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INDUSTRIAL DEVELOPMENT IN THE CONDITIONS OF DIGITALIZATION OF INFOCOMMUNICATION TECHNOLOGIES

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The advancement of the innovation sector as a key driver for the development of the industrial sphere, which is the foundation of the economy, has become a worldwide trend. In its turn, the form of economic development based on innovative processes is permanently undergoing changes in connection with the introduction of advanced information and communication technologies developing in the direction of global digitalization. The digital development strategy, which is a fundamentally new platform for the implementation of digital solutions in the field of information and communication technologies, is one of the main priorities from the point of view of ensuring the competitiveness of the economy in general and the industrial sector in particular, as well as raising the population's standard of living, which determines the relevance of the topic of the article. The purpose of the study is to identify the specific features of the transforming Russian economy and of the industrial sector in particular, as well as to develop the principles of the digital economy in terms of identifying additional sources of efficiency of business systems, taking into account the development of infocommunication technologies in the direction of digitalization. Both quantitative (mainly statistical) and qualitative research methods (analogy method, methods of content and expert analysis and synthesis) are used in the study, on the basis of which the modern level of industrial development of Russia is analyzed and assessed in terms of conditions for transition to a new industrial-digital platform. At the same time, this transition is connected with the technological modernization of the manufacturing industry, which involves integrated development of fixed assets and technologies, the renewal of domestic research and development, based on education and science. Special models of the methodology of studying innovative processes are also used in the article, such as push and pull models, as well as an interactive dual model, tested in terms of adequacy to digital technologies. The article proves the feasibility of an interactive nonlinear model based on the paradigm of open innovation and cloud business systems implemented at the expense of the current level of development of infocommunication technologies. We have identified the sources of growth of the efficiency of business systems in general and innovations in particular through the reduction of transaction costs resulting from the transfer of a significant volume of business processes to electronic form, as well as transformation costs resulting from the implementation of the paradigm of network business systems, which increases the efficiency of both material and labor resources and reduces the transformation costs in terms of their conditionally constant component. The article describes the path of further research in the direction of creating institutional conditions for the development of network-centric (cloud) systems and high-tech businesses, as well as updating (or adapting) the methods and tools for analysis and evaluation of economic efficiency.

Keywords: digitalization; labor productivity; linear and nonlinear models of innovation process; closed and open innovations; cloud business systems; infocommunication technologies; transaction and transformation costs; economic efficiency

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ИНДУСТРИАЛЬНОЕ РАЗВИТИЕ В УСЛОВИЯХ ЦИФРОВИЗАЦИИ ИНФОКОММУНИКАЦИОННЫХ ТЕХНОЛОГИЙ

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Выдвижение инновационного сектора в качестве ключевого драйвера развития индустриальной сферы, являющейся фундаментом экономики, стало общемировой тенденцией. В свою очередь, форма экономического развития, основанная на инновационных процессах, перманентно претерпевает изменения в связи с внедрением передовых инфокоммуникационных технологий, развивающихся в направлении глобальной цифровизации. Стратегия цифрового развития, представляющая собой принципиально новую платформу реализации цифровых решений в области инфокоммуникационных технологий, является одним из приоритетов с точки зрения обеспечения конкурентоспособности экономики вообще и индустриального сектора в частности, а также повышения уровня жизни населения, что определяет актуальность темы исследования. Цель исследования – выявление специфических особенностей трансформируемой российской экономики вообще и промышленного сектора в частности, а также развитие принципов цифровой экономики в части выявления дополнительных источников эффективности бизнес-систем с учетом направления цифровизации. Применяются как количественные (преимущественно статистические), так и качественные методы исследования (метод аналогий, методы контентного и экспертного анализа и синтеза), на основе которых анализируется и оценивается современный уровень индустриального развития России с точки зрения условий для перехода к новой индустриально-цифровой платформе. Данный переход связан с технологической модернизацией обрабатывающей промышленности, предполагающей интеграционное развитие основных фондов и технологий, возобновление отечественных исследований и разработок, базис которых – образование и наука. Используются специальные модели методологии исследования инновационных процессов, такие как выталкивающая и втягивающая модели, а также интерактивная дуальная модель, протестированные с точки зрения адекватности цифровым технологиям. Обосновывается целесообразность интерактивной нелинейной модели, базирующейся на парадигме открытых инноваций и облачных бизнес-систем, реализуемых за счет современного уровня развития инфокоммуникационных технологий. Выявляются источники роста эффективности бизнес-систем вообще и инноваций в частности за счет снижения трансакционных издержек в результате перехода значительного объема бизнес-процессов в электронный вид, а также трансформационных издержек в результате реализации парадигмы сетевых бизнес-систем, что повышает эффективность использования как материальных, так и трудовых ресурсов и снижает трансформационные издержки в части их условно-постоянной составляющей. Заданы траектории дальнейших исследований в направлениях создания институциональных условий развития сетецентрических (облачных) систем и высокотехнологичного бизнеса, а также обновления (или адаптации) методов и инструментов анализа и оценки экономической эффективности.

