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Digital technologies of investment analysis of projects for the development of oil fields of unallocated subsoil reserve fund

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Abstract. The task of objective economic estimation of unallocated subsoil reserve fund (USRF) objects is especially important for regions characterized by late phase of development and aggravation of mining-and-geological modes of occurrence of deposits to be implemented. This article presents an information-analytic technology for evaluation of investment prospects of USRF oil fields. This technology is a methodological base for the technical-and-economic estimation with regard to specific industrial aspects, such as: probability estimates of confirmed reserves; determination of primary technological oil field development parameters, etc. Making techno economic estimations is possible in case of using specialized software which allows to process big data, such as EVA (economic estimation of oil fields), EVA-Risk, etc. The suggested info-analytic technology has been practically tested and parameters of investment prospects have been determined for USRF oil fields in the Komi Republic which is the region having highly developed oil and gas sector and unstable prognosis regarding oil extraction for the nearest decade.

1. Introduction

At the current stage of economy digitalization, introduction of up-to-date info-analytic tools in various business processes is becoming especially desirable [1]. One of the key strategies of the oil and gas industry of our country is development and improvement of digital technologies [2] which allow performing investment analysis of oil fields development projects in order to generate reasonable managerial decisions in the context of sharply changing market conditions [3, 4].

The present article suggests an info-analytic model for investment analysis of oil fields of the unallocated subsoil reserve fund. The model is based on consolidation of research findings.

The objective of this work is creation of a unified technology of investment analysis meant for updating data about commercial and budget efficiency of implementation of unallocated subsoil reserve funds (USRF) oil fields.

Practical use of the suggested technology will improve the accuracy of geologic and economic data about USRF oil fields, which, in turn, will give a boost to attracting more investments in the industry [5].

2. Research methods and materials

The info-analytic model of investment analysis consists in sequential realization of the four key stages: analysis of geological information about an object under study [6], geological risk assessment [7], determination of optimal technological parameters of development [8], and the comprehensive assessment of commercial significance [9] which includes assessment of investment risks [10], justification of feasibility of project continuation [11] and of using financial schemes [12] of the USRF fields development project. The block algorithm of assessment is presented in figure 1.

