oil prices, while the correlation coefficient calculated by the authors is 0.54 (Fall in US Shale Oil Production Continues, 2016). This indicates a fairly strong relationship between the given values. The relationship between the growth rate of global GDP and gas prices is relatively low – in this case, the calculated correlation coefficient is 0.32 (Taleb, 2012).

Thus, the oil and gas market is very unstable and difficult to forecast. Therefore, educated investment decision-making must take into account the fact that the study and development of hydrocarbon deposits is a probabilistic process, and it carries the high level of uncertainty and risks.

2. METHODS

In everyday understanding, uncertainty is often associated with such characteristics as randomness, unpredictability, fuzziness and ambiguity. We will consider uncertainty in this work as the presence of several possible outcomes of each alternative. The concept of "risk" shall mean the likelihood of the quantitative evaluation of an unfavorable outcome in the face of uncertainty.

Table 1: Growth rate of industrial production volume, % (Finam, n.d.)

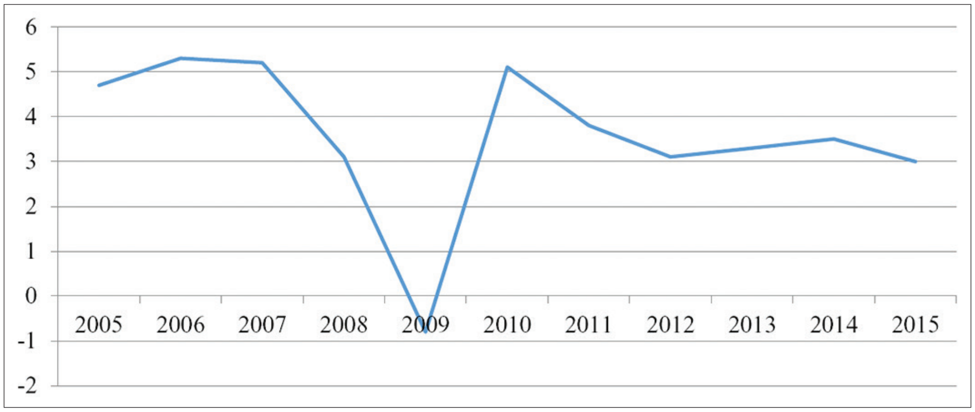
Year	China	USA	European union	India	Russia
2005	29.5	3.2	1.3	7.9	4
2006	22.9	4.2	3.2	7.5	4.8
2007	13.4	−1.7	−0.3	8.5	7.4
2008	9.3	−2	−10.8	4.8	3.5
2009	9.9	−5.5	−0.4	9.3	−13.1
2010	11	3.3	4.1	9.7	8.3
2011	13	4.1	3.1	4.8	5
2012	7.9	0	0	0	2.6
2013	7.7	2.5	−0.2	0.9	0.1
2014	7.3	2.8	0.9	3.8	0.6
2015	7	3	1.5	2.8	−3.5

At the initial stages of the implementation of the investment project, the probability of obtaining a negative result from the implementation of the project is the largest due to poor knowledge of the field. Thus, at the beginning of the investment process, the scale of potential investment loss is relatively small (Nazarov, 2007).

The following factors of uncertainty in hydrocarbon production should be taken into account when assessing the efficiency of the investment project (Gert et al., 2007):

1. Geological uncertainty. This factor means the risk of non-compliance of quantity parameters and quality of extracted reserves with their initial estimates, i.e. oil and gas reserves and their quality will be below the target level.

Figure 3: Growth rate of global gross domestic product, % (All statistics: Global commodity markets, n.d.)



2. Economic uncertainty. It is caused, first of all, by changes in the world prices for oil and oil products, level of inflation, unstable market conditions, and changes in exchange rates, tax rates, etc.
3. Uncertainty of the commercial value of the open field can be considered both from a geological and an economic point of view. The commercial value depends on the following parameters: The volume of reserves and resources of oil, oil deposition conditions, geographical location of the field (climatic features, distance to the pipeline), level of capital and operating costs.
4. Technological uncertainty is associated with the prediction of technological parameters of the field development. This factor is also understood as the probability of adverse situations, including accidents due to improper choice or non-compliance of the equipment with technical standards, incorrect choice of the technological scheme of the field development.
5. Political uncertainty is determined by the unstable political situation in the country.
6. Environmental uncertainty. This factor is determined by the incurrence of liability for environmental damage, as well as damage to life and health of third parties. It occurs because of the anthropogenic and natural events.
7. Managerial uncertainty. In real business, the investment decision-making is delegated from the owners to the manager. In this case, the manager pursues his or her own goals in managerial decision-making. This fact determines the uncertainty associated with managerial decision-making and defining the financial and economic parameters of the IP during its life cycle. Managers who make investment decisions are used to inflate their own capabilities and to overestimate the results of projects under their direct control.