Ключевые слова: цифровизация; производительность труда; линейные и нелинейные модели инновационного процесса; закрытые и открытые инновации; облачные бизнес-системы; инфокоммуникационные технологии; трансакционные и трансформационные издержки; экономическая эффективность

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Introduction. The concept of economic development associated with the process of introducing innovations replaces the concept of economic growth (as an increase in the time of production and consumption of goods) in the new economy. The innovation sector advancing as a key driver for the development of the industrial sphere (which is the foundation of the economy) has become a worldwide trend. This form of economic development is the basis of national security and technological independence of a country [13]: in a globalized world, countries that have not solved the problem of achieving progressive industrial development can not become an integral part of the core of the global economic system and will be relegated to the sidelines as, for example, a raw material appendage, a source of cheap labor, etc. It is beyond argument that none of these roles are acceptable for Russia because of historical and cultural characteristics.

Thus, there is a common opinion among scientific researchers and practitioners in the field of economics that gaining leading positions requires a transition to the so-called innovative model of the economy [see, for example, 1, 9, 10, 18],[1] that is, an economy based on the flow of innovation, continuous technological progress and the production of products with high added value. As infocommunication technologies are evolving towards global digitalization and the implementation of the «Industry 4.0» concept, which implies that a digital society and digital ecosystems are formed, the concept of «innovative economy» has been transformed into the concept of «digital economy».

Problem statement. Thus, an exceptional opportunity to ensure competitiveness and positive development of the national economy is its transformation according to the innovative scenario, taking into account the development of infocommunication technologies in the direction of digitalization. Moreover, while the principles of this transformation (as a scientific basis) are common to all industrial countries, the set of approaches and methods for the formation of the national digital economy must have its own specifics, since simply copying the models implemented in other countries will not bring the desired results due to differentiation of the stages of development of the industrial sector.

The following sequence of stages of successful transformation of the economy into an innovative digital one is suggested:

– gaining a comprehensive understanding of the transformed economy, taking into account all specific aspects.

– studying the principles of formation and the laws of the development of the digital economy.

– developing the approaches, methods and tools for creating a digital economy adequate to the current state and capabilities of the society.

– analyzing the ability of both spheres of society (public and private) to implement a developed system of approaches, methods and tools.

The goal of this study is to identify the specific features of the Russian economy being transformed in general and the industrial sector in particular, as well as to develop the principles of the digital economy in identifying additional sources of efficiency of business systems, taking into account the development of infocommunication technologies towards digitalization.

Methodology of the study. Both quantitative and qualitative research methods were used in the course of the study. Quantitative methods include collection and comparative analysis of statistical data characterizing the economic indicators of Russia's development. The qualitative methods included the analogy method used to justify the applied parameters, as well as the methods of content and expert analysis and synthesis generalizing the results.

Furthermore, it is known that a country's competitiveness depends on the commercialization of new knowledge rather than on its production. It is the business model aimed at commercializing innovations, determined, among other things, by the organizational and marketing innovations implemented, that gains importance in these conditions. Chesbrough, who is one of the leaders in technology and business, demonstrated with specific examples that similar technologies introduced to the market as part of different business models bring different economic results to enterprises [5]

The modern methodology of innovation studies (like the logistic methodology of research) identifies three main models of innovation processes:

– the push model, from research to the market;

[1] **V. Glukhov, E. Balashova.** Economics and management in information and communication: a tutorial, St. Petersburg, Peter, 2012; Innovation economy: Training manual. Moscow: Moscow state university, 2016.

