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Technological Development of Innovation Ecosystems in Conditions of Digital and Human-Centric Economy

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***Abstract*—Nowadays, due to changes in the global economy (structural, technological, geopolitical) for country's competitiveness at the international level, it is necessary to digitally transform the activities of the Russian enterprises in the context of its managerial and technological processes and models, as well as enhance interaction enterprises among themselves and with other participants of the innovation system at the meso and macro levels. That is all defined as guiding lines to the achievement of the scientific and technological development of the Russian Federation (The Strategy for Scientific and Technological Development of the Russian Federation on January 12, 2016, № 642). The scientific novelty of the proposed paper is to develop a theory and practical mechanisms for the transformation of managerial, technological and logistics processes at the level of individual enterprises and regional innovation systems using the latest information technology (big data analytics, cloud computing, digital twins, blockchain technology, etc.), which will ensure a drastic change in enterprise business processes and technologies for decision-making support. The interdisciplinary nature of the research causes introducing of new sources into scientific circulation, rethinking of scientific thought development, principles and mechanisms, as well as patterns of economic development at micro, meso, macro and global level.**

Keywords—digital transformation, ecosystem, innovation development, region economy.

I. INTRODUCTION

The global trend towards a digital transformation of the economy poses new challenges for Russian industry.

Inherent innovators (schools, higher educational institutions), supranational standards, new customer requirements (family, business, society, government) are the drivers of education development.

The world of hi-tech, accelerated development and ever-increasing digitalization has prompted changes to our way of life. In addition to a range of conventional risk factors that mankind faced in the past and that led to crises before, new ones have emerged - those associated with personal data privacy and cyber security, artificial intelligence and new jobs, instant dissemination of information and public opinion manipulation, unequal opportunities and environmental threats.

The pandemic reminded mankind yet again about just how weak and vulnerable humans are - as estimated by the International Labor Organization, 25 million people worldwide may lose their jobs due to the unprecedented, in terms of scale and reach, economic shutdown. Some experts are convinced that mankind will see an automation boom in the near future. In light of the pandemic and its consequences, many employers may see machines as more reliable workers than humans.

During the lockdown, digital technologies became a ‘silver bullet’ for many people - remote jobs, remote education, telemedicine, digital services. Online environment was not only a tool, but rather a real space to live and work in. However, the society has passed through significant transformation during the last 6 months, and so has the attitude towards digital technologies. This transformation does not necessarily mean that digital technologies are now more accepted by broad public; quite contrary, new phobias and mass conspiracy theories have emerged. Another digitalization challenge is alignment of remote and virtual formats, as well as low degree of readiness of common organizations to use digital technologies.

Now investors see the crisis as a time of opportunity: the main thing is to decide what to invest in and how to make money.

This will allow to improve the efficiency of using the systemic potential of the digital region economy through the direct implementation of digital technologies into the economic mechanism of enterprises. In addition, it is important to create an ecosystem of digital twins for individual systems using the methods of industrial analytics (Big Data) that will allow forming an effective system of communication in the field of science, technology and innovation, the system which will provide the increased susceptibility of economy and society to innovations, create conditions for the development of high-tech business.

The economic crisis that followed the coronavirus pandemic around the world and in Russia led to the fact that valuable assets in many markets fell sharply in price. Many investors are wondering what to invest in, so that at the end of the crisis they can not only save their money, but also earn money.

Top 5 technologies in terms of their prospects for development:

1) People tracking systems

2) Online public services

3) Webcasts

4) Online bookings

5) Videoconferencing

44% of high-tech companies believe that the government will be the key driver of technological progress in the future.

Digital region economy programs adopted in different countries make digitalization of traditional industries one of the key indicators. In the industrial sectors, digitalization is largely determined by the increased use of the Internet.

In the development and implementation of these technologies, many actors are interested - both industrial companies, and telecommunications, and equipment suppliers, etc.

The study objectives and description of problem statement are:

1. Development of models and algorithms for digitization all key information (intrafirm and external) about industrial enterprises' activity.

2. Development of methods, techniques and algorithms for "big data" analysing on the basis of the digital twin concept for the management of industrial enterprises in order to develop their businesses.

3. Solution of the problem of information security of an enterprise in the process of digital transformation of its activity.

