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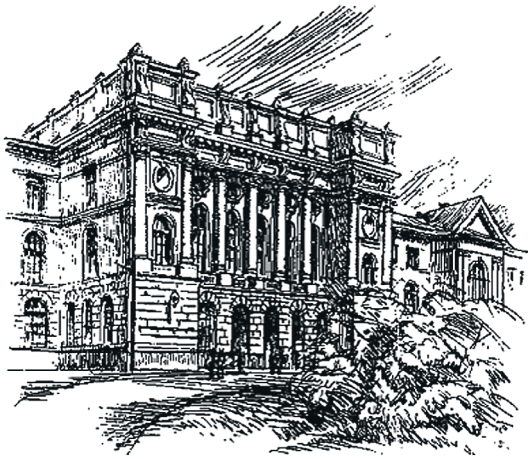

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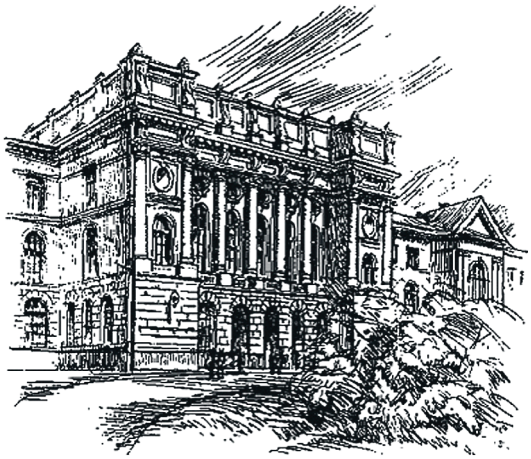
МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ



НАУЧНО-ТЕХНИЧЕСКИЕ ВЕДОМОСТИ

САНКТ-ПЕТЕРБУРГСКОГО ГОСУДАРСТВЕННОГО ПОЛИТЕХНИЧЕСКОГО УНИВЕРСИТЕТА

Экономические науки

Том 12, № 2, 2019

Санкт-Петербургский политехнический
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2019

НАУЧНО-ТЕХНИЧЕСКИЕ ВЕДОМОСТИ САНКТ-ПЕТЕРБУРГСКОГО ГОСУДАРСТВЕННОГО ПОЛИТЕХНИЧЕСКОГО УНИВЕРСИТЕТА. ЭКОНОМИЧЕСКИЕ НАУКИ

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DIGITAL SEGMENT OF THE REAL ECONOMY: DIGITAL ECONOMY IN THE CONTEXT OF ANALOG ECONOMY

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Formation, development and institutionalization of digital economy (DE) is in its third year now in the Russian Federation. However, there is still no comprehensive understanding of DE in foreign or Russian economic science, and no fundamental studies have been carried out on digital economy's relationship with the analog and real economies. The goal of this article is to gain further insight into the phenomenon and analyze the results of the fourth information revolution (using Peter Drucker's definition) and the fourth industrial revolution (using Klaus Schwab's definition), institutional environment of digital economy, and, ultimately, the digital segment of the real economy. The study presents the theoretical and practical fundamentals of analog, real and digital economies, refining their definitions. Digital economy, or, rather digital information economy, is represented in the context of a new type of mixed economy, analog-to-digital; this concept is introduced for the very first time. Information, or, more precisely, energy and information, technological and production know-how are considered as the main resource of the digital economy. Original appraised interpretation is provided for DE as an emerging system (and possibly antisystem) of production and/or economic relations that can function without direct human participation «in the field of production as Industry 4.0 (cyber systems together with the «Internet of Everything»), virtual distribution, exchange via digital platforms and individualized consumption as the main phase of reproduction of information goods» in digital form. Technological essence, parameters in the form of digital technologies and the role of digital economy as a digital segment of the real economy have been defined. The new practically important results obtained in the study are the correlation between the digital sector and the real economy, exceeding economic growth rates of DE compared to those of analog economy at the present time. Viability of the analog economy is demonstrated in contrast to speculations on the «demise of analog economy» (discussed at the Information Technology of Industrial Russia conference). Interaction and direct correlation of analog and digital economies have been revealed.

Keywords: digital segment of real economy, analog economy, real economy, digital economy, analog and digital economy, information and digital economy, information, technological and production know-how, digitalization, information technology of Industrial Russia conference

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ЦИФРОВОЙ СЕГМЕНТ РЕАЛЬНОЙ ЭКОНОМИКИ: ЦИФРОВАЯ ЭКОНОМИКА В КОНТЕКСТЕ АНАЛОГОВОЙ

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Третий год идет формирование и развитие цифровой экономики, ее институционализация в России, однако целостного ее осмысления, фундаментального исследования ее взаимодействия с аналоговой и реальной экономиками в зарубежной и российской экономической науке не произошло. Цель данного исследования – дальнейшее осмысление и анализ результатов четвертой информационной (по Питеру Друкеру) и четвертой промышленной (по Клаусу Мартину Швабу) революций, институциональной среды цифровой экономики, а в конечном итоге – цифрового сегмента реальной экономики. Отражены результаты исследования теоретических и практических основ аналоговой и реальной, а также цифровой экономик, уточняются их определения, параметры. Цифровая экономика, а точнее, информационно-цифровая экономика, позиционируется в контексте нового типа смешанной экономики как аналогово-цифровой – понятия, введенного автором впервые в научный оборот. Информация, а конкретнее, энергия и информация, технологическая производственная информация, представлены как основной ресурс цифровой экономики. Дана оригинальная апробированная авторская трактовка цифровой экономики как формирующейся системы, а возможно, и антисистемы производственных и/или экономических отношений, которая может функционировать и без непосредственного участия человека «в сфере производства как Индустрии 4.0 (киберсистемы вкупе с “интернетом всего”), виртуального распределения, обмена посредством цифровых платформ и индивидуализированного потребления как главной фазы воспроизводства информационных благ» в цифровой форме. Определены технологическая сущность, параметры в форме цифровых технологий и значение цифровой экономики как цифрового сегмента реальной экономики. С точки зрения практической новизны показано соотношение цифрового сектора в реальной экономике, а также превосходящие темпы экономического роста цифровой экономики, по сравнению с аналоговой, на современном этапе. Показана жизнеспособность аналоговой экономики, в отличие от концепта конференции ЦИПР–2017 «Цифровая индустрия промышленной России» об «умирании аналоговой экономики». Определены взаимодействие и прямая связь аналоговой и цифровой экономик.

Ключевые слова: цифровой сегмент реальной экономики, аналоговая экономика, реальная экономика, цифровая экономика, аналого-цифровая экономика, информационно-цифровая экономика, энергия и информация, технологическая производственная информация, цифровизация, цифровая индустрия промышленной России (ЦИПР–2017)

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«I know everything,» said Wikipedia.
«I can find everything,» said Yandex.
«I am the greatest of them all,» said the Internet.
«Well now,» grinned the electricity.

Mikhail Kovalchuk

Introduction. It was only in January 2016 that the President of the Russian Federation announced a policy towards building a digital economy (DE) as the economy of the new technological generation. Over the next two years (2017–2018) and in early

2019, the digital economy has become a key sociocultural, institutional and economic concept in the vast majority of foreign, Russian and international economic information platforms, such as summits, conferences, congresses, forums, symposia, round tables, lectures, seminars, reports, speeches, programs, as well as in publications in the media and in academic publishing. Since 2018, our country is facing the challenge of a digital technology breakthrough [10]. It has been three years now that digital economy has been integrated into Russian economic practices (although it has been first introduced into practice much earlier) as digitalization of different aspects of human life (including economic aspects); moreover, simultaneous digitalization of the entire society (transformation of the information society into a digital society, referred to as society 5.0 and society 6.0) is underway.

The World Bank 2016 Report on Developing the Digital Economy in Russia ranked the country 28th in the world in terms of the human capital development index [1, p. 6], and 41st in terms of the social and economic benefits obtained from digital transformation. Russia was ranked 61st in terms of the impact of information and communication technologies (ICT) on the efficiency of public administration, 75th in terms of the impact of ICT on new forms of organization, 88th in terms of the impact of ICT on the availability of basic services [1, p. 12].

Holding a speech before the students of the Sirius Educational Center, the President of the Russian Federation said that the prize for creating a digital economy would be to rule the world. This situation with DE is similar to the creation and possession of nuclear weapons in the 1940s. Many countries of the world are participating in the big digital game to rule the world, with the digital economies of USA and China leading the race. However, no comprehensive analysis has been carried out so far on the most urgent and vital problem of digital economy and digital society in the context of analog and real economies. Digital practice and its institutionalization (in the form of World Bank Reports, Decree of the President of the Russian Federation, Government Program on Digital Economy of the Russian Federation, etc.) are currently ahead of fundamental and even applied studies on socio-economics and philosophy of economics. In the context of information warfare and cyberwarfare, there is much speculative, false, fake or non-professional data on DE, including the data given in the scientific literature. The prospects for the real and analog economies of the Russian Federation, its neo-industrialization, re-industrialization and digital transformation have not been clearly outlined, given the country's digital dependence and Internet dependence on the United States. Fundamental economics, whose foundations were laid down by Lomonosov, should be able to answer the question put forward by the President of the Russian Federation, namely, how the Russian economy could move into a «higher league of economies».

Problem statement. The goal of this study is to better comprehend and analyze the results of the fourth information and fourth industrial revolutions, the digital information economy (DIE) as information economy 2.0 and the institutional and economic environment of digital economy, and, ultimately, the digital segment of the real economy through the prism of a new type of mixed economy, analog-to-digital. This problem is the subject of our analysis.

Research methodology. The studies of well-known foreign scientists have served as a primary theoretical and methodological basis for the study. For example, Peter Drucker considered the information revolution of the 1970s, without presuming to call it the fourth information revolution (terming the revolution related to invention of the printing press as the third information revolution). The ideas and concepts of digital economy did not originate with Russian scientists and officials. This is a global challenge in the context of hybrid, humanitarian, genetic and cyber warfare, a megaproject and a metaproject, which was first theorized in 1994 by the «cyber-guru of the world», Canadian scholar Don Tapscott [7], and by Nicholas Negraponte [14] from the Massachusetts Institute of Technology (USA) in 1995. Notably, the term digital economy has been adopted in the European Union and in Russia, while the more technology-oriented term «API economy»

is common in the USA (used by such companies as Deloitte, IBM, etc.). Klaus Martin Schwab's fundamental works are dedicated to the fourth industrial revolution, the «conceptual framework for understanding the technological revolution» [8, p. 11] and to digital revolution technologies [9]. The Oxford Dictionary defines digital economy as «an economy which functions primarily by means of digital technology, especially electronic transactions made using the Internet» [15]. Many studies of both foreign and Russian economists have been written on the subject of DE, namely, on information and digital economies (Apatova, Babkin, Dyatlov, Lugachev, Strelets, Chinaeva, Yudina, and others). Particular attention has been paid to applied problems of DE: electronic commerce (Lapidus et al.); digital platforms, platform economy (Geliskhanov, Markova, Shastitko and others). Nevertheless, there has been as yet no comprehensive study of digital economy, and its purposes, essence and beneficiaries have been largely left ignored; moreover, the concepts of analog and real economies are fading into oblivion in academic discussion.

The study used the following methods of economic analysis: comprehensive, systemic, deductive, institutional, historical/economic, philosophical/economic, statistical, as well as the project method.

Digital, analog and real economy. Let us try to provide theoretical and methodological answers to the difficult question of the relationship between digital and analog economies, defining the very concepts of digital, analog and real economics in terms of digitalization as one of the current trends in the development of national and global economies and explaining their practical significance, parameters and directions. In the context of real economy, digital economy should not be confused with augmented reality as a technique that allows to use information and digital technologies to supplement the real world with data about it. Back in 1997, Ronald Azuma postulated that augmented reality is a system combining the virtual and the real, which «interacts in real time; is registered in three dimensions» [12, p. 356].

Extensive debate on the topic of digital economy started in the Russian Federation after the World Bank's Digital Dividends report was presented at the Open Innovations platform in Skolkovo in the autumn of 2016. The concept of institutionalizing the «digital economy» of the Russian Federation was compiled and circulated by the World Bank in 2016 and is described in the Digital Dividends World Development Report (2016 World Bank Review). The report pointed out the following directions for digitalization in Russia: «open data, e-government system, efforts of domestic digital giants like Yandex, Kaspersky, online order services, reducing the term of registration of ownership rights by using information technology to 10 days» [19]. Within this document, the World Bank defined digital economy as «a system of economic, social and cultural relations based on use of digital information and communication technologies» [19]. However, some methods proposed in the 2016 WB Report for digitalization in the Russian Federation contradict the Russian Government's 2017 statements on digital economy. For example, according to the summary program of the Government of the Russian Federation in 2017, the following directions for forming DE in the Russian Federation emerged: legal regulation, competences, education and personnel, cybersecurity, infrastructure [4].

However, it was earlier that the era of digital economy began in Russia and around the world: it was in the early 2010s with the advent of affordable smartphones. The user of a smartphone, i.e., not a supercomputer but a terminal with access to the global network is the very image of the digital economy itself. The economic and institutional origins of digitalization in the Russian Federation are thus interwined. Meanwhile, the digital economy has begun to expand, interacting with the real and analog economies.

The concepts of analog and digital computers and analog and digital signals from the theory of signals should be introduced to facilitate understanding of analog and digital economies from the standpoint of technology and information as the main production factors of information economy. Analog and digital computers, as well as their corresponding analog and digital technologies and carriers are the criteria for analog and digital

economies only in the narrow (technological) sense of the word.

Analog economy in the narrow sense of the word is connected with use of analog computers, technologies and carriers. They process information presented in analog or continuous form by reproducing the connections and relationships between constantly and continuously varying physical quantities equivalent to the original data, which are typical for this class. Electrical currents and voltages are used as machine variables in electronic analog computers. There are analog computers with automatic software and with manual control. The difference between analog and digital computers is in the set of problems solved and the methods for their execution; in addition, the latter have higher speeds and are easy to program. Digital computers also process information represented in digital form. Each digit in digital computers corresponds to one or several discrete signals, with a digital algorithm (1,0 binary code) used. Modern digital computers are represented by computers and supercomputers whose wide use actually marked the beginning of the digital economy.

Analog economy is connected to analog technologies used in the real economy (for example, analog television, photography, etc.), as well as analog information carriers (gramophone records, videotapes, etc.). In the broad sense of the word, analog economy can be synonymous with the real economy. Real economy, according to reproduction theory (political economy, economic theory), is the economic activity of the society associated with reproduction of real non-digital goods and services. This is also a set of production and economic relations that evolve in the system of production, distribution, exchange and consumption of material and non-material, real, non-virtual goods, which has its own institutions and anti-institutions, i.e., rules and regulations.

However, use of computers, supercomputers, the Internet, mobile phones, smartphones, etc., and in the long term, quantum computers and neural networks (Neuronets) has brought on institutional changes into the functioning of the economy as a whole. Use of the Internet and gadgets should be regarded as a kind of consumption, industrial and individual. The digital economy can be then represented as part of economic relations mediated by the Internet, cellular communications, ICT, etc. The phenomenon of real digital enterprises emerges.

There is a direct dependence of digital economy on electricity and other energy information resources and potential which are one of the main products of the real economy [5, p. 40–41], as well as on natural phenomena (for example, solar eclipses), etc. Docking of the Soyuz (USSR) and Apollo (USA) spacecraft is vivid evidence of the advantages of Soviet analog technologies over the American digital technologies. All of these dependences are well understood by specialists integrating information and communication technologies (ICT) and digital technologies in modern business processes, as well as by scientists using interdisciplinary analysis.

Indeed, an independent digital economy cannot exist without real and analog economies; only control over the economy and society can be digital, or, more precisely, electronic. According to V.V. Ivanov (Doctor of Economic Sciences, Corresponding Member of RAS), digital economy is «a virtual environment that complements our reality». There is another similar definition of DE as a supplement to analog economy.

Let us define digital economy, understood within this study as a supplement to the analog and only partly to the real economy, in the following manner: digital economy is an emerging system (and, possibly, an anti-system) of production and/or economic relations that can function without direct human participation «in the sphere of production of both Industry 4.0 (cyber systems together with the Internet of Everything comprising the Internet of Things, Internet of Ideas and Internet of Agreements), virtual distribution, exchange through digital platforms and individualized consumption as the main phase of reproduction of information goods» in digital form [11, p. 14]. Digital economy is a web-based, computerized and, in the future, neural-network-based mechanism as information economy 3.0, which is also simultaneously virtual economy, including, for example, gamers (players who, along with real products and services, consume large quantities of digital and virtual goods).

The difference between real economy (RE), analog economy (AE) and digital economy (DE) can be also traced in terms of the main resource that is the production factor for the economy (this is labor and accumulated labor in the form of capital for the real and the analog economy, and information, knowledge, data, big data, digital twins for the digital economy); in terms of type of economic relations (vertical, hierarchical for AE and RE; horizontal, network, platform for DE); in terms of the market (geographical markets (local, regional, national, world, global) for RE and a multilateral communication space of network interactions, hybrid global organized space for DE), etc.

Digital economy also differs from real economy by the results of its production that are information and digital goods and services (DGS). Given the characteristics of production and consumption of DGS, they can be divided into four groups:

firstly, the DGS produced from the start in digital format are «cloned» and do not have a material prototype (for example, software, films and video materials shot with a digital camera, e-books without paper equivalents, etc.);

secondly, these are digital copies of material non-digital goods that retain the functional qualities of their real prototypes (digital copies of films that were originally made using analog film technologies, digitized printed books, materials, documents, original works of art, etc.);

thirdly, these are digital images of traditional goods in the service sector, which do not replace their prototypes in consumption but allow to manage these prototypes more effectively (for example, the Uber system, managing a fleet of taxi cars with a digital image, and the similar Yandex. Taxi system); fourthly, these are material goods created using digital technologies such as additive technologies, 3D printing or robotization when digital images are transferred to real products while consuming real material products produced on the basis of their digital images (for example, a bridge in Amsterdam 3D-printed using robots, a motorcycle 3D-printed in Sweden, «printed houses», etc.).

It follows then that digital economy cannot replace the real economy associated with reproduction of tangible and intangible non-virtual goods using analog and even partially digital technologies necessary for vital human activities. Digital television, digital photography, digital medicine, digital education, etc., increase the amount of information goods produced, but not their quality. Digital economy does not have a life-affirming basis, acting instead as a supplement to the analog and the real economy. DE can become a system for control over the real economy and for managing it. Indeed, there are two segments of the real economy: the analog segment as a synonym for the real economy itself and the digital segment in the context of digital enterprises and information and digital goods («printed» real houses, bridges, motorcycles, components, etc.).

Digital segment of real economy: life in reality instead of the digital world. The new interpretation of digital economy as a supplement to the real economy and, so to speak, the complementary component of the analog economy is in principle capable of stimulating the development of real sectors of economy and of the national economy as a whole. There have been attempts in some Western European countries (Great Britain, Denmark, Norway, Germany, etc.) to organize and accelerate the DE; however, these attempts proved somewhat artificial, bearing no correlation to the analog economy. Accelerated development of the DE without taking into account the development of the analog and the real economy resulted in a slowdown in the overall economic development of the country. In practice (for example, considering railways in the UK, energy in the US, etc.), there is a direct link between the development of the real and the analog, the material and the analog (technological) sectors of the economy and the digital one. Real processes of digitalization of objects and production processes stimulate the development of goods and services of analog and real economies. Digital economy cannot exist and evolve without the analog and the real economy, since life itself is analog, and analog technologies are, in practice, of better quality and more effective for production of unique products. DE, RE and AE can complement each other, participating in the growth of goods.

The example of e-commerce in the world where digital and real economies are interconnected is particularly illustrative: exchange of real goods happens through digital platforms (DP). In 2015, the US was the leader in electronic commerce (without a financial market) with a volume of $287.39 billion, «ahead of China ($247.03 billion), Japan ($76.11 billion), Great Britain ($66.7 billion) and Germany ($57.33 billion)» [6, p. 80]. This is mainly explained by two reasons: firstly, many transnational digital platforms present in the USA [3] and, secondly, the volume of the more expensive American digital information product that is traded electronically. Another important factor for American leadership in the field of e-economics is a huge amount of available venture capital in the US compared to other countries. In view of this, even foreign startups in the field of digital economy prefer to launch in the United States due to more affordable financing and a large domestic digital economy market in North America. China is second because it has fewer transnational electronic platforms (the main one is the Ali Baba transnational digital platform) and cheaper real, i.e., material product. The main reasons for China's leadership in e-commerce and digital economy are the following:

• Protectionism of the Chinese government, which limits the presence of international players (Google, Facebook, Amazon, instant messengers, etc.) in the country;

• Underdeveloped classic analog retail platforms (a significant proportion of China's population still lives in rural areas with no modern trade);

• Cheap mass domestic production of electronic equipment (computers, smartphones, etc.), accessible even to people with low incomes, increased Internet usage;

• Large population.

From the standpoint of the digital segment of real economy, a new type of mixed economy can be said to have evolved, that is, from the standpoint of technologies, the analog-to-digital economy. Some sources even describe «symbiosis of man and computer» (according to Eric Schmidt, Executive Chairman of Board of Directors at Google) because, indeed, digital economy is positioned as a person with a smartphone which is a terminal for accessing the Internet and the «cloud». «For me, there is no independent digital economy: there is a digital segment of the real economy» [17], claimed Dzhomart Aliev, top manager of a number of large companies, who introduced new management systems and technologies. As Aliev stated, «People are material beings living in a non-virtual world. So digital contracts for supply of oil are still based on the fact that real oil is needed for sale. Like food, clothes, etc. Of course, there are some people (such as gamers) who spend more on «life in the digital world» than on «life in reality» but they are few and they do not set economic trends» [17].

Digital economy is in fact digital information economy (DIE), since reproduction of an information product is its essence, and digitalization is its form. Collection, storage, processing of data and Big Data as inefficient assets and digital twins as effective assets should be goal-oriented. The three institutional principles of the digitalization of the economy in each country should be clearly understood: «goal, ideology and mechanisms of implementation» of DE. The main phase in digital economy is consumption, a person can become a consumer instead of a creator or a producer (although consumerism is also described as a combination or symbiosis of the consumer and the producer in one person); accordingly, the society makes the ultimate transition to consumerism, with consumer addiction through digital control systems.

The Government Program of the Russian Federation on the «digital economy» considered the relationships between the «digital» and the «analog» worlds in a special, Russian way. According to the Program, a new digital economic model that is not based on raw materials and is not neo-industrial is created in Russia. Without defining a common strategic life-affirming goal, the Program lists the following tactical objectives: «create at least 10 high-tech IT enterprises, 10 industrial digital platforms for the main sectors of the economy» (education, healthcare, etc.), 500 small and medium-sized enterprises in the field of digital technologies. An additional task is to ensure annual graduation of 120,000 IT specialists and to provide 97% of Russian households with broadband Internet access at a speed of at least 100 Mbit/s (the average speed was 12 Mbit/s

in 2016) [4]. According to this Program, it is necessary to «make sure that 95% of network traffic goes through domestic networks. To establish sustainable 5G coverage in all cities with a population of over one million and to ensure that Russia's share in the global market for information storage and processing services is 10 percent (it is currently less than 1 percent). All of this should be accomplished by 2024 with annual funding of 100 billion rubles from the state budget. The implemented program should decrease the share of foreign computer and telecommunication equipment purchased by government agencies to 50 percent, and of software to 10 percent» [18]. The problem of the digital divide between regions and industries, with the continued Internet dependence on the US, does not lose its relevance in Russia.

The program «Digital Economy of the Russian Federation», dated July 28, 2017, is based on the concept of the fourth industrial revolution according to Schwab, consisting of three waves in the opinion of its developers. The first wave involves «digital development of banks, telecommunications companies, public services, i.e., the areas where technologies only affect the transformation of work algorithms» [4]. Implementing these measures may result in creating a so-called «digital concentration camp» and/or electronic concentration camp, like in China, earlier than the digital segment of the real economy can evolve. For example, the Chinese project of the Social Credit System was widely described in scientific publications as «digital dictatorship» and/or «electronic concentration camp» («electronic concentration camp» is a concept that was introduced in 2016 by the British magazine The Economist). Complex technological changes in industry and transport should be introduced only in the second wave, taking into account the relationship between the digital and the analog economy. Finally, the third wave is the era of institutional and technological breakthroughs in such areas as genetics, quantum and energy technologies, neural networks, etc., which can essentially change the institutions or rules of the game. This can be the start of a big digital game without rules, maybe with anti-institutions.

Thus, theoretical discussions as well as practical confirmations can only concern the digital segment of the real economy, the analog-to-digital economy from a technological standpoint as a new type of mixed economy and also life in the real rather than the digital world; there is no speaking of an independent digital economy and its boundaries.

2017 Conference on Information Technology of Industrial Russia: «the analog economy is dying». There is a point of view in the global information space that the analog economy is dying. Our task here is to weigh the pros and cons of this concept and to draw a balanced science-based conclusion taking into account socio-economic considerations and aspects of philosophy of economics.

In May 2017, the annual conference on Information Technology of Industrial Russia was held at Innopolis, an innovation center in the Republic of Tatarstan. The conference serves as a modern digital intersectoral platform, connecting representatives of the Russian industry as the real sector of the economy, in particular, its military-industrial complex, information and communication technology professionals as representatives of the digital economy, investors and the state. The discussions cover a range of practical issues on forming and developing digital economy in the Russian Federation. Systemic fundamental theoretical and methodological problems of the digital economy are not considered at the conference, which does not provide a comprehensive view of the digital economy.

Issues of non-resource exports, further conversion in the sectors of the military-industrial complex, ensuring cybersecurity protection of Russia's economic space in an open, public Internet as a modern weapon of the US (following Ashmanov's definition) are also presented at the conference. The conference was held with the support of the Presidential Administration of Russia, the Ministry of Economic Development, the Ministry of Industry and Trade of the Russian Federation, the Ministry of Digital Development, Communications and Mass Media, the Government of the Republic of Tajikistan, the Digital Economy Autonomous Non-Commercial Organization, a strategic partner of the conference, and others.

This representative forum was visited by Dmitry Peskov, the then director of the Young Professionals Department of the Agency for Strategic Initiatives. He stated that the share of the analog economy of the Russian Federation would halve over the next twenty years, commenting, «the analog economy is dying». Peskov pointed out that the main danger in development of Russia's real sector of economy was shortage of highly qualified specialists to work at high-tech enterprises with new equipment. Peskov said, «Today we are stimulating the training of personnel not for the digital but for the analog economy. We are preparing students for weak enterprises. There are currently no programs in the world (at least, not full-fledged ones) for preparing adults for work in the digital economy in the world. We need to develop such programs, we are working in this direction because we see that the analog economy is dying» [16].

Believing that the analog economy is dwindling, Peskov sees the future of the Russian economy, firstly, in searching for «new markets in other countries» and, secondly, in creating «digital enterprises in Russia». Peskov proposed, «We need to look for new markets that emerge in the conditions of the technological revolution. Following this logic, we should stimulate the creation of new digital companies. The share of the analog economy will be halved in 20 years» [16].

First of all, this key thesis of the dying analog economy, put forward by Peskov (who went on to become the special representative of the President of the Russian Federation for Digital and Technological Development) on May 17, 2017 at Innopolis, could be argued, if its proponent would be willing to do so, within the framework of scientific discussions and ethics; secondly, it is quite logical to conclude that this assumption is unrealistic, since life itself is analog. Virtual «life» is only attractive for gamers, satisfying their basic needs for virtual, artificial, digital goods, even though gamers still use real goods as well. The civilized scientific community sees the boundaries of the digital economy and does not at all deny it, regarding it as a digital segment of the real economy and as part of the digital information economy as information economy 2.0.

Digital Information Economy: basis for interaction of «physical, digital and biological domains». Informatization, computerization, cybernization, intellectualization, internetization, platformization, digitalization, virtualization, and even neuro-cybernization are the processes evolving in the modern «biodigital» world, which is accompanied by increased uncertainty and risks. Digital economy has emerged because of these phenomena. According to Drucker, the information civilization and information economy 1.0 formed as a result of the fourth information revolution of the mid-70s. Historically and ontologically speaking, information as one of the basic concepts of cybernetics is the exchange of data between people, between human and machine, between machine and machine; now it is the result of data conversion and analysis that has become the main factor of production. Technological and production know-how has taken priority over economic data. Technological and production know-how is actually a derivative of fundamental scientific knowledge. Notably, not just economic information or information concerning technological production processes should be taken into account but information as energy and energy as information, which is «a direct expression of economic and productive power», while humans are «the energy and information potential» [5, p. 40]. The amount of information continues to grow exponentially, having increased by more than 90 % over the last 2 years. However, it would be more correct to analyze information together with energy, since «energy-information primarily ensures reasonable organization of economic life» [5, p. 41], and, possibly, vice versa, since energy has two origins, positive and negative.

At the present stage, information economy 1.0 is transformed into digital information economy as information economy 2.0 in the epoch of so-called technological breakthroughs. Digital economy is also «surveillance capitalism» [11, p. 12] and the platform economy [13]. The observed trend is platformization [2, p. 22], destroying the vertical structure of production, creating a post-market.

In the context of Schwab's concept «Technologies of the Fourth Industrial Revolution» [9], 12 types of digital technologies determine the essence of «digital

economy». These include, first of all, new artificial intelligence and/or machine learning, Big Data, blockchain, 3D printing, cloud and quantum technologies, virtual and augmented reality and others. According to Schwab's theory, outlined in «Technologies of the Fourth Industrial Revolution», chips can be inserted into the brain, transforming humans into cyborgs.

Dmitry Medvedev said at the 2018 Open Innovations International Forum in Skolkovo that the share of digital information products in the global GDP is already about 10%. The digital information economy is growing much faster than the real economy (in fact, about 9 times faster). Not only «smart people», «smart houses» and «smart companies» but also «smart cities», which currently number about 221, and «smart countries» (now still at the stage of strategic development) become products of the digital information technologies. According to Schwab, all recent phenomena are interaction of «physical, digital and biological domains» [8, p. 17]. According to the Strategy for the Development of the Electronics and Radioelectronics Industry in Russia up to 2025, «Every individual should be constantly connected with global information and control networks of the Internet type. Nanoelectronics should be integrated with biological objects and ensure continuous monitoring of the maintenance of their life activities, improving the quality of life, and thus reducing the social costs for the state. Built-in wireless nanoelectronic devices ensuring a person's constant contact with the surrounding intellectual environment should become widespread, along with means for direct wireless contact of the human brain with objects, vehicles and other people» [20].

Thus, interaction of «physical, digital and biological domains» forms a «biodigital world». The modern phenomena of digital transformation of economy can be explored only within the framework of new concepts.

Results obtained. The following new results have been obtained in this study:

1) we have given a refined definition to the concept of digital segment of real economy as a digital economy in the context of analog economy;

2) we have substantiated the direct correlation between the development of digital, analog and real economies;

3) we have proved that the idea that analog economy is dying is far from reality;

4) we have refined the important definition of digital economy, previously given in Theoretical Economics, 5 (2018) [11, p. 14];

5) we have introduced a new concept of analog-to-digital economy as a new type of mixed economy, where digital economy should represent only the digital segment of the real economy.

Conclusions

1. Finding strategic comprehensive solutions for the problems of forming the digital information economy as information economy 2.0 in the Russian Federation, it is important to see its life-affirming goals, with all economic resources and geopolitics depending primarily on traditional values, on the mentality of the people, on the relationship between the analog and the digital economy as a new type of mixed economy (analog-to-digital). This should help Russia gain access to a «higher league of economies».

2. The Internet dependence of the Russian economy on the USA should be eliminated; at the same time, efforts should be made to reproduce the dependence of digital economy on one of the main products of the real economy that is electricity and other energy information resources.

3. The digital information economy created in the context of analog-to-digital economies should be the result of deeper understanding of the fourth information and fourth industrial revolution, digital information economy as information economy 2.0, keeping in mind that life itself is analog.

4. The idea that analog economy is dying is clearly far from reality.

5. The potential of analog and real economies for forming the digital segment of the real economy should be determined.

6. Digital economy should act as an addition to the real and analog economies; as an emerging system, and possibly, as an anti-system of production and/or economic relations in the field of production as Industry 4.0 (cybersystems together with the

Internet of Things), virtual distribution, exchange through digital platforms and individualized consumption as the main phase of reproduction of information benefits and anti-benefits in digital form.

7. The new interpretation given, in principle and in practice based on the experience of Western European countries, to the digital economy as a supplement to the real and analog economies and humanization of the achievements of scientific and technological revolution are the factors stimulating development of real sectors of economy, of national and world economy as a whole. The new concept that socio-economic progress should be qualitative rather than quantitative at the current stage of globalization is a challenge and an opportunity to create a digital segment of Russia's real economy and to develop the real economy itself.

Directions for further studies. The following directions can be chosen for further research on digital economics:

1. digital transformation of Russian economy at the present stage;
2. digital information economy as information economy 2.0;
3. digital infrastructure;
4. population and digital technologies: relationships and trends.

