Improving the Risk Management System in Oil Production

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Abstract. The article describes an original approach to assessing the risks in investment projects of oil-and-gas companies and proposes an improved methodology for risk management in oil production, which accounts for the special nature of investment projects of oil producers. For each field development program, it is proposed to produce a risk evaluation map that would allow for the most unbiased assessment of risks to be faced by the company to let it focus the efforts on managing those risks typical for each project phase. The companies will be able to quantify the risks of the oil-and-gas field development project by the life cycle phases of an investment project.

1. Introduction

Today, risk assessment in the hydrocarbon production segment is mainly performed during the definition phase of field development projects [1; 2]. In general, the assessment itself comes down to estimating the sensitivity of the project net present value to key uncertainties [3, 4]. At the same time, a field development project is an investment project and, like any such project, it includes several stages of development [5; 6; 7]. Each stage may be characterized by an individual set of risk-contributing factors and a varying degree of expression of the same factor at different stages of the project life [8; 9]. Moreover, there are several stages of field development, associated with hydrocarbon production volumes. At each of these stages an array of risks and their impact level may vary. Consequently, it is necessary to adjust the risk management system of an investment project of oil field development with regard to the above premises.

2. Problem statement

The basic principles of the risk theory were proposed by foreign scientists: P.L. Bernstein [10], M. Butterworth, T. Bachkai, T. Saaty [11], J. Bernoulli, F. Knight, F. Galton, J. Pickford, A. Smith, N. Luhmann, J. Schumpeter and others [12].
Over a period of market economy development, the Russian scientific community generated an entire series of studies on risk management. Theoretical issues of risk management in investment projects are discussed in the works of P.L. Vilensky, V.N. Livchits [13], A.S. Koshechkin, O.I. Larichev, A.V. Pospelov, R.M. Kachalov [14], I.A. Blank, I.T. Balabanov, P.D. Polovinkin, V. L. Tambovtsev, N.V. Kapustina and others [15; 16]. Such scientists as A.F. Andreyev, M.L. Vyukov, E.B. Gerasimova, S.I. Ermoshin, V.D. Zubareva, A.A. Lobanov, A.A. Miloserdov, V.S. Romanov, V.K. Selyukov and A.V. Chugunov deal with the subject of risk management in the oil-and-gas industry.

At the same time, while the proposed methods have certain strengths, they also have their shortcomings: they do not consider industry specificity when choosing the overriding factors, there is no association to the investment project phases and so on.

The authors attempted to fill in the identified gaps, thus, determining the purpose, objectives and subject matter of the study.

Methodology. The study subject is risk management of investment projects in oil production. The risk management methodology for oil-and-gas field development projects is the focus of this study. The study objective is to improve the risk management methodology used for investment projects in oil-and-gas field development. To achieve the stated objective we had to accomplish the following major tasks: to analyze theoretical aspects of risk management in the oil-and-gas industry, particularly, the types of risks and risk management methods in investment projects; to improve the risk assessment methodology used for investment projects in oil-and-gas field development and to test it.

3. Risk assessment methodology with regard to the field development project phase

In general terms, the process of project risk management includes the following stages [17]:

1) Gathering information on all risks.
2) Identification of risks inherent in the field development project.
3) Risk assessment [18; 19].
4) Development of risk management measures.
5) Monitoring the efficiency of risk management process.

The study focus is on the stages of risk identification and assessment.

It is proposed to use the following as the basic principles of the developed method:

1) Integration of the time factor, which is evident in the fact that investment project has individual phases that change during project formulation and implementation. Each stage may be characterized by an individual set of risk-contributing factors and a varying degree of expression of the same factor at different stages of the project life.

2) Integration of the processing factor, which means that there are several stages of field development, associated with hydrocarbon production volumes. At each of these stages, a set of risks and their impact may vary.

3) Correction for the risk impact on the project efficiency.

It is proposed to examine each field development stage in terms of the associated type of work and costs before proceeding to the risk identification stage. This will allow for the identification of certain common groups of risks that are typical for projects of oil-and-gas field development.

That said, all stages of field development are counted as the operating phase (the third phase of the project life cycle) in the general framework of the investment project. It is preceded by the pre-investment phase (first phase) and investment phase (second).

The authors propose to adjust the risk management system of the investment project of oil field development with regard to the above principles and premises. The methodology was refined with regard to the life cycle of the field development project and, consequently, with regard to significant changes, both external and internal, affecting the project during its implementation, and the risks associated with these processes, whose types and level of impact on the project vary.