4. Development of a full cycle of information support at the enterprise throughout the product life cycle (Figure 1).

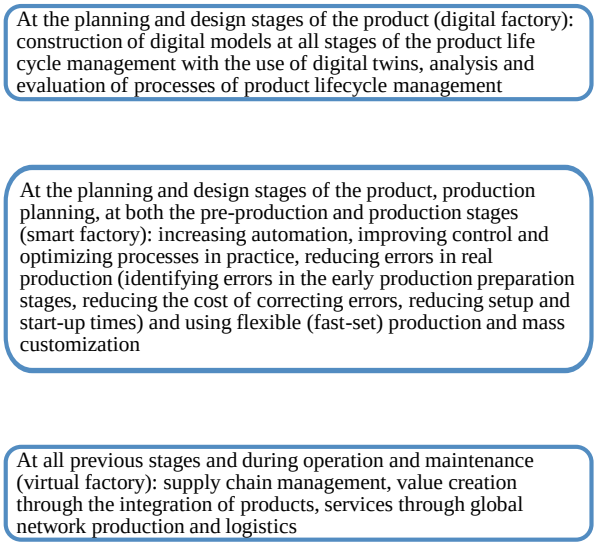

Fig. 1. Development of a full cycle of information support at the enterprise throughout the product life cycle

5. Developing forecasting model for decision making in optimizing of enterprise operation and digital transformation of managerial processes using virtual communication method in electronic networks based on the service-oriented interaction of intelligent agents (twins).

6. Development of a methodology for evaluating the effectiveness of measures for digitizing managerial, production and logistics processes at an enterprise that takes into account formation mechanisms of both transformational and transaction costs.

7. Development of a methodological approach and conceptual model of regional digital ecosystem, combining industrial enterprises with partners and other stakeholders within the framework of the closed production process "design-production-operation".

8. Establishment of a laboratory for analysing, evaluation and engineering of existing processes at industrial enterprises from the standpoint of digitalization, productivity, project-orientation and efficiency.

II. METHODS

General scientific methods of analysis and synthesis were used as research tools, as well as specific research methods such as: monographic method, abstract-logical, calculation-graphic, economic-statistical, comparative financial-economic analysis, etc.

III. MAIN PART

The scientific novelty of the proposed project is to develop a theory and practical mechanisms for the transformation of managerial, technological and logistics processes at the level of individual enterprises and regional innovation systems using the latest information technology (big data analytics, cloud computing, digital twins, blockchain technology, etc.), which will ensure a drastic change in enterprise business processes and technologies for decision-making support.

Within the framework of the program "Digital Economy", four projects based on the blockchain technology are proposed: the specific document circulation system on the

letter of credit investment transactions; the national personal identification system for bank clients "Masterchain"; a unified system of real transactions, which can be automatically performed in 24x7 model; treasury support for budget expenditures.

It is proposed to support the initiative of the state and business to develop digital platforms based on alternative statistics, industrial analytics, Analytics 3.0 with the use of Big Data technology for operational monitoring of sectors of national economy and industry.

The accessibility of the solution to the problem and the possibility of the anticipated results obtaining is supposed to ensure by means of: the scientific background of the group; optimal composition of the key competences of project's participants, experience in managing the creative teams of the leading scientists and a number of the team's participants; use of an interdisciplinary methodological approach, representing a constructive tool for researching managerial, technological and logistical processes; application of modern theoretical and practical research methods; using a wide range of information resources for conducting the research.

The priority directions in the world scientific research are as follows: the artificial intellect and its subsystems: machine learning, neural networks, image recognition. An analysis of various state programs shows that leadership in this area is provided by massive funding and coordinated efforts on the part of state bodies. The world experience of transition to a digital region economy is described in the works [1–3].

Examples and analyses of successful digital transformations are outlined in a significant number of published works on the digitalization of the economy [4–8].

A significant contribution to Russian scientific research on the digital region economy was made by the Lomonosov Moscow State University's scientific school. One of its earliest works on digital economics was devoted to the importance of the integrated application of technology. It is noted, for example, that the joint use of Building information modelling (BIM) and geoinformation technology (GIS) can contribute to building systems that work effectively in the life cycle of design, construction and operation of a building.

A crucial element for the digital region economy is cyber-physical systems. This problem is poorly studied in the literature. At the same time, its importance is obvious. There is also an intersection with another interesting research field – cyber-social systems, which can be attributed to the projects of electronic document management and e-government.

The work is devoted to the description of models and business processes. It examines, in particular, and BSI standards for Smart Cities.

An important aspect for the digital region economy is maintaining data connectivity.

