



Systemic Representation of Sophisticated Economic Structures of Oil and Gas Sector of the Economy

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ABSTRACT

Complex economic agents are always a subject of scientific research aimed at systemizing and generalizing the existing knowledge and finding out new knowledge about their structure, general and peculiar properties, transformational change. With regard to this, one of the widely used definitions here is the "sophisticated economic structure" (SES), the conceptual aspect of which is not represented in scientific literature. In this paper, the author describes the content of the said definition based on the general scientific methods of systemic and logical analysis, analogies and generalization. Its key properties are outlined as follows: Emergence, hierarchy, purposefulness. As a result of the study, the oil and gas economic agents' belonging to SESs has been proven. The key attributes that allow ranking the oil and gas companies as sophisticated are the multi-element composition, managerial and production complexity, a large quantity of internal relationships and interaction with the external environment. As a result of the research, a system model has been developed that describes the objectives being set, internal and external environment parametrically, and variants are outlined of systemic and structural representation of oil and gas companies reflecting the levels of managerial hierarchy, composition of adjustable elements of the value-added chain in the oil and gas sector of the economy.

Keywords: Sophisticated Economic Structure, System Properties, Oil and Gas Company, System Approach, Integrated Structure, Managerial Hierarchy

JEL Classifications: F15, L95

1. INTRODUCTION

The scientific literature and practical activity widely uses the definition "sophisticated economic structures (SES)" for characterizing the economic agents of various branches and spheres of activity. However, there are few if any scientific and research published works reflecting the conceptual view of this notion. Meanwhile, quite a lot of studies and scientific works are dedicated to defining and structurally representing the complex systems in characteristics of various subjects and economic complexes that are peculiar to them, branch and spatial structure of the economy. The study of genesis and modern condition of organizational forms of functioning of oil and gas sector enterprises confirms their diversity: The national oil companies, vertically integrated oil companies, transnational companies etc. A comparative analysis of the composition of structures, their internal and external relationships, factors influencing the objectives definition and activity strategizing, multitasking of

the in-house management allows concluding that a generalizing notion can be introduced. The author believes that the convergence of approaches to studying the systems and companies and the results of studies in oil and gas sector companies' functioning and development allows wording the definition as a "SES."

The globalization and integration processes taking place, the worldwide change of resources and production factors flow, national policies of oil producing countries and other factors condition the inevitability of structural transformations of oil companies and, accordingly, actualize the questions of choosing a rational business model under the changing conditions. The dynamic progress and large scale of restructuring processes can be confirmed by the experience of Shell Group (Grant, 2008).

With regard to this, it seems quite relevant to create a system model of an oil and gas company as a SES that reflects the systemic and structural correlation, determination and multi-variance of

attaining the strategic goals as well as interaction with the external environment.

2. LITERATURE REVIEW

The economic theory and theory of systems uses the word “system” to mean “a total of objects and processes interrelated and interacting with each other that form a single whole possessing properties that are not inherent in its constituent components taken individually” (Grayson and O’Dell, 1988). At the same time, from the standpoint of systemology, a system is a multitude of elements being in relations and connections with each other that form a certain wholeness and unity. The objects are viewed as systems containing a structure and phenomena as systems having a multi-level complex organization of interactions and relations, including both internal and external connections. As Erokhina (1999) believes, the diversity of approaches to determining the notion of “system” can be reflected in several groups (Table 1) the generalization of which is a descriptive definition of this notion: “A system is a total of objects and processes called components that are related and interacting with each other, form a single whole possessing properties that are not peculiar to the components composing it when taken individually” (Erokhina, 1999). Erokhina (1999) singles out three general systemic properties (wholeness, hierarchy, integrity) proving that all other properties ascribed to systems are not such as they reflect specific characteristics of individual systems.

The following definition is given in the work of Ackoff: “A system is such a unity that cannot be separated into independent parts” (Ackoff, 1981) (Figure 1).