The risk identification stage is refined as follows. A list of risks to be analyzed was compiled by “imposing” an array of risks specific to oil production on an array of risks typical for individual stages.
of the investment project. If this classification is applied to a field development project, then the
general risks should be understood as those that may be triggered by external changes and which may
have an adverse effect on the operation of any company regardless of its field of activity. These should
also include systemic risks, such as war, inflation, shifts in monetary and taxation policies, etc.
Industry risks are those risks that may affect industry enterprises. They include geological,
environmental, and natural risks. The concept of project risks has a narrower focus: these are the
enterprise risks associated with a specific project, in this case, with the field development. They may
be associated with a field location. For example, if a field is located in another country, then the array
of project risks will include a country risk. If the field is developed by different companies, i.e. the
field is transboundary (e.g. Romashkinskoye), then there may be an additional geological risk, and it
may only intensify during the field development. If the field is offshore, then it is more exposed to the
price risk due to higher operational costs. Offshore fields are more exposed to industrial risks, since oil
spills do more damage to the environment than accidents happening on land-based installations.
Besides, offshore fields pose more risk in terms of dependence on political relationship with Western
governments, as these installations are more dependent on the imported equipment.

The result of risk identification should be a risk register arranged as a description table providing
the information on each risk associated with the project.

An expert-based method is proposed as a risk assessment method for the field development project,
namely, the pairwise comparison method suggested by T. Saaty. The choice of this method is
conditioned by the need for quantification (Table 1).

| Risk Significance                                      | Quantitative Value of Risk Significance | Characteristic                                      |
|-------------------------------------------------------|----------------------------------------|----------------------------------------------------|
| Equal significance                                    | 1                                      | Equally substantial risk impact                     |
| One is somewhat predominant over the other            | 3                                      | Experience and judgment make one risk slightly predominant over the other |
| Substantial or serious predominance                   | 5                                      | Experience and judgment make one risk substantially predominant over the other |
| Significant predominance                              | 7                                      | One risk is so predominant that it becomes almost significant |
| Extreme predominance                                  | 9                                      | One risk is obviously seriously predominant over the other |
| Interlocutory decisions between two proximate judgments| 2, 4, 6, 8                             | Applied in case of a compromise                     |

We propose to form a group of experts by bringing the diversified specialists: a geologist, a
drillman, a PSCM specialist, a production shop foreman, and an economist. Five to six people in total.

The methodology, essentially, is that each phase of the investment project of field development
should be characterized in terms of all risks to which the project is exposed. Moreover, all risks are
ranked depending on the probability of an adverse event and significance of the risk in terms of its
influence on the final economic criteria of project success. Note that the emphasis is made on the risk
ratio within each investment project phase, i.e. the total array of risks is recognized as 100% during
each stage and the risks are ranked just then.

To obtain an ordered estimate, the experts assess each risk type based on its significance within the
general range of risks (including the assessment done for a specific project phase) and estimate the
probability of an adverse event.

The methodology is implemented in the order described further.
The experts evaluate the significance of every risk at each phase of the project implementation based on the following scale (Table 2).

**Table 2. Table for Risk Significance Evaluation during the Implementation of an Investment Project of Field Development by Pairwise Comparison.**

| Risk | R1 | R2 | ... | Rn | Amount | Abs. Prior. | Risk Weight |
|------|----|----|-----|----|--------|-------------|-------------|
| R1   | 1  | ...| ... | ...| ...    | ...         | ...         |
| R2   | ...| 1  | ... | ...| ...    | ...         | ...         |
| ...  | ...| ...| 1   | ...| ...    | ...         | ...         |
| Rn   | ...| ...| ... | 1  | ...    | ...         | ...         |
| Total| ...| ...| ... | ...| ...    | 1.0         | 1.0         |

This approach is attributed to the fact that, first, some risks are, in general, more significant for the project and, second, their significance can change depending on the project phase. For example, at pre-implementation, the geological risk is much higher than during the field development stages.

1) By comparing all combinations of potential risk types for each investment project phase, the experts produce a pairwise comparison matrix for each phase of the project. This means that if there are five experts and four phases, there will be twenty such matrices.

2) A scale of the risk impact level is generated.

The scale of the impact level can be arbitrary. Each impact interval may be narrowed down to a single interval of estimate, or expanded up to three points or more, as shown in Table 3.