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DEVELOPMENT OF FORM OF INTERACTION OF PARTICIPANTS OF NON-CASH PAYMENTS IN CONDITIONS OF ECONOMY DIGITALIZATION

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New high-tech methods for making non-cash payments have appeared in the conditions of digitalization of economy (in systems of electronic payment and crypto currency, including the possibility of signing smart contracts). These methods satisfy the requirements of the Internet community: safety of storage and information processing in payment and settlement systems, low cost and high speed of transactions, simplicity and usability, possibility of carrying out payments for small sums in virtual space and others. Despite the absence of legal regulation of the circulation of new hi-tech payment tools, the number of transactions with their participation and the volume of the performed operations increases annually. At the same time, we can note that the traditional ways of non-cash payments fulfillment are still equally popular in the financial and economic sphere (by means of financial instruments in material form, at an office of the money transfer operator, in the system of remote bank service). We have considered the types of payment and settlement systems (traditional electronic and innovative digital). The result of comparative analysis of advantages and disadvantages of each type of systems is presented. We have characterized the forms of interaction of participants of non-cash payments with different methods of initiation of payment operations. On the basis of the obtained results, we have proved that introducing scientific and technical progress into all spheres of public life has promoted change of forms of interaction of participants of non-cash payments from personal contact to digital due to automation of financial processes. However, in the future, in the conditions of globalization of economy, decreased reliability of a world currency system, high level of cyber threats in the financial and economic sphere, intense geopolitical situation in the world, integrated use of traditional and innovative technologies in the sphere of payments and settlements both at the national level, and on the international scene is advisable for increasing reliability and efficiency of non-cash payments, counteracting money laundering, ensuring national and economic security of the country.

Keywords: non-cash payments, technology of distributed registers, interaction form, digital system, electronic system

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РАЗВИТИЕ ФОРМЫ ВЗАИМОДЕЙСТВИЯ УЧАСТНИКОВ БЕЗНАЛИЧНЫХ РАСЧЕТОВ В УСЛОВИЯХ ЦИФРОВИЗАЦИИ ЭКОНОМИКИ

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В условиях цифровизации экономики появились новые высокотехнологичные способы совершения безналичных расчетов и платежей (в системе электронных денег и в криптовалютной системе, в том числе с возможностью заключения смарт-контрактов), удовлетворя-

ющие потребности интернет-сообщества: безопасность хранения и обработки информации в расчетно-платежных системах, низкая стоимость и высокая скорость транзакций, простота и удобство использования, возможность проведения расчетов на небольшие суммы в виртуальном пространстве и др. Несмотря на отсутствие (наличие слабого) нормативно-правового регулирования обращения новых высокотехнологичных финансово-расчетных инструментов, ежегодно возрастают количество транзакций с их участием и объем совершаемых операций. При этом наравне с ними в финансово-экономической сфере не менее популярными остаются традиционные способы совершения безналичных расчетов (финансовыми инструментами, имеющими материально-вещественную форму, в офисе оператора по переводу денежных средств, в системе дистанционного банковского обслуживания). Выделены типы расчетно-платежных систем (традиционные электронные и инновационные цифровые) и представлен результат сравнительного анализа, на основании которого определены достоинства и недостатки каждого типа систем, а также охарактеризованы формы взаимодействия участников безналичных расчетов при разных способах инициирования расчетных операций. На основе полученных результатов доказано, что внедрение научно-технического прогресса во все сферы общественной жизни способствовало изменению форм взаимодействия участников безналичных расчетов от личного контакта до цифрового за счет автоматизации финансовых процессов. Однако в будущем в условиях глобализации экономики, снижения надежности мировой валютной системы, высокого уровня киберугроз в финансово-экономической сфере, напряженной геополитической обстановки в мире для повышения надежности и эффективности безналичных расчетов, противодействия легализации преступных доходов, обеспечения национальной и экономической безопасности страны целесообразно интегрированное применение традиционных и инновационных технологий в сфере расчетов и платежей как на национальном уровне, так и на международной арене.

Ключевые слова: безналичные расчеты, технология распределенных реестров, форма взаимодействия, цифровая система, электронная система

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Introduction. In the conditions of digitalization of economy, improving, developing and promoting non-cash payments is directly related to computational and information technologies. Advances of scientific and technological progress introduced in the financial sector, resulting in new ways of non-cash payments, have accelerated cash flows, reduced the impact of territorial restrictions, reduced the time, financial and labor costs of storing, processing and transmitting information, as well as provided a higher security level of payments. At the same time, we note that using innovative technologies for organizing payment and settlement systems contributed to changing the forms of interaction between participants in payment and settlement operations.

Ever since network technologies have been introduced for accessing information systems, financial organizations have been constantly threatened by intruders. Successful attacks on traditional electronic systems not only lead to substantial financial and reputation losses for the affected organizations, but also destabilize the economy as a whole. Therefore, recently, special attention of scientists and researchers has been directed to studying the essence of high-tech payment and settlement instruments, their role in life and economy, developing proposals for improving traditional electronic systems, as well as the possibility of using innovative technologies in the field of payment and settlement that can reduce (eliminate) the disadvantages of traditional systems, including those concerning information security (Geva [1], Chiu [2], Robbek [3], Atey [5], Andryushin [6], Ason [7], Babkin [9], Baldina [10], Vavrenyuk [13], Genkin [14], Dostov [15], Dubyansky [16], Kashirina [18], Kosten [8], Kochergin [19], Lukasevich. [21], Obaeva [11],

Popikov [22], Revenkov [23], Simanovsky [24], Stolbov [25], Trofimov [26], Fedorova [27]).

The goal of the study is to determine the form of interaction of participants in non-cash payments when they use different technologies to perform payment operations.

Research methodology. The methodological basis of the study consisted of a set of dialectical principles that made it possible to identify the essential characteristics of the studied processes and the forms of their manifestation. We have used the techniques of formal logic, a systematic approach and the method of comparative analysis.

We have carried out comparative analysis of electronic and digital payment and settlement systems; identified the advantages and disadvantages of each type of digital economic systems; given the forms of interaction of participants of non-cash payments considering the technologies they use for performing settlement operations; proved the feasibility of integrated application of traditional and innovative technologies in the field of payment and settlement.

Results. High-tech innovations in payment and settlement play a key role in increasing the efficiency and competitiveness of payment systems [20]. Today there are two types of payment and settlement systems, depending on the technology that underlies them: traditional electronic and innovative digital systems, whose comparative characteristics are presented in Table.

Comparative characteristics of traditional electronic and innovative digital payment and settlement systems

Parameters	Traditional electronic systems	Innovative digital systems
Information processing device	Dedicated server (server group)	Distributed network of servers
Data storage	Database	Distributed databases
Format of records on accounting units in system	Numeric entries on user accounts	Transaction records in the form of blocks signed by user's private key
Transaction view format	Record for operation of transfer of funds between accounts	Script in a cryptosystem programming language (additional conditions)
Application architecture	Traditional client-server solution	Distributed registry technology
Network architecture	Network with dedicated servers	Peer-to-peer network
Public key equivalent	Account number	e-Wallet number
Private key equivalent	Password	Unique server ID
Access to financial account or user account in system can be restored	+	–
Transaction conditions	Uninterrupted operation of at least one server, incl. subscriber devices, communication channels and software	Uninterrupted operation of most servers and communication channels in network, subscriber devices, and software
Smart contracts can be signed	–	+
Issue of accounting unit in system	Centralized	Decentralized
Limited number of issued accounting units can be established in system	–	+
Maximum divisibility of accounting unit	10^{-2}	10^{-8}
Transaction data sharing	–	+
Anonymity	+/– (depending on amount of transfer)	Not guaranteed
Exchange rate of accounting unit system for legal tender	+ (electronic money) / not required (non-cash system)	+ (secured units of account) / – (varies depending on demand on unsecured basis)

End Table

Parameters	Traditional electronic systems	Innovative digital systems
Exchange rate volatility	Low	Low (secured units of legal tender) / Medium (secured units of precious metals and natural resources) / High (unsecured units of account)
Availability of accounting unit	+	+/ – (unsecured cryptocurrency, social trust)
Form of security	Law, legal tender	Legal tender, precious metals, natural resources
Participation of user devices in system	–	+
Form (type) of accounting unit in the system	National currency / Private	Private
Operator responsible for system's operation	+	+/–
State control and regulation	+/– (depending on the amount of transfer)	–
Private control	+	+
Private regulation (by the operator)	+	–
Amount of commission for conducting operations in system	Average	Low
Level of reliability of financial information in system	Low	High
Impact level of operational risks	High	Low
Temporary restrictions on operations in system	+ (office) / – (remote maintenance in system)	–
Territorial restrictions on operations in system	+ (office) / – (remote maintenance in system)	–
Number of parties involved in payment and settlement transactions in system	= 3 (sender, recipient, system operator)	⩾ 2 (sender, recipient, if necessary, third party in case of smart contracts signing, or intermediaries involved in order to conduct anonymous calculations to «blur» transferred amount)
Mechanism (processing) of payments and settlements	Complicated	Simple

A centralized approach is used for organizing traditional electronic payment and settlement systems, which involves storing information in a single database and processing operations on a dedicated server that has a unified «interface» for interacting with the user. The user's device is not involved in this process.

When organizing an innovative digital payment and settlement system, a decentralized approach is used with cryptographic methods for protecting information, which does not include a unified interface, and all the servers in the decentralized system are equal. The digital system is based on distributed registry technology [4, 12]. A transaction is typically processed in such a system by several computing servers at the same time, simultaneously performing an operation, confirming or rejecting it. One of the main advantages of an innovative digital system is its substantial territorial distribution, which makes it immune to loss of individual servers. Note that the innovative technology not only provides secure storage of user data and financial information, but also provides a guarantee of reliability of these data [17].

Based on the structured information presented in the table, it is possible to highlight the advantages and disadvantages of traditional electronic and innovative digital payment and settlement systems.

The main advantages of existing traditional electronic systems are:

– protection of personal data of users;

– security for units of account in the system (non-cash funds (law) and electronic money (legal tender or precious metals);

– strict exchange rate of electronic and legal money;

– official representative of the system responsible for its functioning and regulation, for resolving disputable issues and considering claims, providing advice on working in the system;

– third parties are capable of influencing the operations carried out in the system: blocking accounts, suspending or refusing to conduct suspicious transfers;

– access can be restored to financial account or user account in the system, etc.

Typical disadvantages of traditional electronic systems are:

– complex mechanism for payments and settlements;

– centralized nature of system management and information storage, with risks of different types of attacks, such as «denial of service», phishing attack, MIM, and others;

– low level of transparency of system management, which consists in the lack of access to statistical data, difficulty of verifying the provided information;

– operative control over the activities of money transfer operators (electronic money transfer operators) is impossible to exercise;

– third parties can access funds without knowledge and coordination of the account holders for the purpose of unlawful actions;

– high level of operational risk;

– unsecured emission of funds in the system, etc.

The main advantages of innovative digital payment and settlement systems operating today are:

– simple mechanism for payments and settlements, requiring special knowledge in the field of information technology;

– immunity to attacks peculiar to traditional electronic systems;

– system performance is maintained in case of failure of no more than half of the total number of servers;

– transparency of all financial transactions;

– low level of commission;

– software source code available to its users for system modification and auditing;

– high level of cryptographic security, sufficient for safe storage of personal data and financial information;

– transferred amounts are immediately visible in electronic wallets of the sender and the recipient, confirming the transaction takes some time, after which the recipient can freely manage the amount, etc.

The following disadvantages of modern innovative digital systems should be considered:

– no official representative of the public system responsible for its functioning (for example, Bitcoin);

– it is impossible to resolve disputes and consider claims due to lack of technological capabilities in the system (in the case without smart contracts signing);

– no collateral guarantee of the accounting unit in the system (if it is not provided for), or no option for the system operator to conduct online checks on collateral guarantee of the accounting units;

– high volatility of an unsecured cryptosystem accounting unit, depending on its demand level;

– risk of «51%», «dust», Sibyl attacks;

– no option to block accounts and refuse to make suspicious transfers, i.e., influence the account status and transfer process;

– no option to correct operations in the system in the event of an error, restore the e-wallet's private key and cancel the transfer;

– irretrievable loss of funds in the electronic wallet to which access is lost;

– private key to the electronic wallet cannot be changed (it is dangerous to store cryptocurrency in a compromised electronic wallet);

– low transaction confirmation speed, etc.

The large-scale implementation of scientific and technological innovations in all spheres of public life contributed to different methods emerging for initiating non-cash payments (office, ATM, remote banking services, electronic money, cryptocurrency), which, in turn, improved the procedures and transformed the form of interaction between non-cash payments entities from personal contact to digital. The forms of interaction between the sender and the recipient of funds when performing payment operations initiated in different ways are presented below, based on the assumption that the payment operation (the amounts payable by one party to another are calculated exclusively by means of

mentally represented money, making sense only when completed with payments, i.e., transfer of legal tender) consists of four procedures:

1) ensuring the availability of funds for transfer or delivery to the recipient (to the account/e-wallet);

2) providing the order initiating the payment operation (movement of funds);

3) implementing non-cash payment (transfer of funds);

4) confirming the execution of non-cash payments.

Historically, the first form of interaction between economic entities when performing payment operations was personal contact between the sender and the recipient of funds in real world using financial instruments (the sender transfers the funds to the recipient «from hand to hand»: checks, bill of exchange or receipt with a tangible form) (Fig. 1).

According to Fig. 1, such a scheme of interaction of economic entities corresponds to the following procedures of non-cash payments:

– procedure 1 «ensuring the availability of funds for transfer to the recipient (to the account /e-wallet)» corresponds to personal contact between the sender and the issuer of the financial instrument in order to deposit funds and receive the payment tool;

– procedure 2 «providing the order initiating a payment operation» is absent, since the payment tool, which is received personally from the issuer and has a material form, is at the same time confirmation of the recipient's right to receive funds and the sender's acceptance of payment;

– procedure 3 «implementing non-cash payment» corresponds to transfer of the payment tool by the sender of funds to the recipient «from hand to hand»;

– procedure 4 «confirming the execution of non-cash payments» corresponds to the sender receiving the confirmation personally upon settlement of the payment tool.

Over time, at a certain stage of social development, payment and settlement operations began to serve not only cash, but also non-cash money. As a result, a new form of interaction between the sender and the recipient of funds emerged for performing payment and settlement transactions: **indirect interaction**, suggesting indirect contact in real world (Fig. 2). In this case, the sender and the recipient of funds do not contact directly with each other in the process of making a payment operation; the representative of the money transfer operator acts as a link between the two, serving the sender personally at their location (in the office), while the sender's functions include carrying out procedures for transfer of funds from the time of entering the details provided by the sender of the funds to confirming the payment.

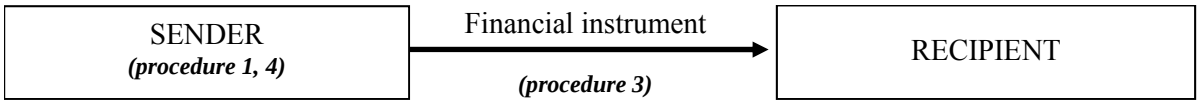

Fig. 1. Personal contact between sender and recipient in payment operation

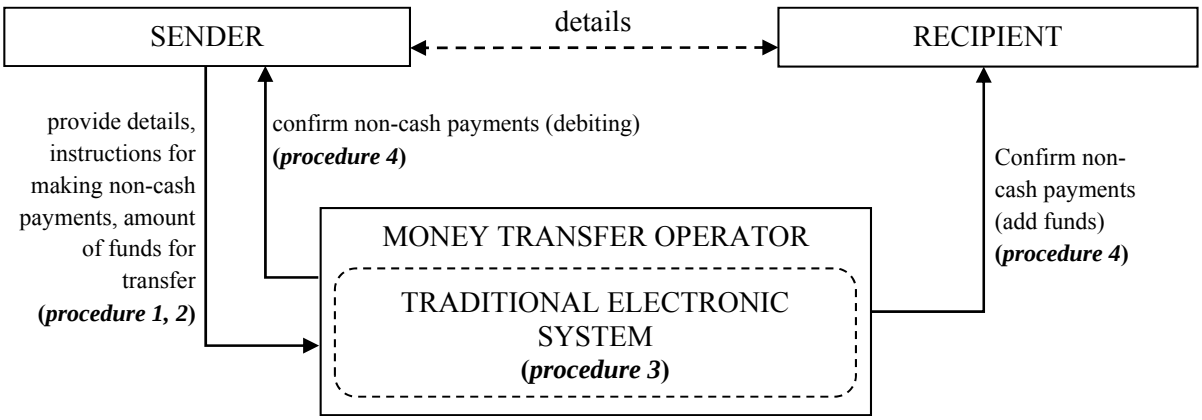

Fig. 2. Indirect interaction of sender with recipient in real world during non-cash payments

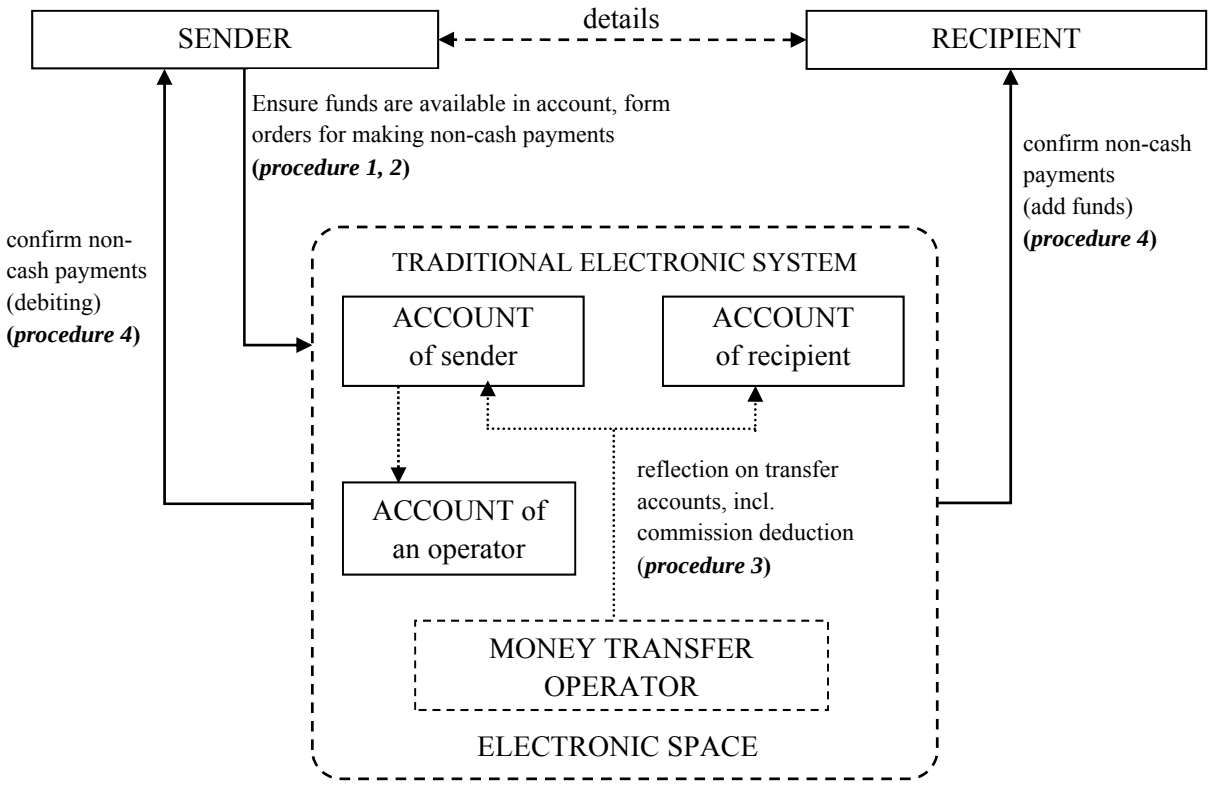

Fig. 3. Electronic interaction between sender and recipient when making non-cash payments

Fig. 2 visually presents non-cash payment procedures for indirect contact:

– procedure 1 «ensuring the availability of funds for transfer to the recipient (to the account)»: replenishing the bank account with cash or non-cash money in case of personal contact between the sender and a representative of the money transfer operator in the office in case of shortage of funds for non-cash payments;

– procedure 2 «providing the order initiating a payment operation»: the sender transfers the recipient's details and personal confirmation of the transfer in the office to the representative of the money transfer operator;

– procedure 3 «making non-cash payments»: the transfer is made by the money transfer operator without the participation of the sender;

– procedure 4 «confirming non-cash payments»: the representative of the money transfer operator either sends a confirmation of the non-cash transaction by personal contact with the sender (recipient), or sends a notice via communication channels (SMS message, e-mail, letter, etc.)

The next stage of transformation of the form of interaction between economic entities in the area of payments and settlements is related to the advent of ATMs, remote banking systems and electronic money systems, i.e., **electronic interaction** involving indirect contact in electronic space (Fig. 3).

Electronic interaction means that the sender and the recipient of funds do not contact each other directly in the process of non-cash payments, the money transfer operator acts as a link between them, providing an opportunity to perform payment operations without a personal visit to the office through the traditional electronic payment and settlement system, while initiating the transfer is fully performed by the sender who enters details of the recipient of funds, generates and sends an order on the movement of funds. Thus, electronic interaction of non-cash payments is carried out in the traditional electronic payment and settlement system, in which a third party can influence the course of payment operations, the status and state of accounts, including without the consent and knowledge of the account holder.

Electronic interaction between the sender and the recipient of funds in each procedure of non-cash payments presented in Fig. 3 has the following form:

– procedure 1 «ensuring the availability of funds for transfer to the recipient (to the account)»: replenishing the account with cash or non-cash money in case of personal contact of the sender with a representative of the transfer operator at the cash desk or through an ATM, terminal, payment aggregators, exchange services with no need for personal contact with a representative of the operator, etc.;

– procedure 2 «providing the order initiating a payment transaction»: the sender independently enters the details of the recipient of funds within the traditional electronic payment and settlement system and confirms the transfer without the participation of third parties;

– procedure 3 «making non-cash payments»: this procedure is performed by the operator without the participation of the sender of funds (in automated or manual mode);

– procedure 4 «confirming non-cash payments»: confirmation is carried out in the personal account of the traditional electronic payment and settlement system (electronic form).

Organization of innovative digital systems based on the technology of distributed registries encouraged the emergence of a new form of interaction between non-cash payment participants: **digital interaction** (Fig. 4), involving direct contact in the digital space without intermediaries and without personal contact through a decentralized cryptosystem, where the sender needs only to enter the recipient's electronic wallet number to transfer funds. Electronic interaction of non-cash payments is carried out in an innovative digital system whose technology (distributed registry technology) eliminates the influence of a third party on the transfer of funds, the status and state of electronic wallets, and the information in the system is non-repudiable and genuine.

The form of interaction between the sender and the recipient of funds during each payment procedure in virtual space is shown in Fig. 4:

– procedure 1 «ensuring the availability of funds in the sender's electronic wallet for transfer to the recipient»: the replenishment operation is carried out only remotely by mining or purchasing (buying) cryptocurrency units (transfer from an electronic wallet to an electronic wallet);

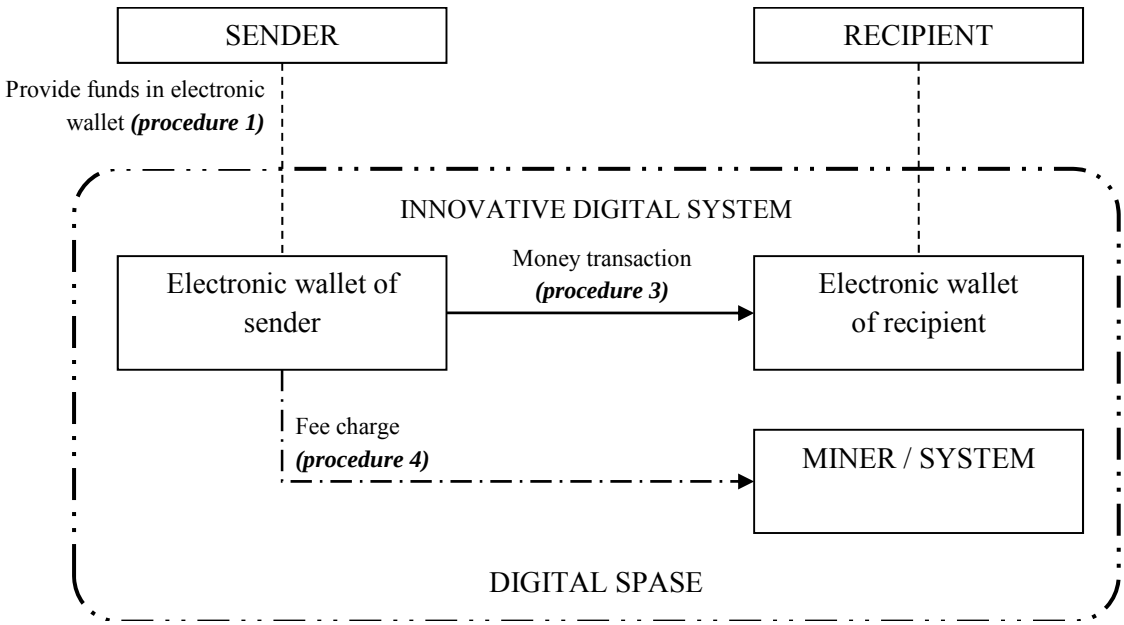

Fig. 4. Digital interaction of sender with recipient when making non-cash payments

– procedure 2 «providing the order initiating a payment operation» is absent, since functioning innovative digital systems based on distributed registry technology have no option for the operator (if it exists) to regulate and influence e-wallets, the system does not provide instructions or confirmation of the sender;

– procedure 3 «making non-cash payment»: in the innovative digital system, the sender transfers funds directly to the recipient without the participation of third parties by entering only the electronic wallet number;

– procedure 4 «confirming non-cash payments»: this procedure consists in entering the operation into the block of transactions of the cryptosystem (commission collected).

Thus, as a result of the study, we have obtained the following results:

– it was established that traditional electronic and innovative digital payment and settlement systems form the basis of the digital economy; each of the systems has its advantages and disadvantages; a regulatory framework governing the sphere of circulation of digital financial assets of the new generation has to be developed, with integrated functioning of traditional and innovative technologies in the area of payments and settlements;

– the modern forms of interaction of participants in non-cash payments when they use different technologies to perform payment operations have been identified; that confirms the importance of each method for initiating payment operations in the conditions of digitalization of economy.

Findings. Technological and communication progress contributed to transformation of the form of interaction of participants carrying out non-cash payments, providing the opportunity for the sender to transfer funds in the virtual space to the recipient directly without personal interaction and participation of intermediaries. Each new stage of technological development significantly accelerated, simplified and cheapened the payment operation by automating financial processes. By applying new methods of initiating non-cash payments, the senders of funds no longer need personal interaction and intermediaries; the level of operational and technological risks, as well as the influence of the «human factor» on the procedures for payments and settlements, is reduced. At the same time, each type of payment and settlement system (traditional electronic and innovative digital) has its advantages and disadvantages; therefore, in the future, it is advisable not to categorically reject the use of one technology, but to integrate them, which will provide a qualitatively new level of organization of payment and settlement systems, increase security, reduce costs and raise the speed of payment operations.

The directions of further research are seen in defining the financial essence of digital financial assets of the new generation and offering practical recommendations for developing a mechanism for their circulation, based on the technology of distributed registries through integration into international payments.

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OPPORTUNITIES AND RISKS OF COLLABORATIVE CONSUMPTION ECONOMY UNDER CONDITIONS OF DIGITALIZATION OF SOCIETY

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The object of the study is the Sharing Economy (SE) and its future in the context of globalization, digitalization of society and the fourth industrial revolution. A relatively recent notion of «Sharing Economy or the Collaborative Consumption Economy« has been formulated, and the main prerequisites for its occurrence have been identified. We have briefly explored the forms of Sharing Economy (SE) in various fields of activity (in transport, energy, real estate, tourism, finances, etc.). The possibilities and benefits of SE for various segments of the population, organizations, administrative entities, and the state are identified. The changes that have taken place in the economy in the last decade are described by several authors related to this ecosystem, such as Zoellick and Subacchi, among others. These changes have occurred within different industries and within companies that grow rapidly, due to globalization and the growing use of the Internet. Now we can observe how new terms appear; for example, the «Collaborative Economy« which seeks to reflect the growing role of entrepreneurs, promoting a new replicable model, which can be used in different cities regardless of their characteristics, and also involves work without strictly established hours or a certain degree of permanence, which some associate with the era of interdependence (Grevy, 2009). The problems and risks of SE are described. We have identified a range of issues (legal, organizational, economic, environmental, etc.) that arise during introduction of SE and which should increase its effectiveness. Some proposals have been put forward to improve the activities in the Sharing Economy, not only in the present but also in the future. Additionally, proposals are made for improving activities in the conditions of a shared consumption economy, and for improving the welfare of society in the future. The processes of digitalization of society are becoming the prerogative of the global economy and individual countries, which increases the significance of discussing these problems. The article should contribute to popularization of Sharing Economy and dissemination of information regarding which problems currently exist in it and that they need to be solved.

Keywords: sharing economy, internet, digitalization of society, online services, aggregates

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ВОЗМОЖНОСТИ И РИСКИ ЭКОНОМИКИ СОВМЕСТНОГО ПОТРЕБЛЕНИЯ В УСЛОВИЯХ ЦИФРОВИЗАЦИИ ОБЩЕСТВА

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Объектом исследования является экономика совместного потребления (ЭСП), а также ее будущее в условиях глобализации, цифровизации общества и четвертой промышленной революции. Сформулировано сравнительно недавно появившееся понятие «эко-

номика совместного потребления», выявлены основные предпосылки ее возникновения. Кратко исследованы формы ЭСП в различных сферах деятельности (на транспорте, в энергетике, недвижимости, туризме, деньгах и т. д.). Выявлены возможности и выгоды ЭСП для различных слоев населения, организаций, административных образований и государства. Изменения, которые произошли в экономике за последнее десятилетие, охватили разные отрасли и компании, растущие под влиянием глобализации и возросшей популярности интернета. Сегодня возникающие новые термины, в частности, такие как «экономика совместного потребления», продвигают новую модель, которая может использоваться в разных городах независимо от их особенностей, а также предполагают работу без строго установленных часов или определенной степени постоянства, что некоторые связывают с эпохой взаимозависимости. Высказаны проблемы и риски, которые несет ЭСП. Выявлен круг вопросов (правовых, организационных, экономических, экологических и др.), которые возникают при внедрении ЭСП и которые должны повысить ее результативность. Выдвинуты некоторые предложения по улучшению деятельности в условиях ЭСП не только в настоящее время, но и в будущем. Также выдвинуты предложения по улучшению деятельности в условиях экономики совместного потребления в будущем для увеличения благосостояния общества. Процессы цифровизации общества становятся прерогативой глобальной экономики и отдельных стран, что повышает значимость рассматриваемых проблем. Исследование будет способствовать популяризации ЭСП и распространению информации о том, какие проблемы существуют на данный момент в ней и как их надо решать.

Ключевые слова: экономика совместного потребления, интернет, цифровизация общества, онлайн-сервисы, агрегаты

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Introduction: Modern society is characterized by rapid development of the digital economy, based on wide use of the Internet, information and communication tools, cyber-physical systems, Big Data technology, the Internet of things, cloud and other information technologies. Under the influence of globalization and increasing digitalization, the structure of the world economy is changing: many traditional industries are losing their importance, new industries are developing rapidly, new business forms are being introduced, new production and social relations are being generated. In particular, a concept such as the economy of collaborative consumption has emerged. Many experts note its appearance around 2010, after which it quickly became popularized in the media, economic and other journals [2]. A special role in this was played by the publication of the article by Rachel Botsman and Roo Rogers, «What is Yours: How Collaborative is Changing the World» [3].

Experts from the University of Valencia [4] indicate that the term sharing economy is closely related to the term collaborative consumption, which is discussed in the works of Gansky (2010), Botsman and Rogers (2010) [3]. Having considered these studies, we can state that both terms are synonymous.

Within the framework of this concept, the term «cooperation economy« can be confused with the term «joint consumption«. However, taking into account the traditional definition of the economy, according to which the economy is interpreted as a science about the economy and related activities of people, about the use of various resources to meet the needs of the individual and the society as a whole, it should be understood that co-consumption is studied by the economy, and more specifically, by a narrower discipline called the sharing economy.

Our definition of Collaborative Consumption is the following: «Collaborative Consumption Economy is a dynamically developing socio-economic model

aimed at obtaining benefits from consumption of goods and services, coordinated through the Internet and other media, where the participants can share what they own and what they can do for a certain fee without losing ownership».

Collaborative Consumption began to play a large role after the 2008 financial crisis. Such large international servers appeared as the Airbnb rental platform, BlaBlaCar travel companion service (2008) and Uber taxi service (2009), which gave even greater importance to Collaborative Consumption, which meets various needs in markets around the world. Today, Collaborative Consumption is a powerful socio-economic movement of exchange of goods and services [5]. The macroeconomic and geopolitical situation in the world and the country has caused a decline in income among people primarily belonging to the middle class. This contributed to development of Collaborative Consumption trends, when it is important not to own the object, but to be able to use it. On the one hand, such a model of the economy provides benefits to those for whom owning the asset would be too expensive because of its high price or owning it would not be profitable due to its rare use. In addition, it is possible to receive additional income or cover the costs of ownership of the asset.

Studies have shown that Collaborative Consumption is currently undergoing rapid development, its scope of application is expanding, which is primarily promoted by digitization of society, Globalization 4.0, whose significance is, at the very least, indicated by the fact that the recent 49th annual Forum in Davos was dedicated to the theme «Shaping a New Architecture in the Age of the Fourth Industrial Revolution». All of the above speaks about the relevance of the problem under study.

Goal of this study: to consider the possibilities and risks of Collaborative Consumption, on the basis of systematization and analysis of existing and evolving forms of Collaborative Consumption, as well as to find out which organizational, economic and legal issues need to be addressed.

