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STRATEGIC PLANNING OF ARCTIC SHELF DEVELOPMENT USING FRACTAL THEORY TOOLS

Vitalii S. VASILTSOV, Veronika M. VASILTSOVA
Cherepovets State University, Cherepovets, Russia

The paper justifies the necessity to utilize new methods of strategic planning in oil and gas field exploitation in the Arctic shelf during the implementation of high-technology diversified model of development for oil and gas companies (OGC) based on principles and tools of fractal theory. It has been proved that despite its challenging conditions the Arctic represents not only resource potential of the country and a guarantee of national safety, but also a key driver of market self-identification and self-organization of OGCs. Identified and analyzed problems in institutional procurement of shelf development and utilized methods of strategic planning and project management, both on the levels of state and corporate governance, demonstrate that reductive approach of the fractal theory allows to take into account diversification of heterogeneous multicomponent project models, which can be reduced to a single management decision with inverse iterations of neural network modelling. Suggested approach is relevant for strategic planning not only on the stage of investment portfolio justification, but also for identification and assessment of project risks; ranking of projects according to the order of their implementation; back-and-forth management (monitoring and supervision) and project completion. It has been detected that such basic properties of the fractal as self-similarity, recurrence, fragmentation and correlation between all fractal dimensions allow to systematize chaotically changing values of market parameters in the Arctic shelf development project, which provides an opportunity to forecast market development with minimal prediction errors.

***Key words*:** Arctic shelf; oil and gas megaproject; strategic planning; fractals; recurrence; risks; neural network programming.

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Introduction. Almost any strategy, developed in accordance with the Federal Law «On Strategic Planning in the Russian Federation» every 6 years and updated annually, assigns an important role of national economy's driver to the development of the Arctic shelf [17]. This megaproject, initiated in Soviet times due to the energy crisis of 1973-1974, was given renewed momentum in modern Russia.

Nowadays efficient development of the shelf is even more probable due to technical and technological progress – e.g. drilling can occur at significant sea depth under harsh climate conditions [5]. Apart from political, climate, environmental and other problems, project implementation is limited by lacking financial resources, as the volume of required investment is enormous, and multiplicative chaotic growth of types and level of project risks. The problem lies not only in gigantic costs, which by roughest estimates amount to 2.5 trillion USD [12]. Utilized planning methods and strategic management models of project implementation do not fully meet the requirements for sustainable development of oil and gas companies (OGCs) operating in the Arctic shelf, as their assessment of chaotically changing external and internal factors associated with investment substantiation is insufficient [25].

The paper focuses on an important scientific issue of Arctic resource development under unstable political and economic conditions, when active exploitation of the Arctic Ocean's coastal band is being postponed. Apart from bringing income to the state budget and increasing OGC's profit, the project is also supposed to guarantee sovereignty of the state. The problem lies in substantiation of the necessity to update and extend methods of strategic planning and operational control of project implementation during the development of OCG's carbohydrate reserves using cutting-edge economic and mathematical methods and fractal theory tools.

The goal of this research is to provide methodological substantiation of the necessity to utilize fractal theory tools as one of the methods to increase the efficiency of corporate strategy design and

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realization of investment plans of oil and gas hydrocarbon development in the Arctic shelf of Russia. To attain this goal the following tasks have been completed:

• institutional procurement of oil and gas extraction in the Arctic has been studied;

• critical analysis of existing methods of strategic planning in OGC has been performed;

• methodological substantiation of the necessity to utilize fractal theory tools during the development and implementation of corporate strategic plans in OGCs as regards risk management optimization in investment projects.

A search for ways to overcome crisis pressure on the national economy in general and oil and gas business in particular actualizes the need to realize the project of Arctic shelf development, selected as a research object. Therefore development of methodology aimed at corporate strategic plan substantiation of oil and gas carbohydrates in the Arctic shelf and their operational control based on new methods and tools will allow to select optimal solutions to the stated problem.

Literature review. Judging by nationwide significance of the project under consideration, top-priority data sources include relevant laws and regulations. The authors studied and analyzed not only federal laws [17], but also subordinate acts, like Basic Principles of State Policy of the Russian Federation and Development Strategy in the Arctic Zone, a whole range of state programmes [15, 19] and other official documents regulating key objectives and directions of Arctic shelf development [12, 13]. Problem statement and search for its solution have been performed using scientific periodical literature and treatises on Arctic development: A.E.Kontorovich [8], V.A.Yazev [20], G.B.Kleiner [7], N.L.Antonov and M.L.Lisitsyn [1], V.M.Vasiltsov [4], V.F.Shurshev and N.P.Ganyukov [18] and others.

