Petroleum and Coal

Article **Open Access**

Ecosystem approach to the analysis of oil companies efficiency and state regulation policy

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Received February 5, 2025; Accepted May 12, 2025

Abstract

Recently, several opposing trends have been observed in the world. On the one hand, in several countries, the private sector is undergoing expansion, and the number of small businesses and individual entrepreneurs, commonly referred to as the self-employed, is increasing. On the other hand, there is a clear trend towards the globalization of state-owned companies and their transition to the status of transnational state corporations. This trend is characteristic not only of developing countries, such as China, Russia, Brazil, India, but also of countries with developed economies, such as Norway, France, Italy, and South Korea. A significant number of transnational state corporations have been observed in the energy sector, specifically in the nuclear industry, oil production and refining, and transportation of oil, gas, and oil products. For this reason, it is important to consider the efficiency of such companies. In order to conduct a more comprehensive examination of the activities of companies with public ownership, a comparative analysis of the operations of the largest Russian private and state enterprises, as well as foreign private and state enterprises, was conducted. The analysis was conducted on the basis of the methodology employed in the data envelopment analysis, which aims to determine the relative efficacy of the objects under consideration based on the 'input' and 'output' parameters of the model. The analysis was carried out in the Maxdea program.

Keywords: *Ecosystems; Sectoral management; Government control; Oil companies; Efficacy.*

1. Introduction

In addition to administrative, legal, and tax instruments for industry regulation of oil companies, the government actively uses organizational and economic management instruments. These include direct ownership of shares in oil companies, including a controlling interest or "golden share", delegation of government representatives to the boards of directors of corporations, as well as the creation of various forms of organizations with the state participation (state corporations, state companies, federal state unitary enterprises, state unitary enterprises, etc.). Furthermore, in addition to direct ownership of several major assets, the state has the ability to control over a number of corporations that are formally public joint-stock companies. The effectiveness of the activities of such organizations and the entire structure of state capitalism in Russia remain highly important.

At the same time, there are numerous contradictions between the state, economic entities in the oil industry and public and expert organizations. These contradictions are reflected in divergent interpretations of short- and long-term objectives, the existence of inconsistent concepts and strategies for the advancement of distinct industries and areas, and the inconsistent implementation of various federal target programs, state programs, projects, etc. The aforementioned contradictions result in a decrease in the efficacy of the system of government

control over strategic sectors of the economy, as reflected in a significant lag in labor productivity. Today, the labor productivity of Russian organizations with state participation is 3-5 times lower than that of comparable global corporations, their capitalization differs by 5-10 times, and the indicators of the efficiency of functioning as a whole are 10-15 times lower (EBITDA, ROI).

The fundamental scientific problem that the work is aimed to solve is that traditional methods of state industry management of oil companies (federal target programs, budget and tax instruments, administrative regulations, etc.) in the modern, dynamically changing world have a number of serious limitations. Initially, these are the contradictions between the short- and long-term objectives of the government and oil corporations, resulting in an imbalance in the advancement of the industry during the implementation of regulatory functions. Secondly, there is a discrepancy between a number of adopted state and corporate decisions and the provisions of the Energy Strategy of the Russian Federation, as well as a lack of mechanisms for coordinating the provisions of various federal target programs and projects. Thirdly, at present, industry management in the oil sector is executed practically without utilizing the methodology and tools of process management, relying on the project approach and hands-on management.

Thus, the development of a more effective system of state sectoral management of the oil industry is of significant scientific interest.

In order to address the aforementioned issue, a program for the implementation of specific measures and actions is proposed, as outlined in this article. It is imperative to augment the existing classification of ecosystems by defining concepts such as "management ecosystem", "corporate management ecosystem", and "industry management ecosystem" [1-3] in order to gain a more precise comprehension of the subject matter and object of the study.

Before delving into the essence of these concepts, it is noteworthy that in contemporary science, the term "ecosystem" is employed in various contexts to denote diverse functions of economic systems. Thus, in academic literature, the most commonly associated definition of the notion of an ecosystem pertains to the so-called entrepreneurial ecosystems, which are communities comprising organizations and individuals from the realm of entrepreneurship who interact within them. In developing the theory of J. Moore, some authors sought to structure the elements of business ecosystems, highlighting the parent company, participants and external contractors, the relationships between stakeholders and the value created [4]. Other scientists consider ecosystems to be clusters in which several companies and/or services are present. The task of the company management in the process of joint activities is to develop the main directions and strategies for the development of the entire formed ecosystem.