Materials of research. We consider the features and different approaches to the new business model, the Collaborative Consumption Economy, as well as the scope, opportunities, risks and negative consequences associated with this.

The main characteristics of Collaborative Consumption are as follows:

– exchange of goods and services is carried out using the Internet and other information media, which primarily connect individuals;

– income is obtained with the help of little-used resources. Participants share their underutilized resources, which at the same time are necessary for others. Goods and services can be offered at a lower price to the consumer, which leads to lower costs and substantial savings;

– consumers get more opportunities to choose the necessary product or service since the range of suppliers is no longer limited to companies only;

– continuous improvement of competitiveness in the market: commercial companies must actively innovate and improve the quality of their services, taking advantage of the new economy with a completely different business strategy;

– Collaborative Consumption reduces unemployment, gives additional income to the unemployed, to the less busy or to people with low incomes due to entering new markets, including remote ones;

– virtual platforms of Collaborative Consumption allow their users to offer services themselves. Thus, new forms of independent work with wide income opportunities become relevant.

Let us consider the most popular organizational forms of The Collaborative Consumption.

Online taxi services («peer-to-peer» taxi). The Uber mobile service is well known all over the world, its largest competitor is the leader of the Chinese market, Didi Chuxing; YandexTaxi operates in Russia. These services are often mistaken for a taxi service aggregators, however, they position themselves as services that allow non-professional drivers to earn extra money during their free time. In fact, for example, in the UberPool service, the driver can pick up other fellow travelers, and the price of such a trip for each of them will be much lower. More and more of these services appear in the world, claiming to be a niche between urban public transport, tied to tight schedules and bus stop points, a city taxi too expensive for the masses, and a

personal car, which is getting more and more expensive to maintain and use. In 2017, mobile services accounted for about a third of the global taxi market, which reached $108 billion. According to Goldman Sachs, by 2030, mobile services will exceed traditional ones by five times [6]. In Russia, the process of consolidating this area of the transport business is gradually taking place. In large cities, up to 85–90 % of the taxi market is already occupied by aggregators [7].

Ridesharing and carpooling is sharing a private vehicle with the help of online search services companions. There are many companies abroad and in Russia, whose services connect drivers and passengers who want to share the cost of a trip. BlaBlaCar and BeepCar are the most popular sites in Russia. Recently, such services as PoedemVmeste.ru, Poputchiki.ru, doedemvmeste.ru, etc., have appeared. Drivers provides their cars, management service, and traveling companions undertake travel expenses.

New startups of such services plan travel routes based on user needs, including a dynamic data-based routing system, providing competitive prices for services.

Carsharing is a system of short-term car rental with pay per minute, common mainly in large cities. People rent cars not from the company, but from each other. For many, this is a good alternative to public transport, private cars and taxi. The client pays only for the actual time of use of the car and fuel. The owner of the car is responsible for maintenance, paying taxes and insurance. The largest carsharing services in Russia are Delimobil and Yandex.Drive. In addition to cars, short-term rental of other types of transport is possible (bicycles, scooters, micro-electric transport), which is one of the most effective ways to solve the «last mile« issue in urban transport logistics of people. Today, carsharing is considered the main alternative to personal transport. According to expert estimates, the prospects for the development of the Russian market suggest an increase in the share of cars used in carsharing to 10 percent by 2025 [8]. Recently, in the world, carsharing companies have cooperated to make it more convenient for their customers to use carsharing in other countries. Consideration is being given to replacing per-minute rent with per-kilometer. With the economic downturn in the country, there are more people willing to rent their cars.

Airbnb is an online platform for locating, searching and short-term rental of private housing around the world. This is a community of people who want to rent out their accommodation, and travelers who need this accommodation, based on trust and reputation. Airbnb offers better deals than in hotels, or much more attractive conditions for the same money. Services for rental housing help their owners to improve their financial situation, upgrade housing, promote the development of service services, and bring a similar market of services out of the shadows. The Airbnb short-term rental service is one of the leading in shared consumption economies. Rover.com, also known as Airbnb for Dogs, is also widely used if there is no place to leave the dogs, while the owner has to leave home for a while.

Co-working centers offer workplaces that can be rented for the required time (from an hour to a month) with technical equipment, high-speed Internet in the same office space with other tenants. Co-working centers can also offer a wide range of different services: from catering, meetings and business negotiations to hotel accommodation, which is very convenient, for example, for non-residents. Clients of co-working centers are aspiring entrepreneurs, start-ups, freelancers, companies (for events, seminars and conferences), business travelers, foreign guests.

Crowdfunding is the collaboration of people who voluntarily pool their money or other resources together, usually via the Internet, to support the efforts of other people or organizations. Fundraising can serve a variety of purposes, such as assistance to disaster victims, support from fans, support for political campaigns, funding for start-ups and small businesses, and more.

Crowdlending is a kind of crowdfunding when people voluntarily send their own money to implement an idea or project. Crowding assumes that funds will be subsequently returned to investors, and investors will be able to rely on certain interest or share in the business [9].

The economy of co-consumption offers new opportunities in **the field of education:** it can connect people who need to exchange knowledge or adopt the desired skills, and possibly gain access to previously inaccessible sources. Classical education, in turn, will develop interaction between teachers and students, as well as provide access to virtual platforms at lower cost using smartphones or other portable devices.

Online freelance means the employer and the performer can be located at any distance from each other. The freelancer is a free worker, a specialist who can simultaneously carry out private orders for different clients. The types of remote work are constantly expanding, including IT services, translations, design, programming, creation and promotion of websites, marketing and advertising, writing texts, business consulting, etc. According to NAFI analytical center, at the beginning of 2018, the share of freelancers in Russia grew from 10 to 18% of the working-age population, i.e., about 13.5 million people. A freelancer can work under an employment contract, under a civil contract as an individual or as an individual entrepreneur.

Collaborative Energy exchanges the energy from solar panels installed in private homes. The energy overly accumulated in the batteries of one house is used by others. Thus, such energy does not have additional costs for these communities. With this method, the future of the world will get more control and energy savings and better preserve the environment [10].

Opportunities. The Collaborative Consumption Economy offers producers new forms of independent work with wide opportunities for generating additional income. Sharing goods and services also benefits consumers, because it implies lower prices and more efficient use of the owner's existing resources offered to others. On the other hand, this is an opportunity for companies that can adapt and benefit from the new economy with a completely different business strategy [11].

Users in the transport sharing business models discussed above (ridesharing and carpooling, carsharing) are attracted by a lower price, a shorter waiting time for a car, the ability to place an order and track its performance using a mobile phone application. The credibility of the service increases the ability to evaluate the direct performer. With the advent of transport services, the drivers have the opportunity to see incoming orders and accept them depending on their own load and proximity of the call. This significantly speeds up the process of receiving an order from the consumer to the direct executor. In the process of using transport and trip services, a lot of data is accumulated, which can be used as the basis of new types of business, providing people with comfort and personalization. The model of using transport services instead of owning transport is one of the most promising market segments based on a sharing economy model.

In transport logistics, servers appear that provide opportunities for sharing one container by several companies. The development of a vehicle-sharing business model has led to proliferation of Mobility as a service technology (Mobility as a Service, MaaS), which manages multimodal transportation in real time from the beginning of the route to the destination using different types of transport (public transport, transport rental, taxi, shuttles by request, etc.) and allowing to choose the best route according to a set of criteria (time, cost, user preference, etc.). With proper alignment of logistics processes, a manufacturer can save up to a third of its logistics budget. As it becomes less profitable for organizations to maintain their own fleet in these conditions, they increasingly transfer logistics to specialized companies for outsourcing. According to a McKinsey study [12], more than 60% of respondents plan to increase or significantly increase the use of transport services via new business models such as carsharing or ridesharing in the next 2 years.

The Collaborative Consumption Economy in transport has a positive effect on reducing the harmful impact of vehicles on the environment, primarily by reducing the number of vehicles while ensuring the required level of mobility. By sharing existing assets without the need to invest in new ones for exactly the same consumption, there will also be a reduction in the harmful effects on the environment.

The Collaborative Consumption Economy helps reduce unemployment and poverty. The new economy creates additional income for the

unemployed or owners of unpopular specialties whose skills are difficult to transfer to other activities. But they can, for example, drive a car, give private lessons or rent their property. In view of all of these considerations, Collaborative Consumption Economy provides citizens of different countries the opportunity to take advantage of their place of residence, taking into account the overall demand and its specificity [13]. The enterprises will increase the capacity utilization, which will undoubtedly have a positive result on their economies.

These trends help to reduce differences in age and gender, differences in specialties, education, etc., because anyone can use digital services, acting both as a consumer, and as a collaborator . This approach, for example, helped popularize the use of Internet payments, as well as everything new that comes with the Sharing economy.

The Collaborative Consumption Economy greatly enhances both demand and supply, with the result that the optimal price is revealed, which most closely matches market conditions. Moreover, market factors affecting the price (state intervention, regional differences, etc.) are eliminated as a rule. A low market price is not acceptable for many participants: the state, direct and indirect competitors of producers of goods and services, and producers themselves. Only consumers who receive the lowest possible prices for goods and services are satisfied with it.

The level of competition in the market is increasing: now companies must innovate more actively, produce new products, reduce prices and improve the quality of their services. The development of Collaborative Consumption Economy leads to reduction in the traditional market economy with its global corporations, banks and supply chains.

With the development of Collaborative Consumption Economy, urban municipalities are expanding the opportunity to promote public services. Through platforms for promoting social services, local residents will be able to offer their experience and knowledge to foreign citizens in order to achieve greater efficiency and lower resource costs in various areas, which will contribute to development of tourism.

Risks. Currently, the number of entrepreneurs who base their projects on the principles of Collaborative Consumption Economy in various sectors: transport, food, clothing, real estate, travel, money, etc., is growing. A business gains access to cheap labor, but at the same time it acquires great risks, in particular, legal ones. The state has little ability to regulate Collaborative Consumption Economy, since today its terminology is rather vague and there is practically no adapted legislation. This leads to certain risks and negative consequences, especially taking into account the high rate of emergence and spread of new business models of Sharing economy.

Collaborative Consumption Economy affects social issues. For example, carsharing and ridesharing services, especially when they are provided with benefits, can cause discontent of urban taxi services and car owners. There were demonstrations against Uber in a number of European countries (Belgium, France, Spain, etc.), accusing it of unfair competition, failure to comply with local rules regarding security, taxes and licensing. Recently, the State Duma of the Russian Federation submitted a draft Federal Law N 69583-7 «On Amendments to Certain Legislative Acts of the Russian Federation in terms of improving state regulation of passenger and luggage transport of passenger taxis in the Russian Federation«, which aims to regulate the activities of taxi aggregators. This draft law provides for the duty of a taxi aggregator to cooperate only with licensed drivers by concluding information and service agreements with them.

Platforms that establish contact between customers and collaborators do not always provide adequate security or guarantees regarding the goods and services provided, although clients are able to evaluate the performers, but only hiring them and using the service. Companies that operate on the principles of Collaborative Consumption Economy themselves create a large number of criteria so that users have the opportunity to choose those who can be responsible for the product or service. But even such measures do not give full guarantees or insurance against accidents, theft, crime or inadequate quality of goods and services. Risks are

always present when the community independently regulates the system of analysis, rating, feedback.

Sberbank intends to take part in crowdlending, acting on its own platform as an intermediary in the transaction between those who want to invest their savings and those who want to attract these funds, earning a commission from borrowers as a percentage of the payment. In this case, the risk remains with the investor, who relies on the borrower's assessment provided by the bank [14].

The legal status of participants in the Sharing Economy and the form of contractual relations between them are not clear. For example, the question of the legal status of the Uber system is debatable. If this is an online information intermediation platform between the vehicle owner and the user, then its activity is outside the scope of national transport regulation and it is entitled to operate in all European (EU) countries without permits. If it is a transport company, then its activities are under the control of national authorities and may even be prohibited [15].

The issue of taxation also requires consideration. The state generates or tightens more and more taxes, but a coherent system of tax collection is not yet available. At present, the efforts of many states are aimed specifically at developing a new tax policy adapted to the economy of the future, including the Sharing Economy. Online payment has to be arranged for this purpose; drivers in ridesharing are currently paid in cash in Russia.

Freelancers have other risks associated with unregulated conditions, irregular working hours, lack of vacations, weak social protection, taxation, etc.

From January 1, 2019 to December 31, 2028 a special tax regime has been introduced for the self-employed in Moscow, Moscow, Kaluga regions and Tatarstan, the so-called «Tax on professional income« [16], which individuals may use, including individual entrepreneurs who receive income from activities in which they do not have an employer and do not attract employees. The tax on professional income is 4% of the income from the sale to individuals and 6% from the income from the sale to individual entrepreneurs for use by business and legal entities.

Relations associated with transport, housing, tourism and many other objects of the Sharing Economy are closely intertwined with legal relations in the insurance industry. It is necessary to develop a system of legal regulation to protect the interests of individuals and legal entities when certain insurance cases occur at the expense of monetary funds formed by insurers from paid insurance premiums (insurance premiums), as well as at the expense of other means of insurers using business models of ESP. For example, the issue of selling short-term unlimited insurance to car owners or tenant tourists during car sharing has not been resolved. Companies are only able to work with those who have already bought all the necessary insurance at their own expense. In the West, insurance companies see carsharing as an opportunity to earn money, since every car needs insurance.

With carsharing, there is a question of liability in case of accidents, as consumers are unlikely to use per-minute car rental if the car sharing agreement with the customer indicates liability for damage to the car. Customer might also use the cars without due care, fail to fix the car's problems or to use high-quality fuel, etc. This, in turn, may adversely affect the environment.

Results of the study.

1. The success of using virtual platforms implies a low price for the services offered that meet the needs of customers. That is why such services are more convenient to consume than traditional ones. Quick access to the offer and the reputation of virtual platforms determine customer loyalty.

2. In the sharing economy, ordinary people compete with professionals. However, as this type of economy is not subject to any regulation and based only on trust, consumers remain helpless in cases of fraud or poor professional practice. This aspect cannot be ignored; therefore, states need to introduce general regulation both for already existing companies and for representatives of platforms.

3. Due to the lack of labor regulation among people working on virtual platforms, the self-employed are subjected to an excessively high rate of work, based on their needs, but exceeding their

working time in many cases without any benefit or protection.

In the present study, the concept of Collaborative Consumption Economy is formulated. The completed studies have shown an extremely high scale and pace of development and penetration of the Collaborative Consumption Economy into the economy and public relations, promoted by active digitalization of society, wide spread of the Internet and other information media. Analysis of numerous publications and practices showed a positive impact of the Collaborative Consumption Economy on the incomes of people and organizations, unemployment and employment, competition in the market, the environment, etc.

However, many technical, legal, social, organizational, economic, environmental, behavioral and other problems have to be solved, in particular in insurance, taxation, increasing tax collection, security, etc. Information systems specialists are faced with the big task of developing communities, which should not only allow the consumer to familiarize themselves with the services provided, their collaborators and feedback on them, but also enter into paid service agreements between them, collect money and make payments between participants, calculate and pay taxes, make banking transactions, etc. State and local authorities should create the appropriate infrastructure.

Directions for further research. Analysis of studies in the field of sharing economy can be the basis for further research, for example, regarding classification and consideration of this industry from the standpoint of traditional 4P marketing (product, price, place, promotion), as well as for introducing directions in government policies. In addition, studies of dynamics of measurements in consumer behavior as the economy of joint consumption evolves will allow manufacturers to better adapt products and services to the requirements of the modern market.

Additionally, marketing professionals need to examine the changes in consumer spending, determine preferred production volumes and their impact on pricing.

Pricing is an important area for further research in sharing economy.

In-depth studies show high importance of a co-consumption economy. A sharing economy operates exclusively in multilateral markets. Thus, pricing affects the demand for services and market capacity, since price affects the income level of each participant, and market participants are also effective distributors of market capacity.

Conclusions. Digitalization of society, the related changes in lifestyles and values lead to transformation of the consumption model, development of the Collaborative Consumption Economy, a relatively new trend in socio-economic development of all countries that is very promising and actively developing. In this regard, one of the essential issues that need to be urgently addressed is legal, economic and environmental regulation of its business processes. Government agencies, lawyers, economists and other specialists face major challenges in solving theoretical and practical issues of joint consumption organization, the legal status of participants, taxation, online payments, licensing, insurance, security, quality of services, etc. An urgent problem is continuous computer literacy of the population at user level and above.

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DEVELOPMENT OF METHODOLOGY FOR ASSESSING DIGITAL COMPETENCE LEVELS IN PERSONNEL TRAINING

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The developing digital economy alters the labor market demand both qualitatively and quantitatively, thus shaping a new paradigm for specialist training. In the RF regions professional education is meant to be significant in supplying economy with human resources. There must be competent trainers to enable trainees' digital skills development. Research in determining levels of trainers' digital literacy is one of the stages aimed at professional education improvement to procure digital economy with specialists. Issues of theoretical modelling of digital competences structure as well as methodological support of competences diagnosis are the key ones. This research is devoted to the development of methods for diagnosing levels of mastering digital competences in training. An overview of literature embracing such concepts as «digital literacy», «digital competences» is introduced. Basic features of currently available digital competences models are being described. Based on the investigations held by colleagues and with account of activities specifity of higher educational structures a new competence model including such major digital competences groups as «Digital office», «Net technologies use», «Digital security in professional activity», «Software and applications installation» has been developed. A description of the toolkit for diagnosing digital competence levels in training is given. Automatic data processing algorithm has been developed to enhance interpretation of digital competences levels. Diagnosis method to determine the level of digital competences proficiency was tried out in 2018 at the Ryazan Region Department of Education and youth policy. The research results may be used by public authorities in the decision-making procedures. Study materials may be applied in the process of further investigations of research and practice issues dealing with specialists training fit for digital economy. The toolset of field research including the method for trainers' digital competences level testing may be replicated and used in both public administration and entrepreneurship activities.

Keywords: digital economy, professional education, digital literacy, digital competences proficiency level diagnosis

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РАЗРАБОТКА МЕТОДИКИ ОЦЕНКИ УРОВНЕЙ ЦИФРОВЫХ КОМПЕТЕНЦИЙ ПРИ ПОДГОТОВКЕ КАДРОВ

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Развитие цифровой экономики качественно и количественно изменяет потребности рынка труда в человеческих ресурсах, что определяет новую парадигму подготовки кадров. В субъектах РФ система профессионального образования играет значительную роль в обес-

печении экономики человеческими ресурсами. Одним из обязательных условий развития у обучающихся навыков в сфере информационно-коммуникационных технологий является наличие компетентных преподавателей. Исследование уровня цифровой грамотности педагогов – один из этапов совершенствование системы профессионального образования, которая должна обеспечивать цифровую экономику кадрами. Становятся актуальными вопросы теоретического моделирования структуры цифровых компетенций и методологического обеспечения их диагностики. Данное исследование посвящено разработке методики диагностики уровней освоения цифровых компетенций при подготовке кадров. Приводится обзор работ, посвященных рассмотрению сущности понятий «цифровая грамотность» и «цифровые компетенции». Описываются основные характеристики существующих моделей цифровых компетенций. На основе рассмотренных исследований коллег и с учетом специфики деятельности преподавателей образовательных учреждений профессионального образования разработана модель компетенций, включающая следующие укрупненные группы цифровых компетенций: «Цифровой офис», «Использование сетевых технологий», «Цифровая безопасность в профессиональной деятельности», «Инсталляция программного обеспечения и приложений, в том числе мобильных». Приводится описание инструментария диагностики уровней цифровых компетенций при подготовке кадров. Разработан и описан алгоритм автоматизации обработки данных для интерпретаций уровней освоения цифровых компетенций. Методика диагностики уровней освоения цифровых компетенций апробирована в 2018 г. на базе Министерства образования и молодежной политики Рязанской области. Результаты исследования могут быть использованы при принятии решений органами государственной власти. Материалы исследования могут быть применены в процессе дальнейших исследований научно-практических проблем подготовки кадров для цифровой экономики. Инструментарий полевых исследований, в том числе методика тестирования у преподавателей уровня сформированности компетенций в сфере информационно-коммуникационных технологий, может быть тиражирован и использован как в сфере государственного управления, так и в сфере предпринимательской деятельности. Исследование выполнено при финансовой поддержке РФФИ и Правительства Рязанской области в рамках научного проекта № 18-410-620002.

Ключевые слова: цифровая экономика, система профессионального образования, цифровая грамотность, диагностика уровней освоения цифровых компетенций

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Introduction. Transition to digital economy sees the growing importance of human resources for the competitiveness of enterprises, regions and the country. New opportunities for doing business come along with new challenges for economy and society. The development of digital economy is connected with more effective use of intellectual capital [1]. Education plays a major role in this. The educational system is the most important factor stipulating the opportunities for the development of any economic system. Russia is currently facing the problem of modernizing education in accordance with the demands of the labor market [2].

In the past decade, the composition of the leading companies has changed. IT companies and those working in the field of information and communications technologies have taken the upper hand: Apple, Microsoft, Amazon, Google, Facebook, Alibaba, Tencent [3]. Companies and organizations are have a demand for digitally competent specialists. Consequently, the structure of employment changes as economy is getting more and more intellectual. There is a growth in demand for qualified ICT specialists in all sectors of economy. Digital skills are required for almost all working places. Traditional ways of teaching are also changing [4].

Introducing digital technologies causes significant transformative influence on the type of skills required in the economy. That is why modern education targets knowledge globalization, life-long learning. The aim of education is to train specialists capable of working in new places in current and future working environments [5].

The program «Digital economy of the Russian Federation» pays special attention to availability of human resources and improving the system of professional education. The goals of improving federal educational standards of professional education in accordance with the demands of digital economy are set in the «Human Resources and Education» activity plan of the «Digital economy of the Russian Federation» program. By 2024, it is planned to annually train up to 120,000 higher education students in the field of information and telecommunication technologies. The number of graduates of higher and secondary professional education with digital competences is supposed to reach 800,000 people per year [6]. The issues of theoretical modelling of digital competences and methodological support of their diagnostics are becoming essential.

Availability of competent teachers is considered to be a prerequisite for the students to be able to make progress in the field of information and communication technologies. One of the stages of improving professional education with the view to supply human resources for the digital economy is studying the trainers' digital literacy. This paper introduces a methodology for diagnosing the development level of digital competences.

Statement and description of the problem. The issues of digital transformation in the Russian Federation are vital both on federal and regional levels. The Ryazan Region carries out the measures set out in the activity plan of the program «Digital economy of the Russian Federation»: updating the regulatory base, building the IT infrastructure, training qualified specialists, implementing applied solutions to use information and communication technologies in state government and municipal administration, education, healthcare and other branches. Integration into cyberspace is supposed to let the region step into a new level of social and economic development.

The major long-term strategic provisions determining the Ryazan Region's socio-economic development are defined in the regional act «Long-term strategy for socio-economic development of Ryazan Region up to 2030» of December 25, 2018. Human capital is declared to be the priority trend laying the groundwork for citizens' life-long education in the evolving educational cyberspace. The human capital trend assumes organizing advanced training for teachers engaged in the system of professional education, setting up a regional training center focused on the issues of professional competences [7].

The project is aimed at developing the methodology for assessing the level of digital competences to be applied by the teachers engaged in the regional system of professional education.

The project set the following tasks:

– analysis of theoretical and methodological approaches used to diagnose digital competences: the concepts of digital literacy and digital competences, analysis of existing models for digital competences;

– developing and testing a procedure for diagnosing the competence levels;

– developing an algorithm for automatic data processing to interpret digital competence levels.

Theoretical and methodological approaches used to diagnose digital competences. Many papers explore the concept of literacy, the issue of its transformation. Earlier, literacy was seen as an ability to read, to write and to count. Now advances in science and technology have increased the number of «partial literacies». Thus, with personal computers widely used in professional activities, the concept of computer literacy emerges [8]. The concept of internet literacy appears with the spread of World Wide Web [9]. There are also other similar concepts: media literacy and information literacy.

Investigating the nature of digital literacy is a multidisciplinary endeavor rapidly evolving at international scale. Tab. 1 offers an overview of approaches to define the concept of digital literacy.

Table 1

Overview of approaches to defining digital literacy

Source	Definition
World Economic Forum in cooperation with The Boston Consulting Group [10]	Ability to use and create content on the basis of digital technologies including search and swap of information, questions and answers session, interaction with other people and computer programming
цифроваяграмотность.рф	Set of knowledge and abilities necessary for secure and effective use of digital technologies and internet resources. It includes digital consumption, digital competences and digital security
Aviram & Eshet-Alkalai [11]	Digital literacy comprises five types of literacy: Photo-visual literacy (ability to read and recognize necessary information from visuals); Reproduction literacy (ability to use digital technology in order to independently create new objects required); Branching literacy (ability to successfully handle objects in non-linear cyberspace); Information literacy (ability to search and critically assess information on the Internet); Socio-emotional literacy (social and emotional aspects of staying online: ability to cooperate, to use socialization tools and simply consume)
Hinrichsen J. & Coombs A. [12]	Ability to interact with mass media, correlate digital content with the events of one's own life by means of four models of interaction with digital environments: text participation, code-breaking, text analysis and text use
American Library Association, USA [13]	Ability to apply information and communication technologies for searching, understanding, assessing, creating and transferring digital information
The Royal Society, United Kingdom [14]	Ability to competently, securely and effectively use computers. It also includes: ability to use office software such as text processors, email and presentations software packages; ability to generate and edit pictures/audio/video; ability to use web browsers and internet search systems
International Telecommunication Union (ITU) [15]	Ability to process data, transform them into information, knowledge and decisions. This requires skills of searching and assessing information, information culture and its ethical aspects and also methodological and ethical aspects necessary to communicate in the world of digital technologies
European Union Commission, Europe (Eurostat) [16]	Competent and critical use of information and communication technologies for work, leisure, studies and communication. It should be backed by basic technical computer and Internet skills

Along with digital literacy, researchers also investigate the issues of describing digital competences. The competence-based approach is put into national educational standards in major European countries including Russia. In Russia, further development and indicators of economic growth are limited by the population's level of knowledge, abilities and skills in using new technologies. Consequently, the level of these competences has to be assessed throughout the country. It is important to compare the data obtained from different regions of Russia [17]. Let us consider the existing digital competences models.

Ershova and Zieva, researchers from the National Center of Digital Economy of the Lomonosov Moscow State University, identified the following trends in determining cross-cutting digital competences:

- computer literacy;
- communication and cooperation;
- digital content generation;
- security;
- problem-solving;
- competences related to career [18].

From Sharikov's point of view, literacy in the modern sense includes components of technological and information and communication content. The scientist comes up with a four-component model of digital literacy in a semantic environment of two constructs: technical and technological/socio-humanitarian and opportunities/threats. The four

components related to digital literacy are identified: technical and pragmatic opportunities, communication content opportunities, technical and technological threats and socio-psychological threats [19].

Since 2015, the Internet Technologies Center, a regional non-governmental organization, has been carrying out, together with Higher School of Economics National Research University, the Digital Literacy Index project aimed at comparative assessment of the digital literacy level throughout Russian regions [20]. The structure of the index is a three–level model consisting of subindices for digital consumption, digital competences and digital security. The following parameters are taken for the index of digital competences:

– competence in information search on the Internet;
– competence in using mobile means of communication;
– competence in using social networks;
– competence in making on-line financial transactions;
– competences in consumption of goods and services via the Internet;
– critically evaluating information and verifying it;
– competence in generating multimedia content for the Internet [21].

Prokofeva, Levina and Zagrebina developed an algorithm for diagnosing professional and cultural competences in the system of higher education. Taking the materials for testing and assessment as a basis for diagnostics, the authors suggested forming professional profiles for university students, including integrated assessment of their competences [22].

A universal method for diagnosing professional competences and soft skills is currently under development (a research group is working in that direction) [23]. Modern mathematical methods are applied for developing a methodology aimed at diagnosing competences and professional soft skills.

The models of digital competences and methods for assessing competences given above are informative, diverse and, doubtlessly, have scientific and practical value. At the same time, developing an instrument for operational diagnostics of the level of digital competences taking into account the professional specifics of the employees is seen as a priority task.

In addition to the above, the instrument to be developed should offer an opportunity to automate the processes of competence assessment, to consolidate information and to analytically handle data, serving to reduce the time spent and obtain not only individual assessments but aggregated results for the entire organization.

Research methodology and results. To construct a valid competence profile, professional activity-related factors should be taken into account, i.e., the functions that the employee is responsible for.

Based on the above-mentioned research and with view to the specifics of the university teachers' professional activities, the following large groups of digital competences have been defined for the purposes of our study:

– Digital Office;
– Using Internet technologies;
– Digital security in professional activity;
– Installing software and applications [24].

Testing was chosen as an instrument for assessing independent competences. The test consists of 40 questions, 10 questions to assess each competence. For each competence there is a selection of random, mixed-level questions.

Knowledge and skills of office packages are assessed in the «Digital Office» competence group. Examples of the test questions include:

Which kind of diagrams can be constructed in EXCEL?

– bar graph
– circle diagram
– high-low chart
– radial chart
– Gaussian

Knowledge and skills of Internet technologies are assessed in the «Using Internet technologies» competence group. Examples of the test questions include:

Which tool could be used by several users to simultaneously edit e-documents?

– Google Documents
– Яндекс.Disk
– Mail.Ru Cloud
– MS-Word 2010
– This is not possible

or

What is the quickest way to deliver the task written on the board to the students missing the class?

– Take a smartphone photo and post it in a WhatsApp group

– Take a smartphone photo and post it in a VKontakte conference

– Reprint the task and send it by email

– Reprint the task and post the file in an electronic educational environment

Knowledge of information and computer security is assessed in the «Digital security in professional activity» competence group. Examples of the test questions include:

If there is a reason to suspect a phishing attack, you should... (choose the appropriate actions):

– Change the password of the resources containing personal data

– Notify the administrator of the original site

– Reply expressing your suspicions

or

What is an electronic digital signature?

– Signature scan

– Facsimile

– Cryptographic sequence used for signing remote documents

– No correct answer

Knowledge, abilities and skills of installing software on computers and/or mobile devices are assessed in the «Installing software and applications» competence group. Both test questions and practical tasks asking to install professionally useful applications on a smartphone are offered.

A comprehensive test on Digital Competences Assessment is hosted at the Ryazan State Radio Engineering University in the system of distance learning based on the Moodle platform. A Moodle-based system of distance learning allows to test a large number of respondents and to automatically assess the tasks fulfilled. Each competence has its own question bank made in advance. The individual test consisting of 40 questions (10 questions for assessing each competence) is generated for each respondent by random selection from the bank. The test includes questions with varying difficulty levels taken into account in assessing the answers. Different types of questions are used: multiple choice with a single answer or several correct answers, matching questions, questions with short answer.

The order in which questions and answer options in multiple choice questions were offered was changed when a new (individual) test was generated. One attempt was given for testing. The time limit set was 90 minutes.

Algorithm for automatically processing data and interpreting digital competence levels. After testing, a table showing the test results was generated. It contains 45 columns and 200 lines. Each table line represents a finished test attempt.

The table for processing the results contains the following columns:

User (user identifier);

Test is started (test start time);

Finished (test finish time);

Time spent (execution time);

Final mark (test result);

Question 1 (competence 1), ..., Question 10 (competence 1);

Question 11 (competence 2), ..., Question 20 (competence 2);

Question 21 (competence 3), ..., Question 30 (competence 3);

Question 31 (competence 4) ....., Question 40 (competence 4).

Thus, the resulting table represents an array consisting of 9000 cells. To automatically process the results in accordance with the developed algorithm, it is necessary to develop a program for calculating the results.

The summary results of the testing (Tab. 2) are input data. Processing complexity and, as a result, the necessity for automation are due to the fact that the test bank contains questions with varying difficulty levels.

Mathematical model for interpreting the test results uses fuzzy logic and soft computing methods.

The output data should be organized, for example, as in the following table (Tab. 3).

It is known that the test bank contains m_1^{kj} questions for each jth competence, which score 1 point. There are also m_2^{kj} questions which score 2 points and there are m_3^{kj} questions which score 3 points.

Table 2

Summary testing results

	competence 1 «Digital office» k_1	competence 2 «Using Internet technologies» k_2	competence 3 «Digital security in professional activity» k_3	competence 4 «Installing software and applications» k_4
User$_1$	$L_{1,1}$	$L_{1,2}$	$L_{1,3}$	$L_{1,4}$
User$_2$	$L_{2,1}$	$L_{2,2}$	$L_{2,3}$	$L_{2,4}$
.....	.....	.....	.....	.....
User$_n$	$L_{n,1}$	$L_{n,2}$	$L_{n,3}$	$L_{n,4}$

Table 3

Output data for interpreting results

User	competence 1 «Digital office» k_1	competence 2 «Using Internet technologies» k_2	competence 3 «Digital security in professional activity» k_3	competence 4 «Installing software and applications» k_4
User$_1$	Advanced Level	Threshold level	Below critical level	Critical level
User$_2$	Critical level	Below critical level	Advanced Level	Threshold level
.....	...	...	...	...
User$_n$	Threshold level	Advanced Level	Threshold level	Critical level

Step 1. Determining the upper interval boundary balanced by probability of getting questions with higher or lower difficulty:

$\forall k_j \quad (j=\overline{1,4}), \qquad m_3^{kj} \qquad \tilde{D}_{k_j} = n(1m_1^{kj} + 2m_2^{kj} + + 3m_3^{kj}) / (m_1^{kj} + m_2^{kj} + m_3^{kj})$, where n is the amount of generated questions from the test bank.