A study of literary sources revealed that the adaptation of fractal theory principles to the global practice of process development – in the areas of biology, chemistry, social sciences, economics and IT – started in the second half of 20th century. As for Russian scientists, it is only recently – after the transition to market economy – that they have approached the theory from the viewpoint of its potential application in economic assessments. Among researchers, specializing in practical application of fractal theory, one can name B.Mandelbrot [10, 21], H.J.Warnecke [29], F.I.Mavrikidi [9], E.Peters [14], L.H.Richard [10], R.P.Rumelt [25], K.Ryu [26], V.Zhou [23] etc. In Russia this issue attracted the attention of V.I.Arnold [2], B.P.Belousov [3]. A.M.Zhabotinsky [30], B.I.Krinsky [6], A.N.Zaikin [30], G.R.Ivanitsky [6] and others. At the same time there is still no original research substantiating development strategy of oil and gas hydrocarbons in the Arctic shelf and operational control of their realization using methods of neural network modeling and fractal theory. Current research attempts to justify the necessity to utilize new methods of strategic planning in oil and gas field exploitation in the Arctic shelf.

Methods. Multivariability of the project implies that simultaneously with technical and economic problems it will solve social, economic, transport and political issues by means of organizing relevant institutional procurement, which only complicates the methodology of problem solving. Notwithstanding undeniable importance of internal institutional regulations within the state, OGCs are permanently affected by chaotically changing influence of global interstate institutions and market forces, which multiplies the risks and brings into question the implementation of shelf development projects, carried out by Russian OGCs using conventional deterministic approaches (e.g., regressions, trends etc.). Nowadays three conventional scenarios in each individual project and investment development of the corporation do not suffice.

Oil corporations, alongside the conventional project approach, need to use a multiple-option non-linear approach that allows to select from several alternative paths and rates of investment development, e.g., using principles of fractal theory.

Applied methods of strategic planning during exploitation of oil and gas fields in the Russian Arctic shelf should be provided with economic and mathematical tools relevant for the crisis stage. It is common knowledge that in the latest years the tools of chaos and catastrophe theories, fuzzy methods, genetic algorithms, neural network modeling etc. are extensively used in the world prac-

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tice of strategic planning. In the process of analyzing market dynamics each of the above mentioned methods can separately take into account internal and external changes. But tools and methods, which allow to take into account the impact of market chaos on management decisions on increasing efficiency of OGC self-organization with a regard towards constantly changing parameters of project risks depending on the factors of external environment, are not enough. In authors' opinion, this problem can better be solved by means of fractal theory tools.

On a visual level fractal (from Latin *fractus* – shattered, broken) is a geometrical shape with a property of self-similarity, composed of numerous elements similar to the whole. Deterministic part of the fractal repeats itself over and over. E.g., one angle in Sierpinski triangle (Fig.1) gets fractally multiplied [23], in the rating of oil corporation projects such iterations can occur from left to right, from right to left and interchangeably.

Fractal as an aggregated curve is a self-similar structure invariant to the scale. Fractal graph visualizes a recursive model, separate elements of which dynamically reflect the entire structure. E.g., using these fractal properties in strategic planning for a certain resource or project, the analyst can compare price dynamics in the beginning and in the end of a planning horizon and predict vector of market development with minimal errors.

Discussion. Analyzing existing methods of OGC strategic planning, one should bear in mind that OGC strategy has to be founded on a holistic comprehension of economic and political situation, which in its own turn is based on regular reassessment of revised problems faced by the company. Importance of the project is also supported by the preferences that state-owned OGCs – PAO «Gazprom» and PAO Oil Company «Rosneft» – have in terms of Arctic shelf license grants [19].

At the same time, analysis demonstrates that results of state program implementation do not fully meet the goals set in the megaproject; this fact is also supported by the state audit. E.g., analysis of state participation in the sub-program «Shelf» (Federal Target Program «World Ocean»), the goal of which is to facilitate development of machinery, equipment and high-technology installations for hydrocarbon fields exploitation and construction of 10 sea platforms in the Barents Sea for annual extraction of 10 million bbl of oil and 40 billion m^3 of natural gas, demonstrated the share of federal budget in the program amounts to modest 0.7 % [12]. This example indicates investment and financial priority of OGCs' own resources in shelf development.

The state and OGCs actively cooperate with each other, shaping new institutional environment of shelf development. The crisis makes companies change their organizational structure in real-time mode taking into account simultaneous changes in financial flows (including investment ones) inside and outside OGCs under escalating innovative hypercompetition [28]. Nowadays it is not enough to direct a strategic vector solely to the search of options to cut production costs. A reorganization is needed that will simplify organizational and administrative structure and change the entire business model. In the pre-crisis period the strategy was regarded as a set of rules for making management decisions primarily in the internal environment of the company [7]. The crisis expands horizons and structure of strategic planning, makes the problem more complex, containing at least three blocks: 1) internal environment of the company; 2) market (external) environment; 3) political (external) environment [28].