Russian scientists, representatives of the Russian Academy of Sciences, made a great contribution to the development of the ecosystem approach in business and economics. According to Kleiner and Kobylko [5], an ecosystem is a spatially localized complex of uncontrolled hierarchical organizations, business processes, innovative projects, and infrastructure ecosystems that interact with each other in the course of creation and circulation of material and symbolic goods and values, capable of long-term independent functioning due to the circulation of these goods and systems. In their works, several authors focus on the process of developing strategies and including ecosystems in strategic management. They analyze the reasons for the transformation of the development models of the largest corporations from business units to ecosystems.

Other experts have identified the platform nature of the ecosystem as a distinctive characteristic. The authors persuasively demonstrate that the success of corporations such as Airbnb, Apple, Uber, and DomClick hinges primarily on the platforms they have created, whose primary resource is the communities of consumers, individuals who share a similar commitment to the brand and philosophy of the company.

Adner [6], in turn, identified three key principles for the formation of an ecosystem in the state: the principle of expansion, the principle of creating a minimum viable ecosystem, and the principle of ecosystem transfer.

The processes of digitalization and transformation of familiar business models are also a distinctive feature of the new principles of interaction with customers and other stakeholders within the ecosystem [7-9].

The point of view of authors who consider the ecosystem as a special innovative form of doing business, mainly virtual, seems interesting.

The further spread of the term "ecosystem" is associated with the development of innovations. Some authors emphasized that the effective development of any business structure is dependent on the active implementation of technological, technical, or managerial innovations [10-12].

In the business community, the aforementioned term is commonly comprehended as a amalgamation of various microservices within a single global service that enables consumers to fulfill their diverse requirements through a subscription or membership in a community. Such ecosystems are being built by the largest Russian banks and IT companies - Sberbank, Yandex, Tinkoff and others. The main goal of creating such entrepreneurial and technological ecosystems is to generate maximum traffic and increase the number of transactions within a large conglomerate of interconnected services, which ultimately leads to maximizing the company's profits.

Recently, particularly following the transition to remote work during the COVID-19 pandemic in 2020-2021 and the rapid advancement of digital technologies, the issue of regulating electronic platforms and ecosystem solutions has become exceedingly pressing. In the scientific literature, there is a discussion about tools and methods for regulating ecosystems. Various options are proposed – from total state control and regulation to the transition to self-regulation, by analogy with some industries in which the rules of self-regulatory organizations apply. The complexity of regulating ecosystems is also due to their distinctive characteristics, such as modularity, versatility, the use of a coordination mechanism, and the customization or adaptation of participants to the business ecosystem. The methodology proposed by Shastitko, Kurdin, and Filippova [13] entails the utilization of the concept of a meso-institution in the creation of tools and mechanisms for ecosystem regulation, thereby reducing state control over platforms and services in favor of elements of self-regulation.

As the popularity of ecosystems as research subjects grew, authors began to broaden the conventional boundaries of the ecosystem approach. Prolubnikov demonstrates a correlation between the efficacy of implementing public-private partnership projects in Russia and the advancement of the ecosystem approach. The author introduces the concept of a "Public Private Partnership ecosystem", which he understands as a set of stakeholders, their roles and interests, as well as strategies for interaction between them.

By analogy with the concepts of "entrepreneurial ecosystem" and "innovation ecosystem", and in development of the above concepts, it is proposed to consider the concept of 'ecosystem' not only in relation to technologies and participants, but also to the management process. According to Sirkin, Hemerling, and Bhattacharya [14], who identified three distinct types of ecosystems, namely technological, entrepreneurial, and digital mobility ecosystem, it is proposed to augment this classification with two additional levels (Fig. 1).

Thus, it is proposed to understand the corporate governance ecosystem as a set of project and process management methods and tools used to achieve operational and strategic efficiency, integrate technological, entrepreneurial, and digital mobility ecosystems into the corporate governance structure, and form a collective strategy for interaction between the organizations stakeholders, taking into consideration the influence of external factors and the regulatory impact of meso-space entities.

In turn, the industry management ecosystem is a community of public authorities in the mesosphere that exert organizational and managerial influence on industry micro-institutions by means of process, project, and other mechanisms for implementing state policy in the sector.

