ГОСТЬ НОМЕРА

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EFFICIENCY OF DIGITAL TRANSITION IN INDUSTRY: RUSSIAN EXPERIENCE

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Abstract. *The article is devoted to the study of the digital transition's effectiveness in Russian industry. The purpose of the study is an in-depth analysis of budgets for digital transformation in industrial sectors, as well as their relationship with the effectiveness of production. The study has the following theoretical frameworks: the concept of the fourth industrial revolution, the theory of innovation management and the concepts of digital maturity. The main research methods are structural and comparative analysis. The author obtained the following results: the structure of budgets for digitalization is investigated, the main cost items are highlighted; individual characteristics of each industry are shown. The analysis of «digital» budgets in the Russian industry showed a significant differentiation of industries both in terms of the amount of costs and their structure. The scientific novelty of the article is the matrix of the «digital» budget efficiency and the production growth index. The matrix shows that a number of industries with large absolute values of «digital» budgets are characterized by a rather low relative value and medium growth rates. These industries turned out to be raw materials industries such as oil and gas extraction and processing, metallurgy and the food industry. The study also confirmed the conclusion that the amount of financing for the digitalization of industrial enterprises is not always the main factor in the digital transition. If these costs do not work to increase efficiency (production volumes, growth rates), then the problems may lie deeper, for example, the discrepancy between the goals of digitalization and business goals, the lack of involvement of management in digitalization and organizational weakness of business processes, low digital culture at the enterprise, etc.*

Key words: *digital transition, industry, efficiency, digitalization costs.*

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ЭФФЕКТИВНОСТЬ ЦИФРОВОГО ПЕРЕХОДА В ПРОМЫШЛЕННОСТИ: ОПЫТ РОССИИ

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Аннотация. *Статья посвящена исследованию эффективности цифрового перехода в российской промышленности. Целью исследования является углубленный анализ бюджетов на цифровую трансформацию в промышленных секторах, а также их взаимосвязи с эффективностью производства. Исследование опирается на следующие теоретические основы: концепцию четвертой промышленной революции, теорию управления инновациями и концепции цифровой зрелости. Основными методами исследования являются структурный и сравнительный анализы. Автором получены следующие результаты: исследована*

структура бюджетов на цифровизацию, выделены основные статьи затрат; показаны индивидуальные характеристики каждой отрасли. Анализ «цифровых» бюджетов в российской промышленности показал значительную дифференциацию отраслей как по объему затрат, так и по их структуре. Научная новизна статьи заключается в матрице соотношения эффективности «цифрового» бюджета и индекса роста производства. Матрица показывает, что ряд отраслей с большими абсолютными значениями «цифровых» бюджетов характеризуется довольно низкой относительной величиной эффективности и средними темпами роста. Эти отрасли оказались сырьевыми, такими как добыча и переработка нефти и газа, металлургия и пищевая промышленность. Исследование также подтвердило вывод о том, что объем финансирования цифровизации промышленных предприятий не всегда является основным фактором цифрового перехода. Если эти затраты не работают на повышение эффективности (объемов производства, темпов роста), то проблемы могут лежать глубже, например, несоответствие между целями цифровизации и бизнес-целями, недостаточная вовлеченность руководства в цифровизацию и организационная слабость бизнес-процессов, низкая цифровая культура на предприятии и т. д.

Ключевые слова: *цифровой переход, промышленность, эффективность, затраты на цифровизацию.*

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Introduction

The use of digital technologies in industry is a process that has serious expectations of efficiency. However, in order for expectations not to be overstated and unrealized, it is necessary to distinguish the details of this process. Let's say that our subject area is no longer considered as a simple process of introducing ICT into production. We clearly distinguish between the concepts of «digitalization» and «digital transformation». By digitalization, we mean the use of digital technologies in companies' business models to create additional value. At the same time, we define digital transformation as a process of system transition of industry from one technological paradigm to another through the large-scale use of digital technologies and ICT in order to significantly increase its efficiency and competitiveness. Digital transformation is a more holistic concept of change. Moreover, today we are talking about such a the paradigm shift of the business model. And we argue that the digital transition is based not only on significant technological changes, but also on structural, organizational, financial changes, as well as on the transformation of the value created in the industry itself.

While the growth of economic efficiency from computerization and primary digitalization is gradually slowing down and reaching a plateau, it is the digital transition as a system transformation of industry that is becoming the driver of efficiency.