Step 2. Determining the measure of membership in a given competence for each fuzzy set forming the linguistic variable L (Level of competence proficiency) for each respondent User$_i$ $x^i{}_{k_j} = \sum_{q=1}^{n} (B_{user_i} / \tilde{D}_{k_j})$, where B_{user_i} is the point for a correct test answer of an ith respondent.

Step 3. Adjusting the values of membership measures: if $x^i{}_{k_j} > 1$, then set $x^i{}_{k_j} = 1$.

Step 4. Generating a fuzzy set

$\forall$ User$_i$, $(i=\overline{1,N})$, $\forall k_j \quad (j=\overline{1,4})$, where N is the number of respondents, to generate a fuzzy set $L_{\text{User}_i} = \{(\text{x}^i{}_{k_j}, k_j)\}$.

Step 5. Interpreting the results

$$\forall k_j \quad (j=\overline{1,4})$$

if $x^i{}_{k_j} \geqslant 0{,}75$, then print message «advanced level of proficiency for competence k_j», otherwise,

if $(x^i{}_{k_j} \geq 0{,}5) \,\&\, (x^i{}_{k_j} \leq 0{,}75)$, then print message «threshold level of proficiency for competence k_j», otherwise,

if $(x^i{}_{k_j} \geq 0{,}25) \,\&\, (x^i{}_{k_j} \leq 0{,}49)$, then print message «critical level of proficiency for competence k_j», otherwise, print message «level of proficiency for competence k_j is below critical».

Step 6. End of algorithm.

Enlarged flowchart for the algorithm is shown in Fig. 1.

It should be noted that the developed algorithm allows to obtain a fuzzy set which reflects the level of proficiency in digital competences for four established groups («Digital Office», «Using Internet technologies», «Digital security in professional activity», «Installing software and applications, including mobile». We should stress that a procedure of ranging (applied to each specified competence) appears to be useful for further analysis of the results obtained. Existing algorithms (for example, Shell sort algorithm) may be applied for data sorting. It is obvious that data processing in parallel mode is appropriate in that case [25].

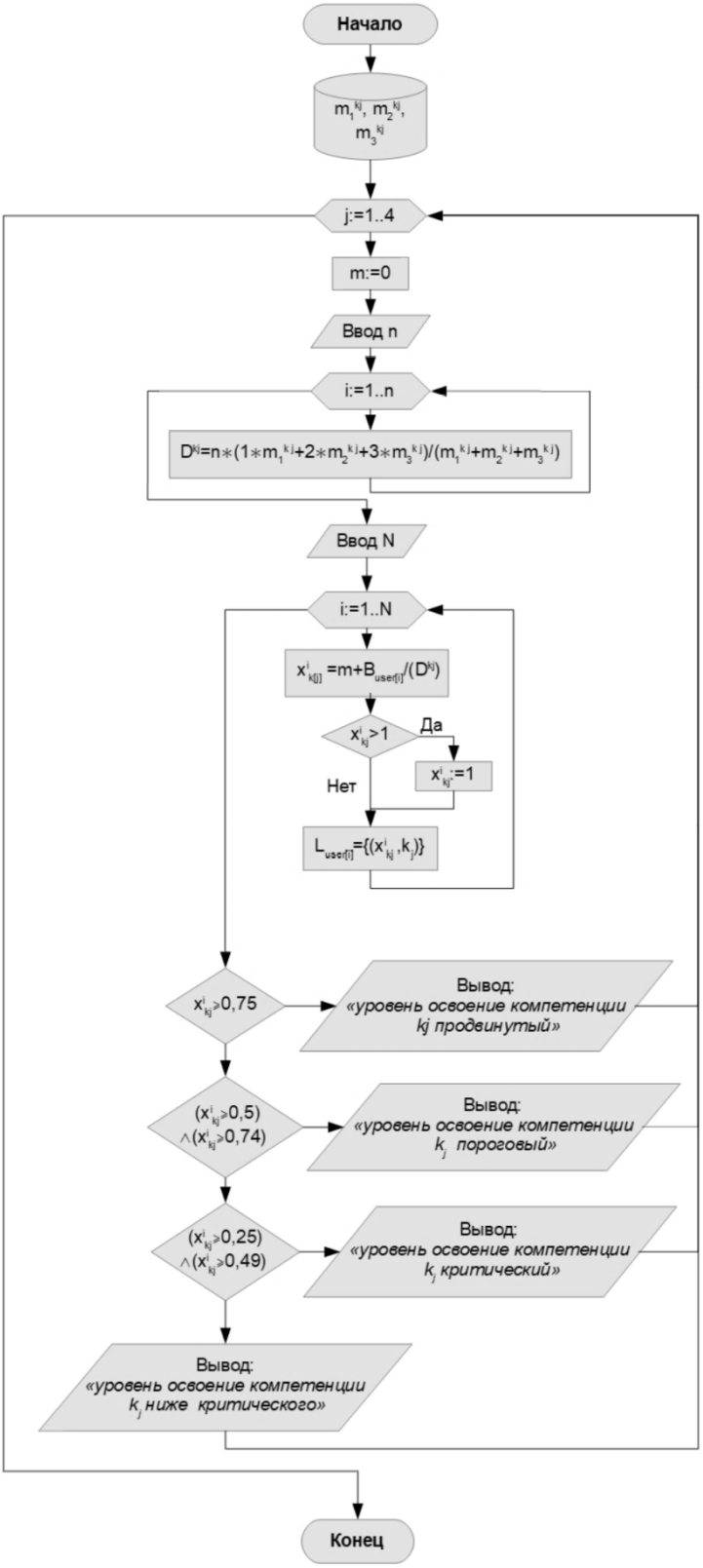

Fig. 1. Algorithm flowchart

In case of a large number of respondents and, consequently, a large data array, it is advisable to interpret the results using the criteria of maximum and minimum. That should allow to calculate the analyzed factors for different combinations of large groups [26]. The results obtained for the teachers' digital competences may be used by the Regional Ministry of Education and Youth Policy for making managerial decisions.

Conclusions and suggestions. The evolving digital economy both quantitavely and qualitively alters the demand of the labor market in human resources, shaping a new regional paradigm for training specialists. A system of professional education provides input resource flows and, thus, fulfills its major task of supplying regional economy with human resources.

Improving the regional system of professional education to ensure the development of digital economy should be started with diagnostics of the system's current state.

A methodology for assessing the level of digital competences in teachers (of professional education) has been developed.

The developed toolset for field studies was registered in as electronic resources. They meet the requirements of novelty and priority. In 2018, we obtained registration certificates no. 23944 «Questionnaire bank for Regional Digital economy» from the Institute of education management of Russian academy of education and no. 23945 «Test system for Digital Competences Assessment» from the Science and Education Joint Fund of E-resources.

The results of the study may be used by representatives of the government and municipal regulatory agencies in order to develop and implement a comprehensive set of measures targeting the support of different educational establishments of the region.

The developed algorithms allow to automate the process of interpreting the results. Fuzzy logic methods were employed to serve as a mathematical model, allowing to transform a quantitative indicator of test results into a qualitative characteristic describing the level of competence proficiency.

The assessment tools are recommended for use in other regions. The described method can be used not only in the system of professional education but it can also have wide applications in the sphere of state administration, in state and municipal organizations, and in entrepreneurial activity.

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DEVELOPMENT OF MANAGEMENT MECHANISMS FOR FORMING INVESTMENT CLIMATE IN BORDER REGION

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The formation of the investment climate, characterized by the positive dynamics of its main parameters, is one of the fundamental tasks of the regional economy of our country. Creating conditions for attracting domestic and foreign investment provides an increase in socio-economic indicators of the economic system of the region, stimulates the development of various sectors of the economy, has a positive impact on the level of employment and unemployment in the region, forms the resource potential. Currently, most regions have a serious need for investment resources, which are necessary for the growth of economic potential and the creation of a comfortable social environment. Conducting financial and economic activities in the border regions is characterized by the presence of additional opportunities for the development of investment activity and the creation of a stable system of foreign economic relations. The border areas of the Leningrad Region have considerable experience in practical implementation of joint economic cooperation programs. Active attraction of investment resources of neighboring countries in conjunction with the regional policy of strategic development determine the positive parameters of the socio-economic state of the Leningrad Region. One of the successful tools for improving economic efficiency is the creation of a positive investment climate in the region. To generate favorable conditions for forming the investment climate in the border regions, it is necessary to develop an effective management mechanism aimed at increasing the investment attractiveness and improving the ways of organizing economic activities. The article deals with the conditions of formation of the investment climate as a source of sustainable growth of socio-economic development of the border area. The study discusses the specifics of forming a mechanism for managing the investment climate of the border region as a basis for increasing the investment attractiveness, the specific conditions and the possibility of adapting them under the influence of a certain set of factors, offering a mechanism for managing the investment climate in the border regions. Effective organization of economic activity is currently impossible without attracting foreign investment. Due to peculiarities of the geopolitical position, geographical, economic and political characteristics, the border regions have a significant impact on the modern system of international investment relations. The field of foreign economic interests of the states is actively formed in the border areas. The investment climate that has developed in the border region is mainly formed by the state authorities in order to create comfortable conditions, primarily for foreign investors through a set of measures for using the mechanisms of state guarantees to protect foreign investments. It should be noted that today, despite all the prerequisites for development of local self-government in the Russian Federation, the regional and municipal governments of the border areas do not have sufficient authority to address the whole range of issues arising in formation of the regional investment climate.

Keywords: regional economy, investment climate, foreign investments, cross-border cooperation, adaptation mechanism

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РАЗВИТИЕ УПРАВЛЕНЧЕСКИХ МЕХАНИЗМОВ ФОРМИРОВАНИЯ ИНВЕСТИЦИОННОГО КЛИМАТА В ПРИГРАНИЧНОМ РЕГИОНЕ

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Формирование инвестиционного климата, характеризуемого положительной динамикой основных его параметров, является одной из основополагающих задач управления региональной экономикой нашей страны. Создание условий для привлечения отечественных и зарубежных инвестиций обеспечивает прирост социально-экономических показателей экономической системы региона, стимулирует развитие различных отраслей народного хозяйства, оказывает положительное влияние на уровень безработицы, занятости в регионе, формирует ресурсный потенциал. В настоящее время большинство регионов испытывают серьезную потребность в инвестиционных ресурсах, которые необходимы для роста экономического потенциала и создания комфортной социальной среды. Ведение финансово-хозяйственной деятельности в приграничных регионах характеризуется наличием дополнительных возможностей для развития инвестиционной активности и создания стабильной системы внешнеэкономических связей. Приграничные районы Ленинградской области имеют значительный опыт практической реализации программ совместного экономического сотрудничества. Активное привлечение инвестиционных ресурсов соседних стран в совокупности с региональной политикой стратегического развития определяют положительные параметры социально-экономического состояния Ленинградской области. Одним из успешных инструментов повышения экономической эффективности выступает создание положительного инвестиционного климата в регионе. Для организации благоприятных условий по формированию инвестиционного климата в приграничных регионах необходимо выработать эффективный управленческий механизм, направленный на повышение инвестиционной привлекательности и совершенствование способов организации экономической деятельности. Рассматриваются условия формирования инвестиционного климата как источника устойчивого роста социально-экономического развития приграничной территории. В качестве основы повышения инвестиционной привлекательности в рамках исследования рассматриваются особенности формирования механизма управления инвестиционным климатом приграничного региона с его специфическими условиями и возможностью их адаптации под влиянием определенного набора факторов. В современном мире эффективная организация экономической деятельности невозможна без привлечения иностранных инвестиций. В связи с особенностями геополитического положения, географических, экономических и политических характеристик приграничные регионы оказывают значительное воздействие на формирование современной системы международных инвестиционных отношений. На приграничных территориях активно формируется поле внешнеэкономических интересов государств. Инвестиционный климат, сложившийся в приграничном регионе, в основе своей формируется органами государственной власти с целью создания комфортных условий, в первую очередь, для иностранных инвесторов посредством разработки комплекса мер по использованию механизмов государственных гарантий защиты иностранных инвестиций. Следует отметить, что сегодня, несмотря на все предпосылки развития местного самоуправления в России, органы власти приграничных региональных и муниципальных уровней не обладают достаточными полномочиями для решения всего комплекса вопросов, возникающих при формировании регионального инвестиционного климата.

Ключевые слова: региональная экономика, инвестиционный климат, иностранные инвестиции, приграничное сотрудничество, адаптационный механизм

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Introduction. Today, effective organization of economic activity is impossible without attracting foreign investments. Due to peculiarities of the geopolitical position, geographical, economic and political characteristics, the border regions have a significant impact on the modern system of international investment relations [1]. The field of foreign economic interests of the states is actively formed in the border areas. The investment climate that has developed in the border region is mainly maintained by the state authorities in order to create comfortable conditions, primarily for foreign investors, through developing a set of measures set using mechanisms of state guarantees to protect foreign investments [2]. It should be noted that despite all the prerequisites for development of local self-government in the Russian Federation, the border regional and municipal governments currently do not have sufficient authority to address the whole range of issues arising in formation of the regional investment climate [2].

The goal of the study is to develop an effective mechanism for managing the investment climate in the border region with the example of the Leningrad Region.

Research methods. In order to develop an effective mechanism for managing the investment climate in a border region, it is necessary to formulate the factors affecting the management process, to analyze the characteristics of the economic situation in the Leningrad Region, to identify the specific patterns by which the mechanisms for managing international investment cooperation are formed. The methods of aggregation, induction, quantitative and qualitative analysis are used as research methods. The results of the study allow to develop a mechanism for managing the investment climate, which includes a description of the system components, as well as procedures and methods for implementing management impact.

Results. When considering the main approaches to management of investment processes in the border region, it is necessary to take into account its features, the general principles of management and the characteristics of the participants in the investment process [3]. In order to create a favorable investment climate, it is necessary to evaluate the specific conditions characterizing the border region, as well as to assess the possibility of their change under the influence of various factors (Fig. 1).

Factors that can have both positive and negative impact on the level of investment attractiveness can be combined into the following groups:

1. Political: the attitude of the state and regional authorities to foreign investors, compliance with investment legislation, the professionalism level of the local administration.

2. Organizational: proximity of investment markets of neighboring countries, opening access to raw materials, development of new markets, use of cheaper and (or) more skilled labor, research potential of the adjacent territory; intensity of inter-economic relations; availability and development of resource base [4].

3. Social: institutional support of investments by the population of the border region, the degree of involvement and trust of the population and economic structures of the current government of the border region.

4. Infrastructure: efficiency of decision-making, availability of information, market capacity, development of market infrastructure, transport and storage facilities.

5. Financial: conditions of capital movement, inflation rate, efficiency of the banking sector, assessment of investment risks [5].

6. Environmental factors, including consideration of the regulatory framework in the field of environmental safety, as well as the characteristics of natural and climatic conditions of the border area [6].

Based on the objectives of regional development, the established priorities and the formed system of values, each subject of the investment market forms its own idea of the investment attractiveness of the border area and the specific investment object located in it [7]. Development of management strategies for improving the investment climate in the regions is based on a number of basic features that characterize the conditions of economic activity in the border areas [8]. At the same time, the specific methods and

measures for organizing investment activity should take into account the industry specifics, the stage of the life cycle of the company (product), the internal resource potential [9]. The set of investment strategies of individual economic entities forms the basis for increasing the investment attractiveness of the entire region [10].

In our opinion, management of the investment process in the border areas should ensure the implementation of the following main functions:

1. Information function, aimed at developing communication between all subjects of investment activity, including potential.

2. Research function, aimed at establishing a statistical base for different parameters that form the investment process.

3. Economic function that contributes to developing an economic strategy and regulating investment relations in order to create a comfortable investment environment.

4. Motivational function, stimulating the investment process [11].

Resource-saving function provides priority of technologies aimed at environmental protection and saving of natural resources.

The Leningrad Region is a structural component of the North-Western Federal District, engaged in economic cooperation within the framework of cross-border cooperation. In 2018, the Leningrad Region was ranked 12th in the National Rating of investment climate in the subjects of the Russian Federation; according to the RAEX-Expert rating, the region has a characteristic of 3A1, with a minimum risk level [12]. According to the results of 2018, the Center for Development of public-private partnership awarded the 14th place to the Leningrad Region [13]. Assessing the region's level of investment attractiveness, Standard & Poor's, an international credit-rating agency, gave it a «BB+» long-term rating [14]. So, the parameters of the economic situation of the Leningrad Region and the trends in their development indicate the presence of prerequisites for increasing the level of investment attractiveness and improving the investment climate.

The dynamics of investments in the Leningrad Region is shown in Fig. 2, the structure of the region's economic complex from the position of investment in fixed capital in Fig. 3 [15].

Leningrad Region ranks 5th among all subjects of the Russian Federation in terms of attracted foreign direct investment (Fig. 4) [15].

The main areas of foreign investment are the fuel and energy complex, extractive industry, trade and public catering, transport and communications. Industry characteristics of the investment objects are shown in Fig. 5 [14].

The main foreign investor in the region is Finland. The share of Finnish companies is about 20% of all investments in the economy of the Leningrad Region. In 2017, the trade turnover of cross-border cooperation increased by 26%, more than 280 projects worth €500 million are being implemented. The Finnish business actively invests in such areas as wood processing, pulp and paper, telecommunications and communications, mining, energy, environmental programs [16].

In the socio-economic sense, a cross-border region is a territory inhabited by communities of people, closely connected by various kinds of relations, but separated by a border [17]. It is important to note that regardless of the socio-political system to which these communities belong, the socio-economic system of the border regions has a number of specific features, the main one being adaptability. As practice shows, the effectiveness of border management of the region with neighboring states usually has a direct dependence on the degree of use of the adaptation mechanism in the management process. An adaptive system can adjust itself to changes in internal and external conditions [18.] The mechanism of managing cross-border cooperation at the level of regional and municipal entities is a set of basic elements of management affecting the process of development and implementation of joint international programs and projects. At the heart of the mechanism of regional investment climate management is a system of management of regional socio-economic development. The set of tools for increasing investment attractiveness from the standpoint of organization of international economic relations is based on the regional development strategy and includes a set of interrelated subsystems (Fig. 6).

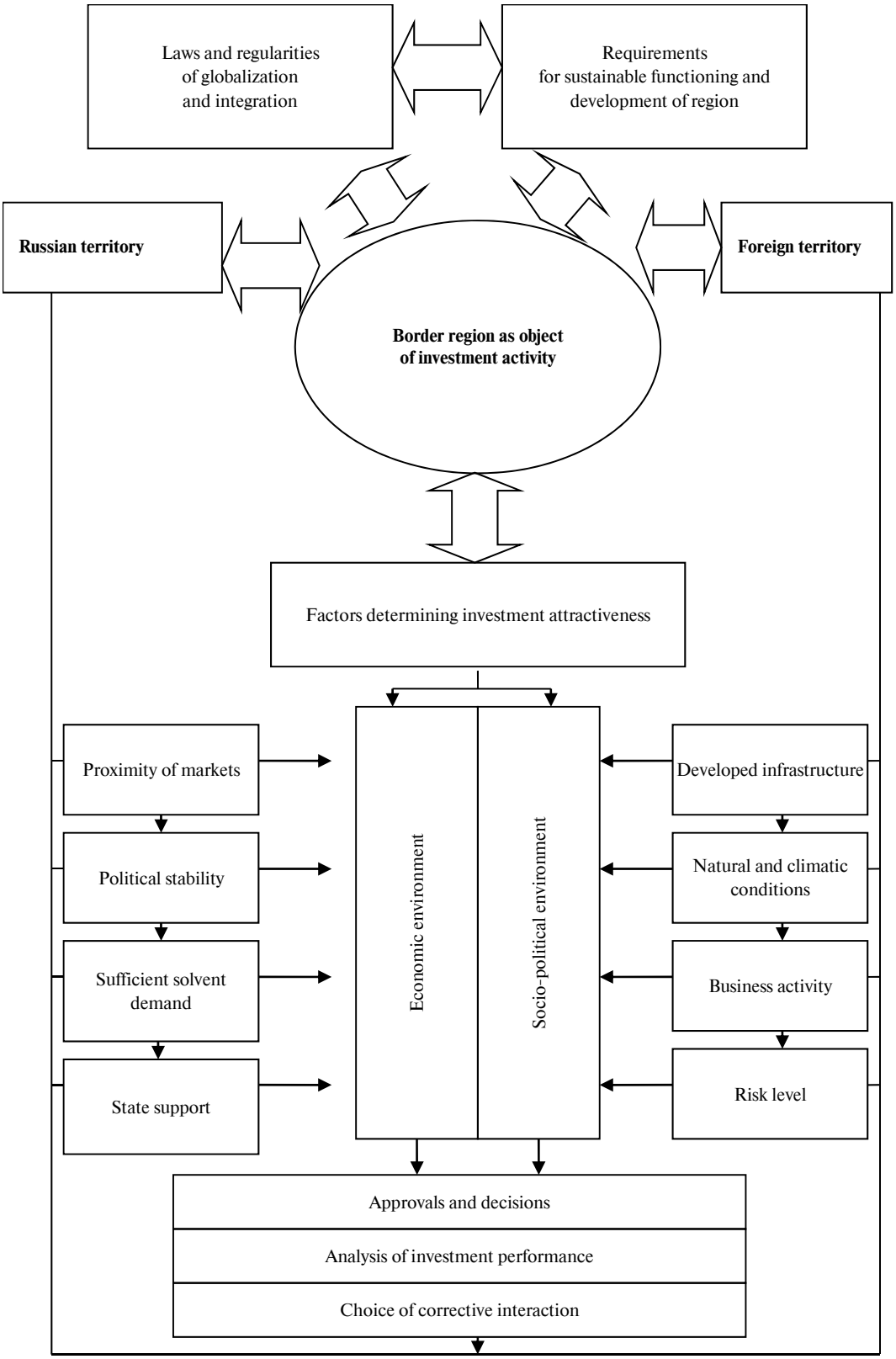

Fig. 1. Factors of investment attractiveness of border region

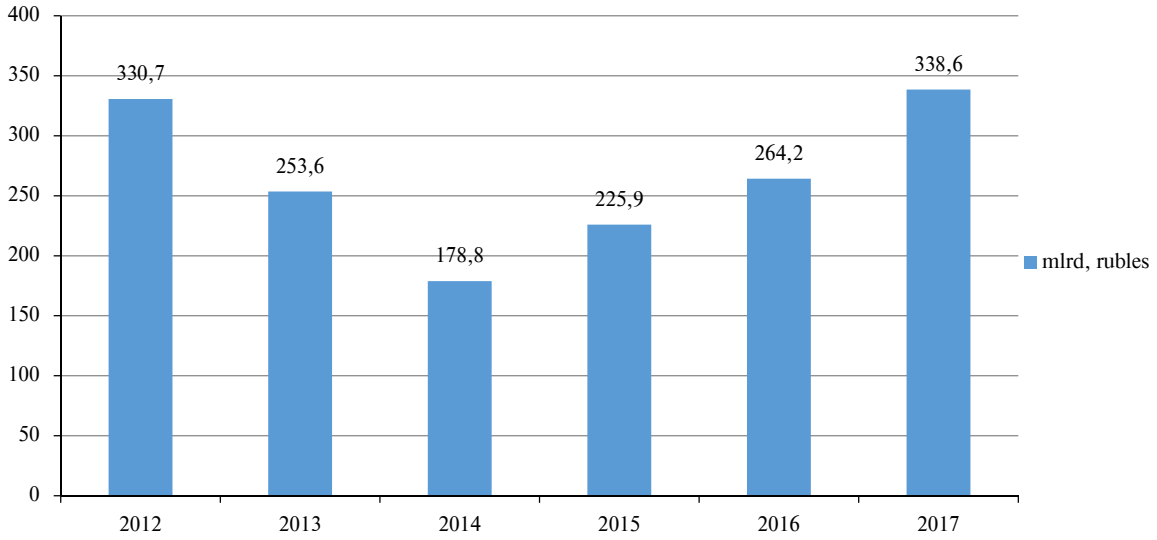

Fig. 2. Investments in fixed capital

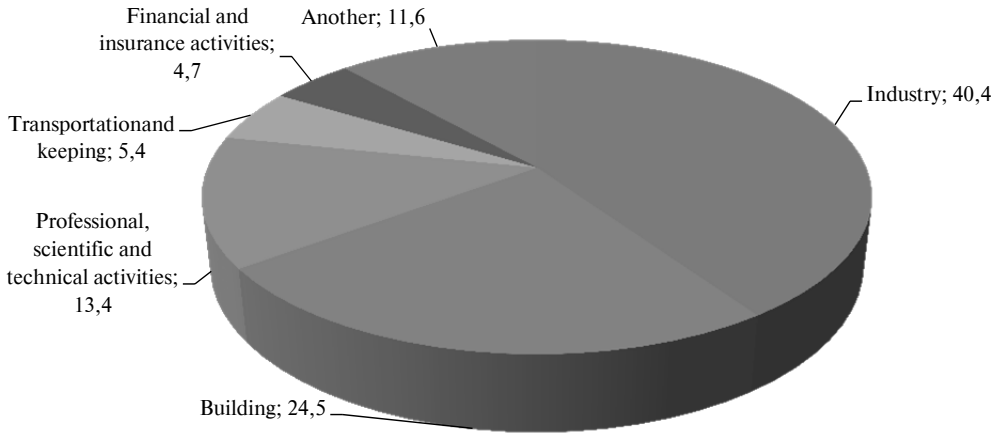

Fig. 3. Structure of investments in fixed capital by type of economic activity

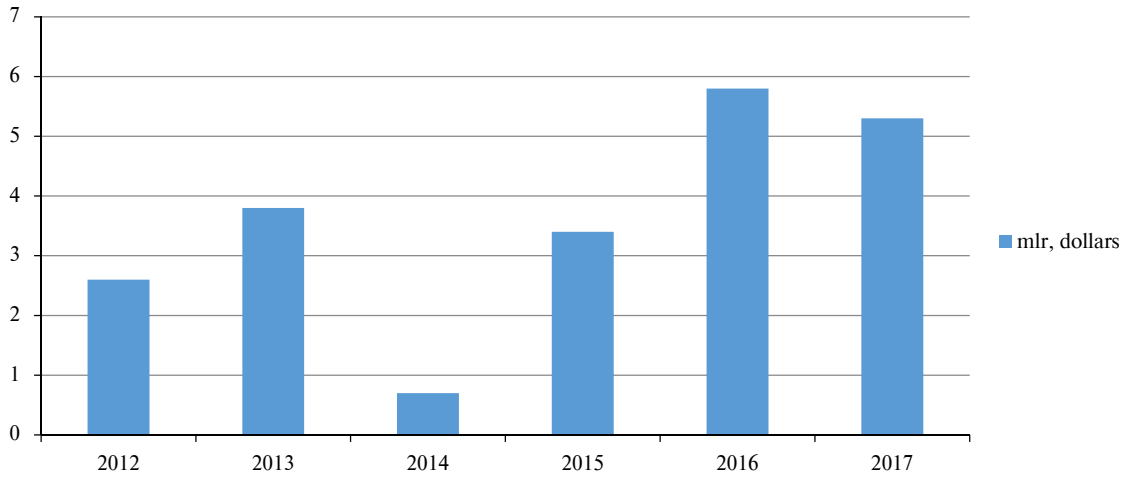

Fig. 4. Foreign investment

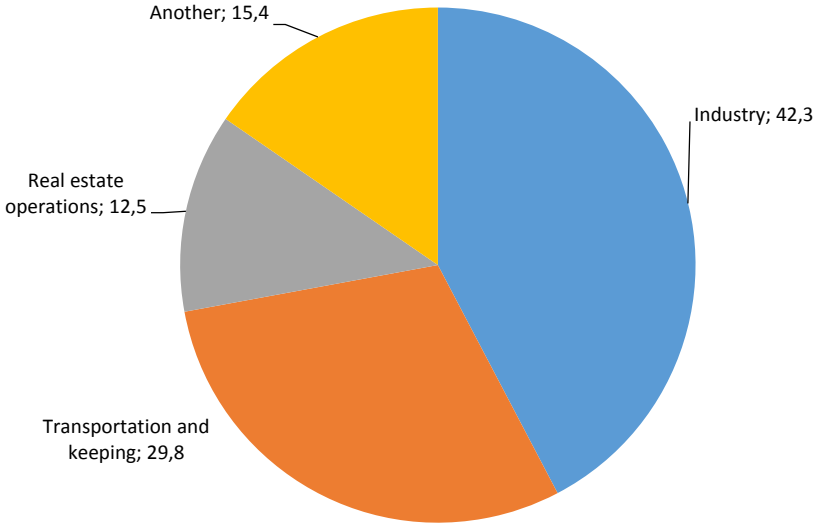

Fig. 5. Structure of foreign investments in the Leningrad Region

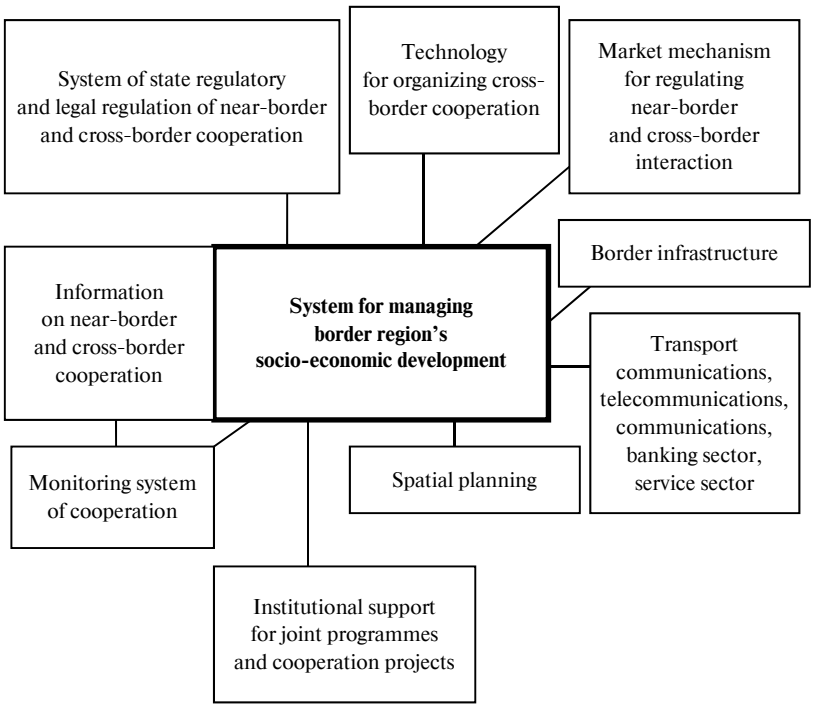

Fig. 6. System for managing formation of investment climate in border region

The activity of municipal authorities in developing cross-border cooperation is an element of the regional investment policy [19]. Involving a wide range of foreign investors in major investment projects of the border areas requires support and coordination at the state level. The fundamental condition for the formation of creating a favorable investment climate in the border region is state support of investment activity [20]. Regional authorities should focus their efforts on modernizing the order of the regional economy, ensuring the competitiveness of domestic markets, improving the quality of life of the population.

Forming a mechanism for managing international investment cooperation, it is necessary to consider a number of important features, such as:

– expediency of introducing restrictions and prohibitions on foreign investments in the border regions [21];

– definition of measures to control the activities of foreign investors;

– development of regional investment programs aimed at international financing;

– assistance in accreditation of foreign legal entities;

– preparation of international agreements on investment cooperation.

Discussion. The proposed structure of the mechanism for forming the investment climate can serve as a basis for constructing an effective system for managing the border relations. At the same time, the specifics of the border area, the peculiarities of relations with the neighboring states will make adjustments to the composition and set of tools for adapting management decisions in the implementation of international contacts.

In order to further improve the effective mechanisms and management principles of forming the investment climate, it is advisable to conduct a comparative study in other border regions of the Russian Federation and to assess the relationship between regional investment programs and the level of foreign investment in their economy.

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OPTIMIZING ENERGY BALANCE OF CHINA: PROBLEMS AND PROSPECTS

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The article analyzes the compliance of the current energy structure of China with the existing requirements of the socio-economic system and the principles of sustainable economy. The problems of the Chinese energy sector, which are increasingly dependent on imported fuels, have been identified. This fact predetermines the need to optimize China's energy balance and energy transform to meet the demand of modern society and the rapid growth of economic demands. It is substantiated that China needs to focus on energy efficiency, energy saving, renewable energy sources and transition to the main source of energy, i.e., natural gas, during formation of China's energy balance. Simulation for prediction of prospective energy balances is proposed; using it should allow to form the Chinese industrial structure of the electricity sector of industry in accordance with its production process, production volumes and resource consumption.