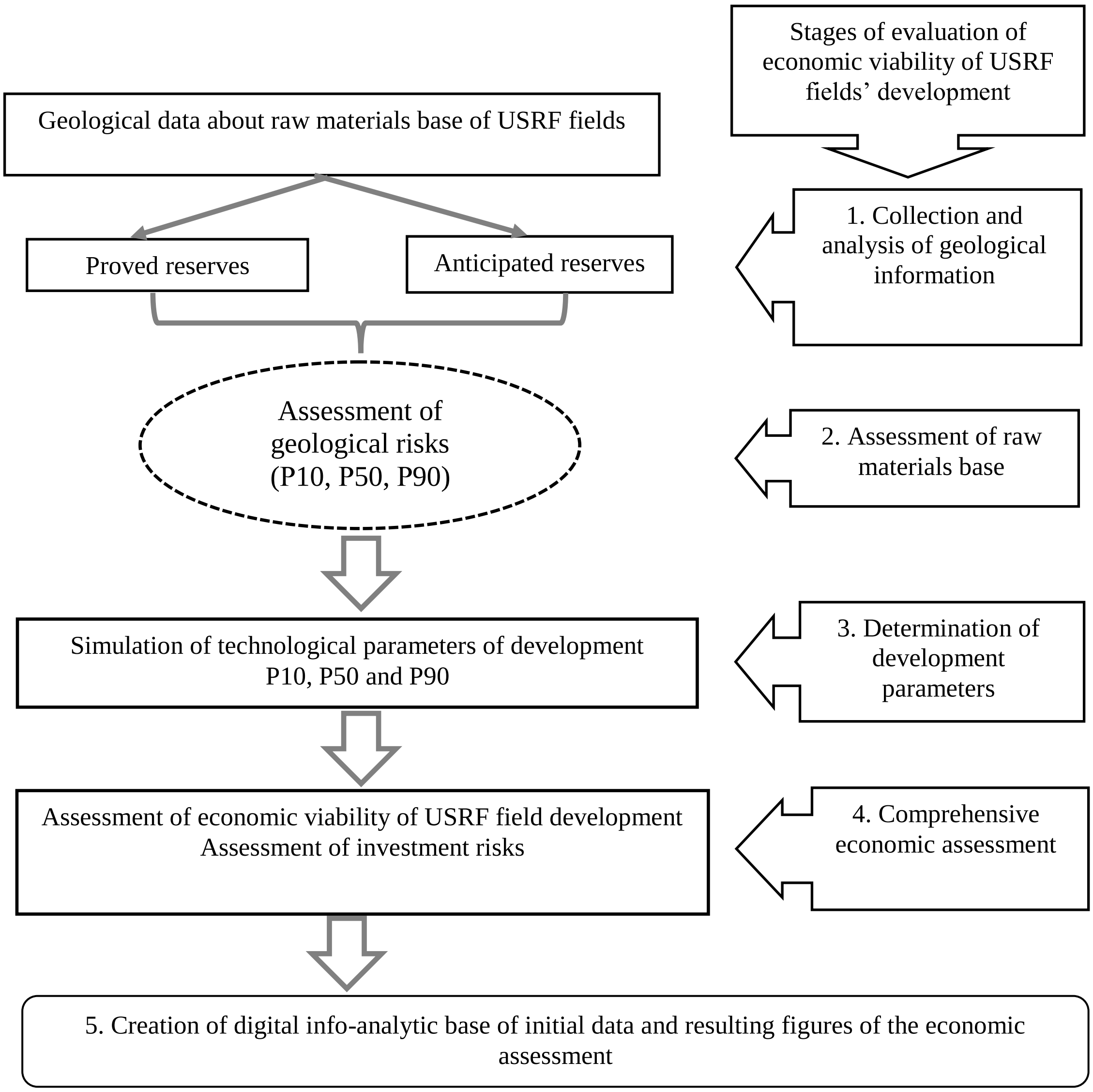

Figure 1. Info-analytic model of investment analysis [13].

At the first stage, it is proposed to collect and analyze the geological information on licensed objects to be evaluated including the results of quantitative evaluation of resources based either on the actual USRF objects data or the information on comparable. On this basis, a standardized field-geological description of the licensed object is to be made up.

The second stage consists in the system of methods and algorithms used to eliminate uncertainty in the available geological information on USRF objects. It is recommended to evaluate the risks using the Monte Carlo technique. For this, the volumetric method of reserves estimation is used, which implies taking into account volumetric parameters [14] varying within the ranges established by expertise depending on the exploration degree of a particular oil-bearing area [15]. The estimation results are used to determine the most probable (P50), maximum (P10) and minimum (P90) values of recoverable oil reserves of the objects subject to licensing.

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At the third stage, the definition and optimization of the main technological parameters of the development of the evaluated licensing object. This part of simulation implies the following: systems analysis of the existing and emerging oil extraction technologies; thereupon, building simulation models for oil field development and interactive business workflows for oil field commercial development.

The fourth stage stipulates comprehensive economic evaluation of development of oil objects subject to licensing [14].

The final stage of cost estimate includes building up a digital info-analytic database which comprises the initial information and the obtained results. This database contains the blocks with cost figures for geological exploration, oil field commercial development, and raw material transportation as well as macroeconomic indicators system and resulting data on investment prospects estimation for the oil fields. It is suggested to use deflator indexes in order to keep the info-analytic database updated.

Storage of the digital geological and economic information makes it possible to do analytic research for any periods of time as well as to compare key parameters and estimation indexes over time in order to take business decisions on USRF oil fields implementation with the use of the specialized technical-and-economic data processing software.

One more issue worth of consideration is the system of additional investment potential criteria which makes it possible to take into account the indirect and multiplicative effects of USRF oil fields development.

To evaluate geological efficiency of geological exploration it is recommended to calculate the following:

- increment of B and C_1 reserves for 1 m of exploratory drilling (P):

$$P = \frac{Q_{BC_1}}{H}; \tag{1}$$

where H is the depth of exploratory wells (linear m),
Q_{BC1} is the volume of prepared B and C_1 reserves;

- increment of oil reserves per one exploratory well:

$$q = \frac{Q_{BC_1}}{N}; \tag{2}$$

where N is the quantity of exploratory wells drilled;

To evaluate cost effectiveness of geological exploration:

- specific cost of preparation per reserves unit (C_0):

$$C_0 = \frac{C}{QBC_1} \ ; \tag{3}$$

where C is the cost of exploratory activities;
Q_{BC1} is the volume of prepared B and C_1 reserves;

- specific cost for additional exploration operations (C_1):

$$C_1 = \frac{Q_{C_2}}{C_\alpha} \ ; \tag{4}$$

where Q_{C2} is the volume of overlooked oil reserves which are technically accessible for extraction,
C_α is the cost of overlooked reserves exploration.

