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## **ANALYSIS OF INDUSTRIAL DEVELOPMENT IN THE COUNTRY'S REGIONS BASED ON INDUSTRY PROGRAMS 4.0**

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Industry is the most important sector of the country's economy of the Russian Federation. Industry has a significant impact on the economic development of the country, for the entire course of its expanded reproduction. Mechanical engineering, metallurgy, chemical production, production and processing of hydrocarbons are most developed in the regions of Russia. Industrialized regions differ in industries and levels of technological development. After conducting research on the indicators and dynamics of industrial production, it is possible to identify the most successful industrially developed regions. The introduction of new technologies requires significant financial resources, and many enterprises have problems with investments. The production of those regions that actively introduce new technologies is effective. It is shown that the industrial revolution led to creation of digital production facilities, automation and robotization of which accelerated production processes and significantly increased quality indicators. Digital transformation is the leading direction of technological development of the industry. The study reveals the role of new technologies, points to the need for their intensive implementation in the industrial sphere, analyzes the state of industry in the regions, reveals the role of digital platforms. It is emphasized that Industry 4.0 requires leading production managers to review their strategic priorities. Digital technologies provide for the creation of communication networks, digital platforms for working with various data, as well as a research base in the country. The participation of the state in the implementation of regional strategies and the formation of high-tech industries is an important mechanism for the implementation of economic policy. The article considers the regions of Russia where the industrial production potential is high and Industry 4.0 technologies are being successfully implemented. It analyzes the extent to which the Russian industry has mastered advanced digital technologies, the scope of application of digital automated lines and modern software products. The role of digital technologies in production management, in the dissemination of knowledge and the promotion of new developments on world markets is revealed. Knowledge, intellectual resources, information technologies, automated systems, the developed infrastructure of the national innovation system, a modern technological platform, and high technologies play an important role in the activation of the innovation process. Effective investment in industry contributes to increasing the competition of manufactured products, updating the technological base. Digital transformation of manufacturing industries is carried out on the basis of the latest equipment, new machines. It is shown that the key factor for the successful functioning of the economy is the high level of development of science, the creation and application of innovative technologies, standardization in the field of high technologies. The main objectives of the established development centers are the activation of innovation activities in the regions, the concentration of resources and factors of production in a limited area.

**Keywords:** industry, digital technologies, innovation activity, regional development, knowledge bases, intellectual activity results, digital industry standards

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## АНАЛИЗ РАЗВИТИЯ ПРОМЫШЛЕННОСТИ В РЕГИОНАХ СТРАНЫ НА ОСНОВЕ ПРОГРАММ ИНДУСТРИИ 4.0

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Промышленный сектор является важнейшим в структуре экономики Российской Федерации. Промышленность оказывает ключевое влияние на экономическое развитие страны, на весь ход ее расширенного воспроизводства. Машиностроение, металлургия, химическое производство, отрасли добычи и переработки углеводородов, транспортные средства наиболее развиты в регионах России. Различные регионы отличаются по отраслям промышленности, уровню технологического развития. Анализируя показатели и динамику промышленного производства можно выделить наиболее успешные промышленно развитые регионы. Внедрение новых технологий требует значительных финансовых средств, проблемы с инвестициями присутствуют у многих предприятий. Эффективны производства тех регионов, которые активно внедряют новые технологии. Показано, что промышленная революция привела к созданию цифровых производств, автоматизация и роботизация которых ускорила производственные процессы и значительно повысила качественные показатели. Цифровая трансформация — это ведущее направление технологического развития промышленности. В исследовании выделена роль новых технологий, необходимость их интенсивного внедрения в промышленный сектор, проведен анализ состояния промышленности в регионах, раскрыта роль цифровых платформ. Выделено, что Индустрия 4.0 требует от руководителей производств пересмотра стратегических приоритетов. Цифровые технологии предусматривают создание в стране сетей связи, цифровых платформ работы с различными данными, а также исследовательской базы. Важным механизмом реализации экономической политики является участие государства в реализации региональных стратегий, формирование высокотехнологичных производств. Рассмотрены регионы России, в которых производственный потенциал промышленности высок, успешно внедряются технологии Индустрии 4.0. Анализируется, в какой мере российская промышленность освоила передовые цифровые технологии, объем применения цифровых автоматизированных линий и современных программных продуктов. Раскрыта роль цифровых технологий в управлении производством, в распространении знаний и продвижении новых разработок на мировые рынки. В активизации инновационного процесса важнейшую роль играют знания, интеллектуальные ресурсы, информационные технологии, автоматизированные системы, развитая инфраструктура национальной инновационной системы, современная технологическая платформа, высокие технологии. Эффективное инвестирование в промышленность способствует повышению конкуренции производимой продукции, обновлению технологической базы. Цифровая трансформация обрабатывающих отраслей промышленности осуществляется на основе новейшего оборудования, новых станков. Показано, ключевым фактором успешного функционирования экономики является высокий уровень развития науки, создание и применение инновационных технологий, стандартизация в области высоких технологий. Основными задачами созданных центров развития выделены активизация инновационной деятельности в регионах, концентрация ресурсов и факторов производства на ограниченной территории.