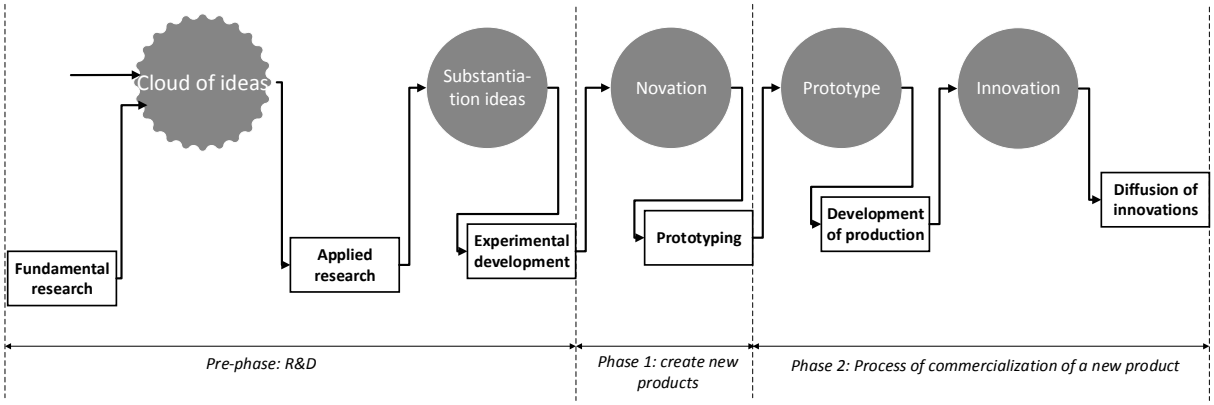

Fig. 1. Linear model of the innovation process

– the pull model, from the market's needs to research;

– the interactive dual model, including feedback.

The driver of innovation within the push model is fundamental and applied research and development (R&D), and the innovation process is a succession of the three main phases: pre-phase, phase 1 and 2 (Fig. 1). Prerequisites for the innovation effect, which is generated during the second phase and is subsequently distributed among the participants (subjects) of the innovation process (innovators) and consumers, develop within the first phase of the innovation process.

The strict sequence of steps implemented in the push model is described by a linear model of the innovation process (Fig. 1), which establishes a direct linear relationship between the volume of R&D and the number of innovations being introduced.

The push model has the following drawbacks:

· the focus of investments is shifted towards fundamental research, which causes a low frequency of commercialization.

· the consequence of this shift towards R&D is also the low efficiency of capital investments:

– firstly, the model does not take into account the market needs, therefore phase 2 often simply does not occur in the push model;

– secondly, applied, let alone fundamental research is by no means always necessary for creating innovation.

The driver of innovation within the pull model are the market needs that trigger the chain of steps presented in Fig. 1. Taking into account these needs significantly increases the effectiveness of innovation compared to the push model, because the innovation process is launched only when there are market conditions for successful commercialization of innovations. In addition, the pull model allows to exclude the R&D pre-phase (it is involved only if necessary), which significantly increases the return on innovative investments.

At the same time, the pull model has the drawbacks of the linear innovation process, such as the weak interconnections between the stages, the absence of feedback, and the low correlation with the distant external environment (i.e., the development trends of the global and national economy, society, environmental requirements).

The solution is the implementation of the so-called interactive models, in which the innovation process acquires a complex nonlinear character (Fig. 2).

The nonlinear model has the following distinctive characteristics:

· new ideas can arise and be developed at all stages of the innovation process;

· different stages are connected with each other by loops of feedback, which ensures their interconnectedness and reduced duration of the entire innovation process due to the possibility of parallel implementation;

· the correlation with the near (market) and distant external environment is strengthened;

· it is possible to commercialize various forms of research results at all stages of the innovation process.

The interactive nonlinear model is based on the paradigms of open business models and open innovations, the transition to which was largely due to the development of information technologies [4, 6].