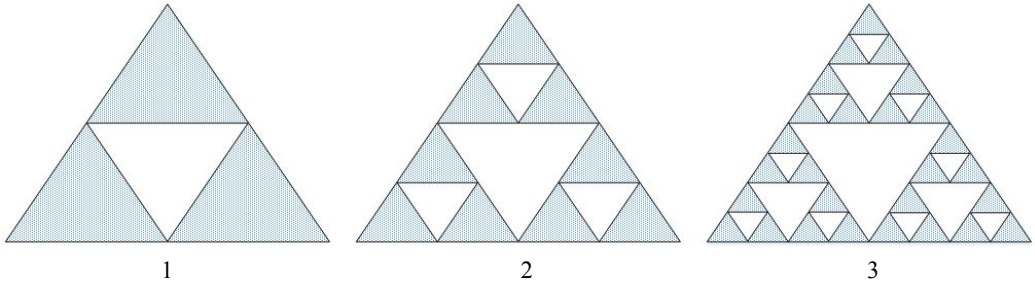


Fig.1. Sierpinski triangle of oder 1, 2 and 3

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The first block in strategic planning of shelf OGC projects actively utilizes American guidelines *Project Management Body of Knowledge (PMBoK)* – a set of standards for project management [24]. PMBoK is n overall structure-forming method that in general terms sets parameters and the structure of project planning. It does not specify the position and importance of key elements of administration mechanism: goals, objectives, procedures, assessment criteria, participants, resources, methods and tools of leverage, monitoring system, regulatory support. Moreover, applied methods do not contain a precise set of instruments to calculate specific indicators of project efficiency, and above all market parameters, like the risks. The following methods are either insufficient or altogether absent:

• prediction methods (modeling and analysis of risks (uncertainty) in the assessment of project efficiency (time and financial costs);

• analytical methods for the checklist of risk sources, based on the history of risk situations having occurred in similar or previous projects;

• methods of anticipated losses estimation based on mathematical expectations of losses associated with each risk type.

Today there are numerous tools and areas of economic mathematics, applied in the management of economic processes, and each one has its advantages and disadvantages. Particularly, net present value (NPV) is the most frequently used indicator in investment planning, which serves as a relatively precise criterion of project efficiency. One of its advantages is that the calculation takes into account how the value of money changes within the time lag – money gets discounted and discount rate depends on the risk level – the higher the risks, the higher the discount rate and vice versa. The greatest disadvantages include the difficulty to differentiate the discount rate in multi-industry projects or project profile of the corporation and probabilistic, forward-looking method of discount rate calculation.

Fundamental reasons that determine low efficiency of strategic planning methods also include three groups of problems.

• From the viewpoint of climate, geology, economy and politics, Russian Arctic zone differs significantly from similar shelf areas, already involved in oil and gas field exploitation (Alaska, Canada, Norway). Therefore existing methodical approaches require adjustment to the specifics of Russia, moreover – to the specifics of each project.

• Russian OGCs have no practical experience in exploitation of Arctic shelf fields in the context of the megaproject in question, which only complicates the matter. The initial stage of project development often gets postponed due to lengthy negotiations regarding methodological issues in Russian business model of shelf development.

• In Russia there is no complex methodological approach, which would allow to select criteria and assess their parameters in order to choose a strategy of field development in the Arctic shelf under new, non-linear and catastrophic conditions of operations in the energy market. Declaring their transition to the market, most OGC managers regard the prospects of shelf development not as a company's objective, but rather as a problem of the state – despite the fact that the government takes care of institutional procurement whereas OGC must provide financial resources for its implementation (investment burden) and solve the technical task of field exploitation. The government in this case plays a paternalistic role of «hands-off management», detached from the technological process. In the worldwide practice state interference is confined to authorization and supervision. E.g., in the US up to this day oil extracting companies apply the wildcat method – on the off-chance, without any substantiation, carried out by private owners of spatially confined fields relying solely on their own resources – financial and technological.

Under crisis conditions, industry-specific and global destabilization, it is not enough to regard development of OGC strategy only as a mission of the company, a budget or a short-term development plan. Sustainable development of modern OGCs in the Arctic requires consolidation of companies and separation of centralized top-management from individual industrial plants, which com-

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plicates strategic management as it multiplies forward and backward signals – increases the amount of preparatory data, as well as data on generated and time-rated projects with constantly changing parameters.