The main technologies that need to be implemented into Russian industrial enterprises are as follows:

- digital simulation (CAE, FEA, CFD);
- digital twins;
- digital logistics;
- cross-sectoral cooperation, technology transfer;
- information platform of the enterprise EIM = PLM + MES + ERP;
- convergence of the functionality of the digital control system (P + D);
- digital reverse-engineering;
- additive production;
- lean production.

Today we have to admit that Russian enterprises have limited experience with digitalization.

For example, since 2018, ROSATOM has been implementing a Uniform Digital Strategy (UDS), which is focused on supporting the digitization of the Russian economy, developing the Corporation's own digital products and putting them on the market, and internal digitization. In 2019, ROSATOM prioritized yet another cross-cutting area: digital and technological research and development. In addition, the UDS was updated taking into account the results achieved by ROSATOM and changes in the market.

As part of the strategy update, ROSATOM placed greater emphasis on end-to-end technologies, expanded its approach to mergers and acquisitions (M&A), developed uniform principles and identified key priorities of digitization programmes in its Divisions, and built an integrated system and organizational structure for digitization management. The Steering Boards (SBs) of the Digital ROSATOM Programme and the SBs in the Divisions play a key role in the organizational structure.

The Uniform Digital Strategy relies on the following major pillars:

- Strategic partnerships and M&A;
- Organizational change;
- Digital competences and culture.

The key driver of effective implementation of the UDS is its close integration with digitization programmes that are being implemented in ROSATOM's Divisions and enterprises in the industry.

In addition, 2019 saw the development of uniform methodological guidelines for assessing economic benefits from digitization projects. Projected total benefits from projects initiated in 2019 exceed RUB 10 billion.

In order to implement the UDS, the Digitization Unit has been formed within the Corporation; it includes the following divisions and companies:

- The Digital Transformation Department (established in 2019);
- The Information Technology Department;
- The IT Department of JSC Greenatom (including the CRTESIIT);
- The Digital Economy of Russia Project Office;
- LLC JV Kvant, an operator under the road map for the development of a quantum computer (established in 2019);

- Private Institution Cifrum, ROSATOM's digital technology laboratory (established in 2019);
- LLC Rusatom Digital Solutions, a trading firm selling digital products and solutions (established in 2019);
- The Process Architecture Centre at JSC RPS.

ROSATOM is a competence centre under the Digital Technology Federal Project, which forms part of the Digital Economy National Programme. In the reporting year, all targets set under the project were achieved. ROSATOM initiated the preparation of seven road maps for developing end-to-end digital technologies in Russia.

Based on the developed road maps, government support was provided for 105 projects of various Russian companies worth a total of RUB 14 billion, including RUB 941 million allocated for seven projects directly involving ROSATOM.

In 2019, an agreement was signed with the Russian Government on developing a high-technology area: quantum computing. Under the agreement, a large-scale project was launched to develop a Russian-designed quantum computer. The use of quantum computers will enable a major breakthrough in solving a wide range of problems, such as modelling the behaviour of molecules to develop new drugs and tailored materials, complex logistical problems, big data management, ensuring information security, etc.

ROSATOM's road map for quantum computing successfully underwent stress tests conducted by the expert community and the federal executive government.

A project code-named Liman was successfully completed in 2019 under the supervision of FSUE Dukhov Automatics Research Institute (VNIIA). The project involved developing technology for creating superconducting two-qubit systems (a prototype quantum computer) and demonstrating single-qubit and twoqubit operations.

ROSATOM is not the only participant of the project to design a quantum computer, which is scheduled to be completed in 2024. The Corporation coordinates the efforts of key teams and organizations performing R&D in the sphere of quantum computing, as well as potential users of quantum technologies. ROSATOM is developing quantum computing for the benefit of the nuclear industry, the Corporation's new businesses and the Russian economy as a whole. ROSATOM is the organizer of the National Quantum Laboratory. It is an integrated ecosystem comprising a variety of R&D centres, research institutes, technology start-ups and university laboratories in order to efficiently coordinate joint initiatives on quantum computing.

In 2019, the development of ROSATOM's digital product portfolio was focused on six prioritized areas [9]:

- Science-based modelling and R&D;
- Enterprise and production management;
- Digital infrastructure;
- Design and construction/digital twins;
- Information security and digital physical security;
- Digitization of municipal services and processes.

Flagships have already been developed in each of these areas. They were created by various Divisions and enterprises of the Corporation, and the first customers for these products include major industrial, energy, and oil and gas companies, which are leaders in strategically important sectors of the Russian economy. At year-end 2019, the Corporation's digital product portfolio included about 150 products.