Thus, systematization of the uncertainties inherent in investment projects in the oil and gas industry leads to the conclusion about the importance of their complex accounting in the process of constructing the evaluation models in order to make the best managerial decisions. In view of the limitations of traditional DCF method for complex accounting of the discussed uncertainties, the need arises to introduce more modern and advanced methods of assessment and use them in practice. The real options method (ROM), probabilistic modeling using the Monte Carlo method and decision tree can be attributed to such methods (Mkrtchyan et al., 2012).

Ignoring the risks and uncertainties could lead to multibillion losses for investors, drop in goodwill and loss of market positions in comparison with competitors. Creation and implementation of the effective risk management that allows to correctly take into account multiple risk factors and uncertainties, as well as their relative impact on the assessment of investment projects, should become a priority for the hired managers and owners of the leading oil and gas companies.

3. IMPLEMENTATION

The abovementioned uncertainties can be reduced to some degree thanks to analyzing the fundamental processes in the oil and gas industry, cyclical dynamics of prices for raw materials and finished products, as well as the relationship of the degree of the industry development with so-called “super cycles” in the global economy. Super cycles may be detected using the economic filters. One of the most common approaches is a band analysis (BP filter). It allows to smooth out the short-term fluctuations in the economy – in particular, a variety of short-term recessions.

3.1. Alternative Approaches to the Assessment of Investment Projects: The ROM

The ROM is based on the assumption that any investment opportunity is an option, i.e. the purchased right to buy or sell a fixed asset at a certain fixed time interval at a price that is set in advance.

In accordance with this criterion, the options can be divided into the following types:

1. Successive investments. This type is a set of the projects implemented one by one. In this case, the implementation of each subsequent project depends on the results of the previous one. In this situation, it is possible to change the time of the planned investment project or completely reject its execution.
2. Refusal of execution of the project provides an opportunity for the organization to complete the project implementation at negatively developing conditions for its implementation.
3. Option of expectation is the right to choose the moment of making the managerial decision. It is especially significant for the organizations that implement projects in the extractive

sectors. For example, in the case of the detection of new fields by the organization, a decision is made to preserve the wells until the time of the establishment of maximum profitability of resource extraction.

4. Option of growth is a possibility of additional revenue after the implementation of the project.
5. Option to rescale is the ability of the organization to modify the production volumes within the framework of the project. It is of the greatest benefit for industries prone to cyclical fluctuations (Vilensky et al., 2008).

The use of the ROM in current conditions is not always justified. This is due to the fact that in some cases the exact compliance with the pre-formed requirements appears more effective and efficient than attempts to promote adaptability in managerial decision-making. A significant drawback of this method lies in the elasticity, because of which the organization is likely to lose its strategic focus. This occurs due to over-hasty decision to change the strategic course (Bratvold, 2015).