Keywords: evolution of electrical power industry, coordination of interaction, distribution efficiency, energy balance, energy structure

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ОПТИМИЗАЦИЯ ЭНЕРГЕТИЧЕСКОГО БАЛАНСА КИТАЯ: ПРОБЛЕМЫ И ПЕРСПЕКТИВЫ

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Анализируется соответствие современной энергетической структуры Китая сложившимся требования социально-экономической системы и принципам устойчивой экономики. Выявлены проблемы китайской энергетической сферы, которая все больше зависит от импортного топлива, что предопределяет необходимость оптимизации энергетического баланса Китая и преобразования энергии для удовлетворения спроса современного общества и быстрого роста требований со стороны экономических задач. Энергетическая составляющая рассматривается как важный индикатор оценки национальной экономики, а топливно-энергетическим ресурсам уделяется ключевое место в стратегических программах и во внешнеэкономической политике страны. Электроэнергетика, которая обеспечивает деятельность предприятий, различных отраслей, функционирующих на территории страны, безопасность государства и материальные условия жизни населения, является базовой стратегической системой. Влияние состояния электроэнергетического комплекса на экономику трудно переоценить, учитывая большую энергоемкость валового внутреннего продукта и рост спроса на энергоносители, что выводит проблемы эффективного функционирования энергетических предприятий регионов в ряд важнейших. Обосновано, что при формировании энергобаланса Китая необходимо сосредоточиться на энергоэффективности, энергосбережении, возобновляемых источниках энергии и переходе к основному источнику энергии – природному газу. Современная энергетика, являясь основополагаю-

щей отраслью в экономических системах, оказывает серьезное воздействие на развитие стран и их национальную энергобезопасность. Для выявления основных тенденций и подходов для определения влияния энергетического фактора на макроэкономические показатели стран наиболее важным представляется изучение сложившегося положения в энергообеспеченности их и мирового сообщества в целом, направленное на формирование и разработку обновленных способов, приоритетов, подходов и схем управления территориального развития национальной экономики с учетом энергетической составляющей. Происходящие на мировом и национальном уровне преобразования в этом направлении влияют и на организационно-структурную модернизацию производства в топливно-энергетических компаниях, на механизмы управления ими и на перспективы развития. Предложена имитационная модель для прогнозирования перспективных энергетических балансов, использование которой позволит сформировать китайскую промышленную структуру электроэнергетической отрасли в соответствии с ее производственным процессом, объемами производства и потребления ресурсов.

Ключевые слова: развитие электроэнергетики, координация взаимодействия, эффективность распределения, энергобаланс, энергетическая структура

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Introduction China consists of more than 30 provinces and special regions, and some of them are large not only in terms of area and population, but also in terms of production. It is very important to understand the differences between these regions in order to fully analyze the current energy infrastructure of China and optimize its future needs and necessary investments [13].

Currently, the task of developing country's energy balance with maximum detail is top priority in the fuel and energy complex. Based on the energy balance of the country, it is possible to develop or adjust the energy strategy in the field, and most importantly, gain an understanding how to construct an optimal system for forming tariffs [15]. It is necessary to understand exactly how much primary (oil, gas, fuel oil, coal, nuclear fuel) and secondary (heat, electricity, gas) energy resources a country has. Development of energy balance means a system of quantitative indicators of mining (production), conversion and final consumption in its territory for a certain period of time. The formed general energy balance serves as an information base of initial data for calculations of various derived indicators for determining the efficiency of using fuel and energy resources and a tool for controlling its flows at all levels from mining (production) to conversion processes and final consumption.

The absence of regional energy balances not only complicates, but practically eliminates clear tracking of fuel and energy flows along the whole chain of their passage, from mining (production) to final consumption, determining energy efficiency indicators, developing forecast balances to solve strategic directions for development of the fuel and energy complex, making the right decisions when concluding long-term contracts for import, transit and re-export, conducting continuous monitoring of the domestic market's energy resources, etc. [17]. These factors make the task of identifying the problems, opportunities and prospects for optimizing the energy balance of China all the more urgent.

Research methodology. The methodology of forming a general energy balance as a whole or individual balances by type of energy, territorial dependence, or by type of economic activity should be based on international recommendations of energy statistics, taking into account the specifics of the state and regional system of statistical accounting and respondent reporting, regardless of their affiliation. In addition, the energy balance is forecasting, comparing and balancing of supply and demand for all types of primary and secondary energy resources in physical and monetary terms necessary to ensure the life and development of the country.

According to methodological provisions [6, 7, 10, 20], the total energy balance includes the types of fuel and energy extracted or produced from natural

sources, or from conversion; those imported or removed by export; as well as difference in balances at the beginning and end of the current year. Volumes of fuel are provided in natural and arbitrary units calculated in caloric coefficients of coal equivalent. Electricity and heat energy produced by thermal power plants, boiler houses or other equipment that use fossil fuels were recalculated to fuel equivalent according to actual specific fuel consumption for their supply. Nuclear energy, hydro energy, energy of non-traditional sources were recalculated using averaged indicators of actual specific fuel consumption for electricity supply by power plants using organic fuel.

Nowadays in China, development of balances or the main types of energy resources occurs fragmentarily, not systematically and late, that is, the country does not have a clear answer to the question of what coal production volumes are needed. There are periods when coal companies' warehouses are overcrowded, and there are periods when thermal power plants operate «on wheels». So if a real balance that takes into account absolutely all aspects of supporting one or another generation is not developed in the regions of China, this can lead to large-scale disruptions in power systems. We can agree that the energy balance is the main and extremely difficult task, whose solution is connected with developing scenario forecasts of energy balance of the country and regions, which should allow to introduce a mechanism of financial risks [12, 19]. In scenario forecasts and balances, it is wrong to replace, for example, one energy source by another, it is necessary to follow the path of introducing technologies with high conversion rates, and rejecting the old industry approaches.

A very promising tool to solve these tasks is formation of an optimal energy balance at the state level, taking into account geographical features, administrative division, economic and socio-demographic characteristics [2]. The combined energy balance of the country is developed as a set of interrelated scenario forecasts of the processes of formation and distribution of energy resources by economic sectors in accordance with the scale and trends of the country's socio-economic development for the relevant period.

Analysis of methodological approaches to determining the future demand for fuel and energy resources (FER) shows that it is traditional to use optimization models for forecasting the development of the energy system. The same class of models were created in the Soviet Union for planning the development of the energy industry at different hierarchical levels. For the energy system of China, where the energy supply of the country's economy is perhaps the most acute issue of national policy, for a number of objective reasons, virtually no studies of this type have been conducted [3]. In conditions of deregulation in the energy sector, modeling the evolution of the fuel and energy complex (FEC) and its sectoral subsystems becomes much more complicated, especially for countries whose economies are in a state of transition to market regulation. In addition, violation of dynamic data series caused by repeated changes in methodological principles of collecting and processing economic and energy statistics makes entire classes of energy models almost impossible to use. Under such conditions, it is now highly advisable to develop a simulation energy-economic model for China.

The basis of this technique is the inter-branch balance matrix, which includes additional features. In order to eliminate possible disagreements between the indicators during the final operations of the balance division, the mathematical algorithms for its maintenance have been developed:

$$P_{G.C.} + P_{C.S.} = P_{C.E.S.} + P_{F.C.} + P_{loss} + P_{N.P.} + P_{ST.D.}, \quad (1)$$

where $P_{G.C.}$ is the level of energy resources supplied under the «Gross consumption» section; $P_{C.S.}$ is the level of energy resources converted with respect to the «Conversion sector» section; $P_{C.E.S.}$ is the level of energy resources consumed by enterprises of the conversion sector under the «Consumption by energy sector» section; $P_{F.C.}$ is the level of energy resources consumed under the «Final consumption» section; P_{loss} is the level of energy resources lost under the «Losses during transportation and distribution» section; $P_{N.P.}$ is the level of fuel consumed as a raw material for non-energy purposes under the «Consumption for non-energy purposes» section; $P_{ST.D.}$ is the energy levels under the «Statistical deviation» section.

The algorithms for determining the energy resource levels under the «Gross consumption»

section ($P_{G.C.}$) are written in the following form (expressions (2) and (3)):

$$P_{G.C.} = P_{vid.} + P_{imp.} + P_{\exp.} + P_{C.R.}; \quad (2)$$

$$P_{G.C.} = \sum_{j=1}^{n}(\sum_{i=1}^{g} P_{vid}^{i} + \sum_{i=1}^{n} P_{imp.}^{i} - \sum_{i=1}^{n} P_{\exp.}^{i} \mp \sum_{i=1}^{n} P_{C.R..}^{i}), \quad (3)$$

where $P_{vid.}$ is the level of energy resources mined or produced by the country; P_{imp} is the level of imported energy resources; $P_{\exp}$ is the level of exported energy resources; $P_{C.R.}$ is the level of change in the energy resource reserve for the end of the current year; i and j are the indices of energy resource type and section number, respectively.

Results. The resource base of the energy balance is determined by the existing reserve of fuel and energy resources (FER), the level of their geological exploration, the readiness of the existing production potential for extraction (processing) of these resources. The results of the simulation are [3]:

- FER consumption volume determined for the economy of the country and for its main sectors;
- Influence of individual state regulatory mechanisms on the level of energy consumption determined;
- Most rational structure of FER import and export determined;
- FER consumption optimized by the criteria of energy and environmental efficiency of the economy due to improvement of technological structure of production, processing and consumption of energy resources. The decisive factor for ensuring the implementation of a certain structure of the energy system is investment in creation of new production facilities and reconstruction of the existing energy facilities based on innovative models of reproduction of energy potential and introduction of new technologies both in production and in energy consumption.

The basic task of energy balance modeling is to assess the future demand for FER on the basis of initial information to determine the potential possibilities and sources for meeting this need. According to the expected volumes of energy consumption, the demand for key material and financial resources is projected. Forecasting the rate of socio-economic development and structural economic change is the basis for such assessment. For this purpose, it is necessary to identify the quantitative interrelations between energy and economics, which may have a different nature depending on the changes in public life, political and economic environment, scientific and technical base, management methods, world market conditions, environmental conditions [20].

We can agree with researchers who believe that the interdependence between economic development rate, changes in its structure and energy consumption is determined by a complex set of factors [9, 14, 16, 18]. Even for industrialized countries, there is no steady correlation between the rate of economic development and changes in energy consumption, and the quantitative impact of economic growth rates on the size and nature of energy consumption is difficult to identify. Among the factors, a special role is played by the structure of the country's energy capacity, consumer properties of individual energy resources and their interchangeability, the dynamics of energy prices, including in world markets, the nature of the mutual influence between prices and volumes of international energy exchange taking into account technological, economic and other factors.

The calculation of the future demand for energy is carried out using a modified production function, which takes into account the price and income elasticity of energy consumption and the coefficient of autonomous technical progress. The linear relationship between the volumes of final fuel consumption and, for example, the emissions of harmful substances (externalities) can be determined by the relevant conversion factors: the coefficients of environmental characteristics and other factors used for predictive calculations.

To analyze the effectiveness of predictive energy balances in accordance with the scenarios of economic development, a system of indicators should be developed, allowing to assess the coverage of energy consumption in the country. Conceptually, such assessment is developed on the basis that the fuel and energy complex should ensure the planned rates of socio-economic development of the country and comply with the set of key requirements for the environmental load, ensure energy and economic security, take into account the real financial and material support to adequately increase the production potential of the fuel and energy sectors. In particular, the main indicators for optimizing the energy structure, in addition to the energy and electricity intensity of the economy, are:

- Level of self-sufficiency by energy resources;

• Share of the dominant resource in the structure and sources of supply of primary FER;

• Share of final energy consumption in total energy supply;

• Indicators of physical deterioration and renewal of fixed assets of the industry's enterprises.

Analysis of statistical data on the sources of electricity production in China shows that the main share is for coal, which is the least environmentally friendly energy resource (Fig. 1).

Consumption of large amounts of coal led to a number of environmental problems: 85 % of sulfur, 35 % of suspended particles and 75 % of CO_2 in the atmosphere come from fossil fuel combustion. That is, the current structure of energy consumption determines the need to transition to renewable energy resources (RES), such as wind, sun and biomass, which are environmentally friendly. Renewable energy sources have become an important choice for China [4].

Considering production and consumption, the north-eastern, north-western and southern regions have significant excess generating capacity, and this situation of excess capacity will continue over the next decade without interference from regulatory authorities. Northern and central regions may have sufficient production capacity, but additional resources may be required in a scenario with higher growth rates. The eastern region requires new resources. Large differences in reserve capacity between the provinces indicate the need for greater coordination between them for ensuring sufficient generation throughout China [3]. Fig. 2 shows the electricity consumption distribution by regions, uniting nearby provinces whose energy structure is combined.

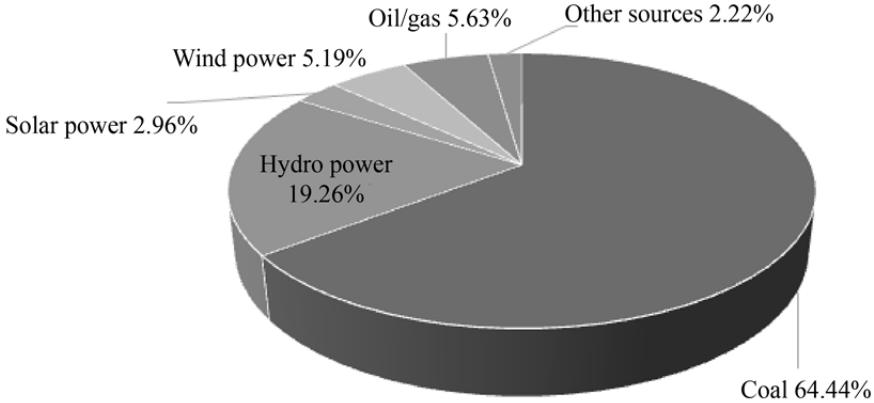

Fig. 1. Installed power capacity by source, 2015 (compiled from [1, 2])

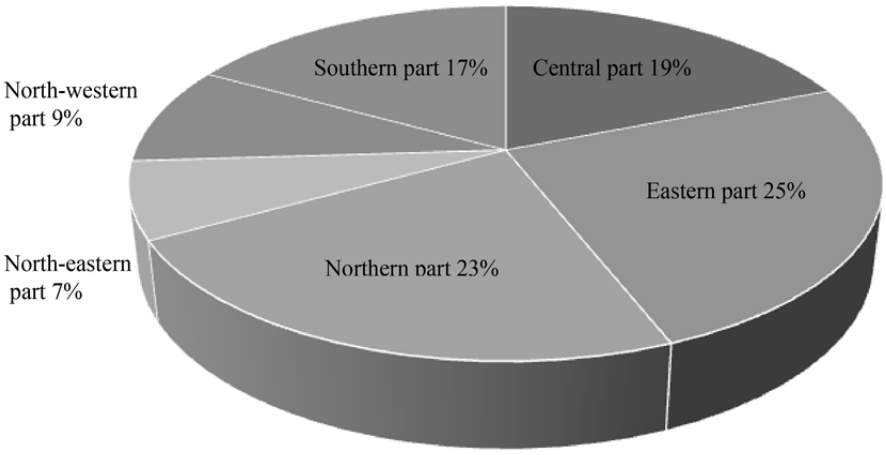

Fig. 2. Shares of regions of China's energy system in total electricity consumption, actual data for 2014, % [1] (compiled from [1, 7, 11])

[1] Key China energy statistics. China Energy Group – 2016. URL: https://china.lbl.gov/sites/default/files/misc/ced-9-2017-final.pdf; National Bureau of Statistics of the People's Republic of China, different years. URL: http://www.stats.gov.cn/english/

As seen from the figure, a large share of consumption falls on the northern and eastern provinces, while energy generation does not correspond to the consumption structure: most of the energy is generated in the northern part (20.8 %), the central part (20.2), and the eastern part (19.7 %), but ultimately, the volume of generated energy is insufficient for consumption (Fig. 1).

Despite this imbalance between supply and demand, research results show that China does not need new thermal power plants, or at least new coal units with a base load. This conclusion underlines the critical importance of improving the investment planning processes in China in order to avoid deterioration of the current problem of overcapacity (which is present in large amount in the country) and to achieve multiple policy goals of creating a reliable, environmentally friendly and cost-effective power system.

Based on the data from Tab. 1, we propose the main goals and objectives for optimizing China's energy balance.

Table 1

Actual data on generation and consumption of electricity

Region	Generation (GW)	Consumption (GW)	Level of correspondence, %
Central part	277.1	1091	25.4
Eastern part	269.8	1381	19.5
Northern part	285.3	1311	21.8
North-eastern part	122.6	397	30.9
North-western part	167.8	520	32.3
Southern part	246.4	932	26.4

Compiled using data from [1, 7, 11]

Table 2

Goals and objectives for optimizing energy balance in China

Goals	Objectives
1. Integrating energy system of provinces throughout the country 2. Improving energy efficiency of energy consumption 3. Balanced and sustainable development of RES 4. Optimization and modernization of energy infrastructure	1. Synchronization of China's energy system with production processes of national economy 2. Improving energy efficiency of energy consumption 3. Development of RES, focusing on increased use of hydro resources, solar energy, biomass and wind energy, use of renewable energy sources for production of centralized heat supply and domestic heating 4. Construction of interconnections in power industry 5. Providing balanced local capacity in production, reservation and balancing; cost-benefit analysis
1. Electricity prices in industrial sector should be the same for all provinces, and for citizens it is necessary to reduce the share of energy costs compared to average income 2. Smooth transition from fossil energy sources to renewable energy sources	1. Improving energy efficiency of energy consumption (energy intensity should not exceed the average in the world) 2. Development of RES, focusing on development of solar energy and wind energy, as well as further use of renewable energy sources for production of centralized heat supply. 3. Use of alternative fuels in transport sector and its electrification. 4. Creating necessary conditions for development of environmentally friendly energy production methods. Development of small and flexible local power-generating plants
1. 80 % of the country's energy requirements come from sources without pollution (zero emissions of greenhouse gases and other air pollutants) 2. 100 % of local electricity production in gross electricity consumption in the country	1. Completing necessary steps for development of environmentally friendly energy production methods 2. Development of efficient and environmentally friendly technologies for production, supply, storage/accumulation and consumption of energy

Compiled using data from [4, 9, 10].

Conclusions. Summarizing the above, it can be concluded that using energy models in the process of planning the development of the energy sector has become a common international practice. Analysis of applied model developments shows that creating a simulation model for predicting energy resources is a standard methodological approach for energy balance modeling. The methodology proposed in this article, based on an intersectoral balance matrix, can become a basis for studying the provincial relations between demand and supply in the power industry. In addition, the obtained results can be used to assess the level of development of electric power industry and effectively describe their dynamically changing coordination relations.

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ORGANIZATIONAL AND ECONOMIC MECHANISM OF MANAGEMENT BY INNOVATIVE POTENTIAL OF INDUSTRIAL CLUSTER

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The development of industry and the improvement of the competitiveness of Russian industrial enterprises in the domestic and foreign markets are associated with the transition to a digital model of economic development, involving a high concentration of knowledge-intensive production, knowledge and technology. At the same time, the current level of innovative development of Russian industry does not fully meet the expectations associated with the formation of a new type of economy. The insufficient level of innovation activity of Russian industrial enterprises poses a direct threat to the country's economy due to an increase in import dependence. The quantitative growth of the national economy should be accompanied by innovations, ensuring the qualitative side of the production activities of economic entities, while strengthening their financial sustainability and the financial sustainability of Russia as a whole. In this situation, as shown by foreign and Russian experience, the integration of business entities is becoming an indispensable tool stimulating enterprises' susceptibility to innovations, as well as increase their innovation activity in general. The creation of industrial clusters is one of the current trends in economic transformations of the Russian economy. In accordance with this, the authors formulated the purpose of the study – based on studying the essence of clusters, as well as the concepts and assessments of their innovative potential. The directions of further research are seen by the authors in the study and approbation of the organizational and economic mechanism for managing the innovation potential of clusters of various sectoral orientations.

Keywords: integration, industrial cluster, innovative potential, control system, organizational and economic mechanism

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ОРГАНИЗАЦИОННО-ЭКОНОМИЧЕСКИЙ МЕХАНИЗМ УПРАВЛЕНИЯ ИННОВАЦИОННЫМ ПОТЕНЦИАЛОМ ПРОМЫШЛЕННОГО КЛАСТЕРА

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Развитие промышленности и повышение конкурентоспособности российских промышленных предприятий на внутреннем и внешнем рынках сопряжены с переходом на цифровую модель экономического развития, предполагающую высокую концентрацию

наукоемкого производства, знаний и технологий. Вместе с тем сложившийся в настоящее время уровень инновационного развития промышленности России не в полной мере отвечает ожиданиям, связанным с формированием экономики нового типа. Недостаточно высокий уровень инновационной активности российских промышленных предприятий представляет прямую угрозу экономике страны вследствие увеличения импортозависимости. Количественный рост национального хозяйства должен сопровождаться инновациями, обеспечивая качественную сторону производственной деятельности хозяйствующих субъектов, укрепляя при этом как их финансовую устойчивость, так и финансовую устойчивость России в целом. В данной ситуации, как показывает зарубежный и российский опыт экономической деятельности, интеграция хозяйствующих субъектов становится тем необходимым инструментом, который может стимулировать восприимчивость предприятий к нововведениям, а также повышать их инновационную активность в целом. Создание промышленных кластеров – одна из актуальных тенденций экономических преобразований российской экономики. Сформулирована цель исследования – на основе изучения сущности кластеров, а также понятия и оценки их инновационного потенциала разработка организационно-экономического механизма управления инновационным потенциалом промышленных кластеров. Показано, что реализация организационно-экономического механизма управления инновационным потенциалом промышленного кластера позволяет структуре максимально полно адаптироваться к условиям жесткой конкуренции на занимаемом рынке, развивать существующие технологии и запускать новые, осуществлять выпуск сложной инновационной продукции за счет максимального использования имеющегося инновационного потенциала, а также его увеличения, что в итоге повышает конкурентоспособность структуры. Направления дальнейших исследований видятся в исследовании и апробации организационно-экономического механизма управления инновационным потенциалом кластеров различной отраслевой направленности.

Ключевые слова: интеграция, промышленный кластер, инновационный потенциал, система управления, организационно-экономический механизм

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Introduction. The development of industry and the improvement of the competitiveness of Russian industrial enterprises in the domestic and foreign markets are associated with a digital transformation of the Russian economy, involving a knowledge-intensive production, knowledge and modern technology. At the same time, the current level of innovative development of Russian industry does not fully meet the expectations associated with the formation of a new type of economy.

The insufficiently high level of innovation activity of Russian industrial enterprises poses a direct threat to the country's economy due to an increase in import dependence. The quantitative growth of the national economy should be based on innovations, ensuring the qualitative side of the production activities of economic entities, while strengthening their financial sustainability and the financial sustainability of Russia as a whole. In this situation, as shown by foreign and Russian experience in economic development, the integration of business entities is becoming an indispensable tool that can stimulate enterprises' susceptibility to innovations, as well as increase their innovation activity in general.

The creation of industrial clusters is one of the current trends in economic transformations of the Russian economy. By joining in cluster, enterprises are able to more flexibly respond to changes in demand, and organizing joint production improves the quality of various technical developments based on the systemic use of intellectual potential, and also

allows saving resources and obtaining synergistic effect. These circumstances contribute not only to increasing production volumes, but also to the development of high-tech innovative types of products, which leads to an increase in the efficiency of innovation activities of clusters and industries in general.

One of the factors of innovative development of business entities is the formation and effective use of their innovative potential. Assessment of innovation potential plays an important role for the development of innovation policy and innovation strategy of the activities of enterprises. However, the assessment of innovation potential does not allow for a comprehensive coverage of all aspects related to its formation, development and implementation. To this end, it is necessary to create a system for managing the innovative potential provided by the organizational and economic mechanism. An effective management mechanism is the main tool of successful adaptation of industrial clusters to uncertain and rapidly changing environmental conditions and ensures the formation and implementation of such a development scheme in which the best results in a particular situation are achieved. These factors determines the relevance of the research topic.

The purpose and objectives of the study. On the basis of studying the essence of clusters, as well as the concepts and assessments of their innovative potential, develop an organizational-economic mechanism for managing the innovative potential of industrial clusters. In accordance with the objective, the authors consider the following tasks:

analysis of the definition of «innovative potential of an industrial cluster»;

development of a management system for the innovative potential of an industrial cluster;

analysis of modern approaches to the definition of the term «organizational and economic management mechanism»;

formulation of the author's understanding of the organizational and economic mechanism for managing the innovative potential of an industrial cluster and highlighting its main components;

development of an organizational and economic mechanism for managing the innovation potential of an industrial cluster.

Research methodology. The concept of the innovative potential of the industrial cluster. In modern economic conditions, increasing the competitiveness of any market entity, entering new markets and increasing cash flow is possible only by creating the necessary prerequisites for further development based on the creation, introduction and dissemination of technical, technological and organizational innovations. In this context, the transition to an innovative development path is a prerequisite for the sustainable development of market actors. Innovative development is a systemic process of social and economic development based on knowledge and innovations, realizing the competitive advantages of economic entities and ensuring their sustainable economic growth.

One of the factors of innovative development of economic entities is the formation and effective use of their innovative potential [18]. The assessment of innovation potential plays an important role in the development of innovation policy and the innovation strategy of enterprises, as well as industrial policy and development programs for individual economic entities, industries, regions and the economy as a whole. Innovation potential is one of the factors that determines the intensity of innovation, and, ultimately, its effectiveness.

Innovation potential is a complex and multidimensional category, which is discussed by foreign and domestic scientists, starting from the third quarter of the XX century. The study of the essence and content of the term «innovative potential» is devoted to the work of such scientists as Antonenko I.V., Balabanova I., Bortnik O.A., Gubin E.P., Danko M., Glukhov V.V. ., Emelyanov S.G., Bogdanova E.L., Zinchenko I.V., Silkina G.Yu., Kozlov A.V., Kokurin D.I., Makarchenko M.A., Korobeinikov O.P., Kravchuk I.S., Monastyrny E.A., Morozova, L.E., Suvorinov A.V., Trifilova A.A., Tyulkov G.I., Fedoraev S.V., Cherednikova L.E., Yuryev V.M. and others. Despite the fact that a large number of publications are devoted to the problems of

determining the innovative potential, currently there is no single established definition of this term in the Russian scientific literature.

Currently, the Russian scientific literature uses different approaches to the definition of the term «innovative potential». The analysis of approaches conducted by the authors is presented in Tab. 1.

Taking into account the existing approaches to the definition of the term «innovative potential», the authors proposed to consider the innovative potential of the industrial cluster as the capability of the cluster members to transform the available resources into the results of innovative activities. This definition includes three main elements:

1) resources that are the material basis for the implementation of innovation activities;

2) abilities, i.e. the ability to translate the available resources into the results of innovation activities (innovative products, works, services), while the author proposes to assess abilities through specific results of innovation activities;

3) opportunities, i.e. the presence of favorable or unfavorable trends in the development of innovative activity of the subject.

The author's definition of innovative potential allows not only to characterize the level of cluster innovation in specific periods of time, but also to reflect the trend of its change, thereby presenting the innovative potential as a complex indicator in the Resource-Abilities-Opportunities coordinate system. This approach provides a comprehensive view of the innovation potential and allows you to more fully reveal its essence.

Table 1

Approaches to the definition of the term «innovative potential»

Approach to the definition of the term «innovation potential»	Authors	Content of the approach
1. Innovative potential as an integral part of economic potential	Morozova L.E., Bortnik O.A., Kravchuk I.S. [17], Huseynova T.T.K. [4], Donets O.V. [7]	Innovation potential is considered as an integral part of the economic potential, which determines the ability of an economic entity to innovative development
2. Innovative potential as a scientific and technical potential	Danko M. [5], Leontyev B.B. [14]	Innovative potential is considered as a set of resources and conditions for the implementation of applied research and development, including experimental design and experimental technological work
3. Innovation potential as a set of resources	Fedoraev S.V. [27], Antonenko I.V. [1], Vasyukhin O.V., Pavlova E.A. [3], Zhits G.I. [9], Reshetnicov A.V. [23], Chudakov F.I. [29]	Innovation potential is considered as a set of human, material, scientific, technical, informational and financial resources intended for the implementation of the innovation process
4. Innovation potential as the ability and willingness to implement the innovation process	Monastyrny E.A. [16], Fatkhutdinov R.A., Shamina L.K. [30]	Innovation potential is considered as the ability and willingness of an economic entity to organize and implement processes aimed at achieving innovative results
5. Innovation potential as a set of opportunities	Trifilova A.A. [25], Lisin B.K., Fridlyanov V.N. [15], Nikolaev A. [19], Kozlov A.V. [10]	Innovation potential is considered as a set of scientific, technical, technological, infrastructural, financial, legal, sociocultural and other opportunities to ensure the perception and implementation of innovations, i. e. getting innovation

Source: compiled by the authors.

The combination of the three components of the innovation potential and the connections between them allows us to consider the innovation potential as a system. The input of the system is a resource component; the output of the system is the obtained innovative results (goods, works, services, technologists, etc.). The interaction of the innovation potential with the external and internal environment of the industrial cluster is manifested in the performance of certain functions, among which are:

1) research function – the innovation potential contributes to the development of the cluster's scientific and technical activities, acts as an ideas generator;

2) production and technical function – the innovation potential contributes to the development and introducing of improved, more efficient ways of producing goods (works, services);

3) organizational and management function – the innovative potential facilitates the processes of optimal organization of manufacturing, transportation, sales and supply;

4) information function – the innovative potential contributes to the organization of information flows in the field of scientific, technical and innovation activities, increasing the reliability and efficiency of obtaining information.

Thus, the innovation potential is a comprehensive indicator of the level of development of the innovation activity of the industrial cluster, which characterizes the capability of the cluster members to develop and introduce innovations. The main purpose of the innovation potential is to ensure ultimately its effective use, such a level of cluster development is ensured that would meet or exceed the necessary one.

The management system of innovative potential of the industrial cluster. Management of innovative potential is a system of management actions aimed on the achievements of the goals through transforming resources into innovative products (works, services).

The process of managing innovation potential can be represented in a sequence of stages. So, Knyazev SA [11] identifies six stages of innovation potential management:

1) the definition of the mission, setting goals;

2) development of a basic strategy;

3) the definition of innovative goals;

4) assessment of innovation potential;

5) the development of innovative projects, the choice of an alternative set of options;

6) implementation of the innovation potential in the framework of the selected innovation projects.

A similar point of view is expressed by Reshetnikov A.V. [22], however, in its model there is a cyclicality factor, which allows adjusting the mission, goals and strategies depending on the results obtained. Another example of an innovation potential management model is given by F. Chudakov, highlighting four main management stages [28]:

1) analysis of the position of an enterprise and its prospects on the market, taking into account the existing strategy;

2) the formation of innovative potential;

3) potential analysis;

4) the implementation of innovative potential.

According to the authors, the universal model of managing the innovative potential of an industrial cluster should include the following elements: setting innovative goals; determination of the current level of innovation development; analysis of internal and external factors affecting the level of innovation potential; realization of innovative potential; adjustment of the developed innovation strategy; the presence of «feedback».

On the basis of the research conducted, the authors identified seven stages of managing the innovative potential of an industrial cluster:

1) the formulation of problems of managing the innovation potential of the cluster;

2) the formulation of the goals and objectives of the management of innovative potential;

3) analysis of the current state of innovation cluster development, including analysis of the internal and external environment, as well as the current situation in the market;

4) assessment of the innovative potential of the cluster;

5) development of organizational and economic measures to increase the innovation potential of the cluster;

6) implementation of organizational and economic measures to increase the innovation potential of the cluster;

7) adjustment of organizational and economic measures to increase the innovation potential of the cluster.

The management of the innovative potential of an industrial cluster contributes to the formation of the necessary conditions for its innovative activity, since strategically determines the direction of efforts in the creation of innovative products, works, services, processes and technologies based on the development and adjustment of the cluster's key areas in accordance with changing business environment [6, 20].

The process of managing the innovation potential of the cluster is inextricably linked with the organizational and economic management mechanism that provides this process. In this connection, there is a need to develop an effective organizational and economic mechanism for managing the innovative potential of an industrial cluster, which will allow the efficient use of all the resources and capabilities of cluster enterprises for the implementation of the innovation process.

The management system of the innovative potential of the industrial cluster is part of the innovation management system of the cluster, which in turn is an element of the overall enterprise management system [2]. Analysis of modern management and theoretical foundations of management made it possible to determine the cluster's innovation potential management system as a set of components, including the subject and object of management, strategic attitudes, functions, principles, resources and tools, interconnected and forming a mechanism to influence the innovative potential of the cluster in order to improve efficiency of innovations. In this case, the organizational and economic mechanism for managing the innovation potential is formed by the cluster innovation management system through the components listed above. The model of the innovation potential management system, determining the place of the organizational and economic management mechanism is presented in Fig. 1.