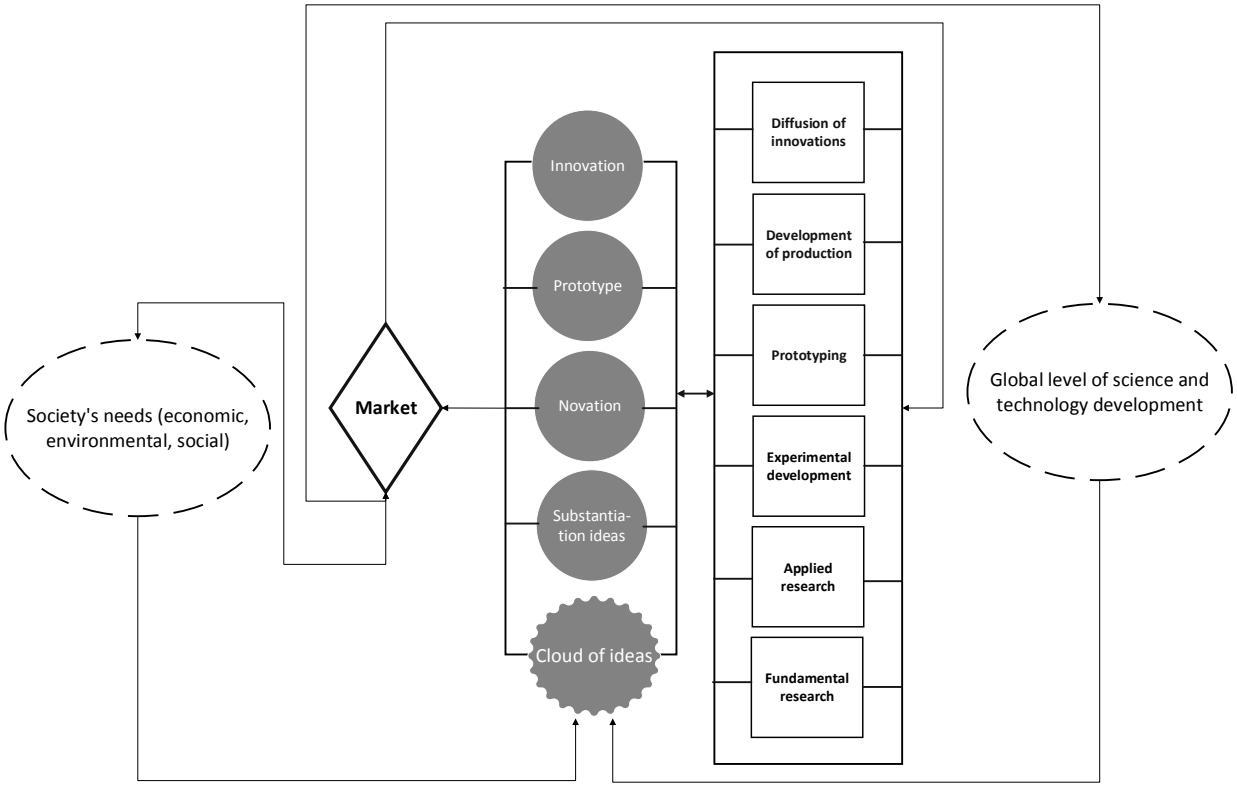

Fig. 2. Interactive non-linear model of the innovation process

Results. Analysis of official statistical indicators leads to the conclusion that there has been a weak economic growth in Russia in 2016-2017, which should indicate the benefits of direct and retaliatory sanctions. At the same time, the gap between the commodity and manufacturing sectors shows that the recovery trend is highly deceptive. Thus, the analysis of the dynamics of the index of industrial production showed that domestic industrial production has been falling after 2013 which was the borderline, in terms of imposed sanctions; the weak growth in 2016 is due to growth in the commodity sector, caused by improving conditions in the energy market.

Fig. 3 presents discrete GDP dynamics for PPPs of Russia in comparison with established world economic leaders (USA, Germany, Japan), as well as with former outsiders with comparable GDP at the start of comparison (China, India) for 20 years.

Analyzing the data in Fig. 3, it can be noted that developed world leaders demonstrate a stable growth of the economy, despite the high base effect. In the catch-up zone, China is the undoubted leader with an almost tenfold increase in GDP. China is also the world leader in terms of economic growth and the absolute value of GDP for PPPs, starting from 2014. India, although still a backward country, has impressive GDP growth rates. With almost the same «base» in 1996, India's GDP has since grown almost twofold compared to Russia's.

Unlike isolated dynamics, Russia's economic growth is practically unnoticeable compared to other countries,. The share of the Russian economy with respect to the economy of the countries taken for comparison is just over 6 %. This can be explained by the postulated thesis that sustainable economic development is provided by development of the industrial sector and, above all, the manufacturing industry. This could be confirmed by the example of China, as its fantastic breakthrough is primarily due to the growth of manufacturing industries, which have grown by almost 14 times in almost 20 years, making it a new industrial world leader.