According to studies in the theory of economic systems, by economic systems such systems are meant that participate in general economic processes - production, consumption, distribution, and exchange. As Klejner thinks, “such an approach allows determining the ways of constructing a rational structure of integration connections of enterprises... that ensure... a steady and efficient functioning...” (Kleiner, 2012). With regard to this, economic system is viewed in the studies as a real multi-dimensional object that is characterized by spatial and temporal integrity and that is functioning simultaneously in different related spheres of activity (social, political, technological etc.). Kleiner (2005) notes that by a system “a relatively stable part of the surrounding world characterized by the external wholeness and internal diversity” should be understood (Kleiner, 2005). In particular, the “external wholeness of systems implies mutual accordance of its components, regardless of the components structuring being viewed,” while the “internal diversity means the existence of components varying in quality that enable the system to perform economic activity” (Kleiner, 2012).

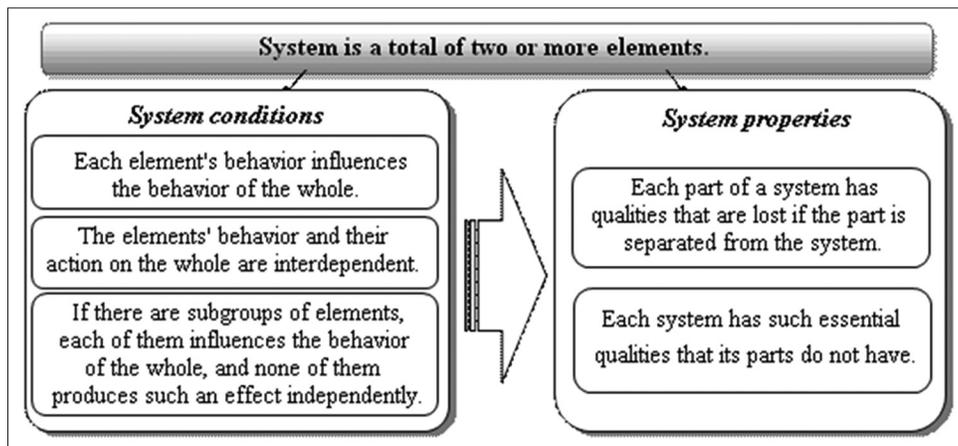
Another property inherent in systems is their integrative character. For example, Zhilin gives the following definition of a system: “A system is a total of objects having the integrative property”

Table 1: Differentiation of approaches to the notion of “system”

Group	Approach to definition	Representatives
1	System is a total of variables, properties or entities	W. R. Ashby, M. Toda, E. Shuford
2	System has a purposeful activity	I. M. Vereshchagin, N. G. Belopolsky
3	System is a total of elements related with each other	A. N. Averianov, Yu. V. Tchaikovsky, G. Creber, M. Zadeh, Ch. Desoer etc.
4	System is a complex of elements being in interaction; descriptive and constructive definition of system	L. von Bertalanffy, A. M. Korikov, E. N. Safiyanova
5	The system is determined by means of specifying the required attributes: Wholeness; two or more kinds of connections; structural nature; hierarchy of levels; as well as management, purpose and reasonability of its character, self-organization, functioning and development processes	I. V. Blauberg, E. G. Yudin

Source: Compiled by the author according to Erokhina (1999)

Figure 1: Ackoff's approach to definition of system



Source: Compiled by the author

(Zhilin, 2004). A lot of scientists-economists have dealt with the questions of integration. As for the integrated structures as economic systems, the works of the Russian economists Bandurin (1999), Vinslav (2001), Dementev (2001) and others can be pointed out. The researchers take various approaches to the notion of “integration” determining it from the following standpoints: Systemic, situational, structural, synergetic, functional, project, process, strategic, spatial, and dynamic ones.

The economic dictionaries contain the following wordings of the notion of “integration:”

- A unity of economic agents, intensification of their interaction, development of connections between them;
- A notion meaning the condition of cohesion of individual differentiated parts and system functions into a whole as well as the process leading to such a condition;
- Association of two or more companies under one control for the purposes of mutual profit, reduced competition and costs due to smaller overhead expenses, ensuring a larger part of the market, combination of technical or financial resources, cooperation in research and developments and so on.