It is obvious that the processes of digital transformation in industries are not proceeding uniformly. In many ways, this is due to the prerequisites for the digitalization of industries, the readiness of the industry for a digital transition and, of course, the financial capabilities of enterprises. Thus, Dolganova and Deeva investigated in detail the problems of insufficiently large-scale digitalization of business and the problems hindering digital transformation [8]. The expert survey conducted by the authors showed that one of the main barriers to digitalization is the insufficient maturity of the company's business processes, the low level of digital competencies and the inconsistency of the business strategy and digital transformation strategy. The lack of necessary financing as a barrier to digitalization is only in the middle of the rating of all problems [8]. Studies by other authors also show that the financial capabilities of industrial enterprises play an important, but not a leading role in the digital transition of industries [5; 10; 11; 13; 14; 18; 20].

The purpose of this article is a detailed study of budgets for digital transformation in industries and their relationship with the effectiveness of production. We will look at the structure of the «digital» budget in the industry as a whole, highlight the most significant articles and articles for which insufficient funds are allocated. Next, we will analyze the cross-industrial cost structure for the digital transformation of industry and reveal some industry features. Finally, we will determine the sufficiency and effectiveness of the costs incurred for the digital transition in the industries and group the industries from the efficiency assessment.

Literature review

Our research is within the following theoretical framework.

The first theoretical framework of the study is the concept of the fourth industrial revolution and the concept of Industry 4.0 meaningfully embedded in it [7; 12; 17]. As we have already noted earlier [2], the concept of «Industry 4.0» meaningfully corresponds to the concept of «digital transformation of industry». Therefore, in the context of this study, in order to correctly understand «digital» budgets, we will adhere to

the following understanding of the digital transformation of industry – these are the processes of a system «transition of industry from one technological mode to another through the large-scale use of digital and ICT in order to increase its efficiency and competitiveness» [2]. Accordingly, the costs of digital transformation are the costs of the introduction and use of digital technologies, leading to significant changes in the technological structure and ensuring an increase in production efficiency and competitiveness.

The second theoretical framework is the theory of innovation management related to the assessment of the impact of technological changes on the effectiveness of industrial enterprises. In the last decade, management and organizational scientists have been paying increasing attention to the relationship between digital transformation and innovation management [3; 9; 15; 16; 21]. In our opinion, technological and organizational changes associated with the use of digital technologies differ significantly from traditional innovations, since digital technologies have the character of «end-to-end» technologies, and the process of their implementation is complex, multilevel, nonlinear. It is particularly difficult to assess the cost effectiveness of conducting «end-to-end» digital technologies.

The concepts of digital maturity and digital strategies form the third theoretical framework of the study. Since the «digital» budget is the key to the implementation of digital transformation strategies, it will be important for us to understand its structure and impact on the effectiveness of not only the digitalization strategy itself, but also on the effectiveness of business strategies of enterprises and the development strategy of the industry. These concepts have not yet developed into a separate theoretical direction, but there are separate prerequisites for systematization [4; 6; 19].

Data and methods

The study uses data from the Federal State Statistics Service of the Russian Federation - digitalization costs by type of costs for 2021, as well as data on industrial production and indices. In the study, the data are summarized (mining, manufacturing and electric power) and detailed (types of manufacturing industries). The main research methods are structural and comparative analysis.

Results and discussion

1. The structure of the budget for digital transformation in 2021.

In 2021, the budgets aimed at digital transformation in the Russian industry amounted to 478.7 million rubles, of which 72% are internal costs associated with the purchase of equipment, software, personnel training, etc. External costs of digitalization, which include the rental of digital equipment and software, technical support and access to databases, account for 28% of the total budget for digitalization of the industry.

In 2021, 138.2 million rubles (40.2%) was directed to the purchase of machinery and equipment related to digital technologies, of which almost half were computer equipment and office equipment (Fig. 1). The actual digital production equipment was purchased only for the amount of 31.1 million rubles.