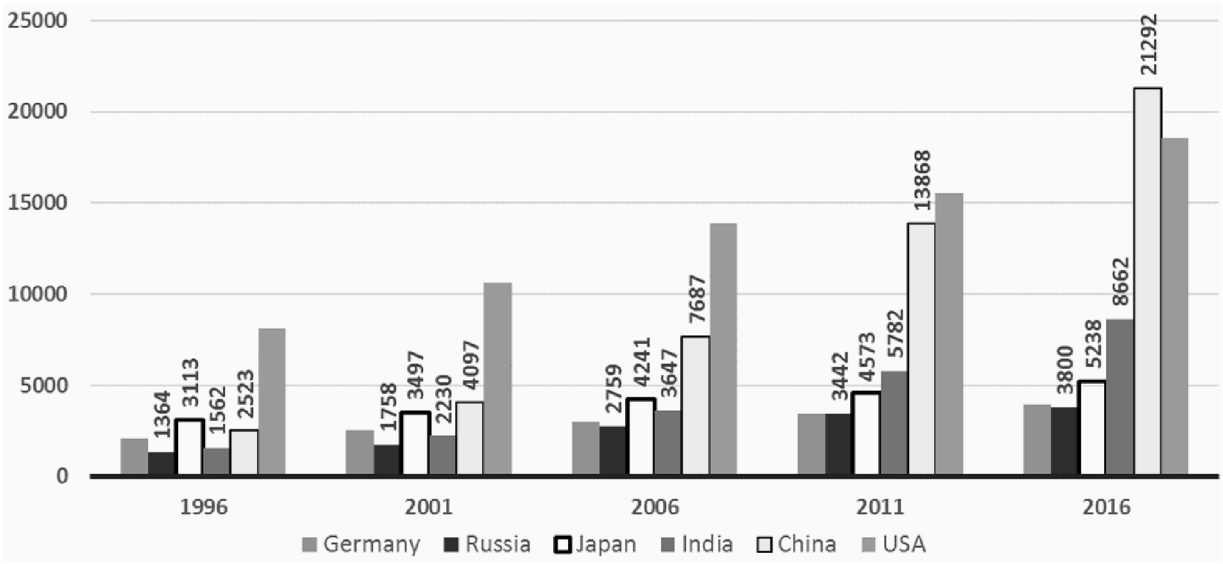

Fig. 3. GDP dynamics for PPPs in different countries of the world, billion dollars

Compared to industrial shifts in other countries, Russia's indicators show signs of de-industrialization. According to UNIDO, the share of Russia in the added value of manufactured goods either stands still or falls even in such traditionally «Russian» sectors as metallurgy, which, without increasing labor productivity, is an indicator of large-scale de-industrialization and primitivization of the economy over the years of market transformation [17].

For successfully transforming the national economy into an economy based on a flow of innovations that significantly enhances the effectiveness of the current system, it is necessary to have this very system in place. In other words, Russia's transition to a post-industrial stage is not possible without going through the stage of industrialization, that is, the current target function of the national economy is the so-called neo-industrial model based on a highly developed manufacturing industry. Researchers claim that the concept of industrial development on a new informational and technological basis is changing the paradigm of a post-industrial society [13, p. 224]

It should be noted that the Chinese model of industrialization is not applicable in Russia, as China has embarked on a path of extensive industrialization, relying on the involvement of an entire «army» of relatively cheap labor made up of former peasants. Russia does not have this opportunity, so the first task that must be accomplished within the above-mentioned target function is to ensure the growth of labor productivity.[2]

At present, there is a significant gap between the indicators of labor productivity in Russia and the leading countries. It is known that there was a steady increase in labor productivity in the USSR from the 1950s until the early 1990s [1]. Further, after a serious drop in indices during the disintegration of the USSR and shock therapy, their recovery growth was observed, followed by stagnation and even a drop, as evidenced by the official data of Rosstat.

In economic theory, two main factors are known to increase labor productivity: the improvement of the means of labor (fixed assets, and, to a large extent, intangible capital), as well as the qualifications and motivation of personnel. With regard to improving the means of labor, it is known that domestic statistics demonstrate the technological backwardness of the country: the depreciation coefficients by industry are increasing, the renewal and retirement rates are very low. In addition to the aging of fixed assets, the share of the active part of fixed assets (machinery and equipment) stagnates with the dynamics of reduction, which is also a factor in the reduction of economic efficiency due to the low level of introduction of new more productive equipment.