**Table 3. Scale of Risk Impact Assessment at Each Project Phase.**

| Impact             | Interval of Estimate |
|--------------------|----------------------|
| Low-Level Impact   | 1.0-3.0              |
| Medium-Level Impact| 3.1-6.0              |
| High-Level Impact  | 6.1-9.0              |

As Table 5 shows, each level has its own sub-level. The expert gives a general estimate of the level of a particular risk impact on the project at a given phase, with an option to account for the intermediate values of the impact level. For example, if an expert believes that the risk has a pronounced high-level impact, then he grades it “9”; if he is uncertain whether this risk has a high- or a medium-level impact, he can grade it “6.1” and so on.

3) At each project phase, every risk is given an integral estimate – the risk level. Each expert completes Table 4 for each project phase.

**Table 4. Estimate of the Combined Risk Profile for the Field Development Project Phase.**

| Risk type | Impact, units | Weight, unit fractions | Risk level, unit fractions | Combined risk profile, % |
|-----------|---------------|------------------------|---------------------------|--------------------------|
| 1         | ...           | ...                    | ...                       | ...                      |
| 2         | ...           | ...                    | ...                       | ...                      |
| 3         | ...           | ...                    | ...                       | ...                      |
| Total     | -             | -                      | ...                       | 100                      |

The risk level is calculated as the product of the impact level and the weight of the risk. The final risk level assessment is obtained through summation over the column. Further, the ultimate risk level is recognized as 100%, the combined risk profile is estimated and the last column of the table is filled in.
After the results of the expert group work are processed, a similar table is produced for each project phase.

4) Production of a map of project risk evaluation completes the assessment stage.

It is proposed to enhance the general risk management mechanism of the field development investment project by introducing stage 4: “Production of a risk evaluation map based on the stages of the field development investment project”.

4. Testing the developed methodological approach

The developed methodology was tested on one of the offshore projects of PJSC Rosneft Oil Company.

At the identification stage, a list of risks inherent in mining and offshore projects was made. Specifically, a risk register was produced for the offshore development project Medynskoye-Sea. Significance of each risk was assessed for the project in general, and the risk grading was done for each project phase with regard to the level of risk impact at one or the other project stage. Next, three tables for estimating the combined risk profile were produced. To assess the impact level of every risk at each project phase, a scale for assessing the risk impact was used.

According to the expert estimate, it has been discovered that during the pre-investment phase the geological risk (51%) and underperformance risk (15%) have the highest-level impact on the project. This is explained by the fact that the project can easily become unprofitable and ineffective, if the drilled proved reserves or the project cash flow are estimated inadequately during planning, approval and validation of the project (due to undervaluation of capital spending, changes in tax legislation, etc.).

During the investment phase of the project, the maximum risk is associated with the construction of the aboveground installations and underground structures, well drilling, and field infrastructure development (28%). In offshore projects, especially in the isolated Arctic area, the deadlines for the facility commissioning can easily be missed, leading to a rise in the project cost, reduced efficiency and increased payback period. At the drilling stage, the environmental risk and the industrial accident risk are of special significance for the offshore projects, since Russian companies have almost no experience in developing offshore fields independently, especially under adverse climatic conditions such as the conditions of the Arctic seas.

In the project implementation phase, the underperformance risk (25%) and the risk of oil and gas price reduction (22%) have the highest level of impact.

Apart from that, the impact of the industrial accident risk, environmental risk and geological risk of inadequate definition of reserves will be quite high.

The resulting risk sharing profile is reflected on the risk map (Figure 1). The risk map will allow the project managers to focus on the main types of risk inherent in each investment project phase, i.e. develop a risk management plan.

This methodology does not rule out modern approaches to risk assessment (scenario, discount rate risks accounting and project sensitivity assessment), but complements the existing ones.
5. Conclusion
Like any method, the approach proposed by the authors has its strengths and shortcomings.

The strengths of this method include, first, the fact that it is based on a tool for the risk measure quantitative assessment; second, this method makes it possible to take into account the impact level of a certain risk during each phase of the life cycle of an oil field development project.

The shortcoming of this method consists in subjectivity of the expert group judgments. This is a universal drawback of all expert-based methods [20].

The field of application of the method:
1) Decision-making on a field acquisition. Companies do not always begin field development by taking up a license at the distribution stage. Sometimes a company considers acquiring a producing field.
2) During the feasibility study for the field development.
3) At the field exploitation stage to develop control measures with respect to risk management of the company to reduce damage by risks.
4) In other extractive industries (coal mining, ore mining, and other).
5) The approach can be implemented in any sector of a vertically integrated oil or gas company, since the investment project phases are standard.

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