**Ключевые слова:** промышленность, цифровые технологии, инновационная деятельность, региональное развитие, базы знаний, результаты интеллектуальной деятельности, стандарты цифровой промышленности

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### Introduction

Industry is one of the most important areas of activity and the country's integration into the world economy. Manufacturing plays a key role. Digitalization in industry is a relevant direction, changing pro-



duction cycles, allowing companies to fulfill the assigned tasks in a short time and providing them with high flexibility in shaping business models. Implementation of innovative activities at the regional level gives higher indicators related to material resources, high technologies. The rate of progress of innovation processes largely depends on the functioning of regional innovation subsystems, on the readiness of regional enterprises to master new technologies [1].

The purpose of the study is to analyze the industrial development of the country's regions based on the use of Industry 4.0 programs.

The object of research is the industry of the regions; the subject of the research is the level of digitalization processes in the industry of the country's regions.

### **Methods and technique**

The research was based on the works of specialists in the field of digital technologies. Methods, technologies and systems of modern development of enterprises in the context of a new technological order were analyzed. Key systems and components of a digital manufacturing plant were examined.

The level of use of the potential of digital technologies in the region reflects success in all areas of national economic activity. Digitalization is becoming more widespread in the leading industrial regions of the country.

The research information base contains structured information from an interview with representatives of consulting services for digital transformation, as well as with representatives of Russian companies that launched digital transformation programs, experience in the practical use of new technologies.

*The goals* and main directions of modernization and innovative development of the domestic economy are defined in the Decree of the President of the Russian Federation dated May 7, 2018 No. 204 "On national goals and strategic objectives of the development of the Russian Federation for the period up to 2024".

The economy is in a process of rapid change: new methods of industrial production are constantly being introduced around the world. Scientific research, design work, experimental design, technological developments and experimental production play a leading role in innovation.

Industry 4.0 denotes "new technologies that connect the physical, digital and biological worlds, affecting all disciplines, economies and industries". These technologies have great potential to connect millions of people and high-tech facilities to the network improving business performance. Technological changes are required to meet the current development needs of the industry. The production potential of the region is an important competitive advantage, therefore, for the development of industry and attracting investment, it is important to apply new technologies [2].

The degree of research and scientific development of the topic is a generalized analysis of the known scientific achievements in the selected area. Analytical materials of specialists from Russia, Germany, Sweden, Japan, China, the experience of introducing artificial intelligence, Internet of things, modeling and visualization, cloud technologies, adaptation of automated functions for changes in external conditions are studied.

High potential in the process of using new technologies is transformed into real economic results. In the regions, industry is developing in conditions, when there are enough material, intangible, intellectual, informational, technological, innovative and other resources, as well as human resources to ensure economic activity. The manufacturing sector is subdivided into four main components: mechanical engineering and metalworking, the manufacture of materials for future structures, and chemical products. It is necessary to systematize the key components of the development of modern digital production technologies in various directions in three organizational dimensions: design, production, enterprise management. First of all, a digital platform is developed taking into account the specifics of the machine-building industry and meeting modern trends and requirements formed by market conditions. The leading processes of modern production are as follows: Modeling and optimization; Digital twins; Production system; Digital logistics; Technology transfer; Intellectual property; Project Management. Digital modeling of the work

of manufactured equipment in production affects the timing of product development and release. Various methods of modeling, from physical processes and individual assembly units to technological processes and production, in general are widely used in all leading manufacturing enterprises today, providing their industry leadership<sup>1</sup> [3, 4].