[2] President's address to the Federal Assembly, 2016. URL: http://www.kremlin.ru/events/president/news/53379

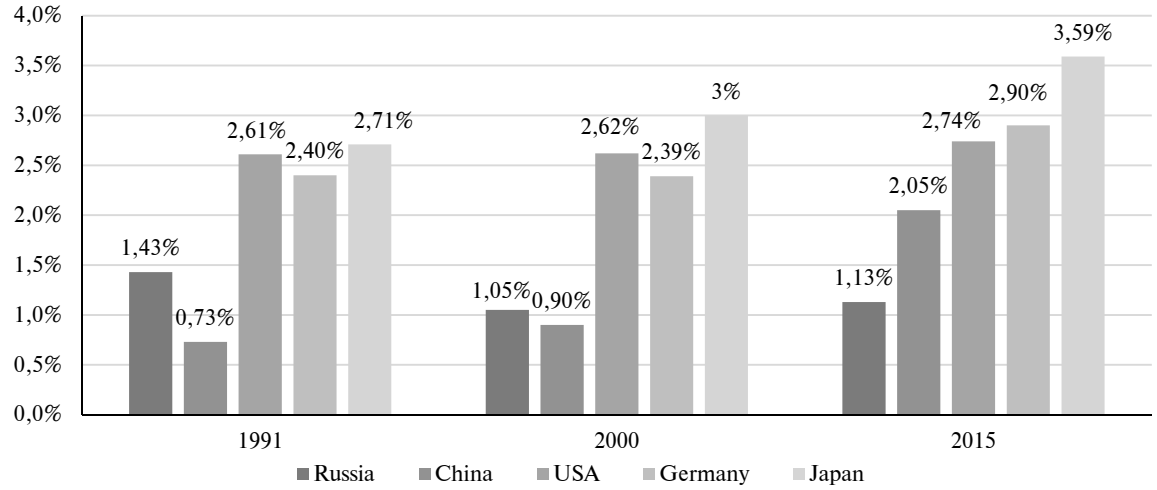

Fig. 4. Dynamics of expenditure on research and development by country, as percentage of GDP

The second factor in the dynamics of labor productivity is the level of workforce qualification. Here, too, there is a rather critical situation, termed de-intellectualization by some researchers.[3] In Russia, there is a systematic reduction in investment in human capital [11], the relative level of public spending on education (as a percentage of GDP) is declining and quite significantly behind developed countries: in 2014, this figure was 3.2 %, for comparison, it was 4.2 % in Germany, 4.7 % in the USA, 4.9 % in France and 5.2 % in the UK [2].

The processes of Russia's de-intellectualization are also observed in the scientific sector. Russian science remains in crisis since the collapse of the USSR. Employment in the scientific sector of Russia, as well as the number of researchers, has declined many times over the years of reform and this process continues [9]. In addition, Russia is seriously lagging behind the leaders in terms of the share of expenditures for research and development in the total GDP (Fig. 4). If we focus on the OECD data, China, with its almost almost 1.5 billion population, has been ahead of our country in terms of per capita R&D expenditure since 2015. In Russia, this indicator was $269 per person based on PPP, and in China it was $271 per person based on PPP.[4]

As noted above, the country's industrial development should be based on a new informational and technological basis. At the moment, the improvement of infocommunication technologies is carried out in the direction of digitalization. As a result, the digital development strategy, which represents a fundamentally new platform for the implementation of digital solutions in the field of information and communication technologies, is one of the priorities from the point of view of ensuring the competitiveness of all sectors of the economy and improving the standard of living of the population [14]. At the same time, according to the report «Global Information Technologies» for 2016, there is a significant gap in the development of the digital economy in Russia compared to other world leaders. The Russian Federation occupies 41st place with a significant gap from the leaders in readiness for digital economy, 38th place with a significant gap in terms of economic and innovative results using digital technologies.[5]

Thus, it is necessary to develop the principles of digital economy in general, as well as to identify additional sources of efficiency of business systems, taking into account the development of infocommunication technologies in the direction of digitalization.

As noted, the traditional paradigm of closed business models implemented during the second half of the 20th century (as the legacy of the first and second industrial revolutions) was linear progression of all phases of the innovation process

[3] **V. Glukhov, E. Balashova.** Economics and management in information and communication: a tutorial, St. Petersburg, Peter, 2012.

[4] Science. Innovations. Information society: 2016: short statistical book. Ed. G.I. Abdrakhmanov, Yu.l. Voinyliv, N.In. Gorodnikova, L. Gokhberg, etc.; the NAT. research. University «Higher school of Economics», Moscow, Higher school of Economics, 2016.