For instance, Babkin (2014) and Dementev (2001) distinguish between the natural integration and quasi-integration (incomplete, partial) proceeding from their research and generalization of approaches to the essence and principles of integrated structures from the standpoint of development of theoretical foundations of economic systems:

- Natural integration involves combination of the key technological stages of production and expansion of in-house relationships; expansion of a business at the expense of purchasing the assets of other companies;
- Quasi-integration is voluntary centralization by its participants of some managerial authorities.

On top of that, it is common practice to classify the integrated structures into vertically and horizontally integrated ones, which also characterizes the structures functioning in the oil and gas sector of the economy. In the traditional theory of firm, the study of problems, principles, forms and efficiency of the vertical interaction was developed both in neo-classical, e.g., J. Bain, G. Stigler, J. Tirole, J. Spengler (Blaug, 1988) and in neo-institutional, e.g., Grossman and Hart (1986), Coase (1937), Williamson (2002) theory of industrial organizations, within branch and interdisciplinary research as well as when studying the vertical integration in the peculiar conditions of the Russian economy, e.g. A. G. Aganbegyan, S. S. Gubanov, A. F. Kryukov, B. Z. Milner, N. M. Rozanova and others.

Meanwhile, the scientists are rather ambivalent on the question of vertical integration of companies which was the prevailing one in the 20th century. So, Williamson (1971) considers the vertical integration consolidating all stages of the production cycle to be a factor conditioning the negative market trends. The works of Blyakhman and Zyabrikov (2015) are dedicated to evaluating the proportion of vertical and horizontal integration. In particular, the authors systemize the advantages of the vertical and horizontal integration as well as their disadvantages (Table 2).

The researchers believe currently the economic agents are to a greater extent oriented to the horizontal integration, consolidation of intangible assets while keeping the independence of structures joined as a result of mergers and acquisition deals due to a number of trends of the world economy, in particular: The integration of goods and services production as a result of re-industrialization; economy greening; international cooperation of development and production of ready products and so on.

It should be noted that while describing the integrated structures (corporations, metacorporations, integrated business groups etc.) from different standpoints many researchers speak about them as “SESs.” This is shown, for instance, in Babkin’s work “integrated industrial structures as an economic agent of the market: Essence, principles, classification” (Babkin, 2014):

- A corporation is a “SES... being an association of individuals and capitals for entrepreneurial purposes...;”
- An integrated economic system is a “complex highly organized association of economic agents...;”
- An integrated industrial structure “is a SES...” etc.

Among the main properties of these structures, they point out the managerial, structural and production complexity, a large quantity of connections between the subjects making it up, orientation to the efficient resources management. As it has already been mentioned, when using the notion of “SES,” the researchers do not make it more precise treating it depending on the objectives and direction of their research and often using it as a determining attribute.

3. OBJECTIVE, TASKS AND RESEARCH METHODS

The objective of the paper is to form a systemic idea about the SESs of oil and gas sector of the economy based on detailing the scientific and theoretical approaches to determining the definition under study and generalization of the experience of large oil and gas companies functioning.

According to the objective set, the range of tasks was determined: To systemize and generalize the theoretical approaches to determining the systems and their principal characteristics; to study the genesis of organizational economic management forms in the oil and gas sector; to find out the essential attributes and to perform comparative analysis of the key systemic properties grounding the oil and gas companies being referred to complex systems; to make more precise the definition of “SES;” to present the SES as a systemic model.

The theoretical and methodological foundation of the research is the provisions of the economic theory, the theory of systems and theory of firm in their evolutionary development, as well as general scientific methods of systemic, logical and comparative analysis, analogies and generalization.