To evaluate technical-and-economic efficiency of oil field commercial development:

- technological oil recovery factor (K_T):

$$K_T = \frac{Q_G}{Q_T} \;; \tag{5}$$

where Q_G is the volume of geologic oil reserves,
Q_T is the volume of technologically recoverable oil reserves;

- period of cost efficient development (T_p):

$$T_p = T_i - 1 \text{ for NPV}_i<0; \tag{6}$$

where T_i is the time point when NPV_i goes negative;

- the volume of commercially viable reserves (Q_{pT}):

$$Q_{pT} = \sum_{t=0}^{T} Q_{t_p} \quad \text{for NPV}_i<0; \tag{7}$$

where Q_{ti} is the production volume in the year t_i;

- economic oil recovery factor (K_E):

$$K_E = \frac{Q_T}{Q_{pT}} \;; \tag{8}$$

To evaluate impact of the tax system on efficiency of oil fields commercial development during the commercially viable period of development T_p:

- net present value of government (NPV_G):

$$NPV_G = \sum_{t=0}^{p} Tax_{t_p} \;; \tag{9}$$

where Tax_{tp} is the volume of the bite of taxes in the year t.

The main result of the info-analytic simulation is accumulation of knowledge on efficiency and conditions of commercially viable development of USRF oil fields at the Rosnedra licensing authorities and subsoil user companies. This knowledge allows the licensing authorities to substantiate their managerial decisions on selection of oil fields subject to licensing as well as on the bidding conditions. It also helps project operators or external investors to optimize their managerial decisions at all stages of oil fields development.

3. Results and discussion

Analysis of investment prospects of USRF oil fields has been performed for 27 objects located in the Komi Republic area, the volume of their reserves being 40 MT.

The oil deposits of 6.54 MT located in some production horizons of the Komi Republic area and overlooked in the course of previous exploration have been taken into account as additional proved reserves. The volume of raw materials base of these objects has been estimated with regard to geological risks (see table 1).

Table 1. Probability estimate of overlooked oil deposits, MT.

Oil and gas bearing area	Production horizon	P90	P50	P10	Modal
Izhma-Pechora	No1	0.069	0.090	0.113	0.101

Pechora-Kolva	No 1	0.83	1.091	1.421	1.051
Khoreiver	No 2	0.397	0.509	0.655	0.466
	No 3	0.595	0.763	0.982	0.777
Northern Pre-Ural	No 2	0.095	0.122	0.151	0.123
	No 3	0.097	0.120	0.153	0.119

The investment potential has been estimated for the conservative scenario (without the overlooked deposits) and for the innovative one (with them). The estimation results are presented in Table 2.

Table 2. Comparison of main geological and economic effects in development of USRF oil fields of the Komi Republic.

Ser. No	Performance factor	Conservative scenario	Innovative scenario	Relation of effects
1	Quantity of commercial fields, pcs.	12	17	+5
2	Volume of commercially exploitable reserves, MT	8.4	14.9	+6.5
3	NPV, bln rubles	3.82	6.22	+2.4
4	NPV_g, bln rubles	40.12	64.6	+24.48

The commercial viability of NSRF oil fields development in the Komi Republic within the innovative scenario is as follows. The quantity of commercially viable objects has increased by five units to reach the number of 17 fields, while the increment of commercial deposits is 5.8 MT. The expected net present value has increased by almost 63% for subsoil users and by 61% for the government.

The economic effects of the innovative scenario realization are as follows: the implementation of objects development of which was business unviable before; the increase in volumes of commercially viable reserves; higher net present values of investors and the government.

Justification of volumes and development rates of USRF oil fields in course of establishing and subsequent development of the oil extraction sector requires their differentiation according to cost efficiency of their development. In so doing, groups of oil deposits get involved in development following the decreasing cost efficiency principle. Thus, at the stage of extraction sector establishing and its initial development the most cost effective objects are taken for development; as they get depleted the other objects get involved in the descending order.

Implementation of the conservative and innovative scenarios will only start in 2020, because the mineral resources licensing must be completed before (see figure 2). For the conservative scenario, the annual increase of oil extraction in the region within the period till 2030 is expected to be of 211 thousand tons in 2020 and up to 503 thousand tons by 2025; for the innovative scenario, it will be 506 to 1036 thousand tons for the same time period.