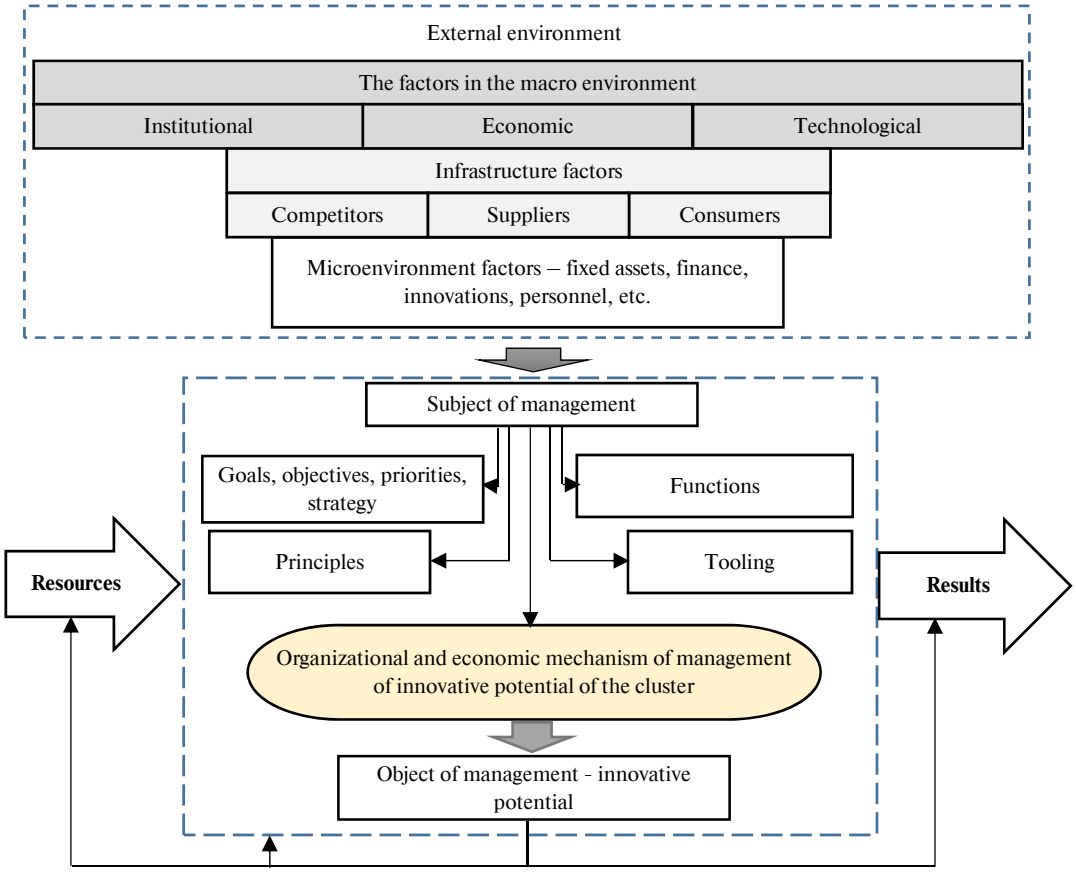

Fig. 1. Model of the management system of innovative potential of the industrial cluster

The subject or governing body is the person or group of persons authorized to make managerial decisions regarding the innovative potential of the cluster. The object of management is directly the innovation potential; the result of management is an increase in its level or the acquisition of new or development of the existing competitive advantages of the cluster in the field of innovation activity.

System «output» – the results of innovation activities – produced innovative goods (works, services) that must be competitive in the market, and also contribute to the achievement of the profitability of the cluster enterprises. As the «input» of the system, various types of resources are considered, including material, financial, labor, production, information resources, etc.

Macro environment, infrastructure and microenvironment that have a direct or indirect impact on the competitiveness, efficiency and stability of the industrial cluster functioning are considered as elements of the external environment [13].

Macro environment factors can be presented in the form of three enlarged groups: institutional, economic and technological factors.

The cluster innovation management system is a highly dynamic system with changing characteristics, and therefore the elements of this system need some coordination of their activities, which is provided by the organizational and economic mechanism for managing the innovation potential of the industrial cluster.

The concept of organizational and economic mechanism. In domestic studies, interest in studying the applicability of mechanisms in the economy in the 70s of the 20th century, when the term «economic mechanism» was introduced, by which was understood the combination of elements of economic management at different levels. Later, the economic literature began to use the terms «economic mechanism», «organizational mechanism», «management mechanism», «financial mechanism», «organizational and economic mechanism», etc. These terms were developed in the works of the authors Abalkin L.I., Osipova Yu.M., Belyaeva A.A., Mocherny S.V., Bunicha P.G., Tambovtseva V.L., Minaeva E.S., Zabredina L.R., Monakhova A.V., Lysenko Y., Egorova P., Mishenina N.V., Kovalenko N.V., Vines A.R., Shmalena G., Kulman A., Burkova V.N., Kondratieva V.V., Raizberg B.A. , Lozovskogo L.Sh., Starodubtseva E.B., Fedorovich V.O. et al. [2–20 et al.].

In the Modern Economic Dictionary [21], the concept of a mechanism is defined as a set of methods and means of influencing economic processes for the purpose of their regulation. Such a point of view is most prevalent, in particular, in the works of SA Egorychev [8], IS Shatilova, NA Slyaeva, MP Tushkanova [31], Holodkova K.S. [32], Nikolaev A. [19] the organizational-economic mechanism is considered as a set of principles, methods, tools, management models, ensuring the achievement of strategic goals.

Tskhurbaeva F.Kh., Farnieva I.T. consider the organizational and economic management mechanism as a multi-level hierarchical system of basic interrelated elements and their typical groups (subjects, objects, principles, methods and tools, etc.), as well as ways of their interaction, including integration and disintegration, during and under the influence of which the economic relations of the state, owners, lenders and personnel are harmonized, including representatives of the top management of the corporation and the society [28].

Authors Titov A.B. and Mashevskaya OV they understand the organizational and economic mechanism of management as a combination of elements that are influenced by external and internal factors, including the processes occurring at the enterprises of the industry, from the totality of which the whole model of control of the object is formed [24].

Gauzhaev A.Z., Ilaeva Z.M., Krolivetsky E.N., Olnev O.K. [12] believe that the organizational and economic mechanism of management should have the following characteristics: efficiency, reliability based on authenticity and modern scientific and technical methods of work, optimal leveling and balance of centralization and decentralization.

Chalenko A.Yu. emphasizes that the organizational-economic management mechanism cannot be considered without a resource component and defines this economic category as a set of resources of the economic process and methods of their connection.

Proponents of the process approach, based on the IDEF0 functional modeling methodology, look at the organizational and economic mechanism of management as a resource management of the process, including a set of interrelated elements that contribute to the process function [21].

According to Uskov A.E. the mechanism cannot exist outside the process, since it is its integrating part aimed at performing process functions only; the mechanism does not have its own governing body depending on control by the external subject; the correlation of the mechanism with the control has an internal meaningful field in terms of statics and dynamics, as well as innovative solutions [26].

In determining the economic essence of the organizational and economic management mechanism, the authors follow a systematic approach and propose to consider it as a set of interrelated elements, including the principles of transforming inputs and outputs, applied functions, applied methods and technologies, as well as organizational and economic impacts of the subject on the object aimed at ensuring the process of managing the continuous development of the facility. The main backbone factor of the control mechanism is its ability to self-control, self-esteem and self-preservation, as well as high adaptability to changes in the external and internal business environment.

In accordance with the proposed definition, we highlight the following features of the organizational and economic management mechanism as a system:

1) the presence of goals and objectives, causing the subject to influence the object;

2) the presence of interrelated elements that form the internal structure of the organizational and economic mechanism;

3) the presence of functions for which the organizational-economic mechanism has been created;

4) availability of resources required for the functioning of the organizational and economic mechanism;

5) the existance of external relations with other mechanisms and processes.

The organizational-economic mechanism is implemented through the impact toolkit – a set of actions of an every tool. The authors distinguish organizational and economic instruments of influence. Organizational ones include: developing development strategies, organizing the implementation of various programs and projects, creating investment attractiveness, etc. The economic impacts include budgeting, financing, auditing, outsourcing, price regulation, etc.

Thus, in accordance with the presented conceptual model, we will consider the organizational and economic mechanism for managing the innovative potential of an industrial cluster as a system, including a set of principles, functions, methods, technologies and relationships between them, as well as ways to influence them in order to increase efficiency implementation of this process.

Results

Development of an organizational and economic mechanism for managing the innovative potential of an industrial cluster. The organizational and economic mechanism for managing the innovative potential of an industrial cluster is shown in Fig. 2.

The object of management is the innovative potential of the cluster, and the subject of management is the management company of the cluster (hereinafter the decision maker – DM), which implements the functions of innovation management. It should be noted that the subject will be affected by such specific internal factors as production and business relations, emerging between cluster members, the level of their innovative development and the specifics of the activity (production, research, finance, sales, etc.).

The purpose of creating an organizational-economic mechanism for managing the innovation potential of a cluster is to increase the effectiveness of its innovation activity and develop its innovation potential.

The objectives of the functioning of the organizational and economic mechanism of managing the innovative potential of the cluster are:

1) maintain the existing and create favorable conditions for the implementation of the innovation process in the cluster;

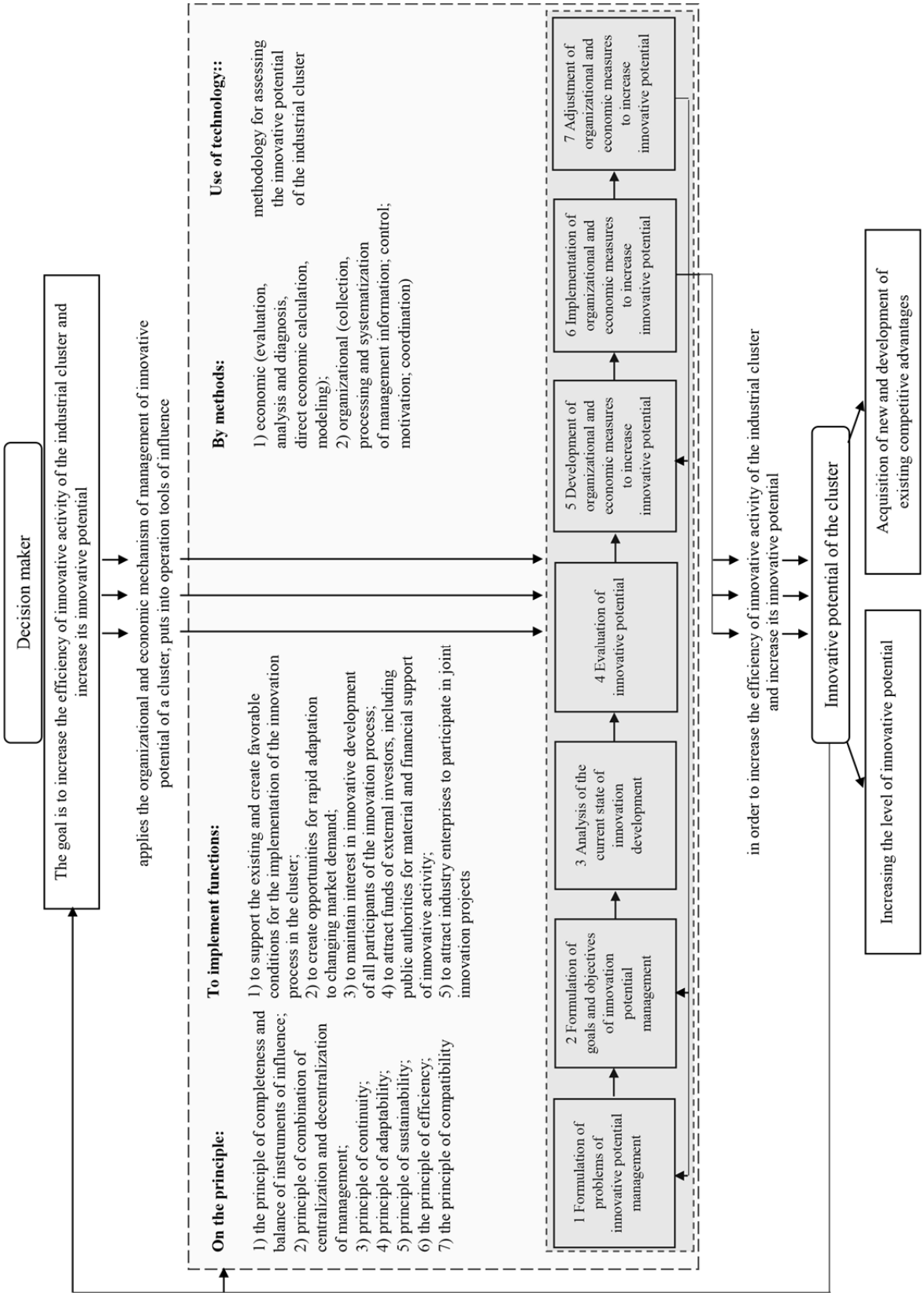

Fig. 2. The organizational and economic mechanism for managing the innovative potential of an industrial cluster

2) to create opportunities for rapid adaptation to changing market demand;

3) to maintain interest in the innovation development of all participants in the innovation process;

4) to attract funds from external investors, including government agencies, for the material and financial support of innovation activities;

5) to attract industry enterprises to participate in joint innovation projects.

As a means of influencing the organizational and economic mechanism on the process of managing the innovation potential of a cluster, the following can be singled out:

1) economic:

– attracting external sources of financing innovation;

– resource provision of the innovation process;

– economic incentives for the development of production and business relations within the cluster and other business entities;

2) organizational:

– organizational and methodological assistance for joint innovation activities of organizations within the cluster;

– organization, coordination and control of the innovation process;

– organization of the system of continuous monitoring of the development of innovation activities in the cluster.

The presented organizational and economic management mechanism is designed to ensure the effective development of the cluster's innovation activities based on the management of its innovative potential.

Effective management of the cluster's innovative potential involves solving the problem of financial sustainability in the long term, as well as solving the problem of sustainable development of the cluster as a whole. In this connection, it is necessary, firstly, to develop the cluster innovative development strategy in a timely manner and formulate on its basis actual goals and objectives for managing the innovation potential; secondly, to systematically evaluate the innovative potential of the cluster; thirdly, to determine the compliance level of the innovation potential of the cluster required.

The coordinated development and interaction of enterprises engaged in innovative activities within the cluster structure forms an innovative system, which is not just the sum of individual components, but a new whole, which causes the appearance of a synergistic effect. This circumstance determines the relevance of improving the organizational and economic mechanism of managing the innovation potential of the cluster, since modern market conditions force us to look for opportunities for a balanced and sustainable innovative development of the cluster through a significant transformation of its innovation management system

Conclusions. During the study, the following results were obtained:

1) the authors' definition of the term «innovation potential of an industrial cluster» is given, which represents it as the ability and ability of cluster enterprises to transform available resources into concrete results of innovation activities;

2) developed a system for managing the innovative potential of an industrial cluster, which is a combination of components, including the subject and object of management, strategic installations, functions, principles, resources and tools, interrelated and forming the mechanism of influence on the innovative potential of the cluster in order to increase the efficiency of innovation

3) the authors' definition of the term «organizational and economic mechanism for managing the innovative potential of an industrial cluster» is given, and the main components of the organizational and economic mechanism are highlighted, among which are functions, principles, methods, technologies;

4) an organizational-economic mechanism has been developed for managing the innovative potential of an industrial cluster, designed to ensure the effective development of the cluster's innovative activities based on the management of its innovative potential.

The organizational and economic mechanism for managing the innovation potential of an industrial cluster is a system of tools and impact processes that are used in practice to obtain innovative results. It should be noted that only the effective and scientifically grounded use of various instruments of

influence will allow to carry out the required influence on the innovation process and to ensure obtaining the desired results.

Thus, the implementation of the organizational and economic mechanism of managing the innovation potential of an industrial cluster allows the structure to fully adapt to the conditions of fierce competition in the market, develop existing technologies and launch new ones, to produce complex innovative products by maximizing the existing innovation potential and increasing it, which ultimately increases the competitiveness of the cluster.

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EVALUATION OF SPECIFICITIES AND MAIN DIRECTIONS OF BUSINESS PROCESSES'S DEVELOPMENT OF THE INDUSTRIAL ENTERPRISE (RESEARCH EXAMPLE RER)

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Scientific and technical progress is inseparably linked with use energy of different forms and potentials, which significantly changed their volumes and types. In modern conditions of development the level of the energy considerably increases consumed by the person, and, therefore, there is a question of environment protection against harmful emissions. Many industrial enterprises are oriented to studying of renewable power which technologies can be used in development of the business processes. Real research is given a characteristic of the present stage of development of the market of the renewable energy resources. The article describes the entity and features of business processes of the enterprise of the industrial sector of economy. The research is carried out an analysis of business processes of the industrial enterprise Électricité de France. In addition, the article describes the main directions of development of the industrial enterprise in the conditions of commercialization of renewable energy resources. Rapid development of technologies of renewable energy resources and the current situation in the world led to consider development of the industrial enterprises in the conditions of commercialization of renewable energy resources as new approach to development of business processes of the enterprises of the industrial sector of economy. Modern conditions appear because of commercialization of renewable energy resources. It becomes necessary for the industrial enterprises adapting flexibly to modify and develop their business processes.

Keywords: commercialization, renewable energy, business process, industrial economy, industrial enterprise, power

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ОЦЕНКА ОСОБЕННОСТЕЙ И ОСНОВНЫХ НАПРАВЛЕНИЙ РАЗВИТИЯ БИЗНЕС-ПРОЦЕССОВ ПРОМЫШЛЕННЫХ ПРЕДПРИЯТИЙ (НА ПРИМЕРЕ ИССЛЕДОВАНИЯ ВИЭ)

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Научно-технический прогресс неразрывно связан с использованием энергии различных форм и потенциалов, которая с течением времени существенно меняла свои объемы и виды. В современных условиях развития уровень потребляемой человеком энергии зна-

чительно повышается, и следовательно, остро встает вопрос защиты окружающей среды от вредоносных выбросов. Многие промышленные предприятия ориентированы на изучение возобновляемой энергетики, технологии которой в дальнейшем можно использовать в развитии своих бизнес-процессов. Дана характеристика современного этапа развития рынка возобновляемых источников энергии (ВИЭ). Раскрыта сущность и особенности бизнес-процессов предприятия промышленного сектора экономики. Проведен анализ бизнес-процессов промышленного предприятия Électricité de France. Выявлены основные направления развития промышленного предприятия в условиях коммерциализации возобновляемых источников энергии. Стремительное развитие технологий возобновляемых источников энергии и текущая ситуация в мире привели к возможности рассматривать развитие промышленных предприятий в условиях коммерциализации возобновляемых источников энергии, как новый подход к развитию бизнес-процессов предприятий промышленного сектора экономики. Государства оказывают поддержку промышленным производствам сектора энергетики и проводят активную политику развития данного сектора экономики за счет применения современных технологий, активного совершенствования бизнес-процессов внутри предприятий и частичного участия в управлении производством. В результате коммерциализации возобновляемых источников энергии создаются новые условия, в которых промышленные предприятия вынуждены существовать, поскольку становится необходимым гибко подстраивать, видоизменять и развивать свои бизнес-процессы. Открывая для себя все большие возможности инвестирования, большинство стран мира нацелены на сотрудничество, взаимный обмен новыми технологиями, ресурсами, финансами. В новых условиях развития сектора энергетики промышленные предприятия вынуждены отвечать новым вызовам, развивать внутренние бизнес-процессы, ориентируясь на новые факторы, влияющие на функционирование и совершенствование производства.

Ключевые слова: коммерциализация, возобновляемые источники энергии, бизнс-процесс, экономика промышленности, промышленное предприятие, электроэнергетика

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Introduction. Development of humanity is inseparably linked with use of energy of different forms and potentials. Throughout the known history of development of a civilization not only sources of the energy changed, but also its volumes, types and potentials. The present stage of development of the world is characterized by the increased consumption of all types of energy, which caused, first of all, an environmental pollution. Fossil types of fuel are characterized by limited resources. This fact is a real problem for the majority of productions of different industries.

Many countries of the world are oriented to development of renewable power which allows not only to reduce the number of harmful emissions in the atmosphere, but also implements an energy saving priority that is especially relevant in a century of «new technologies». A landmark, occurred for the last few years, promoted fixing to renewable energy resources (further – RER) the status of the dominating power source around the world. The energy sector underwent a number of changes which had an impact on changes in development of RER in total and separately. Growth of competitiveness of technological capacities using RER, state programs on questions green economy, conferences on questions of environmental and energy security and low-carbon economy, need of creation of more available energy for the consumer – all this led to creation of the new markets of production capacities and the distributed generation of RER, namely their commercialization.

Research objective. With this in mind, a research objective is a determination of features and the main directions of development of business processes of the industrial enterprise in the conditions of RES commercialization. Due to the research objective it is necessary to solve the following problems:

• give characteristic to the present stage of development of the market of RER;

• reveal an entity and features of business processes of the enterprise of the industrial sector of economy;

• carry out the analysis of business processes of the industrial enterprise Électricité de France (further – EDF) using RER;

• determine the main directions of development of the industrial enterprise in the conditions of RER commercialization.

Research methods. It consists in the analysis of domestic and foreign sources on the studied problems, identifying the specific features of the concept.

The energy sector underwent cardinal changes recently, but 2015 became for development of RER more important. It occurred thanks to the new agreements between countries devoted to problems of need of availability of RER and increases energy efficiency.

The United Nations General Assembly accepted the document «Steady Power for Everyone» that confirmed intention of the majority of the countries about distribution and development of policy on implementation of RER. Many governments agreed to undertake obligations for review of use of hydrocarbon fuel as replacement by «clear» energy. RER provided 19.2 % of the general final consumption of energy in 2014, growth of capacities and development continued also in 2015 [10, 12].

Global investments in RER also reached record level, despite falling of the prices of traditional fuel, the proceeding instability of economy of the countries of Europe and also continuous recession of the prices for unit of rated capacity of the equipment for solar and wind farms. Level of the private investments, enclosed in development of the RER projects, considerably increased for the last 5 years. In addition, the number of banks that are involved in financing of the RER projects increased too.

Along with active development and using of RER technologies on industrial productions, there was a question of effective management of a production, which is understood as the process based on use of modern technologies of management and more perfect forms of its organization. Foreign and Russian scientists are convinced that the solution is in deep connection between adapted management systems at the industrial enterprise and development of its business processes.

In foreign and domestic scientific literature are lots of definitions for the term «business process». According to authors, the most precisely this term described in the work «Reengineering of corporations: revolution in business» by M. Hammer and J. Champi who defined «business process» as «the set of different types of activity within which «on an input» are used one or more types of resources and as a result of this activity at «exit» is created the product which is a value for the consumer» [15]. At the present stage of development of economy restructuring of business on the basis of business processes is adopted by almost all leading companies of the world. It is considered that even partial improvement of business processes of the organization brings effect in the form of increase in production for 10–20 % [17].

Administrative activity at the level of management of the industrial enterprise on the basis of process approach represents continuous execution of a complex of the certain types of activity interconnected among themselves and the general functions of management. However, it should be noted that execution of separate works and functions of management is also considered in the form of process, i.e. the general process is set of the interconnected continuously performed operations transforming some inputs of resources, information, etc. to the corresponding results [11, 16]. In general, management – is the establishing value and an entity of process approach. The description of business processes at the enterprise can be different, but its basis is tracing of accurate structure of all interrelations of participants of processes of production activity. At

the same time, each business process should have the beginning – an input, consistently carried out flows of works, the end – an exit.

Improvement of business processes at the industrial enterprises allows to create the whole complex of strategic advantages and to provide higher level of a competitive stability. Often the industrial enterprises apply the innovation technologies to increase in efficiency of business processes of the complex hierarchical structure of production. The present stage of development of economy differs in the increased level of robotization of many industries and use of «smart»-technologies for increase in overall performance of the industrial enterprise in general.

Commercialization of RER has a positive impact on functioning of the industrial enterprise, thanks to development of its internal business processes. In total technologies of RER and «smart»-developments give the chance to increase growth rates of production capacities, to increase efficiency of functioning of the enterprise, to improve quality of products and to take care of the environment [4, 6].

The French energy company Électricité de France (further – EDF), which is in the lead in the market of the generating enterprises, is the most striking example of how to make use of the accumulated experience and knowledge together with RER technologies for development of all the business processes to construct stable and competitive production of the generating sector as much productive as it is possible [8]. The company began the development in post-war years, and now thanks to the accumulated knowledge and experience is the first company in using of RER on the productions.

EDF is concerned about green economy of our planet and «green» future of humanity. Its research department is oriented to maintenance of the «green» future of our planet and application of RER for reduction of emissions of toxic substances in the atmosphere and receiving «clean» energy, which is the most energy efficient resource for providing «green» life of consumers.

In 2008 EDF Énergies Nouvelles constructed (one of the first) a solar farm with the biggest rated capacity in Europe. EDF already has a large number of low-carbon power plants which use hydraulic power, nuclear energy, and wind energy and also new types of RER. A huge number of investments invest in development of new technologies of the next generation which do not release CO_2 into the atmosphere.

EDF uses different types of RER for creation of productions of new generation:

1) nuclear energy: in France the EDF company builds the first nuclear reactor of new generation of EPR in Flamanville (Manche). His first produced kW · h was sold by the EDF company in 2016. Nuclear projects of the EDF company made significant progress in three countries: China, the USA and Great Britain which made a decision to restart production of nuclear energy;

2) wind energy: around the world EDF Energies Nouvelles started more than 3.500 MW of rated capacity, and power is received more than from hundred wind farms;

3) solar energy: EDF Energies Nouvelles had 494.1 MW of pure ability in the course of construction. By the end 2017 this indicator grew to 500 MW;

4) biomass: the representative office of EDF manufactured 1.5 billion kW· h in Poland in 2016. More than 1 million tons of biomass was used by production [7].

The power plants of EDF using coal make only 9.8 % of all company enterprises. EDF upgrades the old power plants for increasing an efficiency of their work and reduction of emissions of CO_2. EDF used supercritical power plants and gas turbines with the combined cycle for increase the power of the productions. In France, the oldest power plants burning coal were closed in 2015.

They were replaced with gas turbines with the combined cycle, which are more effective in power generation and emit less CO_2 [9]. EDF also continues to work on collecting and storage of carbon. The Havre power plant burning coal uses this special technology in an attraction mode. In Great Britain EDF began construction of 3 gas turbines with the combined cycle on the Western Burton with the rated volume of 1.311 MW [5].

The ecological directions in the innovation activity of the EDF, directed to power generation of the future and to development of access to energy, require special attention. Martiga Gas with the combined cycle is the first experience of using new technology on productions in the Europe countries. Thanks to a double turbine system, with the same fuel quantity, the gas works with the combined cycle produce twice more electricity, than traditional thermal power plant, and throw out less CO_2 [3]. The first turbine of combustion burns down fuel, and gases selected with this combustion, turn the turbine to fill the first transformer. At the same time, water is transformed to steam in contact with hot gas blowouts. This steam turns the second turbine, which fills the second transformer with electricity. Gas works with the combined cycle are adapted to the increasing fluctuations in energy consumption better, and they are more energy saving and are harmless to the environment. They make smaller number of harmful emissions in the atmosphere, than stations of standard power because of using the unique technology of gas.

The originality of the technology applied at the plant in Martige consists in conversion of one unit using oil in 2 combined cycles, everyone with the rated volume of 465 MW, functioning with natural gas [2]. This hi-tech process, which is originally developed for use in the industry of aeronautics, consists in use of some installations (especially steam turbine and the pump station) in connection with new elements of new unit (the combustion turbine, a recovery boiler, reuse of the generator of a turbo transformer, a cold source of the current sections using oil). By estimation, this project will become the most large-scale in the field of power industry across the Europe. Construction of 2 plants with the combined cycle in Martige would require €500 million investments [7].

The plant in Rosière-en-Haye is one of the largest plants of solar energy in Europe. The plant consists of 1.5 million solar panels with the rated volume of 115 MW. The area on which there is a plant is 367 hectares from whom 120 hectares occupy solar panels. Every year the plant makes an equivalent of annual consumption of electricity approximately on 55,000 inhabitants [9].

Photovoltaic solar batteries at the Rosières-en-Haye plant were developed, using the technology of the next generation known as «thin membrane». This technology alternative to the traditional units made of silicon allows adapting to variable conditions of the sun of Lorraine easily.

Research result:

1. The characteristic of the modern stage of development of the market of renewable energy sources is given.
2. The essence and features of business processes of the enterprise of industrial sector of economy are revealed.
3. The analysis of business processes of the industrial enterprise Électricité de France with the use of renewable energy sources is carried out.
4. The main directions of development of the industrial enterprise in the conditions of commercialization of renewable energy sources are revealed.

EDF only a few years ago began to conduct policy of «green» production as most the large international companies are anxious with the corporate and social image, state of environment and profit markup and increase in efficiency of the made products. However, the company can admit what success it achieved in development of the production capacities thanks to RER technologies.

Summing it up, RER is profitable business, especially for those productions having rather developed production capacities, which can qualitatively and quickly make processing and receiving clean energy now. To my way of thinking, new technologies arising thanks to new researches of the market of RER are the most competitive instrument of development of business processes of the industrial enterprises.

Summary. In the final analysis, the executed research allows to draw the following conclusions. Active development of RER technologies and the current situation in the world led to the fact that development of the industrial enterprises in new

conditions, namely commercialization of RER; it is possible to consider new approach to development of business processes of the enterprises of the industrial sector of economy.

Attention of the environment and creation of new technologies gave an impulse to deeper studying of opportunities of RER which were appreciated only a few years ago. The largest industrial enterprises are aimed at use of RER technologies for the purpose of creation of the stable, effective production making not only high profit, but also the «clean» product harmless to consumers and our planet.

The majority of the countries of the world are aimed at cooperation, mutual exchange of new technologies, resources, finance. Even more often, the states began to give support to industrial productions of the energy sector and to pursue active policy of development of this sector of economy, due to use of modern technologies, active improvement of business processes in the enterprise and partial participation in production management [1].

The French energy company EDF, leading in the market of the generating enterprises, is the most striking example of how it is productive to make use of the accumulated experience and knowledge in management together with RER technologies for development of all the business processes to construct stable and competitive production of the generating sector. This enterprise underwent a set of instructural changes, which rendered both positive and negative effect on development of administrative communications of production.

In new conditions of development of the energy sector, the industrial enterprises are forced to answer new calls, to develop internal business processes, being guided by the new factors influencing functioning and improvement of production. At this stage, it is possible thanks to use of RER technologies and active development of the new products of the industrial sector of economy possessing new functions.

In relation to EDF it was shown in the form of implementation of pilot projects which allowed reducing the number of emissions of CO_2 in the atmosphere by 61 % [13, 14].

Directions for further research. Finally, commercialization of RER gives an impulse and continues to stimulate productions of the industrial sector of economy not only to a solution of important problems of consumers, the environment, but also issues of effective management of the enterprises in general, because new conditions, in which they are forced to exist, differ in need flexibly to arrange, alter and develop the business processes. Experience of development and deployment of RER technologies in business structure of the industrial enterprises creates premises for creation of new strategy of management of the enterprises in modern conditions.

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ORGANIZATIONAL AND ECONOMIC PROBLEMS OF APPLYING QUALITY MANAGEMENT SYSTEMS AT ENGINEERING COMPANIES

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Different management systems, including quality management systems, are widely used in enterprises and organizations nowadays. The procedure for establishing and effectively using quality management systems is regulated by the system of national standards. At the same time, the approaches to organization and the performance of quality management systems in enterprises depend on the personnel's training, knowledge and understanding of existing regulations in the field of standardization and technical regulation. The main problems of effective quality management using quality management systems arise from inept application of existing regulations and a formal approach to organization and management of quality management systems. This primarily happens due to lack of involvement of the staff, lack of understanding of the role and responsibility of the process owner. Ensuring the required quality of processes is achieved by hiring competent managers and specialists for the enterprise. This means that human resources are sufficiently prepared, with a quality system of motivation and a high corporate culture. The company has created a system of information support, electronic document management system. In many enterprises, QMS documents are maintained by quality services, which are perceived as units solely responsible for maintaining the quality management system in working condition. Unfortunately, the functions of quality services are often limited to maintaining the QMS documentation in working order. However, all units of the enterprise must have the required documentation for the QMS available and keep the records prescribed by the QMS documents, the employees should know the contents of QMS documentation, have the skills necessary for document management. A formal approach to quality management systems in enterprises means that the resources allocated to maintaining the management system are used inefficiently. The article gives a brief analysis of the specific problems arising in application of quality management systems and the main directions for eliminating non-compliance of systems with the requirements of federal legislation and normative documents in the field of standardization. We have emphasized that the basic principle of building a quality management system in the enterprise should be the adapting the system to the needs of the enterprise while complying with the national standards of the Russian Federation. This paper presents a generalized view of scientists and specialists on actual problems encountered in implementing QMS in enterprises. We have proposed specific practical solutions (recommendations) formed on the basis of practical construction and application of the QMS.

Keywords: management system, import substitution, process approach, quality records, local normative documents, national standardization system, audit, planned documents of quality assurance

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ОРГАНИЗАЦИОННЫЕ И ЭКОНОМИЧЕСКИЕ ПРОБЛЕМЫ ПРИМЕНЕНИЯ СИСТЕМЫ МЕНЕДЖМЕНТА КАЧЕСТВА НА МАШИНОСТРОИТЕЛЬНОМ ПРЕДПРИЯТИИ

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В настоящее время на предприятиях и в организациях широко применяются различные системы менеджмента, в том числе системы менеджмента качества. Порядок создания и эффективного применения систем менеджмента качества регламентируется системой национальных стандартов. Вместе с тем подходы к организации и результативность системы менеджмента качества на предприятии зависят от подготовленности персонала, знаний и понимания действующих нормативных документов в области стандартизации и технического регулирования. Основные проблемы эффективного управления качеством с применением систем менеджмента качества возникают при неумелом применении действующих нормативных документов и формальном подходе к организации и управлению системой менеджмента качества. В первую очередь, из-за недостаточной вовлеченности персонала, непонимания роли и ответственности владельца процесса. Обеспечение требуемого качества процессов достигается при наличии на предприятии компетентных руководителей и специалистов. Это значит, что кадровые ресурсы имеют требуемый уровень подготовленности, качественную систему мотивации персонала, высокую корпоративную культуру. На предприятии создана система информационного обеспечения, электронная система документооборота. На многих предприятиях ведение документов СМК возложено на службы качества, которые воспринимаются как подразделения, исключительно ответственные за поддержание системы менеджмента качества в рабочем состоянии. К сожалению, функции служб качества часто ограничиваются поддержанием в рабочем состоянии документации СМК. Вместе с тем в подразделениях должна быть необходимая документация СМК и должны вестись все предусмотренные документами СМК записи; работники должны знать содержание документации СМК, умело её оформлять и обеспечивать документооборот в соответствующей части. Формальный подход к применению систем менеджмента качества на предприятиях приводит к неэффективному использованию ресурсов, выделяемых на ресурсное обеспечение системы менеджмента. Дан краткий анализ конкретных проблем, возникающих при применении систем менеджмента качества и предложены основные направления по устранению несоответствий систем требованиям федерального законодательства и нормативным документам в области стандартизации. Подчеркнуто, что основным принципом построения системы менеджмента качества на предприятии должно быть построение системы менеджмента качества под нужды предприятия, с соблюдением требований российских стандартов. Получено обобщенное мнение ученых и специалистов по актуальным проблемам, возникающим при реализации СМК на предприятиях. Предложены конкретные практические решения (рекомендации), сформированные на основе практического построения и применения СМК.