The two new classification levels can be amalgamated into a more comprehensive notion of a management ecosystem, comprising a set of stakeholders and the micro-, meso-, and macro-institutional conditions for their interaction with each other. This is to formulate and

implement their collective development strategy, align interests, alleviate strategic contradictions, and achieve a synergistic effect through the mutually beneficial cross-functional utilization of technological, entrepreneurial, financial, marketing, infrastructural, and other competitive advantages.

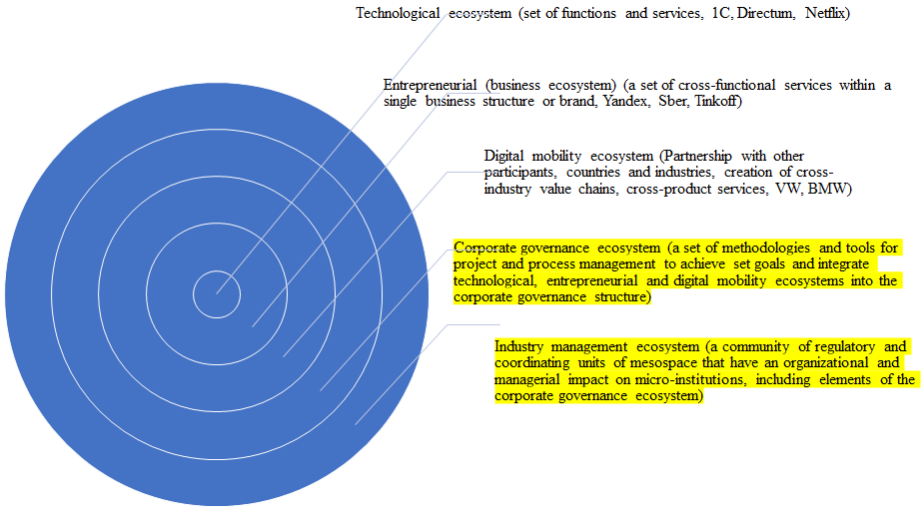

Fig. 1. Classification of ecosystems (the author's approach is highlighted in yellow)

Therefore, the incorporation of the notion of an industry management ecosystem into scientific and business discourse will enable the integration of conventional organizational and economic mechanisms of state regulation and management with a set of disparate actions and processes that have a significant impact on both individual oil companies and the industry as a whole. Examples of such actions and processes that do not fall under the classical definition of 'management mechanism' include management based on a cluster approach and cluster initiative, the use of companies with state participation to influence the industry or other companies, the use of integration processes as a tool for influencing the market, and the use of the potential of intersectoral interaction in the industry, etc.

All of this will enable, firstly, the optimization of state regulation instruments for both the industry as a whole and organizations and enterprises in the aforementioned domain in particular. Secondly, this is the creation of a tool for coordinating and evaluating the regulatory impact of various federal target programs, projects, and enterprise development concepts from the perspective of the long-term strategic interests of the state in the oil sector. The incorporation of novel instruments and mechanisms of influence on companies and the industry within the boundaries of the industry management ecosystem will enhance the speed, quality, and efficacy of government decision-making in the oil industry.

2. Materials and methods

For a more detailed study of the activities of oil companies with state participation, a comparative analysis of the functioning of the largest Russian private and state, as well as foreign private and state companies was conducted. For the purpose of the comparative analysis, the largest foreign companies were selected, namely Petrochina, Sinopec (China), Petrobras (Brazil), Equinor (Norway), and private companies such as ExxonMobil, Chevron (USA), BP (UK), Royal Dutch Shell (UK, Netherlands), and Total (France), as well as prominent Russian oil companies.

The analysis was conducted on the key production and economic indicators of the enterprises' activities for the period from 2014 to 2019. All cost indicators are converted to US dollars utilizing the average weighted exchange rates for every period. The market capitalization indicator is calculated based on the average capitalization of each company over a period

of six years, spanning from 2014 to 2019, in order to mitigate the impact of the COVID-19 pandemic in 2020-2021. As per international norms, oil production is typically measured in millions of barrels per day, the volume of oil production was converted into million tons for the sake of convenience, based on the average density of each grade of oil produced.

The analysis was performed using the methodology of data envelopment analysis, which aims to identify the relative efficiency of the objects under consideration depending on the 'input' and 'output' parameters of the model. The analysis was carried out using the Maxdea program.