4. RESULTS AND DISCUSSION

In the author’s opinion, the contemporary theory of economic systems is rather universal towards the various types of them and

Table 2: Advantages and disadvantages of integration (Blyakhman and Zyabrikov, 2015)

Characteristic	Vertical integration	Horizontal integration
Advantages	<ul style="list-style-type: none"> Centralized profits of all production cycle participants Limited access of competitors to the integrated market segment Consolidated tax payments using the transfer prices in order to minimize them Property control over all links of technological chain Directive price policy and strict control in the supplies chain Higher assets amount due to mergers and acquisitions 	<ul style="list-style-type: none"> Reduction of losses, including the capital ones, when changing technologies and range Adaptability of the structure to the changing economic management conditions Forming of global supplies chain with modern logistics and flexible contracts Upkeep of the global competition in prices and quality within the supplies chain Reduction of managerial costs
Disadvantages	<ul style="list-style-type: none"> Complexity of multi-level management Administrative command management methods prevailing High managerial expenses Low interest of third party suppliers in quality and low prices Rigidity and difficulty of adaptation to the changing economic management conditions 	<ul style="list-style-type: none"> Higher transportation and communication expenses The problems of interests clash of supplies chain participants A risk of low quality and slow delivery

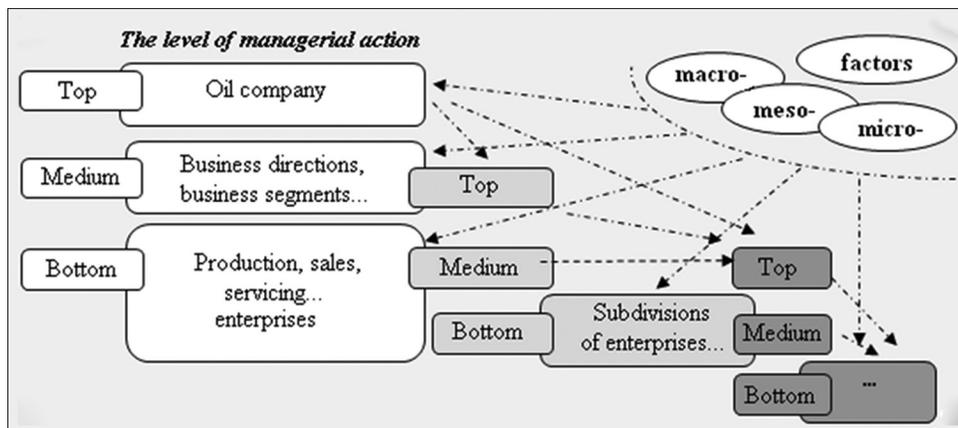
the quoted treatment of the notions of “external wholeness” and “internal diversity” matches the characteristics of economic agents of the oil and gas sector to the full extent within the systemic approach as applied in studying them. Alongside with that, the use of systemic approach for studying the economic systems predetermines the logical relationship of the questions studied subsequently: The forming, structure, functioning and development of an economic system, its interaction with the external systems. A similar logics is applicable for studying the economic structures too, including those functioning in the oil and gas sector of the economy which consequently can also be viewed as economic systems. In particular, the currently actually functioning economic structures of the oil and gas sector of the economy were formed in different time spans and by different ways, they have a differentiated structure and priorities of functioning and development; they use various management tools etc.

In the total of classifications of economic systems, a special place is occupied by complex economic systems that have certain universal and peculiar properties of which the determining systemic principle is the extent of complexity. The constructive critical generalization of various approaches to the characteristic features of complex systems allows singling out the most general of them: Wholeness, hierarchy, non-homogeneity, adaptability, emergence, cohesion, stability, rigidity. Meanwhile, alongside with the common features, some peculiar properties are inherent in the complex social and economic systems, for instance, purposefulness and capacity for self-development, as well as the system’s work capacity ensured by arrangement, functional relevance and efficient interaction of the constituents set. From the theoretical and practical viewpoints, for studying the SESs, the approach of T. Peters and R. Waterman are of interest. They suggested considering the organization as a unity of seven key variables: The structure, strategy, systems and management procedures, shared value attitudes, the total of skills and abilities acquired, the management style and the system of staff (Knorring, 2001).