Technological development will be accelerated by increasing the innovative activity of organizations, introducing new tools to stimulate their development and supporting the innovation infrastructure. Moscow, St. Petersburg and the Nizhny Novgorod region became the leaders in the ranking in science and technology. The leading positions of the two capitals are due to the historically high level of development of science and technology, the presence of leading research institutes of fundamental and applied orientation, high-tech industries.

The economy of the Leningrad Region is developing thanks to of various industries: the most significant segments are mechanical engineering, electric power, aluminum and forestry. There is an active introduction of new technologies in these regions. They are related to the digitalization of design and technological activities, the introduction of various operational planning and dispatching systems, and the modernization of equipment. Many operations are performed by machine tools, robots and computer-aided design systems. The level of automation at the enterprises of the Republic of Tatarstan, Khanty-Mansi Autonomous Okrug – Yugra, Tyumen Region, Yamalo-Nenets Autonomous district is also high. Active work is underway to create Factories of the Future with high-tech enterprises. For example, shipbuilding (Sredne-Nevsky shipbuilding plant Malakhit), aircraft and helicopter engineering (United Aircraft Corporation / Sukhoi Civil Aircraft / Irkut Corporation / Ilyushin Aviation Complex). The software and hardware systems used at these enterprises work in parallel to perform one or more homogeneous tasks. It is possible to increase the efficiency and profitability of production with the help of the introduction of such complexes, and to reduce the volume of working capital.

Blockchain-based solutions (8.1% of respondents), big data (6.9%), artificial intelligence (6.1%) are used among the planned digital technologies for development [5].

In recent months, at the initiative of the President of the Republic of Tatarstan, machine-building enterprises of the Republic of Tatarstan have joined the digital transformation processes: NPO OKB named after M.P. Simonov, Kazan Engine-Building Production Association, Kazan Helicopter Plant and KamAZ. The industry is characterized by high-tech industries. Kaluga Region is implementing a pilot project to create a national data management system. Technical support is provided: the software collects, analyzes, organizes, visualizes the data received from the sensors, and helps a person make decisions or makes them automatically. But the digitalization of production is also constrained by the insufficient penetration of industrial automation systems (MES systems, digital lines). The machine-building complex is one of the significant sectors of the economy, the level of development of which largely determines the state of the economic potential of the Russian Federation, its competitiveness in the domestic and world markets, as well as the state's defense capability [6].

Trends in the development of mechanical engineering until 2030 will be associated with the implementation of measures for the technological re-equipment of enterprises, increasing design work aimed at creating new competitive types of products. The development of the digital economy requires a strong talent pool. For technological leadership, enterprises need to carry out intensive research preceding technological development, create the results of intellectual activity and carry out technology transfer. In addition, organizationally, the following points are of great importance:

- creation of platforms for interaction and knowledge exchange;
- integration of science and technology;
- coordination of efforts between all participants;
- development of a communications network;

<sup>1</sup> "Digit" goes up: production automation dynamics in Russia/RBK partnership project. Digital economy («Цифра» растет: как развивается автоматизация производств в России/партнерские проекты РБК. Цифровая экономика), <https://plus.rbc.ru/news/5b5e4f937a8aa9225f10e22a>

- dissemination of best practices;
- priorities for the development of the cluster;
- support for new projects in the field of communications;
- advisory, methodological and organizational assistance [7, 8].

The first digital industry standards in the country were developed by the Cyber-Physical Systems Technical Committee based on RVC with the support of the Ministry of Industry and Trade of the Russian Federation. The standards are aimed at the effective implementation of digital technologies in the Russian industry, the development of high-quality and independent solutions, as well as ensuring their compatibility. The new standards form the basis for the creation of two new series of national standards for Industry 4.0. They focus on virtual production systems and the convergence of digital technologies and IT systems in industrial enterprises. For example, the preliminary national standard (PNST) “Industrial automation systems and their integration”. This standard specifies provisions for ensuring the safety of industrial plants using automatic process control devices.

Next “Assessment of convergence of informatization and industrialization for industrial enterprises. Part 1. Structure and Typical Model” defines the basic principles of the process of integrating information technologies into industrial production.

The digital transformation model includes the following directions:

1. Creation of a regulatory environment for digital transformation of the industry.
2. Creation, integration and development of platforms of the state information system of industry (GISP) for the implementation of industrial policy.
3. Digital transformation of manufacturing industries [9, 10].