In 2018 and 2019, the Corporation officially launched its digital products on new commercial markets across all segments of its portfolio. Going forward, the key priority for the Corporation is to pool the industry expertise and to progress from local IT systems to developing integrated digital solutions not only for the nuclear industry but also for other segments of the Russian economy.

An important milestone in 2019 was the development of a concept of integrated IT architecture in the nuclear industry. A number of projects entered the commercial operation stage; these include the Project Review automated information system, an Electronic Document Management System for ROSATOM's overseas branches, representative offices and subsidiaries, ROSATOM's Unified Industry-Wide Quality Management System, etc. At year-end 2019, more than 40 projects based on end-to-end Industry 4.0 technologies were at the pilot operation stage in various organizations of the Corporation (including developing a secure corporate email system, online accounts for employees, and the monitoring of financial period closure).

To support NPP construction, automated handover of equipment specifications from the design and procurement functions was introduced. A digital dashboard for the site manager was piloted at Rooppur NPP (Bangladesh). The configuration of design systems was approved for the NPP in Uzbekistan. In ROSATOM's overseas branches, an open-access document management system was introduced, and a two-way connection to the IIDMS was provided. More than 9,000 cyberattacks were prevented during the year. In addition, ROSATOM piloted a system for raising users' awareness of information security matters.

The expected outputs of the project include developed implementation mechanisms and support initiatives to form pilot projects (testbed) for the development of digital factory concept (a smart factory, a virtual factory) in terms of the interaction of digital design and modeling technologies.

It is possible to use the study results in practice along the following primary lines [10]:

- as the basis for the establishment of an effective system of communication in the field of science, technology and innovation, the increase of susceptibility of economy and society to innovations, the development of high-tech business;
- when developing and implementing measures on digitalization of social and economic processes in accordance with the Program "Digital Economy of the Russian Federation", approved by the Government of the Russian Federation in its resolution No. 1631-p dated July 28, 2017;
- in the processes of improving the state regulation mechanisms of innovative economy by the federal and regional authorities;
- while predicting the results of the realization of administrative decisions in the field of economy innovation development;

• as a basis for the development of educational programs for training, retraining and advanced training of specialists in the field of production management.

The project team participants have extensive experience in conducting research, including within the framework of the Federal Target Programs (FTsP) and analytical departmental target programs (ASCPs). In total complexity, about 40 research projects, thematically related to the proposed project, were carried out.

The introduction of the results of the proposed project into the management practice will ensure the overall growth of the economic and innovation development of the Russian enterprises, a reduction in the average duration of the implementation of the life cycle of innovation and investment projects, and the improvement of their quality.

The social significance of the planned results of the project is to obtain the accompanying social effects from their practical implementation, which, first of all, consist in the projected increase in the quality of life in Russia. New technologies open enormous opportunities, allow at times to increase the efficiency, speed, transparency of many processes, the inclusion of citizens in public life.

The planned results of the project correspond to the world level of scientific works in the field of digital transformation of social and economic systems, which is in demand in the direction of world science.

The demand for the project by the world science is confirmed by the correspondence of the topic and content of the declared project to the research fronts (according to the authoritative system Essential Science Indicators).

The result of the scientific project is developing new profiles of undergraduate and graduate educational programs and curricula for the directions «Management», including separate courses as «Digital economy», «Digital business processes management at industrial enterprise», «Decision-making using Big Data analytics tool», «Digital marketing», «Information security management», «Digital project management », «Digital entrepreneurship», etc.

The theoretical foundation of the project contains the management theory, the theory of innovative development, the theory of intellectual and human capital, the evolutionary theory, the neo-institutional economy, fundamental and applied studies of domestic and foreign scientists in the field of entrepreneurship management.

A methodological basis of the study is formed by the general scientific principles of the systemic and synergetic approaches, taking into account the major dialectical regularities, the methods of economic, factor, regression, situational analysis, logical dependencies, prediction, formalization and generalization, comparison, analogy, expert evaluations, construction of managerial technologies and logical schemes, data infographic visualization and interpretation of data.

IV. CONCLUSION

In addition, at various stages of the study, depending on tasks being solved, the following methods and approaches are proposed [11]:

• method of virtual communication in electronic networks on the basis of service-oriented interaction of intelligent agents (twins);

• method of system integration of heterogeneous scientific knowledge;

• system-synergetic approach and software products for building intelligent digital twins [12];

• method of multi-level mathematical simulation of the dynamic variability of intelligent self-organizing components in systems, networks and environments [13].

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