The diversity of systems and objects referred to the complex ones is very impressive. As a rule, the major production,

technical, economic and other complexes encompassing objects and processes at large scales in their domain are referred to the complex systems, and so is the connection of various areas. As it is conventional to consider a system (i.e., any economic structure as well) to be complex if it consists of a large quantity of elements that are related and interacting with each other and is capable of performing a complex function, then the shared feature for them is the increasing complexity both in the quantity of elements and connections and in the processes occurring in them. The researchers subdivide all complex systems into open and closed ones. Closed systems have rigid fixed boundaries, their actions do not depend on the environment while open systems are characterized by a frequent and intensive action of the external environment (Plenkina et al., 2000). In its turn, this conditions a considerable influence of indefiniteness factors such as the risk associated with instability of the economic and political situation, the risk of unfavorable social and economic change at macro- or meso- level, incomplete or inexact information about the technical and economic indices behavior, parameters of the new equipment and technologies, fluctuations of market prices situation and currency rates, the possible natural disasters due to worsening of natural and climatic conditions, indefiniteness of objectives, interests and behavior of the system’s participants etc. The listed factors produce a marked impact on the activity of SES of the oil and gas sector of the economy.

Bearing in mind the interaction with macro-, meso- and micro- social and economic systems in various spheres of activity, as well as the presence of outlined key attributes of SESs, almost all economic agents of the oil and gas sector of the economy can be referred to the SESs. In particular, the oil companies functioning in the oil and gas sector of Russia’s economy can be classified as typical open complex systems; notably, as the market relationships in the industry developed, they became more and more open. The specific character of these structures consists first of all in their having a multi-level hierarchical system of management and the numerous external and internal connections (Figure 2). The process of decomposition of a complex economic oil and gas structure can be performed for structuring the management system according

Figure 2: Structure of the leveled management of a sophisticated economic structure in the oil and gas sector of the economy

Source: Compiled by the author

to the levels of managerial hierarchy (managing and managed subsystems, objects and subjects at each management level, with each smaller subsystem being incorporated into a higher level system as an element).

Relying on the systemic approach principles and systemic analysis methodology, the author suggests presenting the system model of a SES that parametrically describes the objectives set, the external and internal environment, and relationships emerging as follows:

$$M_{sy}: \{J, E, P, Z, F, K, C\}, \quad (1)$$

Where M_{sy} is the system model;

J - Determination of structure of the object's internal environment;

E - Determination of structure of the object's external environment;

P - Parametric description of the internal and external environment;

Z - Objective setting for the object;

F - Determination of mutual influence factors of the internal and external environment;

K - Setting the condition criteria for the internal and external environment;

C - Developing the condition level evaluation mechanism for the internal and external environment and for the object as a whole.

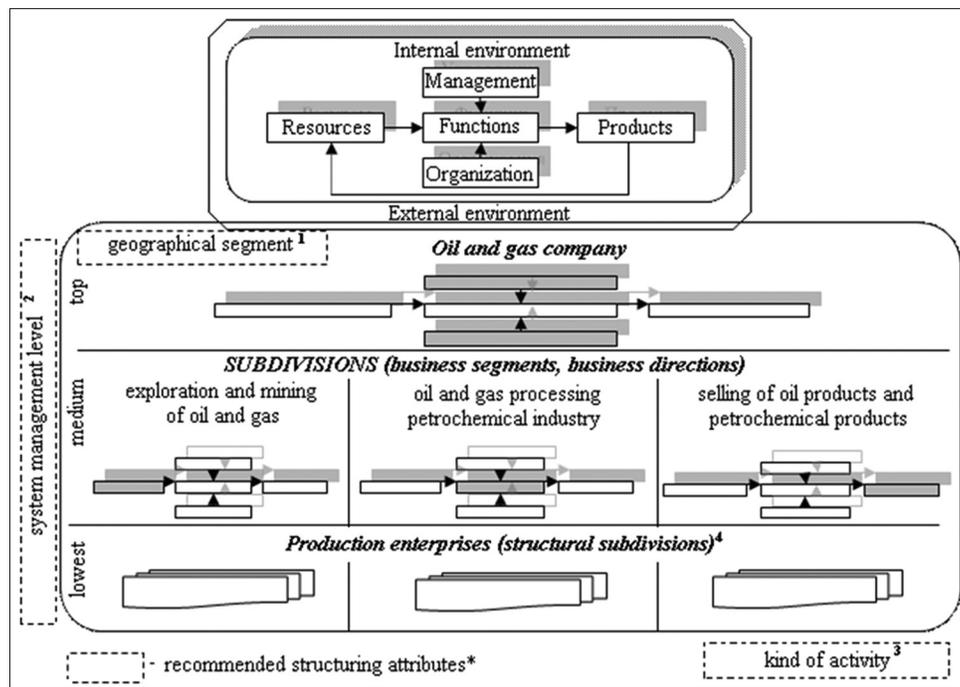
The author considers the evaluation of condition of the external and internal environment to be necessary both for modeling the behavior and development of the structure under study in the dynamic conditions and for selecting the efficient tools for interaction with the external environment and in-house management, as this is the source of resources, the consumer of the enterprise activity results, and a source of funds via paying of the latter, a source of forming of the existence and behavior conditions. For economic structures of the oil and gas sector of the economy, such environment is composed by the entire external background, including the state organizations and institutions, oil and oil products consumers (both in the domestic and in the foreign markets), counterparties with which they enter relationships and the like. Meanwhile, it seems expedient to view the production and economic, resource and raw materials capacity which determine