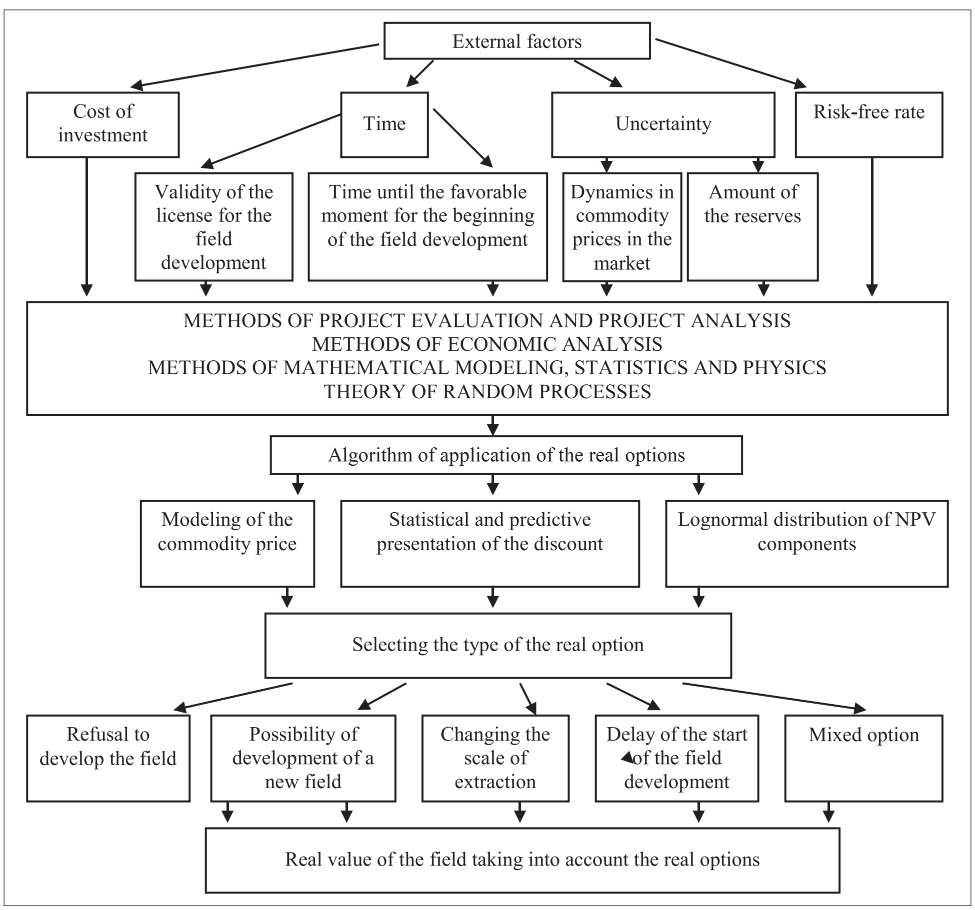
It should also be noted that most of the options in this industry are options of the American type, since the operational flexibility can be used at any point during the predetermined time period. It is known that the value of the financial option of the American type coincides with the value of the option of the European type, in the absence of dividend payout. For real options, the analogue of dividend payout may be the cost of maintaining the option (various regular payments to the budget, not tied to production levels, penalties for suspended production, etc.). The use of real options is schematically shown in Figure 4.

Investment opportunities for huge oil and gas fields in the area of expansion, extension and modernization exist for about thirty years after the discovery. With the emergence of lots of information on the asset performance parameters, the economic uncertainty is eliminated or at least reduced (Ratkin, 2007). Removing this uncertainty potentially leads to the probability of changing the direction and progress of capital investment programs, accelerating, slowing down, or even their termination. Management inevitably has to deal with the consequential, branched investment programs. The contribution to the cost of the asset at the investment phases – from the initial to the intermediate – can only be estimated through a comprehensive review of each of the possible areas of investment. The methods of dynamic programming, which allow to quantify these areas in the construction of decision-making policy, offer a handy mathematical tool (Anshin, 2003). Branched ways of decision-making were not previously considered properly, due to the mathematical complexity in the first place, as well as to much needed for their technical, or related to specific assets, detailed analysis. Generalized principles of work relative to such decision-making are an important risk management tool in the industry.

3.2. Modeling of the Discount Rate

Modeling of the discount rate deserved a particular attention in the theory of the real options, since this value is set as constant in conventional calculations.

Figure 4: Scheme of application of the real options in the oil and gas industry



The use of the field value in the calculation using the ROM allows to model a discount rate for investment projects implemented in the Russian Federation (Oil Market in 2015-2016, n.d.). The level of the discount rate is influenced by many factors of the macro environment. Studies of the impact of the external environment on the discount rate allowed to identify the most important of them: The level of solar activity, the change in the political situation in the country (for example, associated with the presidential elections or elections of deputies to the State Duma), the rate of inflation, the dynamics of which was predicted on the basis of information from the Russian Federation Government.