Ключевые слова: система менеджмента, импортозамещение, процессный подход, записи о качестве, локальные нормативные документы, национальная система стандартизации, аудит, плановые документы обеспечения качества

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Introduction: Creating and maintaining quality management systems (QMS) at machine-building enterprises can be stimulated by several objective needs, including:

– the need to ensure the competitiveness of products;

– compliance with the terms of contracts for supply of products;

– compliance with the mandatory requirements of regulatory documents for certain types of products.

At the same time, as practical experience of machine-building enterprises shows, introducing QMS causes certain difficulties for company managers. A number of significant problems arise in practical implementation of QMS, first of all, of overcoming the internal resistance of workers to changes in work organization. The problem that occurs quite often when building a QMS is that specialists or managers of the company do not always fully understand the amount of work they will have to do after they receive the QMS certificate. The lack of necessary time and human resources for developing QMS leads to the situation when the QMS becomes ineffective and is a pile of outdated and obscure documentation [1].

The following problems were identified in maintaining QMS. First of all, the cost of maintenance is too high for external audit; employee motivation is low there is little continuity. A separate problem are frequent internal audits. An important problem is the lack of material incentives from the state. If the enterprise's specialists have to spend additional time on creating the QMS, with the enterprise spending extra funds on improving their skills, lack of material support certainly has a negative effect on the economic performance of the enterprise [2].

The authors of the works on QMS [3–] also highlighted a number of problems arising from implementation of QMS in terms of domestic production. There are two classes of problems:

– problems of introducing the QMS;

– problems of maintaining the QMS.

Enterprise management are often incapable of redefining their responsibilities. There is some inertia in the thinking of specialists. The increase in workflow due to using QMS proved problematic for specialists. Identifying and analyzing the risks of the production process caused difficulties. Additional complications were caused by planning the integration of QMS due to additional load on the staff of the enterprise.

If the specialists of the enterprise have to spend additional time on creating and maintaining the QMS and the enterprise spends funds on improving the skills of the specialists, lack of material support, of course, has a negative impact on economic performance of the enterprise. As a result, the QMS is often viewed as a perfunctory measure that has to be taken for the sake of appearances. There are enterprises where QMS is implemented only nominally.

One of the main problems of Russian quality management is that the economic conditions in the country differ from the conditions in which the principles of Western quality management were born, i.e., it is a tool for solving problems that the Russian manufacturers have not yet faced. Using the tool for purposes other than the ones it was intended for leads to different results [6].

According to researchers, about 80% of all defects detected in manufacturing and using products are due to insufficient quality of the processes of developing the concept of the product, design and preparation of its production. The reason for about 60% of all failures that occur during the warranty period is in erroneous, hasty or imperfect development. It was revealed that development and manufacturing of a product has a tenfold cost rule: if an error is made at one of the stages of the product quality circle and detected at the next stage, 10 times more money has to be spent on correcting it compared to what it would take if the error was detected on time. If the error is detected in the second stage after it was made, 100 times more money has to be spent, 1000 times more in the third stage, etc. [7]. We come to another conclusion [8]: in addition to the control functions, serious analytic tools are mandatory for use in the QMS, and the analysis should be presented in business terms that are clear to management.

Taking into account the identified problems that occur in construction and application of QMS at the enterprises of mechanical engineering, the topic of the study is relevant and calls for developing solutions to eliminate these problems.

The goal of the study is to analyze the organizational and economic problems of applying the quality management system at a machine-building enterprise and to develop practical proposals (solutions) for improving this system.

Research methodology: Based on analysis of positive (effective and efficient) experience in implementing the QMS at machine-building enterprises of the Russian Federation, practical experience and expertise in managing QMS at machine-building enterprises of serial and individual production, we have highlighted significant problems in application of QMS, proposing methods solving these problems in practice.

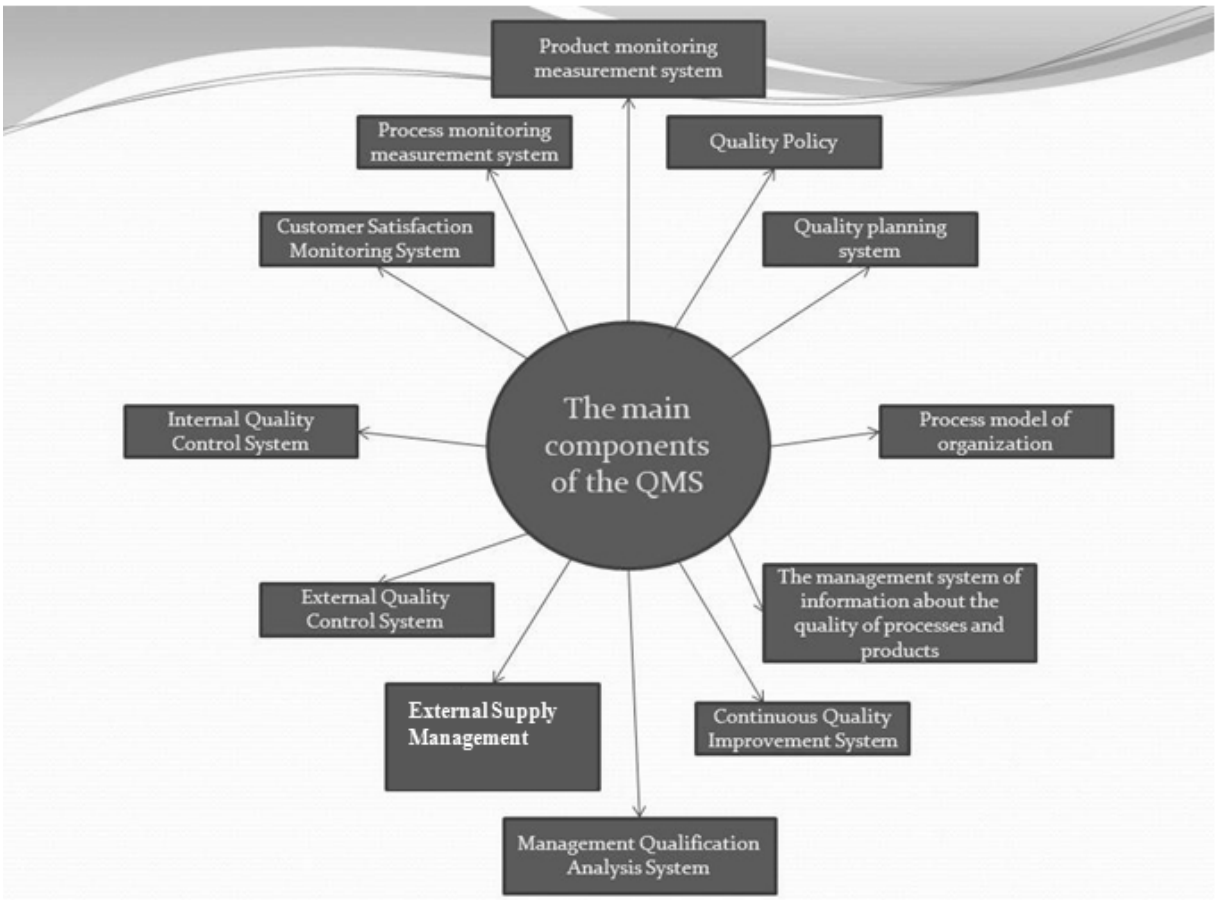
According to modern views [9], the QMS includes a number of components that allow implementing quality management in full (Figure).

Let us consider the typical cases when QMS do not comply with regulatory documents, principles of system and process approaches that occur in industrial enterprises with respect to all elements of quality management systems.

1. Competence in continuous quality improvement. Organizational problems.

Personnel training for implementing QMS processes may either skip the planning stage or involve redundant planning with unreasonable expenditure of resources.

The process of personnel training is not always focused on study of local regulations describing the processes of the first level.



Main components of QMS (9)

Local regulatory documents do not always comply with the requirements of regulatory legal acts (documents of federal legislation, regulatory legal acts of an enterprise, and requirements of national and interstate standards). The most important condition for successful functioning of the QMS is forming an understanding of the essence of the QMS and the role of the employee's personality, instilling the desire to work effectively within the QMS. While that is certainly true [10], a company's employees can be given the best tools, machines and equipment, but if they do not want to work efficiently, all of the employer's efforts will be a waste of money and time. Ideology is needed to form public opinion. For example, the principle «It is a shame for a good person to work badly» is promoted in Japan. In the US, quality is often compared with religion. People cannot be made to believe in God. The same principle works for quality. Employees cannot be forced to do something, but they can be convinced, with an appropriate motivation built up for projects, companies or the whole society. An understanding of the psychology of the employee is needed in order to be able to convey the basic principles of quality to the employees.

Solutions: Creating a unified plan for training personnel on QMS, forming annual financial applications for training in sync with the formation of the enterprise budget. Training employees to understand their role in the QMS. Forming an understanding of the role and business qualities of process owners.

2. System for managing the information on quality of processes and products. Documented information management.

Problems: There is no systematization and normalization of records on the quality of manufactured products or services (no catalogs of documents on quality, no record of forms, no requirements for the composition of details and attributes). The staff is not acquainted with and/or is not guided by the requirements of Part 1 of Article 17 of the Federal Law of October 22, 2004 N 125-ФЗ «On Archival Affairs in the Russian Federation», including the List of typical archival documents formed in the scientific, technical and production activities of organizations indicating the storage period (approved by Order of the Ministry of Culture of Russia dated July 31, 2007 N 1182), in accordance with which employees of the enterprise are obliged to preserve records on quality. A significant systemic problem is the lack of coordination of the requirements of local regulatory documents (enterprise standards/organization standards) with the regulatory legal acts of the enterprise (regulations, manuals, instructions). This problem [11] is due to lack of documented procedures for conducting legal expertise of documents in the field of standardization, including those describing QMS processes.

Solution: Organizing archives and repositories for storing records at the enterprise. Organizing legal expertise of projects of local regulatory documents at the enterprise.

3. System of internal quality checks. Internal audit.

Problems: The requirements of the standardization work plan are not always taken into account in audits of business units within the framework of QMS. The competence of auditors on internal audit issues is not always controlled, which significantly reduces the effectiveness of scheduled inspections. The possibilities of unscheduled audits (including control of volatile production) initiated by the enterprise quality service based on analysis of statistics on failures (non-conformities) are not fully realized. There is a lack of human resources (competent specialists) for conducting audits.

Solution: Maintaining a single plan of work on standardization in the enterprise. Directing competent employees from the technical services of the enterprise to conduct audits.

4. System for controlling external suppliers. Analysis and evaluation.

Problems:

4.1 The possibilities of statistical analysis of product quality are not fully realized within the framework of the quality management system in industrial enterprises, especially those manufacturing serial products, and the process is often formal. The enterprises of individual production are also not fully implementing the results of statistical analysis of inconsistencies that arise during product verification and processing complaints.

4.2 When organizing verification (input control) of materials, semi-finished products and components (hereinafter referred to as CMSFP), enterprises do not always take into account the CMSFP share in the cost of manufacturing products, which does not allow rationally allocating resources for implementing input control operations. Statistics of inconsistencies caused by suppliers is not taken into account. Modeling of verification, in particular to substantiate that it is carried out at the territory of suppliers of CMSFP, is not always applied. Organization of verification, taking into account the quantity of CMSFP nomenclature used, is subject to modeling using economic criteria and cost items (including accounting for storage, transportation, depreciation of storage facilities, etc.).

Solutions: Input control and analysis of claims and reclamations provided by competent specialists from departments. Standardization of the list of works on analysis of statistics of inconsistencies (development and application of the organization standard), terms of information processing and decision-making reflected in the local regulatory acts of the enterprise.

5. System of continuous quality improvement. Improvement.

Problem: The dynamics of improvement in the QMS of enterprises does not fully correspond to the dynamics of new risks, which entails untimely redistribution of resources for implementing QMS processes.

Solution: Providing for an adequate reserve of financial resources for overhead costs in planning the budget of the Quality Service for the year preceding the planned one, based on analysis of statistics of inconsistencies.

6. Process model of organization. Leadership.

Problems: Creating and organizing the operation of the unit for standardization and technical regulation deserves special attention. The most important factor hindering the process of introducing and certifying QMS [11] in our country is not so much unstable economic situation of the enterprise or lack of economic incentives to intensify activity in the industry but insufficient level of knowledge of managers and specialists of enterprises about international standards and new approaches to issues of quality.

It is commonly believed that, according to the system of ISO QMS standards, [12], what matters the most is not blind adherence to standards but orientation towards competitive quality. The latter includes not only contractual relations between the supplier and the customer, but also complete satisfaction of the needs of the client (consumer). The desire to please the client, the continuous monitoring of quality and its constant «improvement» create a culture of quality that is significantly different from that based on a system of simple adherence to standards.

At the same time, it is impossible to ignore the fact that standardization works are the implementation of state economic management, for which an enterprise should have a specialized unit (center) organizing information support of the enterprise, carrying out standardization planning, organizing development, application and control of executing standardization documents including QMS documents. An important aspect in organizing standardization is subordination of the standardization unit to the top management of the enterprise. Combining the functions of the QMS unit and the standardization unit creates unreasonable redistribution of management functions, contradictions in organization of standardization planning.

Solutions: Separating the standardization unit into a separate functional unit answering to the top management of the enterprise.

7. System for managing information about the quality of processes and products. Infrastructure.

Problems: When building (upgrading) the QMS, attention should be paid to the information support of the QMS processes.

Description (normalization) of processes in an enterprise, as a rule, is carried out in the form of standards of the organization (enterprise). Standards set requirements to implementing processes, the procedure for developing standards, their implementation and use, relating to the types of activities and processes in a given organization. The design and content of standards of an organization must comply with the requirements of GOST R 1.4-

2004 «Standards of organizations. General Provisions» and GOST R 1.5-2004 «Standardization in the Russian Federation. National Standards of the Russian Federation. Rules for the construction, presentation, design and designation».

The main tasks within the framework of QMS information support are creating a complete set of standards describing the QMS processes and keeping them up to date. Considering the significant time resources required for developing (cancellation) and updating of standards (from 2 to 9 months for development and approval of a draft standard), the work should be carried out in a planned manner, taking into account the load of the executive units.

Information support may also include procurement and application of foreign regulatory documents, which also requires significant financial and time resources. Of particular note are possible risks of using foreign regulatory documents, namely the risks of using documents that have lost their relevance and the risks of violating license agreements. If foreign standards are used, attention should be paid to licensing of technical translations of standards.

The modern economy is developing in terms of digitalization and is characterized by transition of all its constituent sectors to the information telecommunications platform [13], including transition to using standardization documents on electronic media and placing them in electronic databases of enterprises. The problem of risks (intentional and unintentional) [14] of information leakage arises in the given conditions of information support. The information included in the standards may contain trade secrets, which implies the development of a system for protecting information placed on paper and especially on electronic media.

As a rule, the acquiring, account and storage of regulatory documents in the field of standardization (including original documents) are carried out by the standardization department, which also calculates their needs, reproduces them in the required quantity, and provides copies to the corresponding departments of the enterprise.

Regarding the documentation acquired for execution of contracts, special attention should be paid to the deadlines for production of these documents and timely financing of the process of procurement of documents in the field of standardization. There are risks that contracts might not be fulfilled if the documents are delivered with delays.

Solutions: Creating a system for accounting (on electronic and paper carriers), reproducing and delivering regulatory documents in divisions at the enterprise. Keeping statistics on the cost of procurement and translation of regulatory documents. Timely execution of budget requests for financing information support of production in the year preceding the planned one. Organizing continuous monitoring of the relevance of regulatory documents used by employees in departments of the enterprise when implementing QMS processes.

8. Activities at the stages of the life cycle of products and services.

Problems: In ensuring the conformity of products, it is important to technically and economically justify organization of operational and acceptance controls at the stage of production, performance of works, and provision of services.

So, for example, the main factor in the quality management system in construction organizations [15] is technical quality control, including such active factors as self-control of direct executors, continuous operational control by line production personnel (foremen and workers) and statistical operational sampling control carried out by special personnel of quality management services. The system of operational and acceptance control of product conformity is also widely used at the enterprises of mechanical engineering.

Significant risks of inconsistencies and defects during operational and acceptance control may result from:

8.1. Using metrological assurance tools that do not meet the requirements of the design and technological documentation;

8.2. Involving incompetent employees of technical control units;

8.3. Delayed decisions to eliminate inconsistencies (implementation of corrective and preventive actions);

8.4. There may be risks of mismatch between the amount of resources used in implementing preventive actions and expected losses in case of potential inconsistencies;

8.5. An essential aspect of organizing quality control is the completeness and relevance of control operations in the manufacture of products (performing works and providing services). As is known, control operations are formed and included in technological processes, as a rule, at the stage of development. In this regard, it is important for the division implementing the QMS management functions to ensure timely identification of the necessary control operations (guided by previous experience in manufacturing products) and including them in the technological processes at the stage of development.

8.6. Understanding the role of the QMS at machine-building enterprises [16] is often reduced to organizing control by quality departments, preparing corrective and preventive actions and implementing them by production units. The QMS also stands above the processes and achieves product quality by other means: by controlling the quality of the processes through internal and external audits, calculating KPI. The report on defects for the QMS is only a «signal»: the defect could have occurred not during the final operation, but in any link in the chain. The task of the QMS is to find the causes and outline measures to eliminate the defects. It may be necessary to change the supplier, or the design of the site, or technology, up to developing a new project for modernization of production. The result of this analysis are the ongoing measures on quality and large investment projects.

According to Deming, quality control is an unnecessary function. Quality must be built into the product and process. Unfortunately, for the majority of Russian enterprises focused on physical labor, quality control is the most important element of the process. Therefore, participation in the QMS, the use of QMS tools is a function of all interested employees, from shop personnel to enterprise management.

8.7. An important activity of the quality management division is the preparation of planning documents for ensuring the quality of products. A formal approach to the preparation and application of this category of documents entails the risk that the products are not delivered on time.

Let us consider typical problems in design and application of quality planning documents:

– including operations that do not correspond to the applied technological processes in the control plans;

– including forms of reporting documents on quality (records) not used by the given enterprise in the quality plans;

– status of control points does not correspond to significance of control operations;

– not including planning documents about quality in the terms of the contract;

– procedure for inviting representatives of the customer to monitor operations and notify departments of the enterprise is not carried out on time.

Solutions: Considering the significant resources of the enterprise (with large amounts of employees involved in QMS) necessary to ensure effective use of the existing QMS, complex automated control systems within the existing QMS are vital for resource provision.

Organizing the work of the chief metrologist in accordance with the requirements of the national standards of the Russian Federation.

Developing and organizing the execution of the documented procedure governing the preparation and execution of planning documents in the field of quality.

Researchers note [17] that the management of many companies seeks to obtain an ISO 9001 certificate to achieve a purely tactical marketing effect. Such activities are aimed more at imitation than at fulfilling the requirements of the ISO 9000 series.

Considering the above typical inconsistencies arising from implementation of the QMS in enterprises and in order to build an effective QMS of the enterprise, it is important:

– to implement the above features of the processes at the stage of creating the QMS;

– take into account the comments of certifying authorities when modernizing the QMS;

– when training personnel, to ensure that the employees understand production and QMS as a social and technical system;

– pay special attention to the rigid connections of interacting processes (to ensure the coupling of the inputs and outputs of the processes).

Thus, we have formulated specific proposals for improving the existing quality management systems, taking into account the generalized and practical experience of the enterprises of mechanical engineering of the Russian Federation, recommended as guidelines when creating the QMS.

Findings. In order to solve organizational and economic problems arising in application of quality management systems in machine-building enterprises, we propose practical solutions (coinciding with the views of a number of researchers) to ensure the effective functioning of the QMS in machine-building enterprises, including:

1. Form models for developing QMS for the enterprises based on the given resource opportunities;
2. Justify and propose a method of choosing a rational structure of QMS for a particular enterprise taking into account the nature and scale of production.
3. Justify and propose methods and tools for the management factors in the sustainable operation of the QMS of the enterprise.
4. Find opportunities [18] to continuously improve and perform, carry out the measures needed to fulfill the needs of consumers and meet their demands.
5. Make sure that employees of the enterprise understand their role as owners of processes [19, 20], providing legal independence and specific responsibility within process implementation that are certain and clear to the worker.
6. Apply the practice of legal expertise in developing local regulations, including standards.
7. Ensure legal coordination of the units developing documented procedures.
8. Reduce the time to make decisions to eliminate inconsistencies based on the results of statistical analysis of product quality.
9. When implementing QMS processes, take into account the requirements of standardization documents incorporating elements of the state economic policy. Find a compromise with QMS documents. Make legally sound decisions.
10. Organize information support of the enterprise taking into account requirements of the state and international legal documents.
11. Particular attention should be paid to application of documents in the field of quality. Provide the appropriate legal status, regulated treatment, competent use and storage in accordance with applicable law for these documents.

In order to successfully implement the above proposals for addressing the problems of QMS application in engineering, it is advisable to be guided by the principles of complexity and consistency of decisions.

The solutions we have proposed for solving organizational and economic problems of the QMS at the enterprise imply that the management makes purposeful and conscious changes to the philosophy of organizational development towards quality, increased responsibility and motivation of the staff.

Directions for further research. Further research on the experience of creating and applying QMS in industrial enterprises will be dedicated to analysis of inconsistencies with the requirements of QMS regulations and to developing practical techniques and methods for improving quality management systems.

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INVESTIGATING THE INFLUENCE OF ACCRUED EXPENSES ON THE EARNED VALUE ANALYSIS OF A PROJECT

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Project Earned value analysis (PEVA) is a project performance assessment tool considered to be one of the best-known methods to control and monitor project progress. The earned value analysis assesses the three main aspects of any project: cost, schedule, and scope, and can be used to identify early indications of project performance, enabling project managers not only to identify project progress, but also to control it and hence take corrective actions. The earned value concept allows cost managers to manage projects optimizing time and budget goals, and to identify when the project is behind or ahead of schedule, under- or over-budget, using performance indices and variance parameters. However, implementing PEVA is not without limitations, such as not taking late invoices or purchase orders into account, which results in inaccuracy of actual costs which can significantly affect the outcome and consequently provide an incorrect indication of project progress. This paper outlines the basic format of the earned value analysis, concisely explaining how earned value analysis can be implemented. Moreover, it explores challenges associated with PEVA implementation such as inaccuracy of actual costs, and how accrued costs can be used to tackle this challenge. It also aims to raise awareness regarding accrued expenses and how the tool can be used to address the issue of late invoices in order to help practitioners improve reliability when implementing the earned value analysis tool. In this paper, PEVA has been applied to a real construction project at Petroleum Marine Services Company (PMS), and the findings show that accrued costs enhance the reliability of PEVA.

Keywords: earned value management, cost control, project management, accrued expenses

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АНАЛИЗ ВЛИЯНИЯ НАЧИСЛЕННЫХ РАСХОДОВ НА ОЦЕНКУ ЭФФЕКТИВНОСТИ ПРОЕКТА В МЕТОДЕ ОСВОЕННОГО ОБЪЕМА

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Метод управления освоенным объёмом – система методик, объединённых под общим названием, использующихся для измерения и контроля эффективности выполнения проектов. Он широко применяется за рубежом, а в России только набирает популярность в проектном

управлении с учетом обновления Practice Standard for Earned Value Management, PMI. Данный метод применяется в финансовом управлении проектами или в рамках контроллинга крупных проектно-ориентированных организаций. Метод соединяет в себе анализ всего объема работ по проекту с планом выполнения работ и стоимостью его выполнения. Он основан на применении ряда числовых показателей, рассчитываемых по ходу проекта, и может использоваться для ранней диагностики и контроля эффективности выполнения проекта. Концепция освоенного объема позволяет управлять проектом, оптимизируя временные и бюджетные цели, а также идентифицировать опережение или отставание проекта от намеченных этапов и/или от запланированного бюджета на основе индексов результативности и параметров отклонений. Метод управления освоенным объемом имеет ряд ограничений: например, он не учитывает счета к оплате и заказы на приобретение товара, что приводит к неточностям в подсчете реальных затрат. А это, в свою очередь, может сильно повлиять на конечный результат и исказить картину исполнения проекта. Цель исследования – анализ влияния начисленных расходов на оценку эффективности проекта в рассматриваемом методе. Изучены особенности применения метода управления освоенным объемом, проведен анализ его недостатков, например неточности подсчета реальных затрат. Предлагается усовершенствовать метод управления освоенным объемом путем добавления в подсчеты данных о начисленных расходах и «поздних» счетах. Усовершенствованный подход иллюстрируется подсчетами, проведенными на реальных данных строительного проекта Нефтяной морской сервисной компании (Petroleum Marine Services Company, PMS). Показывается, что учет начисленных расходов увеличивает надежность применения метода управления освоенным объемом.

Ключевые слова: метод управления освоенным объемом, контроль издержек, управление проектами, начисленные расходы

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Introduction. The Project earned Value Analysis (PEVA) is a very effective tool that is mainly used to assess ongoing project performance and progress in quantitative measures at any point during the life of the project against a baseline plan or expectations. It involves the integration of schedule, work scope, and cost. PEVA compares original cost estimates to the actual work performed to determine whether the project is on the budget or not. Moreover, it allows project managers to take corrective actions in terms of cost and duration by extrapolating current trends of a project. Understanding and analysis of those trends provide accurate forecasts of project performance [1]. The earned value management analysis is considered one of the most straightforward and most widely used techniques for monitoring and controlling projects [2].

The traditional method to assess the progress of the project is manually done by calculating the difference between planned cost and actual cost incurred in a project which is very difficult in terms of manually tracking and handling the difference between actual costs and planned costs which does not help managers to get the real progress of the project.

The basic concepts of earned value were originally implemented by the US Department of Defense in the early 1960s [3]. Earned value analysis is a technique that can be applied to the management of all capital projects, in any industry, while employing any contracting approach [4]. Earned value analysis provides project assessments, if correctly applied, to maintain control over the budget, schedule, and scope of several types of projects [5].

The most fundamental part of the Earned value analysis is that project progress is measured through the quantity of money instead of engineering quantity, and in this sense, the project progress would be reflected by work progress transformed from monetary units [6].

The structure of the paper is as follows: the introduction provides a short literature review and background for the research; in the part 1 the main

research objective and tasks are defined, the main concepts of PEVA are explained. Further, in the part 2 the research methodology used to address research objectives is described. Part 3 applies and discusses the study findings by using real project cost data. The paper ends up with a conclusion and directions for further research.

1. Formulating the research problem

There are some challenges associated with implementing PEVA technique. Actual costs inaccuracy is one of the main challenges encountered with the PEVA application. Therefore, the main objective of this study is to increase the accuracy of the PEVA by including the accrued expenses when calculating PEVA; consequently, this will lead to an increase in the validity of the method.

In order to achieve the above objective the following tasks should be performed;

- Exploring and illustrating the main concepts of the PEVA;
- Identify main challenges encountered with the accuracy of PEVA;
- Exploring the main concepts of accrued expenses, and how they may affect the project actual cost, and how to come over this problem. Defining to what extent accrued expenses influence the earned value analysis; suggesting an update to the PEVA to make it more reliable.
- Applying the new approach to real data, and proving the new approach is valid.

1.1. The concept of PEVA

In PEVA, there are three data sources, the planned cost (budget), actual expenditure and the earned value which is the actual physical work done at a given time. Therefore, in PEVA the actual value of the work could be compared with the earned value and the estimated cost [4].

The three basic key parameters used in PEVA are as follows:

$$\text{Budgeted Cost of Work Scheduled (BCWS)} = \text{Planned Value (PV)}; \quad (1)$$

$$\text{Budgeted Cost of Work Performed (BCWP)} = \text{Earned Value (EV)}; \quad (2)$$

$$\text{Actual Cost of Work Performed (ACWP)} = \text{Actual Cost (AC)}. \quad (3)$$

Actual Cost: AC or known as actual cost work performed (ACWP). It measures the actual cost that has been incurred while accomplishing the work performed within a given time period.

Planned Value: PV or budgeted cost of work scheduled (BCWS) it measures the budgeted cost of all individual tasks/activities scheduled to be accomplished within a given time period.

Earned Value: EV or known as the budgeted cost of work performed (BCWP) indicates the sum of budgets for the work that has been accomplished already.

PV, EV, and AC are the basic metrics of the earned value analysis that generates performance indices and variances for project progress [7, 8].

1.2. Variances

The variances are used to check the deviation of a project from the path of the original plan. The variances are as follows;

Cost Variance: It measures the difference between the proposed planned project and the current status on a specific date. It shows the variation of a project in form of cost. The formula used for calculating cost variance is,

$$\text{Cost Variance (CV)} = \text{EV} - \text{AC} = (2) - (3). \quad (4)$$

A negative (–) cost variance means the project is over budget which means that the cost of performed work is higher than the planned cost. While a positive (+) cost variance means that the project is under budget which means that the performed work costs less than the planned budget for it. It is considered a good sign as it shows that the project cost is under control.

Schedule Variance: It is used to check the deviation of the current progress of the project from what was planned for the project [19]. In other words, It is used to compare the quantity of work performed to what has been scheduled to be performed within a given period of time. The formula for calculating the schedule variance is,

$$\text{Schedule Variance (SV)} = \text{EV} - \text{PV} = (2) - (1). \quad (5)$$

A negative (–) SV indicates that the project is behind schedule which means that the project took more time than what was planned to be done within a given period of time. While a positive (+) SV means that the project is ahead of schedule which means that it took less time than what was planned.

1.3. Performance Indices

Cost Performance Index (CPI): The ratio of the cost of work performed (EV) to actual cost (AC). It compares the planned and actual value of works done. The formula for calculating the CPI is,

$$CPI = EV / AC = (2) / (3); \quad (6)$$

• If CPI higher than 1, it indicates that the project is under budget (CPI > 1)

• If CPI less than 1, it indicates that the project is over budget (CPI < 1)

Schedule Performance Index (SPI): The ratio of the work performed (EV) to the planned progress (PV). It compares the cost of work done and planned cost of work. The formula for calculating the SPI is given by;

$$SPI = EV / PV = (2) / (1); \quad (7)$$

• If SPI higher than 1, it indicates that the project is ahead schedule;

• If SPI less than 1, it indicates that the project is behind schedule.

1.4. Forecasting Indicators

Earned value analysis (PEVA) can also be used to forecast project spending. Project forecasting is determined by three indicators, as follows [9];

Budget at Completion (BAC):
the total budget of the whole project. (8)

Estimation at Completion (EAC): is calculated at the date of reporting to serve as a forecast of total project costs. It shows the deviations effect on the total project cost. The formula for calculating the EAC is given by;

$$EAC = AC + ETC = (3) + (10). \quad (9)$$

Estimation to Complete (ETC): This is the estimated remaining cost to complete the project from any given time. It is the difference between the Estimate at Completion (EAC) (8) and the Actual cost (AC) (3).

$$ETC = EAC - AC = (9) - (3). \quad (10)$$

Variance at Completion (VAC): It is an indication to know if the project in under budget or over budget, by calculating the difference between Budget at completion (BAC) (8) and Estimate at Completion (EAC) (9). If the result is positive it means that the project is under budget, and if the result is negative it means that the project is over budget.

$$VAC = BAC - EAC = (8) - (9). \quad (11)$$

The following figure is a graphical representation of earned value parameters;

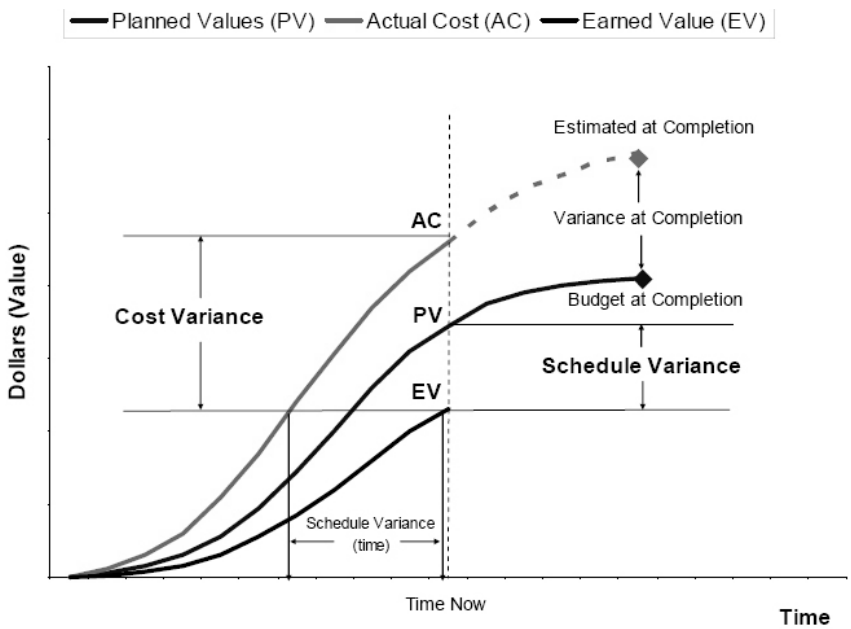

Fig. 1. Key Measures and Metrics from an Earned Value Management System [10]

The above figure illustrates the main concept of the earned value analysis as follows [1];

- Planned Value (PV): the baseline for the analysis, cumulated planned costs at the time of their incurrence;
- Earned Value (EV): the measure of physical progress expressed by the cumulated planned cost of works actually done related to time;
- Actual Value (AC): the cumulated paid amount for work done related to time;
- Budget at Completion (BAC): the total approved budget of the whole project;
- Schedule Variance (SV): the planned duration of the project, it is an estimate of duration variance.