The scale of the problem as a whole necessitates methodological elaboration of its solution in the context of expanding utilized set of economic and mathematical tools: in particular, fractal theory and neural network modeling. Practical application and development of fractal theory provides an opportunity to simplify complex-structured objects and strategic decisions on directing centralized resources. The process is based on regularly updated project rating, determination of investment development using fractal structure and formation of self-learning system of neural network modeling. Benoit Mandelbrot, who coined the scientific term *fractal*, made the following comment: «I invented the word *fractal* deriving it from a Latin adjective *fractus*, which means irregular, recursive, fragmented» [21]. Fractal approach is utilized when the system has numerous development alternatives for separate elements (projects). Current approach allows to adjust development vector basing on identification of recursive connections between objects and socio-economic processes. Determination of the fractal structure of investment development provides an opportunity to define the structure of occurring changes in the internal and external environment. Fractals allow to simplify objects, describe unstable processes and predict their future.

Hence, insufficient scientific coverage of the problem and lacking practical experience under modern market conditions, aggravated by the global crisis, make substantiation of new rational approaches to strategic planning of oil field exploitation in the Russian Arctic a relevant and important task.

Currently OGCs assess project risks using expert methods, opposing them to extrapolation method – also linear, different only in cash flow discounting. In authors' opinion, the process of expert evaluation is, in a certain sense, an extrapolation – experts project (extrapolate) their previous expertise onto possible scenarios of project development, which only increases subjectivity of risk assessment. Besides, research demonstrates that companies often try to «play it safe» when choosing permissible level of project risks. As a result, the most risk-costly negative scenario gets selected, which increases investment costs not only in terms of absolute amount of investment, but also due to credit interest, even in case of budget financing [4, 11].

Increasing the quality of strategic plans developed by the state and OGCs can be attained using revolutionary mathematical techniques of prediction, enabling more adequate analysis of internal and external environment based on cutting edge tools of scenario evaluation and development, required due to non-linear, chaotic and lowly predictable development of the business. The key difficulties with this problem originate from a multitude of specific features, affecting offshore reserves of oil and gas, which calls for alternative methods of strategic planning suitable for the research subject.

Results. Utilization of fractal theory tools opens up new opportunities for strategic planning of Arctic shelf development, because fractals are characterized by the property of self-development, which defines fractal as a controlled element affected by a multitude of determinable and chaotic factors of internal and external environment. Appropriate development of economic-mathematical tools of statistical fractal model will permit OGCs to obtain adequate and precise forecasts for energy, financial and other markets, where resources for the realization of shelf development strategy are sold and bought. On the other hand, fractal approach to the development of resource and product markets permits a more holistic assessment of market changes, which would take into account their heterogeneity. Fractal approach allows to take into account volatile risks characteristic of crisis economy and to perform regular updates of the project rating.

Strategic planning of OGC investment development is aggravated by the necessity to align the portfolio of investment projects with the overall goal of corporate strategy based on improving results and efficiency of separate plants within the OGC. The most problematic issue here is the dis-

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tribution of internal corporate investments. Authors suggest that the key selection criterion for top-priority investment projects should be an aggregated risk coefficient of the project. Hence the approach of reducing a complicated phenomenon to a simple one, combined with a substantiated selection of top-priority projects from the portfolio, allows to take into account stability of their implementation, diversity of risks and other contributing factors [12].

Figure 2 defines the place of fundamental interdisciplinary fractal theory and its tools in the system of economic sciences. The classification is based on a general-to-specific approach. The first level is general theoretical knowledge of physics and mathematics. The basic principles derived from this level shape the entire system. Multiplicity of scenario elements and non-linearity of processes serve as a starting point for application of fractal instruments in strategic planning and management [7, 19]. E.g., chaotic market fluctuations may at first seem patternless, but fractal theory regards chaos as a higher form of organization, where random impulses transform into a cornerstone principle [8, 14].

The second level represents subjectivization, when the principles of fractal theory are seen from the perspective of economic theory and its methodology. Introduction of new parameters (the impact of ownership form and business pattern on managerial decisions) occurs on this stage. Framework conditions of economic laws are taken into account: firstly, the law of time conservation (e.g., when selecting a technology of shelf development or answering the market question «which way of production to use?»); secondly, the laws of supply and demand when answering the questions «what?» and «how much?» to produce and «at what price?» and «whom?» to sell; thirdly, laws of market price formation when choosing investment sources and return patterns based on laws of property, appropriation of production results and other general or specific economic laws and institutions. The second level poses the questions of resources selection, their evaluation, determination of partners and competitors, taking into account the stage of economic development of the system, which allows to specify parameters of the selected vector of economic development. Fractal theory tools allow to describe interconnections between multiple events and to justify the conclusions. This methodological stage forms «self-similarity» parameters of the project in relation to already existing business processes in the company [24]. Naturally, the second level does not imply any precise calculations that can support the conclusions made. Instead of conventional coordinates of the linear approach, fractal diagrams constructed on this stage represent general dynamics of OGC value after project implementation, e.g., not a precise absolute price in a fixed moment of time. Non-linear project management means that an OGC can have multiple scenarios and alternatives of development [9]. So, it is very difficult to take into account a whole range of factors, affecting the choice (seasonal, political, climatic etc.).