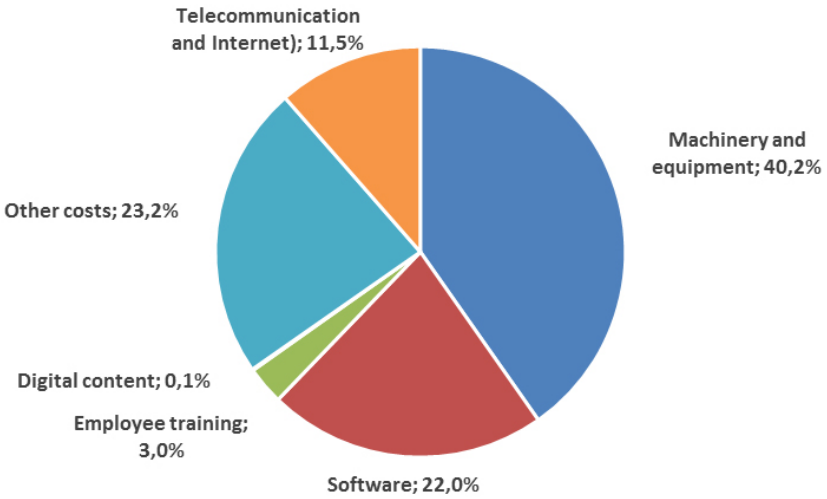

Figure 1. Structure of internal costs for digital transformation in the industry of the Russian Federation, 2021

Source: author's design on data source: Federal State Statistics Service of the Russian Federation, https://rosstat.gov.ru/statistics/science (accessed:14.12.2022)

The share of software purchases in 2021 amounted to 22% of the total budget of internal costs for digitalization, which is 75.4 million rubles. It should be noted that the share of Russian software amounted to 40.5% of the cost of software purchases. At present, the costs of employee training are seen to be quite insignificant

- 3% of all internal expenses for digital transformation. Such expenses as the acquisition of a digital context are practically not found in industry.

2. Cross-industrial structure of costs for digital transformation of industry in 2021.

The budget for digital transformation is unevenly distributed among the regions. Thus, 75% of the digitalization budget falls on 10 industries (more than 30 in total) (Fig. 2). The industry leaders in terms of the absolute value of digitalization costs are energy, production of petroleum products, gas and oil production, metallurgy, electronics and tool industry.

At the same time, certain types of digital transformation costs have pronounced industry features.

Thus, the enterprises transport engineering, production of rubber and plastic products, woodworking and furniture production have the cost of purchasing digital equipment in the amount of more than 10% of the total budget for digital transformation. Moreover, the highest expenses for digital equipment are noted in the automotive industry (58.3%), furniture manufacturing (54.7%), general mechanical engineering (35.3%). In these industries, the main focus is on digital equipment, not on software.

The emphasis on software (the share of purchase or development costs is more than 20%) is made in such industries as oil, gas, coal, metal ores, petroleum products, metallurgy, the production of medicines and electronics, as well as the production of beverages and tobacco. The leaders in the share of expenses for the software are the production of petroleum products (61.4%), the production of tobacco products (41.5%) and the production of medicines (39.8%).