The introduction of new technologies can change the order of using resources by personnel and administration and thereby affect the competitive advantages of companies. The main technologies of Industry 4.0 have been introduced: big data, cloud computing, mobile technologies and social networks. To ensure the dynamic development of the national industry, appropriate macroeconomic conditions and regulators are needed, which must include an effective mechanism of state scientific, technical and industrial policy [11].

Principles of building science and technology policy in the regions:

1. Recognition of intellectual property and products, technologies, services created on its basis, which determine the level of development and competitiveness of the Organization.
2. Use of the results of patent research to determine the priority areas of scientific and technological development. The organization and the concentration of resources in these areas.
3. Ensuring the necessary and sufficient legal protection of the rights to results of intellectual activity embodied in the products of the enterprises in the relevant territories.
4. Considering the rights to results of intellectual activity as intangible assets in order to increase the capitalization of the organization.

The increasing role of knowledge and intellectual capital leads to a change in the organization of the innovation process both within individual enterprises and in individual regions within global value chains. Enterprises form business models to test sustainability and flexibility to changing operating conditions when the external environment requires new management strategies [12, 13].

## Discussion

A number of technological areas provided in the federal program “Digital Economy of Russia”, are already being tested in practice in Moscow. The Digital Russia Index reflects the presence and success of initiatives related to digitalization at the regional level. Each event is categorized into one of seven key sub-indices:

- regulatory and administrative indicators;
- personnel and training programs;

- research competencies and technological groundwork;
- information infrastructure;
- Information Security;
- economic indicators;
- social effects.

Internal backbone factors in relation to the regional industrial complex are:

1) competitive ties characterizing the level of competition within the industrial complex, as well as between enterprises and organizations;

2) cooperative or interaction links, which can be divided into:

- production ties characterizing the degree of interaction of enterprises with each other within the industry, as well as with service and support organizations;

- innovative ties characterizing the degree of innovative activity of enterprises and organizations, the level of their interaction with educational and research institutions and among themselves in terms of the introduction and dissemination of innovations.

Industry 4.0 leads to massive adoption of cyber-physical systems in production, automation of most production processes, installment of artificial intelligence to devices, and introduction of many other modern technologies. All this has a significant effect on increasing productivity and reducing production costs. The Industry 4.0 program includes the following areas:

- digital modeling as one of the basic directions of the implementation of the Industry 4.0 program, which will be actively used in production processes, including virtual modeling of the surrounding physical world to obtain actual data;

- industrial Internet of Things (sensors and equipment in production are united into one network by a hierarchical structure and are subject to a single production management system);

- augmented reality (applicable for various purposes, including when choosing parts of various structures in a warehouse, displaying instructions for the repair and maintenance of equipment);

- big data (BIG DATA) and business analytics used for optimization of product quality, energy saving and improvement of equipment availability). The need to process large databases requires further improvement of “cloud services” [14, 15].

One of the first Russian companies that introduced the programs of Industry 4.0 was SIBUR (Regional Center in Tomsk). The level of technological equipment of the enterprises is one of the highest in Russia. SIBUR uses advanced solutions, such as an improved technological process management system (APC), production system (MES), LIMS laboratory system, SAP ERP enterprise management system, and business processes management system (BPMS).

In SIBUR, Big Data tools are used to maximize the performance of installations and improve product quality, mobile applications, virtual and augmented reality, video analytics, robots, drones and other digital products. Datasience tools are used: online consultants and predictive analytics.

In Nizhny Novgorod, digital production in OJSC TEPLOTEHNIKA is one of the recognized leaders in the production of high-tech products for the aviation industry, which has its own experimental design bureau, research, testing and production base. The TEPLOTEHNIKA company has created a functional model from the BigData zone using machine learning algorithms, systems for construction and storage models. In Tyumen, a modern intelligent control system has been created for an oil-refining factory. This platform created a practically holistic human machine interface to manage a new plant installation, which allowed the operators to receive information on the production process and make the necessary solutions to eliminate the arising problems.

The benefits of digital transformation are best seen in examples. For instance, OJSC KAMAZ created a special Digital Transformation Center, which has already made it possible to implement several successful projects at once. The digitalization of industry is the concept of a new digital space, a unified system integrating production machines, life support and safety systems of the enterprise, that is, all the electronics of



the organization. Sensors and detectors make it possible to combine various physical objects into a virtual network, in which they can interact with each other without human involvement. The main benefit of digitalization lies in the improvement of enterprise productivity by reducing time.