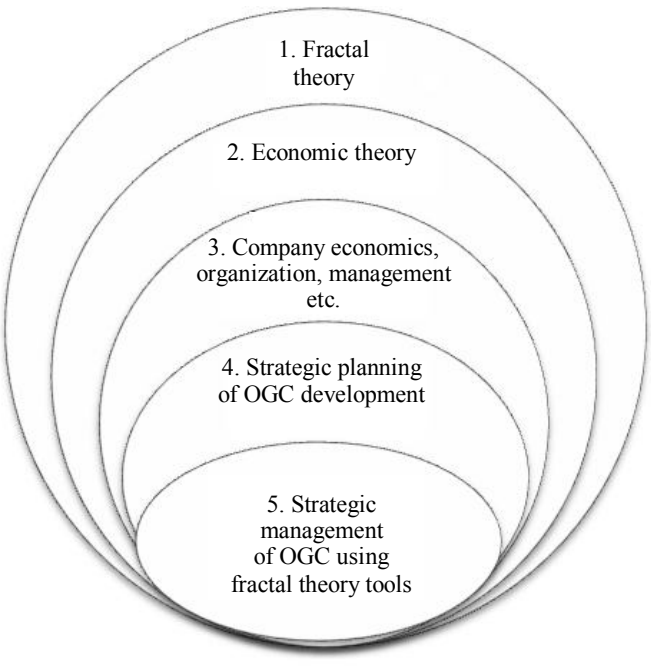


Fig.2. Place of fractal theory tools in the system of economic sciences

The task of choosing a possible set of decision alternatives and selection of the best one for the conditions of a current stage is addressed on the third level, where the main principles and terms of fractal theory application are determined for a specific company. Conclusions made on this stage justify the selection of an optimal investment project and vector of company's strategic development.

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On the fourth level the fractal approach can be used in the evaluation of project efficiency and rating the order of development for offshore fields [27] depending on constant non-linear fluctuation of project risks. Here strategy development is based on the implementation order of a fractal-neural model of OGC strategic planning (Fig.3).

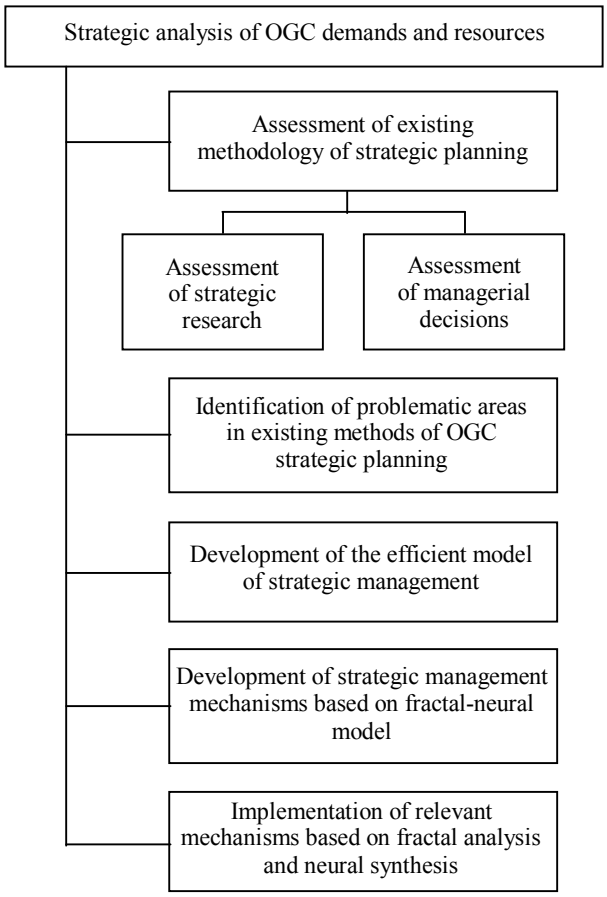


Fig.3. Implementation order of a fractal-neural model of OGC strategic planning

Strategic planning is a process of systematic re-assessment of strategies where fractals are regarded as a self-replicating system of project parameters. Systematic work should be based on a principle of a self-learning fractal program, formalized by means of economic – mathematical modeling. The fifth level (see Fig. 2) contains the final action choice (last step in Fig. 3). This is the stage of project implementation based on the model of efficient strategic management. It represents a model of managers' behavior, which demands constant development of new organizational competences, aimed at reaching higher efficiency as a result of following an approved and updated strategic plan. The mechanism of strategic management, which utilizes fractal principles, is characterized by back-and-forth (reciprocating) movement in terms of processing of project information.