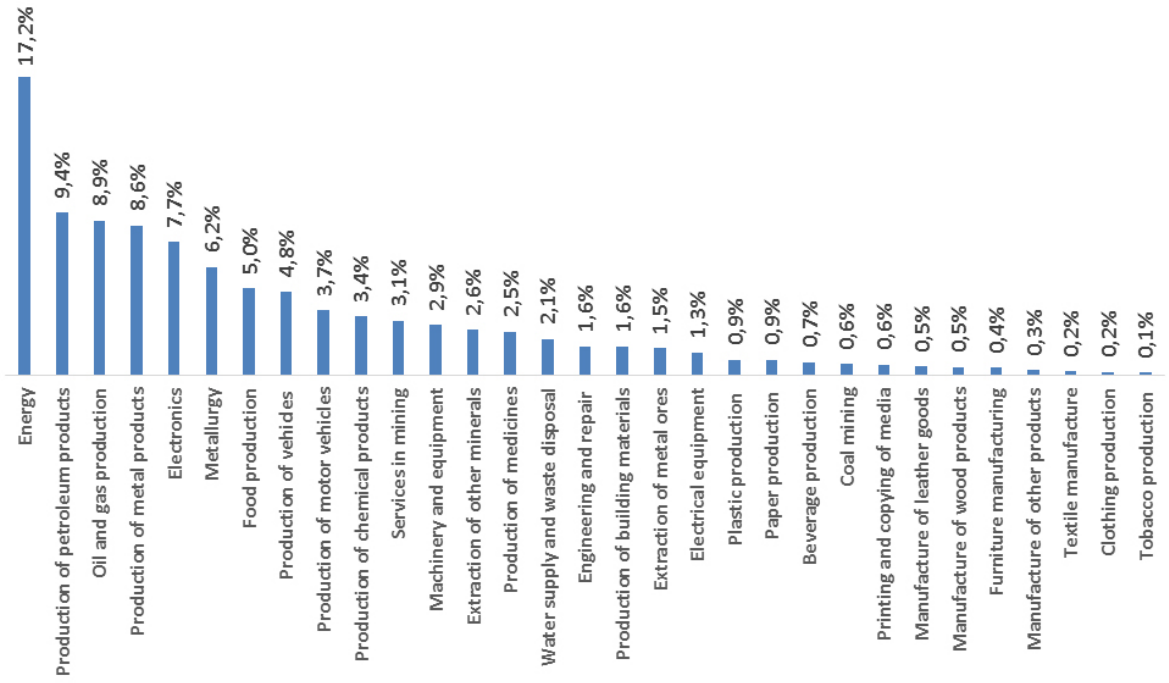

Figure 2. Industry structure of the digital budget, 2021

Source: author's design on data source: Federal State Statistics Service of the Russian Federation, https://rosstat.gov.ru/statistics/science (accessed:14.12.2022)

Adherents of import substitution (the share of Russian software costs in the amount of software costs is more than 50%) are coal enterprises (65.2%), clothing enterprises (56.7%), textile enterprises (69.6%), printing (95.5%), enterprises producing finished metal products (92.4%), electronics companies (54.1%). Oil refining enterprises (6.9%) and tobacco production enterprises (9.4%) are less focused on Russian software.

The costs of personnel training associated with the introduction of digital technologies in the industry as a whole occupy a small share, but a number of industries pay increased attention to this – these are energy enterprises, automotive and chemical industries. The costs of acquiring access to external databases are quite specific. These costs are typical for the food and textile industries, woodworking and printing houses, as well as utilities.

Earlier studies noted that metallurgical enterprises, as well as enterprises producing electrical equipment, electronics and chemical products, are the most ready for digital business transformation, since in these industries the level of primary digitalization and automation is quite high [21]. Today we observe that it is these enterprises that have a significant share of the «digital»

budget, directed not to the purchase of digital equipment, but to the purchase and development of software. Further, it can be predicted that these industries will increase the share of the "digital" budget, which is aimed at increasing the digital competencies of employees and the growth of the human capital of companies.

3. Effectiveness of digital transformation budgets in 2021.

The analysis of «digital» budgets will not be complete if it is not supplemented with an analysis of relative indicators. Let's calculate the value of the indicator «digitalization costs per 1 million rubles of industrial output» and compare them with the index of industrial production. These indicators are shown in Figure 3. The size of the circle in Figure 3 corresponds to the volume of the «digital» budget of the industry for digital transformation in 2021.

In 2021, the leaders were leather production enterprises, electronics enterprises, as well as mining enterprises (except for the extraction of hydrocarbons and metal ores) (Fig. 3). At the same time, these same industries showed a significant (more than 110%) increase in output in 2021.

Coal mining, woodworking, tobacco production, and rubber and plastics production have the lowest values (Fig. 3). At the same time, in 2021, the woodworking and rubber-plastic industry showed fairly high growth rates (more than 110%). For these industries, growth was largely restorative.