3.3. Application of dynamic programming

Successive solutions (of the trajectory of the investment project implementation) can be described using the basic equation of dynamic programming – Bellman equation (Bellman, 1960) that includes the condition of execution of the previous (or initial) phase of the investment project:

$$V^*\left(S_t,X_t,0\right)=\max_{\left(S_t-X_t\right)_i}$$
$$\left[\sum_{i=0}^{n}\frac{1}{\left(1+r_1\right)\cdot\left(1+r_2\right)\cdots\left(1+r_n\right)}E_{t_i}\left\{V\left(S_t,X_t,t_i\right)\right\}\middle|V\left(S_t,X_t,t_{i-1}\right)>0,0\right], \quad (1)$$

Where, $E_{t_i}\left\{V\left(S_t,X_t,t_i\right)\right\}$ is an expected value of V at the moment of time t_i,

S_t is the discounted value of future cash flows,

X_t is the discounted value of capital costs associated with the current investment,

r_t is the dynamic discount rate for the investment,

n is the number of key decisions during the project life.

$V(S_t,X_t,0)$ is the cost of the initial investment $i = 0$ based on data available at $t = 0$. The parameter $V(S_t,X_t,t_i)$ is the estimated value of the i^{th} investment stage based on the data available at the moment $t_i > 0$. $V(S_t,X_t,t_{i-1})$ is the cost of the previous investment based on the data available the moment t_{i-1}. We are trying to maximize revenue S_t-X_t by selecting an investment path with maximum value, using the information available at the moment of time t_i and presenting S_t as a multi-dimensional random variable.

The scheme of the solution based on dynamic programming requires a movement backwards on this tree, starting from the terminal cost for each path. Reduction of non-optimal paths occurs at each decision-making point on each node (i) by applying the function of the choice of the maximum. The solution is an optimal value of the cost for a sequence of investment decisions on the basis of information available at the moment $t = 0$.

This analysis is dynamic in time. Additional information appears and reduces uncertainty by clarifying the final economic parameters. The policy can be changed in accordance with additional information. Therefore, it is required to conduct regular checks to reflect the new information.

3.4. Evaluation of Real Options

There are several approaches to the calculation of investment value V. Historically, the analysts use the deterministic, which is the most likely parameters for the calculation of the investment net discounted value. Probability estimates derived using the statistical simulation (Monte Carlo method) are also used to calculate the net discounted value. To improve the accuracy of the estimate, it is necessary that figure $E_{t_i}\left\{V\left(S_t,X_t,t_i\right)\right\}$ is estimated in such a way that it reflects not only the value created by immediate investment, but also the costs associated with possible future investment alternatives. The mathematical apparatus of real options expresses the selectivity of future investments, as well as the probabilistic nature of decisions using the following basic functional form:

$$V=\max\left(\left(S-X\right)_t,0\right)-C, \quad (2)$$

Where, C is the cost of creating optionality,

t is the time of the investment execution or its rejection.

To calculate the value of the option, it is necessary to know six variables. Five of the six variables have already been presented: S, X, C, t and r_t. The present value of future net revenue (S) and capital expenditure (X) can be calculated on the basis of economic investment model. The future net revenues associated with the considered investment decision should be isolated from any revenue derived from previous investments in the project.

3.5. Volatility of the Options

The sixth variable in the option evaluation is volatility (σ) of the present value of future revenue, i.e. change in S associated with the intensity of the inflow of new information. The option volatility is usually the most difficult variable to evaluate, especially when evaluating projects in an unstable economy. In such cases, it is suggested to use a jump diffusion model (Shokhor, 2006) and the model with dynamic discount rate:

$$V=\sum_{i=0}^{\infty}\frac{e^{-\bar{\lambda}t}(\bar{\lambda}t)^i}{i!}v_i\left(S_0,X,r_i,t,\sqrt{\sigma^2+\delta^2\left(\frac{i}{t}\right)}\right), \quad (3)$$

Where, λ is the number of jumps per unit of time (per year),

κ is the average size of the jump,

δ is standard deviation for the size of the jump,

$\bar{\lambda}=\lambda(1+\kappa)$,

$r_i=r-\lambda\kappa+\frac{i\ln(1+\kappa)}{t}$,

S_0 is a current value of the asset,

X is a price at which we have a right to make a deal,

r is a risk-free rate,

σ is standard deviation for the asset return per one time period,

$$v_i\left(S_0, X, r_i, t, \sqrt{\sigma^2+\delta^2\left(\frac{i}{t}\right)}\right) = S_0 F\left(d_1\right) - Xe^{-rT} F\left(d_2\right),$$