To manage innovation activities, improve the efficiency of innovation processes, the Ministry of Industry and Trade of Russia monitors regional and sectoral projects for the digital transformation of industrial enterprises. There are digital platforms created that have a significant impact on the development of industrial enterprises.

Artificial intelligence is the main direction in the development of control systems, which can help to get the most out of existing industries and build new, most efficient systems. The development of artificial intelligence (AI) systems has made it possible to create automation systems of a fundamentally new level [16, 17].

### Results

1. Digital technologies allow you to analyze the situation in real time and maintain performance when changing control objectives, unforeseen changes in the properties of a controlled object or environmental parameters. At the design level – to improve the efficiency of new product development, automate the selection and evaluation of suppliers, when analyzing the requirements for spare and component parts. At the production level – to improve business processes and coordinate various production systems. At the logistics level – to improve the planning of transportation routes, reduce the delivery time of raw materials and ensure their predictability, as well as track shipments and the delivery process at all stages.

2. The system is capable of changing the control algorithm and looking for optimal and effective solutions. Artificial intelligence will carry out production, quality control, reduce design time and reduce waste, improve product reuse.

The use of intelligent assistants helps to reduce the number of personnel errors, simplify the production process and reduce downtime when rebuilding technological processes. It can also choose a market segment for promoting products on the foreign market, increase export volumes, and carry out production development forecasts based on objective statistical data.

3. Cyber-physical systems can improve production processes by providing real-time data exchange between such elements as industrial equipment, logistics, business and customer management systems. In addition, cyber-physical systems allow automatic monitoring and control of the entire process, including the adaptation of production to the current needs of the customers [18, 19].

### Conclusion

The industry of the regions introducing new technological developments becomes competitive. The country's economy based on the development of the regions shows stable results. Digital platforms have a significant impact on the development of industrial enterprises.

The Industry 4.0 project and program provides for the digitalization and integration of technological, production and business processes vertically throughout the enterprise, from product development and procurement to production, logistics and in-service maintenance. The use of software products in the production cycle of industrial enterprises shows sustainable development of the industrial sector and the economy of the regions.

The presence of digital competencies is important for the successful implementation of the Industry 4.0 concept in industrial enterprises in the regions of the country. Quality analytics of data is a mandatory requirement for the successful implementation of digital platforms in enterprises. It is necessary to implement the tasks of the joint transition to digital production management with the broad integration of business partners within the framework of the value chain and the transition to open platforms (Open Platform for Smart Manufacturing).

Clustering is the real possibility of successful introduction of the cross-cutting technology.

It is important to use international positive experience for applying a flexible production concept (Agile Manufacturing) based on cross-functional production teams. The teams can move between cluster organizations as needed, depending on the production system. In the nuclear industry, Rosatom is already actively using certain elements of digital production in the creation and design of stations and equipment.

Also, advanced companies, like KAMAZ, Joint Aviation Corporation, Russia helicopters produce serial high-tech products and compete in the global market. STVERSTAL actively uses mobile devices to provide transparency for maintenance and repair of equipment, as well as automate personnel planning processes.

Digital transformation is actively used in such areas as advanced analytics, the use of big data for decision-making.

TechNet roadmap proposed by the government in the frame of Industry 4.0 ensures active introduction of new technologies: digital design and modeling; new materials; 3D printing; CNC technology; “smart” sensors; industrial robots; enterprise management information systems; Big data and industrial Internet and others.

The Network Plant concept proposed by Udmurt Machine-Building Cluster suggests that the participants of the production network (cluster), having automated planning and control of production facilities, receive the external information about the production capacity loading reserves. The concept is based on the use of a digital technological platform – a set of software and hardware tools to ensure cloud technology, open data, appropriate applications and services. All information about the “network factory” is stored on cloud servers and integrated with the information systems of the participants of the “Network Plant”.

Large enterprises are just beginning to introduce separate elements of Industry 4.0. The domestic industry is gradually approaching the use of the best practices of foreign industrial production, network interaction, organization of scientific and educational activities and the need for adaptation to a particular industry.

Directions for further research: analysis of the practical results of the introduction of digital technologies in the industrialized regions of the country and connecting elements, indicators of economic development.

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