1.5. Forecasting Scenarios

The Estimate at Completion can be calculated based on three scenarios depending on the performance.

Scenario 1: The project will continue to perform to the end the same as it was performing during the first stage. In this scenario, the Estimate at Completion (EAC) can be calculated as follows;

$$EAC = BAC / CPI. \quad (12)$$

Scenario 2: The project will continue to perform as planned before commencing into the project. The Estimate at Completion in Scenario 2 is calculated as follows:

$$EAC = AC + (BAC - EV). \quad (13)$$

Scenario 3: Project will continue to perform based on the current CPI and SPI. Let us assume that the project is over budget and behind the schedule and the project should be finished on time. In this case, CPI and SPI should be taken into consideration when calculating the Estimate at Completion (EAC) using the following formula;

$$EAC = AC + (BAC - EV) / (CPI * SPI). \quad (14)$$

1.6. Problem Statement

Project earned value analysis (PEVA) technique is an effective analytical tool when used properly, as implementing the PEVA technique helps monitor project performance and progress at any time during the life cycle of executing the project. However, implementing PEVA is not without limitations, such as not taking late invoices or purchase orders into account, as which results in inaccuracy of actual costs. Therefore, the accuracy of the actual costs plays a vital role in the earned value analysis. One of the major earned value management challenges is in most of the cost systems the expenditure is recognized when it is incurred specifically when invoices received and/or paid. Sometimes there is a considerable time lag between completion of work packages and receiving the invoices .This time lag depends on different credit periods and can vary from a month in most cases to three months in some cases after the work was actually done. Therefore, using information from an organization's Management Information System (MIS), such as the Enterprise Resources Planning (ERP) system for PEVA calculations can be very misleading [11].

1.7. Research Methodology

As discussed in the previous section that earned value analysis will not work efficiently unless accurate actual costs are obtained. In order to tackle this problem, the actual costs should be adjusted and this can be done by adding the actual cost from the organization's ERP system, plus the estimate for pending invoices for work finished, and this concept is named Accrued Expenses or Estimated Actual Costs. Estimated Actual Costs is an adjusted value of the actual costs that represents the costs which have been incurred for material and subcontracted items for which earned value has been earned but invoices have not been shown in the cost system [11].

In most cases, the estimated actual cost is typically required for material costs, subcontracts, labour subcontracts and other direct costs such as salaries, purchased labour and travel expenses [12]. The estimated actual cost information is collected from various sources such as invoices, purchase orders, time-card registration, or contract change orders. The Control Account Manager is responsible to monitor if the earned value is claimed and the invoices have not been paid, estimated actual cost should be incorporated into actual costs [13, 14].

1.8. Estimated Actual Cost Implementation

Once the item or the material is received and the earned value is claimed while actual costs do not appear, then the estimated AC should be collected and calculated from various credible sources such as

invoices [15–17]. The Estimated AC then should be integrated with the earned value management software. Before the transaction is due, the Estimated AC adjustments should be reversed [18, 19]. Otherwise, when for example the invoice is paid the actual cost data from the accounting system is transferred automatically to the earned value software, consequently, the Estimated AC will be counted once more [20].

3. Results and Discussion

3.1. Illustrative Application of PEVA

The following example is real project progress after six months. This is a construction project of a barge vessel accommodation at Petroleum Marine Services Company. PMS is one of the major Construction & Marine Services Contractor in Egypt and the Middle East. It shows project progress without taking accrued expenses into consideration.

Table 1

Earned Value Analysis Calculations

Work Package	BCWS	ACWP	%Progress	BCWP
	Planned Value	Actual Cost		Earned Value
1	$100,000	$98,570	100%	$100,000
2	$88,000	$90,233	100%	$88,000
3	$52,000	$40,019	90%	$46,800
4	$121,000	$75,300	80%	$96,800
5	$300,000	$198,530	85%	$255,000
6	$55,000	$32,350	90%	$49,500
7	$23,000	$0.00	0%	$0.00
8	$17,000	$0.00	0%	$0.00
9	$50,000	$0.00	0%	$0.00
10	$255,000	$0.00	0%	$0.00
BAC	$1,061,000	$535,002		$636,100

Cost Variance (CV = EV – AC)	$101,098.00
Cost Performance Index (CPI = EV/AC)	1.19
Schedule Variance (SV = EV – PV)	$136,100.00
Schedule Performance Index (SPI = EV/PV)	1.27

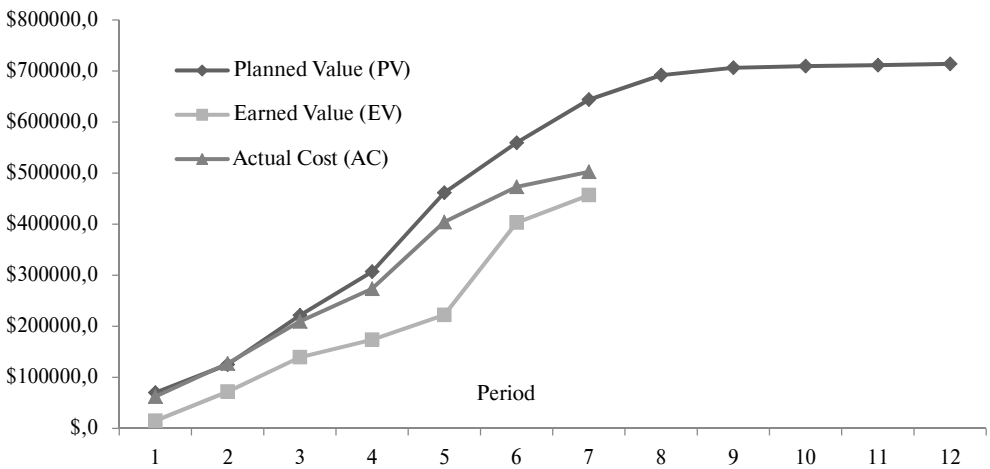

Fig. 2. S-Curve, Project's Progress before Adding Accruals

Table 2

Earned Value Calculations After Adding Accrued Expenses

WP	BCWS	ACWP	Estimated ACWP	Adjusted	Progress%	BCWP
	Planned Value	Actual Cost	Accruals	Actual Cost		Earned Value
1	$100,000	$98,570	$23,500	$122,070	100%	$100,000
2	$88,000	$90,233	$15,740	$105,973	100%	$88,000
3	$52,000	$40,019	$4,950	$44,969	90%	$46,800
4	$121,000	$75,300	$15,320	$90,620	80%	$96,800
5	$300,000	$198,530	$33,715	$232,245	85%	$255,000
6	$55,000	$32,350	$7,850	$40,200	90%	$49,500
7	$23,000	$0.00	$0.00	$0.00	0%	$0.00
8	$17,000	$0.00	$0.00	$0.00	0%	$0.00
9	$50,000	$0.00	$0.00	$0.00	0%	$0.00
10	$255,000	$0.00	$0.00	$0.00	0%	$0.00
BAC	$1,061,000			$636,077		$636,100

Cost Variance (CV = EV – AC)	$-325,525.00
Cost Performance Index (CPI = EV/AC)	0.73
Schedule Variance (SV = EV – PV)	$136,100.00
Schedule Performance Index (SPI = EV/PV)	1.27

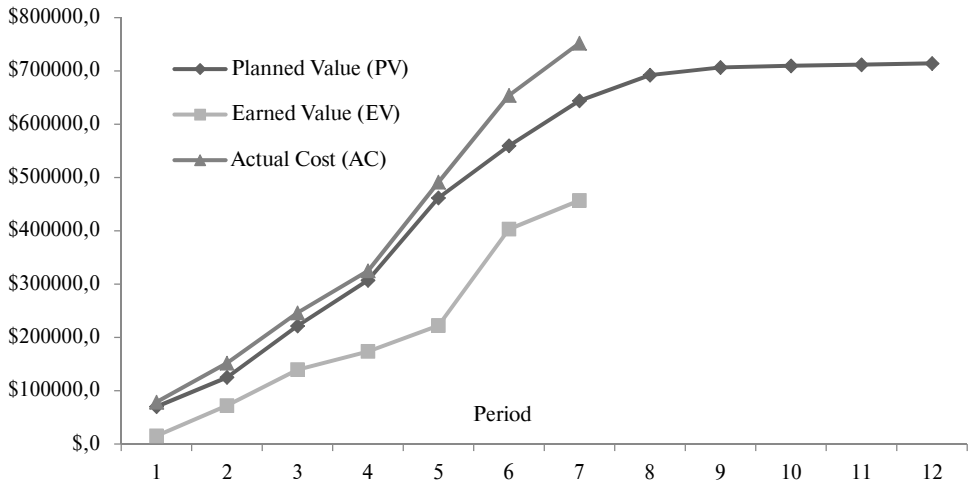

Fig. 3. S-Curve, Project's Progress after Taking Accrued Expenses into Consideration

One can interpret from the above figure that the project is ahead schedule and under budget, which gives positive sign about the project progress. In the following example, the estimated actual cost concept was applied to the same project and the results were as follows;

The Fig. 3 shows how adding accrued expenses to the Actual Costs (AC) can give a more reliable outcome of the project progress which means that neglecting the accrued expenses can give a false indication of project progress.

Conclusion. Earned Value Analysis is one of the most effective techniques of a project cost control if only applied properly. Effective use of earned value analysis should be supported by good cost and schedule control systems.

The paper presented the following;

• an overview of the main concepts of earned value analysis;

• challenges associated with its implementation with a focus on the inaccurate actual costs and how to overcome this problem;

• accrued cost expenses main concept and how it can be used in PEVA in order to obtain reliable results;

• an application of accrued expenses concept on a vessel construction project at PMS company and the results have proved that this adjustment gives a more reliable application of the PEVA.

By using accrued expenses, the inaccuracy of the project can be evaluated. Therefore, the project managers and practitioners may get to know the real status of the project, as it allows them to not only to efficiently control the project but also to generate more reliable forecasts.

Future research can be directed towards the integration and the application of the accrued expenses concepts and the application of the earned value analysis on Management Information Systems (MIS).

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DEVELOPMENT OF A SYNERGETIC RESEARCH ENVIRONMENT FOR MODELING COMPLEX PRODUCTIVE AND ECONOMIC SYSTEMS

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The paper deals with the problems associated with the development of modern computer technology decision-making in the digital economy, as well as methods, algorithms and software for solving control problems and decision-making in socio-economic production systems. The authors of the article propose a promising approach, having an interdisciplinary character, located on the border of the following areas: hybrid intelligent systems, synergistic artificial intelligence, neuro and psychophysiology, philosophy, cybernetics, economic and mathematical modeling, etc. Three laws of synergistic hybrid computational intelligence of complex, poorly formalized, multicomponent production and economic systems (SMPES) are considered: mutual adaptation, discrete series of structures and the law of transformations. A two-level model of the synergistic hybrid computational intelligence of the SMPES is presented, on the basis of which the evolutionary model of the synergistic hybrid computational intelligence of the SMPES is formulated. A model of the synergistic research environment of the SMPES based on hybrid computational models is considered. The architecture of the applied instrumental environment of "soft" mathematical modeling of SMPES is presented. The basics of creating a 5d technology platform for designing intelligent high-tech systems, enterprises and industries are presented, the main advantage of which is the use of a universal information platform in the form of a hybrid intelligent decision-making support system that quickly transforms into a specific system, specific subject area (mechanical engineering, heavy metallurgy, oil and gas, etc.), allowing you to add new quality to decision-making processes, as well as to ensure the creation and wide effective use of new knowledge, both for individual enterprises and entire industries, innovation clusters and zones. Based on the instrumental environment of "soft" mathematical modeling of SMPES and 5d technology-platform design of intelligent high-tech systems, enterprises and industries, the authors developed, patented and successfully implemented a set of applied tools for the development of key socio-economic sectors of the regions of the Russian Federation. The proposed methods, models and applied tools allowed the team to begin creating a universal, unparalleled in the world technology for the synthesis of innovative developments, products and high-tech services, obtained through the integration of various methods and applied tools and the subsequent generation of specialized technological chains and production and economic new generation systems.

Keywords: hybrid computing intelligence, production and economic systems, digital economy, innovative developments, mathematical modeling, synergistic model

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РАЗРАБОТКА СИНЕРГЕТИЧЕСКОЙ ИССЛЕДОВАТЕЛЬСКОЙ СРЕДЫ ДЛЯ МОДЕЛИРОВАНИЯ СЛОЖНЫХ ПРОИЗВОДСТВЕННО-ЭКОНОМИЧЕСКИХ СИСТЕМ

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Рассматриваются проблемы, связанные с развитием современных компьютерных технологий принятия решений в цифровой экономике, а также методы, алгоритмы и программное обеспечение для решения задач управления и принятия решений в социально-экономических производственных системах. Предложен перспективный подход, имеющий междисциплинарный характер, находящийся на границе следующих направлений: гибридных интеллектуальных систем, синергетического искусственного интеллекта, нейро и психофизиологии, философии, кибернетики, экономико-математического моделирования. Рассмотрены три закона синергетического гибридного вычислительного интеллекта сложных, слабо формализуемых, многокомпонентных производственно-экономических систем (СМПЭС): взаимной адаптации, дискретных рядов структур и закон трансформаций. Представлена двухуровневая модель синергетического гибридного вычислительного интеллекта СМПЭС, на основе которой сформулирована эволюционная модель синергетического гибридного вычислительного интеллекта СМПЭС. Рассмотрена модель синергетической исследовательской среды СМПЭС на основе гибридных вычислительных моделей. Представлена архитектура прикладной инструментальной среды «мягкого» математического моделирования СМПЭС. Представлены основы создания 5d технологии-платформы проектирования интеллектуальных высокотехнологичных систем, предприятий и производств, основным преимуществом которой является использование универсальной информационной платформы в виде гибридной интеллектуальной системы поддержки принятия решений, которая быстро трансформируется под системный характер, сложность, неоднородность конкретной СМПЭС, определенной предметной области (машиностроение, тяжелая металлургия, нефтегазовая сфера), позволяя придать новое качество процессам принятия решений, а также обеспечить создание и широкое эффективное использование новых знаний как для отдельных предприятий, так и для целых отраслей, инновационных кластеров и зон. На основе инструментальной среды «мягкого» математического моделирования СМПЭС и 5d технологии-платформы проектирования интеллектуальных высокотехнологичных систем, предприятий и производств разработан, запатентован и успешно внедряется комплекс прикладных инструментариев для развития ключевых социально-экономических секторов регионов РФ. Предлагаемые методы, модели и прикладные инструментарии, позволили приступить к созданию универсальной, не имеющей аналогов в мире технологии синтеза инновационных разработок, продукции и наукоемких услуг, получаемых на основе комплексирования различных методов и прикладных инструментариев и последующей генерации специализированных технологических цепочек и производственно-экономических систем нового поколения.

Ключевые слова: гибридный вычислительный интеллект, производственно-экономические системы, цифровая экономика, инновационные разработки, математическое моделирование, синергетическая модель

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Introduction. In the works of famous Russian scientists in the field of economic and mathematical modeling Prof. V.L. Makarova and Prof. G.B. Kleinar [1–7] the original approach to modeling hierarchical production and organizational economic systems based on various mathematical schemes (apparatus of abstract algebra, differential calculus, etc.) was summarized and comprehensively considered. The obtained models, on the basis of which the state space of a real system is modeled using the mathematical apparatus of the theory of lattices and other approaches, complement the models with an unstructured (automaton) and linear (linear systems) state space, etc. In fact, this class of models represents synergistic, hybrid formal schemes [8,9], designed to search for the universal principles of the formation and evolution of complex, industrial and economic systems [5–7]. Based on these works, as well as on works of other scientists, in various subject areas: mechanical engineering [10], oil and gas industry [11], agro-ecosystems and water ecosystems [8], socio-economic sphere [12], etc., – the authors of the article formulated a statement regarding the need to revise, supplement the traditional approaches to the construction of mathematical models of complex, including poorly formalized, productive and economic systems [13], and also set the task of creating new directions, approaches and methods in the field of mathematical modeling and synthesis of complex systems capable of providing at a qualitatively different level the possibility of formal models development of complex productive and economic systems. In fact, it was about creating new classes of mathematical models of complex productive and economic systems, with an adaptive, synergetic structure [14, 15] – as a special class of «soft» mathematical models based on the principles of adaptive heuristic adjustment [8, 9] of analytical dependencies with heuristic knowledge and soft calculations.

Despite the importance of this task, the research works in this area did not gain active development. In 2016 at the international conference "Hybrid and Synergetic Intellectual Systems: Theory and Practice (GISIS-2016)" (Russia, Kaliningrad, the conference was held with the support of the Russian Foundation for Basic Research) the authors first proposed and received a widespread approbation of a concept of «soft» mathematical modeling of complex systems, based on hybrid computing intelligence [9] as a new interdisciplinary research area located on the «boundary» of: hybrid intelligent systems, synergetic artificial intelligence, mathematical modeling of complex systems, systems theory and systems analysis.

In the study [15] the concept of complex, multi-component productive and economic systems, functioning in conditions of uncertainty, and poorly formalized problems was introduced [14]. The set-theoretic representation of the specified class of complex systems is also implemented in the sources [8, 9].

In the studies [9, 13, 15] a statement regarding the need to revise, supplement, traditional approaches to the construction of mathematical models of complex, including poorly formalized, productive and economic systems (PES) was formulated, and also the task for creating new directions, approaches, methods and applied tools in the field of modeling of complex, multi-component production and economic systems (CMPES) was set.

Purpose of the study. Accumulated to date, in the framework of this approach (the concept of «Soft mathematical modeling of complex systems based on hybrid computing intelligence [9]»), extensive theoretical and practical experience [8,9,15] in various subject areas (agriculture, oil and gas sector, engineering, military-industrial sector, etc.), allowed the authors to formulate the basic theoretical positions in the field of creation of a synergetic research environment for modeling complex, productive and economic systems and also to set the task for developing on its basis a complex of applied systems of various types and purposes.

Research methodology. In the work [9] three laws of synergetic hybrid computing intelligence (HCI): mutual adaptability, discrete structures, and the law of transformations – were formulated.

Due to the fact that the structure of synergetic HCI is a reflection of certain regularities of mutual adaptation of internal components, the law of mutual adaptability determines the presence of internal mutual adaptability processes between components of synergetic HCI as a necessary and sufficient condition for the emergence and development of synergetic HCI.

In accordance with the law of discrete structures, the new structure of synergetic HCI is synthesized from a discrete series of its possible structures. Thus, a method can be obtained for synthesizing the target structure of the synergetic HCI, included in a discrete series, from another structure of this series.

In accordance with the law of transformation, the transformation of one structure of synergetic HCI into another by means of knowledge common to both structures can be achieved. Thus, the law of transformations implies the possibility of creating a method of forming new knowledge, obtaining their interference, as well as the transition from one knowledge to new knowledge, interrelated, associated with the previous one.

In accordance with the law of transformations – the synthesis of a new structure of synergetic HCI is possible only on the basis of the previous structure, which leads to the mutual adaptation of some of the components corresponding to the new structure. Within the framework of the concept of «soft» mathematical modeling of the complex, multi-component productive and economic systems, the law of transformation determines the primary role of fundamental, formalized knowledge in the new structure of the synergetic HCI, as well as the possibility of their integration in the development process with newly emerging heuristic knowledge.

In view of this, the concept of synergetic hybrid computing intelligence is illustrated in Fig. 1. Fig. 1 shows a two-level model of synergetic hybrid computing intelligence [9]: at the macro level – the method as a whole; at the micro level – decomposition of the method using the triad «language – model – procedure».

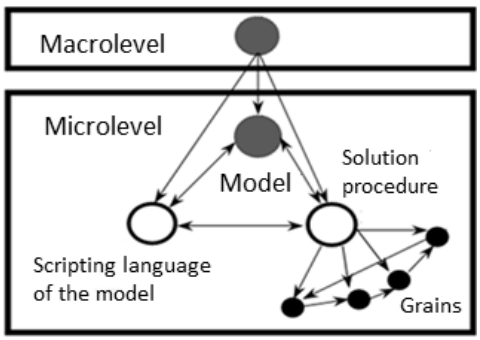

Fig. 1. Two-level model of synergetic hybrid computing intelligence

The modeling method and the corresponding CMPES formal model are two closely interconnected objects. Since the formal model of CMPES has been developed in accordance with a certain modeling method, it is connected with its properties, and obtains all the pros and cons of the method; the same applies to the modeling method that inherits the model properties. Moreover, the modeling method cannot go beyond its model and acquires from it the structuring of the external world, the conceptual apparatus, which largely determines the strength and capabilities of the method. In the study [9] the concept of «phenotype $\leftrightarrow$ genotype» of a modeling method is considered, as well as the laws of transformation of modeling methods when solving applied system problems [9] in complex, multi-component productive and economic systems.

This approach to the representation of the modeling method allowed us to formulate an evolutionary model of synergetic hybrid computing intelligence (Fig. 2) [9].

The evolutionary model of synergetic hybrid computing intelligence leads to the possibility of creating integrated methods – method-systems [9], built using integration relations on a variety of genotypes of other types, and synthesis of integrated models of CMPES – systems of models [9]; built with the help of integration relationships on a variety of other models. Thus, the desired macro-level properties (the goal of hybridization) of descendant methods can be obtained: Method_1^{Π}, ..., $\text{Method}_{N_{\Pi}}^{\Pi}$, representing synergetic hybrid systems [9], and corresponding properties of integrated models of CMPES.

An evolutionary model of synergistic hybrid computational intelligence allows us to formulate a model of a synergistic research environment based on hybrid computational models derived from synergetic hybrid systems.

Suppose Iv^m – set of applied systems [9]. We introduce a set of hybrid computational model, $LANG^m = \{LANG_1^m, \ldots, LANG_{N_{LANG_m}}^m\}$ and set the correspondence $\Psi^{LANG,Iv}$: $LANG^m \rightarrow Iv^n$.

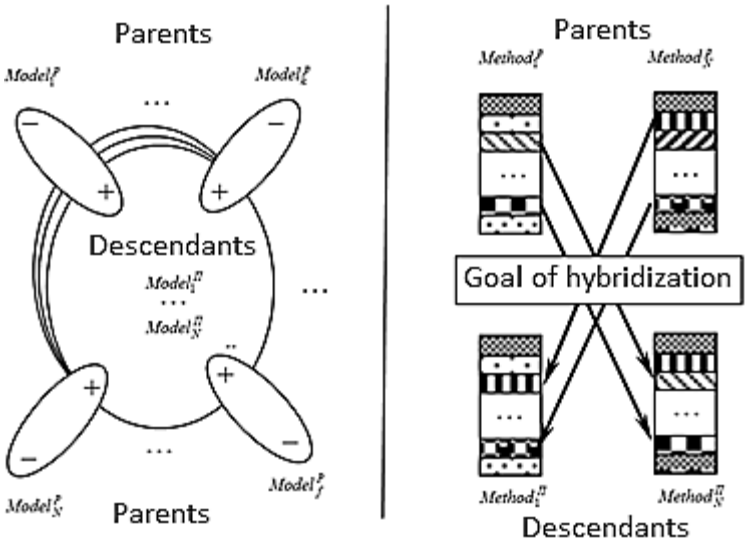

Fig. 2. Evolutionary model of synergetic hybrid computing intelligence

We introduce five sets of micro-level representations of autonomous methods [8, 9]:

$$MET^a = \{MET^a_{An}, MET^a_{St}, MET^a_{Lg}, MET^a_{Li}, MET^a_{Ep}\},$$

$$MET^a_{An} = \{met^a_{An1}, \ldots, met^a_{AnN_{An}}\},$$

$$MET^a_{St} = \{met^a_{St1}, \ldots, met^a_{StN_{St}}\},$$

$$MET^a_{Lg} = \{met^a_{Lg1}, \ldots, met^a_{LgN_{Lg}}\},$$

$$MET^a_{Li} = \{met^a_{Li1}, \ldots, met^a_{LiN_{Li}}\},$$

$$MET^a_{Ep} = \left\{met^a_{Ep1}, \ldots, met^a_{EpN_{Ep}}\right\},$$

works with An-, St-, Lg-, Li-knowledge и Ep-experience, where N_{An}, N_{St}, N_{Lg}, N_{Li}, N_{Ep} are the number of known m^a-methods.

We define five sets of one-to-one correspondence $\Psi_i^{met\,met}$, when $i \in \overline{1,5}$ and met^a_{dl}, $j = l$; $d, q \in \{An, St, Lg, Li, Ep\}$; $d = p$:

$$\Psi_1^{met\,met} : MET^a_{An} \to MET^a_{An},$$

$$\Psi_2^{met\,met} : MET^a_{St} \to MET^a_{St},$$

$$\Psi_3^{met\,met} : MET^a_{Lg} \to MET^a_{Lg},$$

$$\Psi_4^{met\,met} : MET^a_{Li} \to MET^a_{Li},$$

$$\Psi_5^{met\,met} : MET^a_{Ep} \to MET^a_{Ep}.$$

We define correspondences $\Psi_i^{MET\,LANG} : \Psi_i^{met\,met} \to$ $\to LANG^m$ and get five sets, elements of which are tuples $((met^a_{dj}, met^a_{ql}), LANG^m_w)$, where $w \in \overline{1, N_{LANG}}$.

Thus, we have the following model of a synergetic research environment, the elements of which are presented in detail in [8, 9]:

$$E^M = \left\langle LANG^m, MET^a, \Psi_i^{met\,met}, \Psi^{MET\,LANG} \right\rangle. \quad (1)$$

Approbation and results. Based on (1), the applied instrumental environment of the «soft» mathematical modeling of complex, multi-component productive and economic systems [9] was developed (Fig. 3).

The developed model of the synergetic research environment and the instrumental environment of «soft» mathematical modeling of CMPES created on its basis made it possible to set the 5d technology-platform for designing intelligent high-tech systems, enterprises and industries [9] (Fig. 4).

Studies [8,9] showed that the proposed 5d technology-platform for designing intelligent high-tech systems, enterprises and industries [9, 15] can quickly adapt to a system-based nature, complexity, heterogeneity of applied CMPES, various types and purposes, allowing to bring the decision-making process in applied CMPES to a whole new level [13], to ensure the synthesis, as well as a comprehensive and effective use of new knowledge [20, 21], both for individual enterprises and entire industries, innovation clusters and zones.

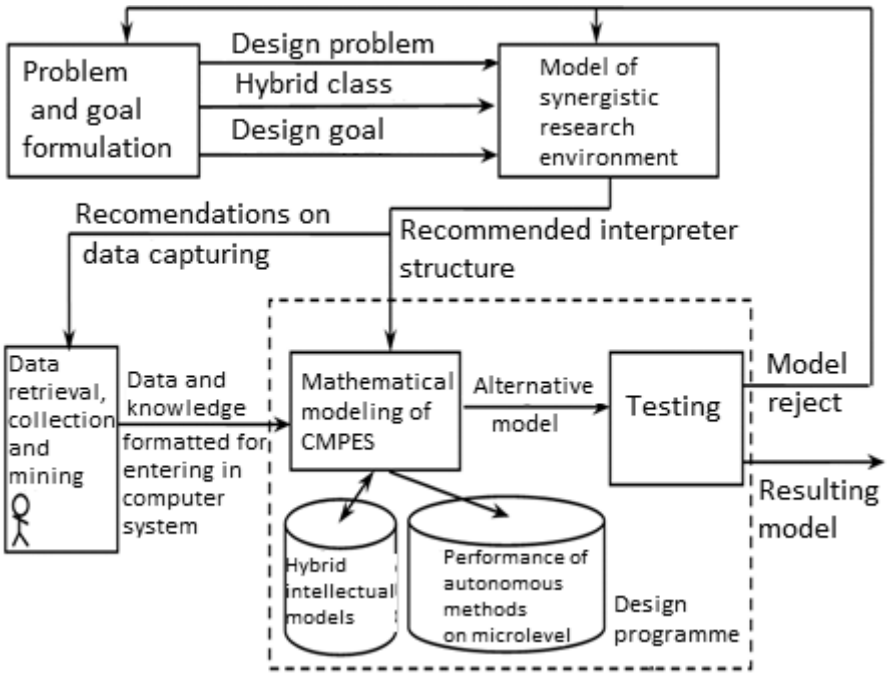

Fig. 3. Instrumental environment of the «soft» mathematical modeling of CMPES

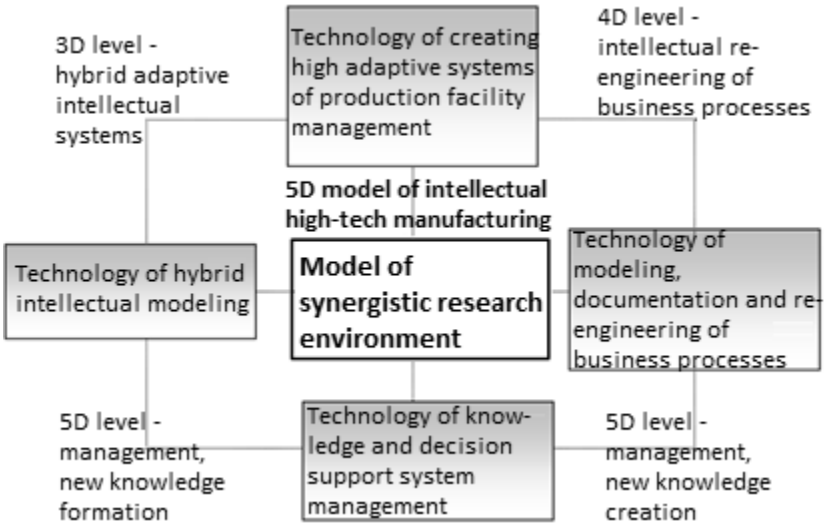

Fig. 4. Technology-platform for designing intelligent high-tech systems, enterprises and industries

Based on the instrumental environment of "soft" mathematical modeling of the CMPES and 5d technology-platform for designing the intelligent high-tech systems, enterprises and industries, the authors developed, patented a set of applied tools [22, 23] for the development of key socio-economic sectors in the regions of the Russian Federation, which is being successfully implemented.

Results

1. Three laws of synergetic hybrid computational intelligence of complex, poorly formalized, multi-component productive and economic systems are considered.

2. A two-level model of synergetic hybrid computational intelligence of complex, multi-component production and economic systems is

presented, on the basis of which an evolutionary model of the synergetic hybrid computational intelligence of CMPES was formulated.

3. A model of the synergetic research environment of the CMPES based on hybrid computational models is considered.

4. The architecture of the instrumental environment of «soft» mathematical modeling of CMPES is presented.

5. The main elements of 5d technology-platform for designing the intelligent high-tech enterprises and industries are considered.

Conclusion. In the course of solving the tasks of advanced (breakthrough) innovative development of the Kaliningrad region, creating a scientific, technical and technological base on the ground of advanced world achievements and breakthrough technologies, the collaborative writing team in 2014 formulated the idea and the main positions in the field of creating the first Russian Center of Computer Engineering and systems engineering design of high-tech systems and productions. In the period from 2014 to the present, the writing team carried out a huge organizational, research and development work, which resulted in the creation of an intellectual and technological basis for the unique, one-of-a-kind in Russia, innovation and technology center «Baltic Engineering Center of hi-tech systems and productions» (supervisor: Prof. Sergei Korjagin, Baltic Federal University of Immanuel Kant), including: a complex of modern educational, scientific and innovative laboratories; developed an advanced scientific-methodological platform «Intellectual Systems Engineering [8]», which represents an interdisciplinary scientific-methodological basis that provides the generation of new knowledge in the inter-, multi- and trans disciplinary areas to solve complex problems of industry, energy, transport, engineering, etc.; developed and patented a unique (ensuring the creation in the shortest possible time of competitive products of the new generation) application-oriented basis of high-tech solutions and tools. At present, on the basis of the methods, models and applied tools proposed in this scientific article, a set of advanced production solutions for the development of socially significant sectors of the regional economies of the Russian Federation has been successfully implemented [22, 23] based on the Baltic Engineering Center, as well as a set of federal-level projects that are important for solving national production, economic and other strategic tasks of the Russian Federation was launched.

Directions for further research. Accumulated to date, a large theoretical and practical experience of applying the model of a synergetic research environment in various subject areas (agriculture, oil and gas sector, engineering, military-industrial sector, etc.), allowed the authors to proceed to the development of the proprietary, internationally advanced, technology for synthesizing innovative developments, products and high-tech services, obtained through the integration of various methods and applied tools, and the subsequent generation of specialized technological chains of the new generation, which allows accumulating advanced science, basic and critical military and industrial technologies, ensuring the generation of new knowledge in cross-, multi- and trans disciplinary areas for solving complex problems of industry, energy, transport, engineering, and etc.

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УСЛОВИЯ ПУБЛИКАЦИИ СТАТЕЙ

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ОБЩИЕ ПОЛОЖЕНИЯ

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