F is the function of normal distribution,

T is time to execution,

$$d_1 = \frac{\ln\left(S_0 / X\right) + \left(r_i + \left(\sigma^2+\delta^2\left(\frac{i}{t}\right)\right) / 2\right) T}{\sqrt{\sigma^2+\delta^2\left(\frac{i}{t}\right)}\sqrt{T}},$$

$$d_2 = \frac{\ln\left(S_0 / X\right) + \left(r_i - \left(\sigma^2+\delta^2\left(\frac{i}{t}\right)\right) / 2\right) T}{\sqrt{\sigma^2+\delta^2\left(\frac{i}{t}\right)}\sqrt{T}}.$$

3.6. Selection of Optional Mathematics

Then the options of the American and the European types are used. The options of calculations for the American options include simulation, binomial tree and analytic form of approximation. Each one has its own strengths and weaknesses. For options of the American type, the appraisal ratio is (Black and Scholes, 2015) $E_{t_i}\{V(S_t, X_t, t_i)\}$

$$\begin{aligned} V = {} & \alpha * S_t^{\beta} - \alpha * \varphi\left(S_t, t_i, \beta, I, I\right) + \varphi\left(S_t, t_i, 1, I, I\right) \\ & -\varphi\left(S_t, t_i, \beta, X_t, I\right) - -X_t * \varphi\left(S_t, t_i, 0, I, I\right) \\ & + X_t * \varphi\left(S_t, t_i, 0, X, I\right) - C, \end{aligned} \tag{4}$$

Where, $\alpha = (I-X)I^{-\beta}$;

$$\beta = \left(\frac{1}{2} - \frac{r-D}{\sigma^2}\right) + \sqrt{\left(\left(\frac{r-D}{\sigma^2} - \frac{1}{2}\right)^2 + 2 * \frac{r}{\sigma^2}\right)};$$

$$\varphi\left(S, t, \gamma, H, I\right) = e^{\lambda} S^{\gamma} * \left[N(d) - \left(\frac{I}{S}\right)^k * N\left(d - \frac{2 * \ln\left(I / S\right)}{\sigma\sqrt{t}}\right)\right];$$

$$\lambda = \left[-r + \gamma\left(r-D\right) + \frac{1}{2} * \gamma * \left(\gamma - 1\right) * \sigma^2\right] * t;$$

$$d = \frac{\ln\left(S / H\right) + \left[r - D + \left(\gamma - 0.5\right) * \sigma^2\right] * t}{\sigma\sqrt{t}};$$

$$k = \frac{2\left(r-D\right)}{\sigma^2} + \left(2 * \gamma - 1\right).$$

The cost I for the immediate purchase of an asset is determined as follows:

$$I = B_0 + \left(B_\infty - B_0\right)\left(1 - e^{h(t)}\right);$$

$$h(t) = -\left(\left(r-D\right)t + 2\sigma\sqrt{t}\right) * \left(\frac{\beta_0}{\beta_\infty - \beta_0}\right);$$

$$B_\infty = \left(\frac{\beta}{\beta - 1}\right) X;$$

$$B_0 = \max\left[X, \left(\frac{r}{D}\right) X\right].$$

This cost works as a trigger – it modifies the state of the asset purchase at the very moment of reaching a certain value. If $S \geq I$, the best choice is to purchase the asset immediately. The created value of this decision is $(S-X)$. Otherwise, the asset is not purchased.

The Black-Scholes formula is used to evaluate the options of the European type.

Mathematics of financial options assumes that the Wiener process (Feller, 1984) represents a random component of the price variable. Unfortunately, this model is based on some additional assumptions, which are not always coordinated with the receipt of information about the oil and gas developments.

These assumptions are as follows:
- Key variables have a standard normal distribution;
- Changes in the variables do not depend on the previous changes.

The above mathematical model can be implemented in software in Matlab programming environment.

4. DISCUSSION

Subject of the study is the object of research of the whole galaxy of Russian and foreign scientists. Let's consider how the problems of investment decision-making in the oil and gas sector are appraised by various researchers.