In the most general version, the input-oriented data envelopment analysis model is written as follows:

$$\max_{u,v} \sum_{m=1}^{M} U_m Y_{mO} \qquad (1)$$

under restrictions:

$$\sum_{m=1}^{M} U_m Y_{mk} - \sum_{n=1}^{N} V_n X_{nk} \le 0 \qquad k = 1,2,\ldots.K, \qquad (2)$$

$$\sum_{n=1}^{N} V_n X_{n0} = 1, \qquad (3)$$

$$U_m, V_n \ge 0 \quad m = 1,2,\ldots M \quad n = 1.2,\ldots N$$

where: 0 - index of the production facility for which the optimization problem is being solved; X – input dimension vector N; Y – output dimension vector M; K – number of production facilities.

Or in dual form:

$$\min_{\lambda} \quad \theta \qquad (4)$$

under restrictions:

$$\sum_{n=1}^{N} X_{nk} \lambda_k \le \theta\, X_{no}, \qquad n = 1,2,\ldots.N \qquad (5)$$

In this model, the possibility of a proportional reduction of inputs without a reduction of outputs is explored. The set of production possibilities of the input-oriented model is the set of the following sets of vectors (X, Y) [15]:

$$\left\{ (X,Y) \left| \sum_{j=1}^{n} X_j \lambda_j \le X, \quad \sum_{j=1}^{n} Y_j \lambda_j \ge Y, \quad \lambda_j \ge 0, \quad j = 1,\ldots n \right. \right\} \qquad (6)$$

3. Results

The results of the analysis are presented in Table 1. The table displays the companies, while the second column displays their comparative efficiency coefficients. After solving the optimization problem for outputs in a comparative analysis of 15 Russian and foreign private and state oil companies, three companies were recognized as efficient: two companies with state participation, Sinopec (China) and Bashneft (Russia), and a private company from the United States, Exxo.

The parallel columns also indicate the target values of the first two 'output' indicators - revenue and EBITDA. The closer to 0 the company's efficiency ratio, the greater the gap between the actual and target revenue and EBITDA. Thus, we can say that these are the indicators that, given the "input" parameters, lagging organizations need to achieve in order to improve their efficiency. Table 2 presents companies with target values of capitalization indicators and dividend yield levels.

Table 1. Results of the data envelopment analysis (DEA) of Russian and foreign companies

Company	Effectiveness ratio	Actual EBITDA, USD billion	Target EBITDA, USD billion	Actual revenue, USD billion	Target revenue, USD billion
Rosneft	0,20	156.7	780.5	670.5	11602.2
Gazprom Neft	0,42	55.5	129.5	210.4	1703.9
Tatneft	0,79	20.8	47.1	70.7	557.7
Bashneft	1	14.7		73.8	
LUKOIL	0,37	95.4	263.9	666.6	3749.8
Surgutneftegas	0,23	37.0	205.9	132.8	3024.4
Exxon Mobile	1	269.6		1668.6	
BP	0,38	132.3	441.7	1601.9	5580.7
Chevron	0,72	196.5	273.7	919.2	2284.4
Equinor	0,38	137.8	363.7	409.6	5407
Sinopec	1	154.1		2290.7	
Petrobras	0,35	130.4	376.4	572.3	5594.9
Total	0,49	166.6	340.9	992.7	4098.4
Royal dutch shell	0,62	287.8	465.5	2004.1	5649.7
Petrochina	0,65	292.6	453.2	1910.7	6736.7

Table 2. Target values of indicators

Company	Effectiveness ratio	Actual average capitalization, USD billion	Target capitalization, USD billion	Actual dividend yield, %	Target dividend yield, %
Rosneft	0.20	57.0	382.9	4.5	30
Gazprom Neft	0.42	19.7	61.4	6.8	15.9
Tatneft	0.79	17.2	21.7	7.0	8.8
Bashneft	1	5.8		7.7	
LUKOIL	0.37	47.3	127.8	6.9	18.6
Surgutneftegas	0.23	22.9	100.7	2.2	9.7
Exxon Mobile	1	316.7		3.7	
BP	0.38	110.5	294.4	5.3	14.1
Chevron	0.72	197.6	275	3.9	5.4
Equinor	0.38	60.6	178.4	0.9	13.9
Sinopec	1	75.6		5.9	
Petrobras	0.35	61.8	184.6	2.6	14.4
Total	0.49	119.1	243.7	4.8	10.3
Royal dutch shell	0.62	203.1	328.5	6.1	14.2
Petrochina	0.65	125.1	222.3	3.3	17.3

The figures presented do not necessarily imply that the selected companies must attain these objective indicators. The findings of the analysis demonstrate that under comparable and model-adjusted input resources, such as oil production volumes, companies exhibit varying impacts on raw materials, resulting in varying outcomes at the output level. The model's objectivity is additionally enhanced by the fact that the analysis was not conducted for a single year, but rather as a cumulative total over the past six years. The specified period minimizes the impact of crisis factors, and also takes into account various long-term investments in design and survey and geological exploration work.