the structure's competitive advantages and ability to survive in the market as the internal environment.

The enterprises functioning in the oil and gas sector of the economy belonging to complex economic systems is confirmed particularly by studying their structures as well as by the advantages and necessity of systemic approach for analyzing their functioning and forecasting their activity development. The use of decomposition technique in studying the oil and gas SESs as economic systems demonstrates that the outlined subsystems incorporated in them (business directions, units) are complex systems by their composition too. The subsystems singled out produce an essential influence on the systems attaining its objectives. They have a necessary and logical functional connection with task performance of the entire system. As a rule, they are created according to attributes revealing the required functional connection with each other and with the system on the whole. They unite smaller subsystems that allow explaining and understanding the behavior of the system as a whole. Finally, they are associated with the behavior of all system elements via its subsystems for connection with the external environment. Thus, such properties of a complex system as work capacity and emergence, ensured by the constituents functional relevance to each other, their arrangement and efficient interaction are manifested. Hence the vertically integrated oil and gas companies as complex structured objects from the systemic approach standpoint are complex systems including a certain set of subsystems and, accordingly, of the functioning and development objectives that are rather peculiar and frequently even contrasting ones.

The author considers it practicable to use the aggregative and decomposition representation of a complex oil and gas structure where the structure as a system is in a certain condition and has input channels and output signals at each time point. With regard to this, one of the features of the oil and gas sector SES is the output signals of certain subsystems being the input channels for the others. Such representation is quite obvious and most acceptable for typical presenting of high complexity objects to which the majority of oil and gas sector enterprises belong (Plenkina et al., 2003) (Figure 3).

Figure 3: Structural representation of oil and gas companies as sophisticated economic structures based on the aggregative and decomposition approach. ¹The domestic market broken down to segments and zones, ²VIOC, joint stock companies, production associations, structural subdivisions etc., ³Business segments etc., ⁴Core production; auxiliary production; non-core production. *Alongside with the above: The financial nature of assets (core, non-core ones); the strategic character of assets (conforming (non-conforming) to the basic competence and synergetic core); the opportunity of controlling the activity (representative offices and affiliates having no legal entity status; subsidiaries having a legal entity status; dependent companies and so on)



Source: Compiled by the author

The approach suggested uses several structuring criteria at the same time: The level of systemic management, the kind of activity and geographical segment. Overlapping and mutual consideration of several structural sections allows identifying the key accents when structuring this or that subsystem of SES. Likewise, in the author's opinion, almost all elements of SES can be structured. In this case structuring is represented with the entire cycle of the value-added chain (except transportation) borne in mind without focusing the attention on the production and raw materials components prevailing in the structure of the capacity of a typical enterprise and on the strategic vector dominating the managerial decision making. The segments of exploration and mining are a starting link in the value-added chain for oil and gas sector ensuring their activity by the resources required for further processing and selling as products of oil refining and petrochemical industry. In its turn, this predetermines the high importance of the raw material component in the capacity of oil and gas enterprises as well as for structures of a higher level (e.g., vertically integrated oil companies).