As an example of a hypothetical fractal model of OGC strategic planning, the authors constructed a theoretical portfolio of key investment projects with suggested values of aggregate risks (see Table).

A 12-year planning horizon has been selected due to the State Strategy for the period of 2013-2020, plus four prospective years (according to the Strategy), because fractal is an advancing signal. In this case key parameters are the projects, chosen by the corporation for priority implementation in the year under examination. Aggregate risks of key projects can be calculated using various quantitative and qualitative methods, including neural network modeling. In the latter case the value of aggregate risks is relative.

The research was carried out in Fractan 5.0, traditionally applied in methods of fractal analysis. This software forms and analyzes number series using Hurst exponent calculation [16, 22]. Based on the assessment of investment efficiency and aggregate risks, carried out with the software in the time lag of 12 years, investment (IF) a risk (RF) fractals have been plotted (Fig. 4).

Whereas investment fractal is already formed and its trajectory is fit for making management decisions regarding investments into key projects: e.g., using loans (lower points) or equity capital (higher points), risk fractal is only beginning to take shape. Analysis of obtained series of aggregate risks (Fig. 4) demonstrates that from the position of investment fractal the greatest threat falls into the interval from 2020 to 2024. Gradual increase in investment threats occurs due to a whole range of factors (growing amounts of project financing, new product market entry, implementation of process innovations etc.). On the other hand, commercialization of projects 7-10 leads to risk fractal development. General analysis of fractals shows that methods of OGC planning and development management need to be actualized in the period from 2020 to 2024, when the number of risks comprising the aggregate system risks begins to expand.

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Aggregate risks of key OGC projects (2013-2024)

Project No.	Aggregate risks of key corporate projects											
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1	0.2	0.9	1	1	1.1	1.3	0.2	0.3	1.3	1.8	2	3
2	0	0	0	0	1.3	1	2.8	1.3	1.9	1.1	2.1	2.6
3	2	2	2	2	2.2	2.5	1.3	1	0.5	0.5	0	0
4	3.1	3.2	3.2	3.3	3	2.9	2.7	2.6	2.4	2.2	2	2
5	3.1	2.7	2.5	2.3	2.1	1.5	1	0.8	0.4	0	0	1
6	0	0	0	0	0	0	0	0	0	0	1.3	2.1
7	0	0	0	0	0.5	1.2	2	2	2	3	3.5	3.5
8	0	0	0	0	0	0	1.5	2	2.3	3.1	3.5	3.8
9	0	0	1.1	1.6	2	0	2	2.1	3	3	3.4	4.1
10	0	0	0	1.2	1.9	2	2.2	2.3	2.9	3	4	4.6

Undoubtedly, techniques of making management decisions on the corporate level require further examination. However, the vector of scientific knowledge is aimed at the development of analytic tools using not only conventional methods of strategic planning.

A formulated strategy of OGC development should be periodically updated by means of neural-fractal analysis of the internal and external environment. Scenarios of its actualization can vary – either current actualization once a year, or a more agile monthly or event-related update, influenced by substantial chaotic changes in the global hydrocarbon market or other circumstances. Primarily the levels of risk and uncertainty of investment projects, included in OGC development strategy (including high-risk projects), are re-assessed by means of neural networks. It is possible to include project, which earlier have not been a part of development strategy, but became promising under changing circumstances. Then new fractal model of strategic development is being formed, and it reveals emerging characteristics of self-similarity in analyzed statistical data (spatial fractal). Updated fractal model can increase the efficiency of strategic management by revealing new connections between existing tasks, re-distribution of cash flows needed for innovative implementation, exclusion of questionable projects etc.