Reidar Bratvold, professor at the University of Stavanger, argues that the process of decision-making and economic risk assessment in the oil and gas industry is quite complex and often ambiguous, at least in view of the high cost and large scale. In his opinion, uncertainties, which have the greatest impact on the success of industrial projects, play an important role. The researcher identifies several critically important uncertainties, such as the price of oil and gas, production of crude oil and gas, reserves and production profile. However, most oil and gas companies do not account for them properly – they do not predict all the possible consequences. And even they do to some extent, they do not do it consistently and systematically, which results in insufficiently optimal decisions and worse outcomes than expected or than possible. Thus, Reidar Bratvold recommends oil and gas companies to turn their attention to the quantitative assessment and modeling of uncertainties and their impact on the decisions made and the possible consequences.

Researchers at PricewaterhouseCoopers – Douwe Tideman, Georges Chehade, Ekaterina Kozinchenko and Dmitry

Mordovenko – are confident that the problems in implementing projects, as a rule, occur due to two reasons. Firstly, the problems of management and control of efficiency can be rooted in an unclear division of responsibilities for strategic and operational decisions, especially if the project is a joint venture. Secondly, the problems of performance are often caused by insufficiently thought-through or too hasty planning, overly optimistic initial assessment of deadlines, necessary resources and technical capabilities, as well as the inefficiency of procurement procedures and logistics. To improve the efficiency of the projects, it is proposed to use four key control levers: Project strategy, business processes, project management and human resources (Kozinchenko et al., 2016).

Vadim Druzhina, a Junior Partner at McKinsey, Moscow, and Guillaume Quiviger, McKinsey Partner, Dubai, believe that from the point of view of the management system, the low efficiency of the implementation of major investment projects in the oil and gas sector is explained by the same factors that can be divided into three categories:

- Organizational structure, processes and skills: Lack of clear definition of responsibilities and roles, lack of personnel in workgroups on the implementation of projects, lack of clear algorithms in the decision-making process, poor quality of preliminary consideration of projects, poor planning and risk assessment skills;
- Management infrastructure: Poor transparency and lack of effective mechanisms to monitor and control the implementation process (including control over the activities of the contractors), which greatly limits the ability to anticipate changes and adequately respond to them, as well as to effectively manage the project;
- Technical skills and leadership qualities: Lack of experience in managing large projects and lack of a culture of responsibility, which leads to the trend to limit transparency and prevents cross-functional cooperation.

Researchers believe that two key levers can be used to avoid the above common mistakes and increase the value created in result of implementation of large-scale investment projects. The first is the process of the project implementation based on the passage of well-defined stages and milestones (Stage-Gate Process). The second lever is a complex system of monitoring of the project control (control tower). Druzhina V. and Quiviger G. concluded on the basis of experience in various industries that the majority of companies in Russia and the CIS have considerable possibilities to improve their activities in both of the above directions (Druzhina and Kivizhe, 2013).

After analyzing the points of view of Russian and foreign researchers, it can be concluded that the key role of the oil and gas sector in the economic development of any country, difficulties in investment managerial decision-making, and the need to optimize the decision-making process cannot be denied.

5. CONCLUSION

It would seem that when carrying out the analysis of the theoretical assumptions of the issue under study, it is difficult to stumble upon anything ill-defined or unknown with such an abundance of literature. However, when applying the methods in practice, we have once again made sure that no matter how carefully the theory is worked out or of what quality the calculations are, the personal factor is still of great importance in the evaluation. Ability to properly interpret and quickly feel confident in an ever changing environment is the indispensable key to a competent assessment of investment projects.

In this work, the authors have identified the main price trends in the market of oil and gas, and presented the fundamental factors affecting the dynamics of oil and gas prices.

In the current unstable time, when spikes in exchange rates and oil prices are alarming, the future depends on the properly selected investment projects. Effective and relevant assessment of investment activities will help restore economic system in a balanced position.

Carrying out the study of the selected investment projects from different sides, we have again realized the need to focus the attention both on qualitative assessment methods and quantitative ones. Living at the times of the rule of information, one cannot focus exclusively on the figures because they often represent a "snapshot" of a specific event on a specific date, which in the near future will be only the basis of the retrospective analysis. We can quote Nassim Taleb as a proof to reflect a remark about excessive admiration for quantitative assessment methods: "Mathematics has the same relation to the knowledge as prosthesis to the real hand; but some deliberately make amputation to replace an arm with a prosthesis" (India Hunts for Oil around the World, 2016).

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