[5] The program «Digital economy of the Russian Federation», Approved by the order of the Government of the Russian Federation of July 28, 1632-p (2017).

within the boundaries of the enterprise, as well as the implementation of centralized (platform-centric) business systems [15]. The platform-centric type of business systems was determined by the level of development of infocommunication technologies, within which they played only a supporting role of information support for «manual» business processes. This determined the high level of costs of interaction between business systems, that is, external transaction costs. As a result, according to Coase's [7] findings, transactions (including those related to the innovation process) were more internalized, which caused the growth of the size of the enterprise, ensuring the effectiveness of large-scale business systems.

Thus, under the paradigm of closed innovations, only large vertically integrated enterprises with a large volume of resources and a powerful research base could really compete in the market. The markets in which such enterprises functioned were characterized by inefficient oligopolistic and monopolistic structures.[6]

Inadequate (excessive) consumption of resources is an essential shortcoming of «closedness» of innovations in particular and business models in general. Large back-integrated enterprises are characterized by a «linkage» of resources in a volume significantly exceeding their average level of needs. Keeping research laboratories requires a large amount of resources, while the «results» of their activities (knowledge, development) are often duplicated by different isolated business systems, and cannot be used in full within a single company. Summarizing, we can conclude that the reason for the ineffectiveness of closed systems is the uneven load on resources: the volumes of ownership of an isolated resource are determined taking into account single peak loads, while a significant part of the load time is close to zero [8]. In other words, the low level of development and use of infocommunication technologies determined the high level of not only transaction costs, but, as a consequence, transformational costs.

The development of infocommunications at the present stage has led to the emergence of such end-to-end digital technologies as wireless communication, virtual and augmented reality, big data, distributed register technologies, robotics, sensorics, etc., which ensured the transition of business processes to electronic form. This, in turn, caused a decrease in external transaction costs, and, as a consequence, a reduction in the effective size of the enterprise. At the same time, ties in modern business structures are beginning to gravitate toward horizontal directions.

New production is quite different from the recent standard of industrial plants. According to data of about 330 thousand industrial enterprises of the USA, these are enterprises with less than 10 employees [13]. In most countries of the European Union, manufacturing enterprises are enterprises with less than 20 employees. At the same time, the aggregate number of small manufacturing enterprises (from 0 to 249 employees) is more than 99 % of the total in the vast majority of countries (Fig. 5).[7] This trend is most clearly seen in innovation-oriented enterprises, increasing their mobility and readiness for permanent development.

The development of infocommunications provides an opportunity to build open network-centric (or, as they are also called, cloud) business systems with a distributed structure, which allows to integrate isolated resources (including innovative ones) into general funds, with a high level of elasticity and scalability, i.e., ready to provide the necessary volume at the right time, but no longer a physical resource, but a service based on a fund of physical resources [12].

Conclusion

1. The analysis showed that in order to build a competitive Russian economy, it is necessary to switch to industrial development on the basis of a new informational and technological platform that ensures an exponential growth in labor productivity. The solution of this task is connected with the technological modernization of the manufacturing industry. This modernization involves the integration development of fixed assets and technologies, which contributes to a qualitative update of production processes and methods of production organization and, as a result, a rapid increase in labor productivity.

As an example of updating the production process, the so-called additive technologies can be proposed, which, according to researchers, allow achieving labor productivity growth by more than 20 times even at their current level of development [13].

[6] **C.R. McConnell, S.L. Brue, S.M. Flynn,** Economics. Principles, problems and policies, Moscow, Infra-M, 2017.

[7] Innovation economy: Training manual. Moscow: Moscow state university, 2016.