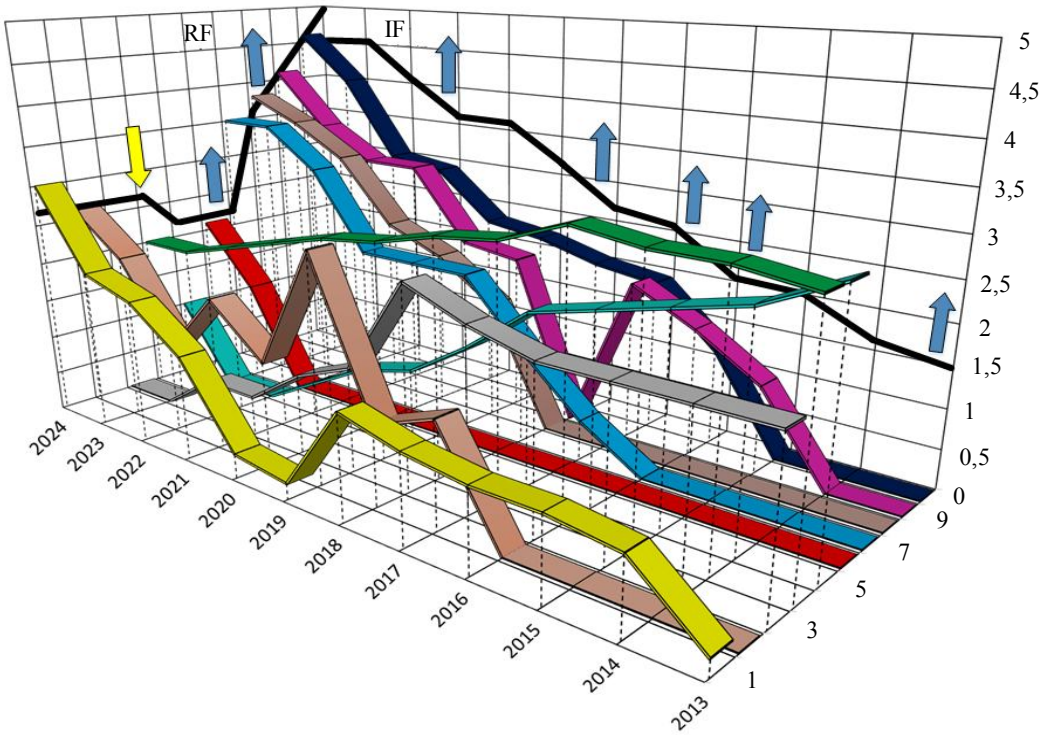


Fig.4. Strategic risk assessment of innovative projects based on comparison of investment (IF) and risk (RF) fractals

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Management methods include monitoring and supervision over project implementation. Meanwhile fractal model of economic and mathematical calculations is replaced by neural synthesis of benchmark data on project implementation.

Conclusion. Taking into account global hypercompetition, in the long term Russia as one of the richest subarctic countries should intensify extraction of oil and gas reserves in the Arctic shelf basing on newest economic-mathematical models and methods of strategic planning and fractal theory tools in particular.

1. According to U.S. Office of Strategic Services, shelf reserves amount to 77.7 billion tons of oil equivalent, or over 20 % of world hydrocarbon reserves. Around 80 % of them are located on the territory of Russia. Until 2020 Russian Government plans to invest around 630 billion rubles into Arctic Research & Development program [1, 12]. For all the importance of institutional procurement and financial resources of the state, practical realization of the project is the responsibility of oil and gas companies.

2. Strategic planning, performed by means of conventional methods of investment justification and Project Management Body of Knowledge, does not allow to take into account full dynamics of changing market parameters taking into account growing market independence of Russian OGCs and spontaneous, chaotic changes in the world energy market that increase quantity, types and unpredictable nature of project risks.

3. Reductive approach of fractal theory allows to take into account diversification of heterogeneous multicomponent project models, which can be reduced to a single management decision with inverse iterations of neural network modeling. On the stage of initial investment calculations, application of fractal theory tools allows to take into account competitive influence of opposing forces, to come to their optimal combination and to create a self-learning model which considers changing parameters of project efficiency and the implementation order of investment projects in the portfolio.

The study presented in the paper is mostly theoretical and its aim was to justify the necessity to apply fractal theory tools in the economic practice, as well as to create methodological foundation for economic-mathematical models of fractal design and strategic management of OGC development in the Arctic shelf.

REFERENCES

1. Antonova N.L., Lisitsyna M.I. Russia in Its Struggle for the Arctic Shelf. *Vestnik SurGU*. 2014. Iss. 1(3), p. 54-58.

2. Arnol'd V.I. Catastrophe Theory. Moscow: Nauka, 1990, p. 128 (in Russian).

3. Belousov B.P. Periodical Reaction and Its Mechanisms. Sbornik referatov po radiatsionnoi meditsine za 1958 god. Moscow: Medgiz, 1959, p. 120-147 (in Russian).

4. Vasil'tsova V.M. Problems of Hydrocarbon Field Development in the Arctic Shelf. *Zapiski Gornogo instituta*. 2016. Vol. 218, p. 345-350 (in Russian).

5. Gubanov A.I. Demarcation of Continental Shelf in the Arctic: Problems and Prospects of International Legislation. Moscov: Zertsalo, 2015, p. 310 (in Russian).

6. Ivanitskii G.R., Krinskii V.I., Sel'kov E.E. Mathematical Biophysics of the Cell. Moscow: Nauka, 1977, p. 310 (in Russian).

7. Kleiner G.B. Mechanisms of Strategic Decision Making and Strategic Planning in the Company. *Voprosy ekonomiki*. 1998. N 9, p. 56-70 (in Russian).