4. Discussion

Inclusion of the specified methodology in the complex of monitoring the process of implementing the state's long-term energy policy will allow establishing economically sound performance indicators (revenue, EBITDA, dividend yield level, cost value, etc.) for all key industry stakeholders depending on the orientation of the methodology towards input or output parameters [16-18].

It is also important that among the effective companies there are also companies with state participation [19-22]. Contrary to the belief expressed in certain scientific publications that only private business structures exhibit genuine efficiency, the author's model demonstrates that compa-

nies with state participation can achieve greater effectiveness and efficiency with a competently constructed management system. It is worth mentioning that the Russian PJSC Bashneft was one of the most effective companies. We believe that the high efficiency of this company is due to its participation in the territorial innovation cluster of the Republic of Bashkortostan.

The comparative efficiency methodology employed in this study can also serve as a measure of the quality of corporate governance subsequent to the implementation of integration processes, as well as governance at the meso-level in the implementation of the Energy Strategy, the Doctrine of Energy Security, and other components of the state energy policy. Therefore, the aforementioned methodology represents an alternative potential avenue for broadening the conventional set of administrative mechanisms utilized in industry management.

Furthermore, it should be noted that utilizing the comparative efficiency methodology of private and state oil companies, it is feasible to modify their taxation, particularly the parameters of the additional income tax, as outlined in the initial chapter of this work. As previously mentioned, presently, following the outcomes of three years of pilot implementation of the new tax regime in various fields, there is a solely a decrease in federal budget revenues. However, in accordance with the logic and concept of introducing the additional income tax of oil companies, it should stimulate the growth of oil production. As experts from the Vygon consulting company note in their study, "another necessary measure is the development of a unified methodology for assessing the effectiveness of the additional income tax and other tax changes in order to eliminate disagreements on the analysis of effects for the budget between the industry and the Ministry of Finance of Russia". The aforementioned methodology has the potential to play a significant role, as it takes into account the investor's profitability, operating and capital expenses, and evaluates the efficacy of management and the current operations of the enterprise.

At the same time, a potential increase in oil production of 5% owing to the enhanced profitability of production resulting from the transition to the additional income tax regime leads to an increase in investment in production of 400 billion rubles and an increase in budget revenues of 670 billion rubles. Thus, the net economic impact of enhancing oil production by 5% could potentially amount to 270 billion rubles, provided that the volatility of global raw material prices remains low.

5. Conclusion

It is currently difficult to predict the long-term economic impact of the transition to the additional income tax. Firstly, the ongoing COVID-19 pandemic and periodically emerging restrictions in China, the world's largest economy, make it impossible to plan demand. Secondly, in difficult geopolitical conditions and a situation where supply chains are disrupted, the terms of the OPEC+ deal may be significantly adjusted. Thirdly, after the introduction of the so-called price cap in December 2022, it is difficult to predict changes in the structure of the global oil market. The mechanism for implementing this restriction remains uncertain, as is the manner in which countries that do not endorse this restriction will be able to engage in trade interactions with companies from Russia without the threat of additional sanctions.

In any case, the described methodology for comparative efficiency of private and state oil companies is an effective tool for adjusting strategic and operational industry decisions.

Thus, using the described methodology, it is possible to continuously monitor the pace of implementation of the process-project model tools into the ecosystem of industry management of Russian oil companies. Currently, as previously mentioned, all conventional industry regulation tools, such as the implementation of the Federal Target Program, tax and administrative tools, among others, possess quantitative characteristics and can be quantified. Hence, the energy strategy has clearly defined key performance indicators and benchmarks that must be attained in the process of industry development and management impact. The author proposed a methodology that focuses on adding individual project management tools and process management elements to the general ecosystem of industry management for oil companies. This methodology enables, analogous to conventional regulation methods, the establishment

of quantifiable normative and indicative indicators, as well as the dynamic monitoring of the utilization of novel tools and their efficacy over a specified duration.