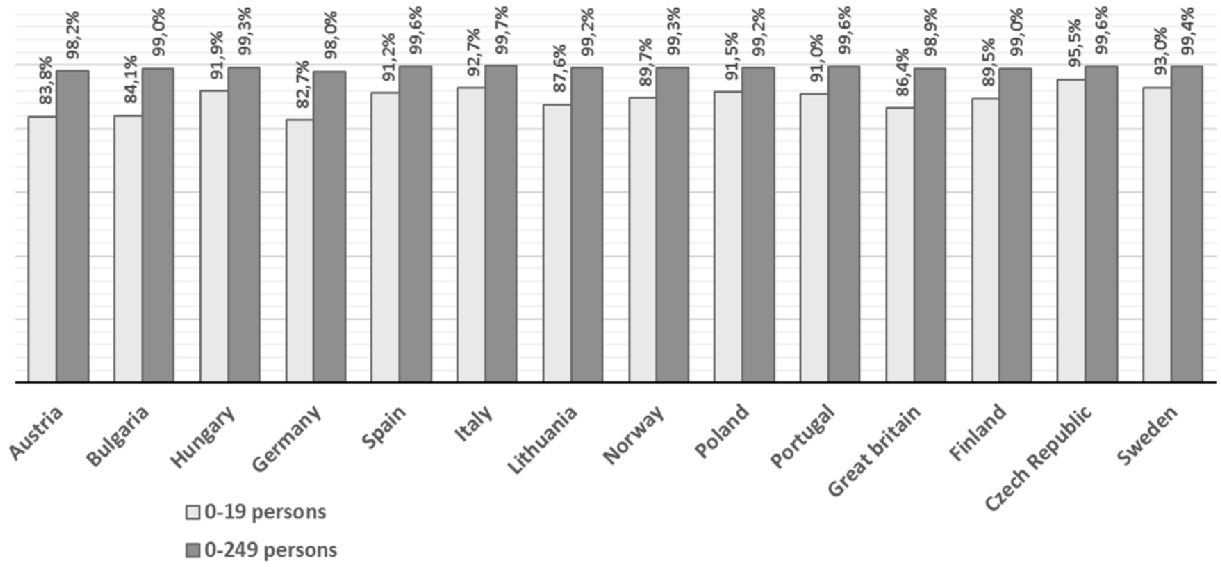

Fig. 5. The share of manufacturing enterprises in terms of the number of employees (percentage of the total number of enterprises)

As an example of renewal of methods of organization of production, the use of cloud services can be proposed, which, among other things, promotes the implementation of the principles of crowdsourcing to attract a wide range of microenterprises, individual entrepreneurs by type of subcontract work, and, among other things, ensuring self-employment of the population.

2. The second direction of technological modernization, in our opinion, should be resuming domestic research and development, the basis of which is education and science. At the same time, fundamental science is the key competitive advantage of Russia. Realization of this advantage requires a revision of the state policy of funding of science in the direction of its growth to promising world standards.

3. The development of information technologies in the direction of digitalization (wireless communication, virtual and augmented reality, large data, distributed registry technologies, etc.) provides an opportunity to reduce the following categories of costs of industrial enterprises:

– First, the transfer of a significant amount of business processes to electronic form causes a decrease in both internal and external transaction costs. In accordance with Coase's findings, the reduction of external transaction costs in turn reduces the effective size of the enterprise, including microenterprises, increasing their mobility and readiness for permanent development. This trend is most clearly seen in innovation-oriented enterprises.

– Secondly, the implementation of the paradigm of open innovation in particular and networked business systems in general increases the efficiency of using both material and labor resources (up to 100 % in the future) by ensuring their consumption only in the required amount, which significantly reduces the transformation costs in part of their conditionally constant component. At the same time, the enterprise is an open system that combines internal functions and interacts with both the distant and the near external environment.

4. By proposing a paradigm for open business processes, we understand that cloud business systems are more sensitive and demanding to the quality of the institutional environment (which is confirmed also by the findings of other researchers [8]). In Russia, there are both significant gaps in the regulatory framework and an insufficiently favorable environment for doing business and innovation even at the government level.[8] Thus, further research is needed on the creation of institutional conditions for the development of network-centric (cloud) systems and high-tech businesses.

[8] The program «Digital economy of the Russian Federation», Approved by the order of the Government of the Russian Federation of July 28, 1632-p (2017).

5. The task of forming methods and tools for creating a digital economy adequate to the current state and capabilities of society also requires updating or, at least, adapting a system of indicators characterizing economic efficiency. For example, a criterion is needed that ensures the interconnection of economic, environmental and social vectors in the concept of sustainable development. It is known that due to differences in the volumes and quality of the factors of production available to each member of society, a state in which 1 % of the population gets 99 % of the national income can be a Pareto-efficient one. Another known disadvantage of the GDP indicator (as a quantitative criteria of economic growth) is its «costly» nature. Economic growth, measured by GDP, is essentially an increase in costs in the economy. However, as was shown above, the development of infocommunications in the direction of digitalization can significantly reduce the entire set of costs of the economic system, both at the level of the transaction and the transformation component. Under these conditions, stagnation or even a fall in such a quantitative growth criteria as GDP can be observed, amid a significant improvement in the quality parameters of the standard of living of the population. Accordingly, the need for new or possibly additional quantitative criteria for economic growth is evolving in the digital economy, taking into account its informational and technological component.

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