8. Kontorovich A.E. Oil and Gas of Russian Arctic: Development History in 20th Century, Resources, Strategy in 21st Century. *Nauka iz pervykh ruk*. 2015. N 1(61). URL: https://scfh.ru (access date 12.09.2018) (in Russian).

9. Mavrikidi F.I. Fractal Mathematics and the Nature of Changes. *Del'fis*. 2008. N 54(2), p. 27-30 (in Russian).

10. Mandelbrot B., Richard L.H. The (Mis)behavior of Markets. Moscow: «Vil'yams», 2006, p. 400 (in Russian).

11. Neilor T.G. Machine Imitations in Economic System Models. Moscow: Mir, 1975, p. 432 (in Russian).

12. Arctic Shelf Development. Materials of the Expert Committee of Russian Government «Development of the Arctic and Northern Sea Route». URL: http://xn----8sbbmfaxaqb7dzafb4g.xn--p1ai/osvoenie-arkticheskogo-shelfa-rossii/ (access date 11.09.17) (in Russian).

13. Fundamental Principles of Russian State Policy in the Arctic for the Period Until 2020 and Further. URL: http://government.ru/info/18359/ (access date 29.12.17) (in Russian).

14. Peters E. Fractal Analysis of Financial Markets: Chaos Theory Applied to Investments and Economics. Moscow: Internet-treiding, 2004, p. 304 (in Russian).

15. Development Strategy of the Arctic Zone of Russian Federation and Provision of National Security Until 2020. URL: http://government.ru/info/18360/ (access date 20.12.17) (in Russian).

16. Tikhoplav V.Yu., Tikhoplav T.S. Harmony of Chaos, or Fractal Reality. St. Petersburg: «Vest'», 2003, p. 362 (in Russian).

17. Federal Law N 172-FZ from 28.06.2014 «On Strategic Planning in the Russian Federation». URL: http://www.kremlin.ru/acts/bank/38630 (access date 20.12.17) (in Russian).

18. Shurshev V.F., Ganyukova N.P. Advancing Management of Corporate Socio-Economic Systems. *Vestnik Astrakhanskogo gosudarstvennogo tekhnicheskogo universiteta. Seriya: Upravlenie v sotsial'nykh i ekonomicheskikh sistemakh*. 2010. N 1, p. 23-27 (in Russian).

19. Energy Strategy of Russia Until 2035 (Revised 21.09.2016). Project ES-2035. URL: http://minenergo.gov.ru/node/1920 (access date 20.12.17) (in Russian).

20. Yazev V.A. Strategic Planning of Technology Innovations as a Key Condition of Arctic Shelf Development. URL: http://federalbook.ru/files/TEK/Soderzhanie/Tom%2015/III/Yazev.pdf. (access date 20.12.17) (in Russian).

21. Mandelbrot Benoit B. The Fractal Geometry of Nature. San-Francisco: W.H.Freeman. 1982, p. 460.

22. Hurst H.E. Long-term Storage of Reservoirs. *Transactions of the American Society of Civil Engineers*. 1951. N 116, p. 770-808.

23. Jia B., Zhou Z., Zhu Z. Hausdorff measure of the Sierpinski gasket. *Analysis in Theory and Applications*. 2006. Vol. 22. N 1, p. 8-19.

24. PMBOK Guide and Standards. URL: http://www.pmi.org. (access date 20.12.17).

25. Rumelt R. Good Strategy Bad Strategy: The Difference and why It matters. London: Profile Books, 2011, p. 336.

26. Ryu K. Methodology for Implementing Agent-based Controllers in the Fractal Manufacturing System. Proceedings of 5th Conference on Engineering Design & Automation. Las Vegas, August. 2001, p. 91-96.

27. Sukharev O.S. Structural Modelling of Economic Growth: Technological changes. *Megatrend Review*. 2016. Vol. 13. N 1, p. 1-14.

28. Vasiltsova V., Dyatlov S., Vasiltsov V. and etc. Methodology of Management Innovation Hypercompetition. *Asian Social Science. Published by Canadian Center of Science and Education*. 2015. Vol. 11. N 20, p. 165-169.

29. Warnecke Hans-Jürgen. The Fractal Company: A Revolution in Corporate Culture. Germany, New York: Springer-Verlag, 2011, p. 248.

30. Zaikin A.N., Zhabotinskii A.M. Concentrational Wave Propagation in Two-Dimensional liquid-phase Self-oscillating System. *Nature*. 1970. Vol. 225, p. 535-537.

***Authors*: Vitalii S. Vasiltsov,** *Doctor of Economics*, *Professor*, *3297@rambler.ru* (*Cherepovets State University*, *Cherepovets, Russia*), **Veronika M. Vasiltsova,** *Doctor of Economics*, *Professor*, *19197676@mail.ru* (*Cherepovets State University*, *Cherepovets*, *Russia*).

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