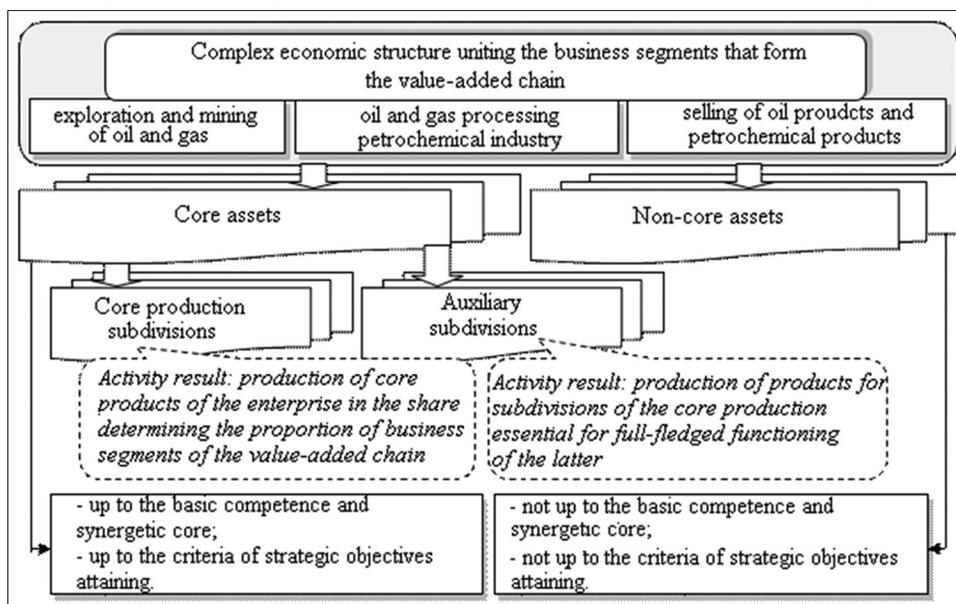
The structural representation SES broken down by subdivision types and nature of assets demonstrates the role in added value creation and in attaining the target reference points of individual elements of the structure and, if required, determines the directions for structural transformations (Figure 4).

Such a representation of SESs in oil and gas sector is rather universal, as the majority of oil and gas companies is integrated

in the production and technological type and fulfills all stages of the value-added chain: Exploration of deposits, mining of the raw materials, transportation, processing and selling. Depending on the national industrial, power generation or other policy, individual links can be excluded from the chain. For instance, in Russia, the stage of transportation is generally excluded, with it being performed by specialized companies. In oil and gas sector of the Russian economy, it is only Gazprom that controls all the stages of the value-added chain.

5. CONCLUSION

Thus, proceeding from the provisions of systemic, synergetic, systemic and integration approach to study of economic systems, of fundamental theory of organization and its modern definition, as well as from the analysis of properties inherent in various systems, the authors considers it possible to view the SESs as a kind of a complex systems and to single out a set of main determining attributes of SESs. According to this, the author believes it to be appropriate to treat the definition "a SES" as an alternative one for economic agents, including ones functioning in the oil and gas sector of the economy, having such main properties as emergence, hierarchy and purposefulness. The highlighted main attributes of a SES are brought into life by manifestation of managerial and production complexity, a total of subsystems and elements united by the shared interests and objectives, related and interacting, and ensuring the work capacity of the system. In oil and gas companies,

Figure 4: Structural representation of sophisticated economic structure broken down to subdivision types and nature of assets

Source: Compiled by the author

these are the upstream, midstream and downstream subsystems as well as elements thereof.

The formed system model of SESs reflecting certain elements, structure and relationships can further be integrated into the overall concept of managing the economic agents of oil and gas sector. The use of suggested variants of structural representation of oil and gas companies (based on the aggregative and decomposition approach in terms of elements of the value-added chain and managerial hierarchy) in practical management of oil and gas business subjects will enhance the relevance of managerial decision making. The systemic approach used in the paper can be recommended to the management of the Russian oil and gas companies as the “basic philosophy” of strategic management. The results obtained may be useful for researchers of SESs in various branches; undoubtedly, they will be further elaborated in the author’s future research.

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