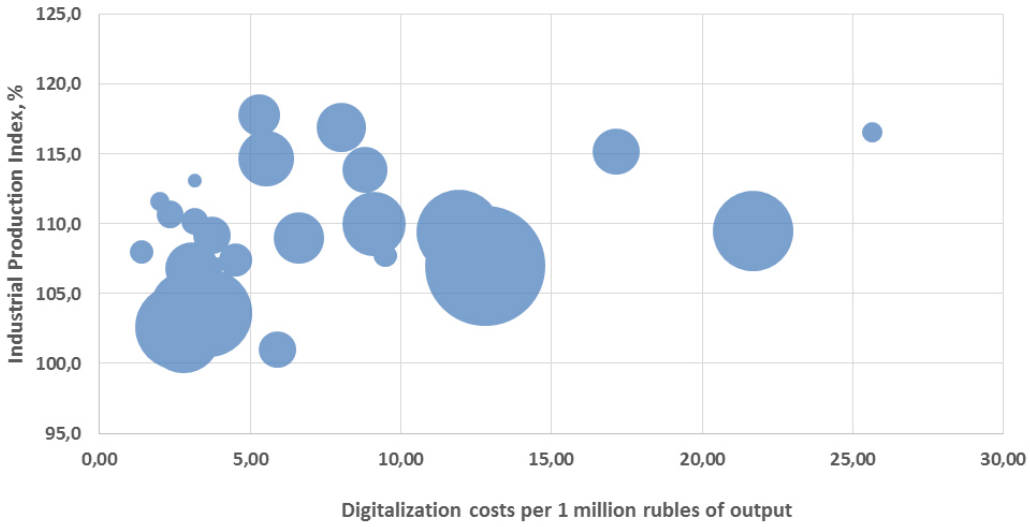

Figure 3. Effectiveness of digital transformation budgets in 2021[1]
Source: prepared by the author

Figure 4 shows a matrix that takes into account the ratio of the cost effectiveness of digitalization and the growth rate of production in 2021. The figure shows that a number of industries with large absolute values of «digital» budgets are characterized by a rather low relative value and moderate growth rates. These industries turned out to be raw materials industries such as oil and gas extraction and processing, metallurgy and the food industry.

Against the background of these industries, digital transformation in the production of medicines, the automotive industry, the production of machinery and equipment, transport engineering, electric power and utilities looks quite effective.

Conclusion

The analysis of «digital» budgets in the Russian industry showed a significant differentiation of industries both in terms of the amount of costs and their structure. Cross-industry analysis showed individual characteristics of industries that are associated with the level of digital readiness and sufficiency of the "digital" budget for a full-scale digital transition. The study also confirmed the following conclusion. If the costs of digitalization do not work to increase efficiency (output volumes, growth rates), then the problems may lie deeper, for example,

[1] Figure 3 shows: 1 – manufacture of leather goods; 2 – manufacture of computers and electronics; 3 – extraction of other minerals; 4 – electricity; 5 – manufacture of finished metal products; 6 – printing houses; 7 – manufacture of vehicles; 8 – manufacture of medicines; 9 – manufacture of machinery and equipment; 10 – mining services; 11 – engineering and repair; 12 – automobile production; 13 – water supply and waste disposal; 14 – furniture production; 15 – electrical equipment production; 16 – manufacture of other products; 17 – production of construction products; 18 – production of beverages; 19 – production of petroleum products; 20 – extraction of metal ores; 21 – production of paper products; 22 – textile production; 23 – production of clothing; 24 – production of chemical products; 25 – food production; 26 – metallurgy; 27 – oil and gas production; 28 – mass production; 29 – tobacco production; 30 – manufacture of wood products; 31 – coal mining.

the discrepancy between the goals of digitalization and business goals, the lack of involvement of management in digitalization and organizational weakness of business processes, low digital culture at the enterprise, etc.

Industrial Production Index, %	*high rate (over 110%)*	metal ore mining (2.3 million rubles) pulp and рцaper industry (4.1 million rubles) textile industry (1 million rubles) rubber and plastics production (4.2 million rubles) woodworking (2.2 million rubles)	medical products industry (11.9 million rubles) production of machinery and equipment (13.8 million rubles) automotive industry (17.8 million rubles) utilities (2.3 million rubles) leather goods industry (9.9 million rubles) furniture industry (2.0 million rubles) mining of other minerals (12.4 million rubles)
	medium rate (100–110%)	coal mining (2.9 million rubles) oil and gas production (42.5 million rubles) oil refining (44.8 million rubles) metal ore mining (7.4 million rubles) metallurgy (29.8 million rubles) chemical industry (16.2 million rubles) building materials industry (7.8 million rubles) light industry (0.7 million rubles) food industry (23.9 million rubles) beverage production (3.5 million rubles) tobacco industry (0.6 million rubles)	electronics (36.7 million rubles) electrical industry (6.1 million rubles) transport engineering (22.9 million rubles) electric power industry (82.4 million rubles) metal industry (41.3 million rubles) printing industry (2.9 million rubles) mining services (14.9 million rubles) engineering and repair (7.8 million rubles) production of other finished products (1.3 million rubles)
	decrease	–	–
		low value (less than median)	*high value (more than median)*
		Digitalization costs per 1 million rubles of output	

Figure 4. Matrix of the «digital» budget efficiency and the growth rate of production in 2021 (in parentheses the absolute value of the budget for digitalization in 2021)

Source: prepared by the author

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In 2002 Victoria Victorovna defended her candidate thesis «Development of a mechanism for forecasting and preparing management decisions at industrial enterprises». In 2011 the doctoral thesis «Methodology for studying the processes of formation and development of economic and technological reality in industry» was defended.