References

[1] Hannon B. The structure of ecosystem. Journal of theoretical biology, 1973; 41(3): 535-546.
[2] Huxham Ch. Collaborative capability: An intra-organizational perspective on collaborative advantage. Public Money and Management, 1993; 13(3): 21-28.
[3] Clarke A, Fuller M. Collaborative Strategic Management: Strategy Formulation and Implementation by Multi-Organizational Cross-Sector Social Partnerships. Journal of Business Ethics, 2010; 94(1): 85-101. https://doi.org/10.1007/s10551-011-0781-5
[4] Moore JF. Business ecosystems and the view from the firm. The Antitrust Bulletin, 2006; 51(1): 31-75. https://doi.org/10.1177/0003603X0605100103
[5] Kleiner G, Kobylko A. Business Ecosystem Strategy: Design and Specifics. Lecture Notes in Networks and Systems, 2022, 442LNNS: 43-51. https://doi.org/10.1007/978-3-030-98832-6_4
[6] Adner R. Ecosystem as Structure: An Actionable Construct for Strategy. Journal of Management, 2017; 43(1): 39-58. https://doi.org/10.1177/0149206316678451
[7] Lipovka MV, Gandzha TV, Kochergin MV, Shuryhin YA, Aksenova NV. Digital twins in the oil and gas industry. Petroleum and coal, 2025; 67(1): 188-199
[8] Brunet M. Governance-as-practice for major public infrastructure projects: A case of multilevel project governing. International Journal of Project Management, 2018; 3(15): 1-18. https://doi.org/10.1016/j.ijproman.2018.02.007
[9] Cleland D. Project stakeholder management. Project Management Journal, 1986; 17(4): 36-44.
[10] Zhang Xiaoren, Ding Lingand, Chen Xiangdong. Interaction of open innovation and business ecosystem. International journal of u- and e- Service, science and technology, 2014; 1: 51-64. https://doi.org/10.14257/IJUNESST.2014.7.1.05
[11] Cuervo-Cazurra A, Inkpen A, Musacchio A, Ramaswamy K. Governments as owners: State – owned multinational companies. Journal of Business Studies, 2014; 45: 919-942. https://doi.org/10.1057/jibs.2014.43
[12] Hunter T. The role of regulatory frameworks and state regulation in optimising the extraction ogg petroleum resources: A study of Australia and Norway. The Extractive Industries and Society, 2014; 1: 48-58. https://doi.org/10.1016/j.exis.2014.02.001
[13] Shastitko AE, Kurdin AA, Filippova IN. Meso-institutions for digital ecosystems. Voprosy Ekonomiki, 2023; 2: 61-82. https://doi.org/10.32609/0042-8736-2023-2-61-82
[14] Sirkin HL, Hemerling JW, Bhattacharya AK. Globality: Challenger companies are radically redefining the competitive landscape. Strategy and Leadership, 2008; 36(6): 36-41. https://doi.org/10.1108/10878570810918340
[15] Ratner SV. Practical applications of data envelopment analysis to solving environmental management problems. Moscow: Infra-M, 2020.
[16] Fombrun Ch, Astley G. Beyond corporate strategy. Journal of Business Strategy, 1983; 3(4): 47-54.
[17] Megginson WL, Ullah B, Wei Z. State ownership, soft-budget constraints, and cash holding : Evidence from China`s privatized firms. Journal of Banking & Finance, 2014; 6(13): 2-19. https://doi.org/10.1016/j.jbankfin.2014.06.011
[18] Bruton GD, Peng MW, Ahlstrom D, Stan C, Xu K. State-owned enterprises around the world as hybrid organizations. The Academy of Management Perspectives, 2015; 29(1): 92-114. https://doi.org/10.5465/amp.2013.0069
[19] Freeman R. Strategic management: a stakeholder approach. Pitman, 1984. 276p.
[20] Freeman R, Mcvea J. A Stakeholder Approach to Strategic Management. SSRN Electronic Journal, 2001. https://doi.org/10.2139/ssrn.263511
[21] Ménard C. Meso-institutions: the variety of regulatory arrangements in the water sector. Utilities Policy, 2017; 49: 6–19. https://doi.org/10.1016/j.jup.2017.05.001
[22] Meyer KE, Ding Y, Li J, Zhang H. Overcoming distrust: How state-owned enterprises adapt their foreign entries to institutional pressures abroad. Journal of International Business Studies, 2014: 1005-1028. https://doi.org/10.1057/jibs.2014.15

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