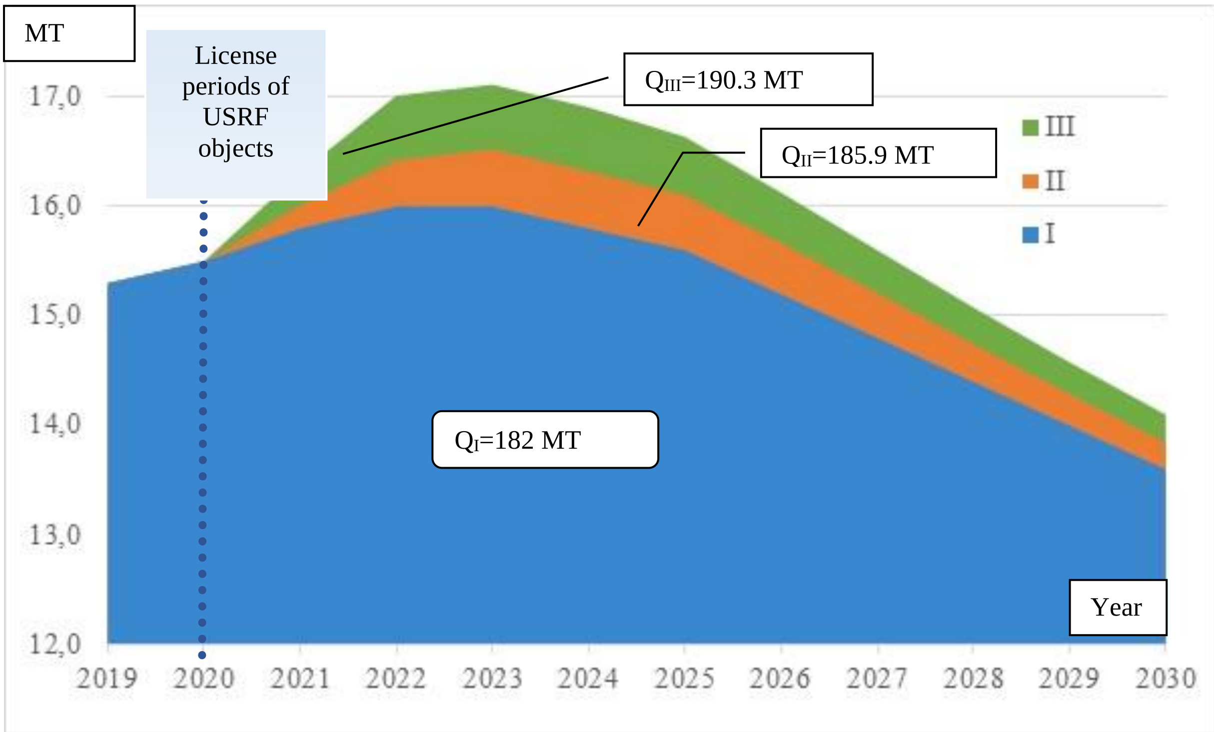

Figure 2. Forecast of USRF oil fields implementation rates in the Komi Republic (I – current estimation, II – conservative scenario, III – innovative scenario, Q – accumulated volume of oil extraction for a respective scenario by 2030).

4. Conclusions

1. The article presents an info-analytic model which is unique due to unification of the evaluation procedure of the investment potential of USRF oil fields development and to the maximum promptness in getting representative results.

2. The authors recommend a system of additional criteria for estimation of the investment potential of USRF oil fields development. Application of this system will allow investors to substantiate their managerial decisions at each step and stage of exploration and development of such objects. Using these criteria for taking managerial decisions by government licensing authorities and operators makes it possible to take into account indirect and multiplicative effects (losses) related to projects implementation.

3. A significant result is creation of a digital info-analytic database containing technical-and-economic indicators of expenditures for types of works related to USRF oil fields commercial development. Digitalization of geological and economic information makes it possible to update the data on USRF objects investment potential any time in order to take reasonable managerial decisions.

4. This info-analytic tool has been practically tested in analyzing investment prospects of USRF oil fields in the Komi Republic. The results obtained have helped to substantiate forecast scenarios of implementation rates for estimated objects; they can be taken as a basis for a concept of organizational and economic measures meant for USRF oil fields implementation.

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