Akberdina V. V. is the author and co-author of more than 200 papers, 45 publications are included in the core of the RSCI.

The scope of scientific interests:

– studies of the structural proportions of the economic development of the state, territories and industries; research on the technological, structural and institutional transformation of the industrial complex and industrial markets in the context of the development of Industry 4.0;

– development of theoretical and methodological foundations for the formation of industrial policy in the conditions of the fourth industrial revolution, substantiation of models of innovative dynamics of the technological development of the regional economy based on the economic and mathematical approach.

Main scientific results:

– theoretical provisions in the field of studying economic and technological development in industry at the regional level are developed, a methodology for studying economic and technological development in the industry of the region is developed, including the principles and algorithm for nonlinear modeling of the innovative dynamics of the region, a mathematical complex for the phenomenon of «innovation resonance» of the industrial system is developed;

– developed and substantiated the theoretical concept of multi-subject industrial policy at the regional level based on resonant effects in the conditions of new industrialization, formalized the interaction between the state and business based on game theory, formalized the motivational potentials of the main subjects of the groups;

– substantiated the methodology for studying structural changes in regional industry markets in the context of the formation of a network industrial complex, developed a system of control actions on the structural parameters of the development of regional industry, developed a methodology for determining the stages of structural changes in industry markets in a digital economy.

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Main prizes and awards:

– medal «For contribution to the implementation of state policy in the field of education, scientific and technological development» (2021);

– Letter of thanks from the Plenipotentiary Representative of the President of the Russian Federation in the Urals Federal District (2020);

– Letter of thanks from the Governor of the Sverdlovsk region (2020);

– Letter of thanks from the Minister of Industry and Science of the Sverdlovsk Region (2015);

– Award named after A.M. Sergeev on regional economics (2013);

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Акбердина В. В. является автором и соавтором более чем 200 работ, из которых 45 публикаций входят в ядро РИНЦ.

Сфера ее научных интересов:

– исследования структурных пропорций экономического развития государства, территорий и отраслей; исследования технологической, структурной и институциональной трансформации промышленного комплекса и индустриальных рынков в условиях развития Индустрии 4.0;

– разработка теоретико-методологических основ формирования промышленной политики в условиях четвертой промышленной революции, обоснование моделей инновационной динамики технологического развития региональной экономики на основе экономико-математического подхода.

Основные научные результаты:

– развиты теоретические положения в области исследования экономико-технологического развития в промышленности на региональном уровне, разработана методология исследования экономико-технологического развития в промышленности региона, включая принципы и алгоритм нелинейного моделирования инновационной динамики региона, разработан математический комплекс явления «инновационный резонанс» промышленной системы;

– разработана и обоснована теоретическая концепция мультисубъектной промышленной политики на уровне региона на основе резонансных эффектов в условиях новой индустриализации, формализовано взаимодействие между государством и бизнесом на основе теории игр, формализованы мотивационные потенциалы основных субъектов групп;

– обоснована методология исследования структурных изменений региональных отраслевых рынков в условиях формирования сетевого промышленного комплекса, разработана система управляющих воздействий на структурные параметры развития региональной промышленности, разработана методика определения стадий структурных изменений отраслевых рынков в условиях цифровой экономики.

Акбердина В. В. является председателем диссертационного совета 24.1.156.02 при Институте экономики УрО РАН по специальностям 5.2.3 «Региональная и отраслевая экономика (экономика промышленности)» и 5.2.5 «Мировая экономика», членом диссертационных советов УрФУ и ПГНИУ, заместителем председателя общественного совета при Министерстве промышленности и науки Свердловской области, членом комитета по энергетике Свердловского областного Союза промышленников и предпринимателей.

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– медаль «За вклад в реализацию государственной политики в области образования и научно-технологического развития» (2021);

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