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**DIGITAL TRANSFORMATION IN MANUFACTURING,
INFRASTRUCTURE AND PUBLIC SERVICES**

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Abstract

The paper states the necessity of digital transformation in manufacturing, infrastructure and public services for improved labor productivity, more competitive advantages for domestic products and provision of high-quality public services for the population. The paper investigates specific approaches, principles and key indicators relevant for evaluation of the effects produced by implementation of digital transformation-related projects in terms of feasibility, sustainability and economic efficiency. The paper also reveals problems in implementing tools of digital transformation, solutions developed will allow achieving goals of digital transformation in manufacturing, infrastructure and public services in the Russian Federation. Improving security of domestic businesses with tools of digital transformation including those related to information security determines procedures and methods for major lines along which transformation proceeds, and the mechanisms, structure, nature and monitoring of measures to be applied. The paper emphasizes priorities in digitization of investment sector. Systemic approach to understanding the process of digitization based on application of advanced tools to achieve the goals of digital transformation in manufacturing, infrastructure and public services is proposed. The paper also dwells on solutions in evaluating the effects of digital transformation in manufacturing and public sectors. Multi-aspect analysis of interrelated phenomena of innovation and digital transformation promotes further increase in rates and scale of innovative activities. The results of analysis are to be accounted for when implementing digital transformation strategy in the national economy.

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Keywords: Digital transformation, innovation, infrastructure, commercialization, scaling, effectiveness.



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1. Introduction

Digital transformation of manufacturing, infrastructure and state institutions is defined as the process of fundamental change in all aspects of society initiated by new competitive advantages resulting from evolution of information technologies in adding value of goods and services.

Digital transformation changes the structure of modern businesses, the scale of operation, consumer behavior, product life cycles, innovative behavior and culture of society, legal regulation, promoting wider innovations to satisfy consumer demands, raise efficiency and improve the quality of goods produced and services provided.

Strategies, platform solutions, competitiveness, human resources from organizational point of view are deemed critical to achieving success under the conditions of Industry 4.0 and digital transformation of company's manufacturing processes (Nwaiwu et al., 2020), such changes provide ever more opportunities for development of new products, processes and services (Colli et al., 2018), with manufacturing systems to meet requirements of adaptivity, self-regulation and self-optimization (Cimini et al., 2017).

Digital transformation today is to play a crucial role in modernization of public services with increased rates of satisfaction and efficiency, higher labor productivity, openness and trust of the public to digital literacy and to lowering labor-intensiveness of manufacturing processes. Digital technologies promote innovative transformation of design and provision of public services adapting those to public and individual needs improving efficiency and quality of government operation.

Result-oriented management of investments in digitization, funding of social innovations provide for higher rates of effectiveness in project implementation, higher rates of customer satisfaction with further spread of digital technologies applications in the field of public services and development of modern approaches to planning for investments in manufacturing and infrastructure.

2. Problem Statement

Development and integration of digital transformation strategy to achieve digital transformation of manufacturing, infrastructure and public services in the Russian Federation faces a number of both external and internal challenges among which, for the purposes of the present studies, the following ones are to be identified:

- Insufficient levels of digital culture among the society and businesses, lacking abilities in commercialization of digital technologies and scaling required to enter global markets;
- Insufficient levels of private and public innovative activities;
- Insufficient levels of investment activities;
- Gap between the key industries of Russian economy and non-risky areas of digital transformation;
- Gaps in the effects and consequences of managing social policies and measures aimed at digital transformation of public sector.

2.1. Insufficient levels of digital culture among the society and businesses, lacking abilities in commercialization of digital technologies and scaling required to enter global markets

Poor digital skills and digital literacy within businesses hamper business development. According to the survey, 20% suffer from lack of expertise and experience in digital technologies which prevents full-scale digitization and slows its pace (Turovets & Vishnevskiy, 2019). Solutions to the problem of lacking digital literacy of both population and businesses and of low levels of corporate innovative culture for the aims of digitization will require establishment of pilot zones of innovation, personnel training schemes and incentives for involvement in innovative projects of university graduates and post-graduates. Support for start-ups and further commercialization and scaling of activities will bring additional benefits for innovative activities at the national level and for employment by creating new jobs across the nation.

2.2. Insufficient levels of private and public innovative activities

Digital innovations today are paramount for innovative activities of most big businesses and examples set by leading global business innovators prove the importance to be given to innovative approaches in modern digital technologies (Lichtenthaler, 2018; Molchanova, 2019). Analyzing the business practices developed in the field of high-tech by the global technological leaders and the stories of their growth we can state that innovative clusters are capable of rendering positive influence on the nation's digital transformation in conditions of the digital economic growth (Polyakov & Stepanova, 2020).

2.3. Insufficient levels of investment activities

Applying digital technologies leading companies develop new business models and new opportunities for ways of rendering services or operation. This, in its turn, will necessitate investments into R&D and corporate infrastructure, like, for instance, corporate cloud solutions, databases etc. It will also require expansion of businesses, ecosystems, establishment of new strategic alliances and investments of corporate venture capital in start-ups based on digital technologies (Szalavetz, 2019).

2.4. Gap between the key industries of Russian economy and non-risky areas of digital transformation

Setting priorities in development of particular sectors requires conditioning on the industry's capacity to unassisted digitization, development of programs to support prioritized directions of transformation and new approaches to restructuring legal regulation. In recent years the trend towards advancing information and communication technologies has promoted establishing within the society of conditions for digital transformation of both businesses and non-profit organizations.

2.5. Gaps in the effects and consequences of managing social policies and measures aimed at digital transformation of public sector

Digital transformation induces radical changes in the mechanisms of digital technologies application by state and local authorities and bodies while optimizing operational expenses, lowering costs and increasing labor productivity by 30% as analysts forecast (Lorenz et al., 2018). It will also increase the efficiency of public spending and eventually – on the basis of established platform ecosystem – will allow achieving new levels of trust to in the public to state and local authorities and bodies.

3. Research Questions

- What role is to be played by digital transformation in modernizing public services, improving labor productivity and reducing labor-intensiveness of production?
- What are the principles for evaluating the effectiveness of digital projects?
- What are the tools and schemes for digitization of national economy?
- What are the measures for evaluating the levels of digitization in the national economy in conditions of scaling and replication of digital technologies by businesses and government agencies and the methods of financing them?
- What are the possible approaches, stages and principles of implementing digital transformation projects and measuring their feasibility, efficiency and economic effects?

4. Purpose of the Study

Establishing systematic representation of digital transformation processes with modern tools and procedures used to achieve the desired levels of transformation in manufacturing, infrastructure and public services in the society.

5. Research Methods

Among the main principles for evaluating the economic effectiveness of digitization projects most typically mentioned are the following: feasibility in terms of technical and economic justification and their expediency in terms of implementation. Expenses on digital transformation are to cover for the expenses on production automation, business operation informatization, transition and adaptation to digital technologies in solutions for technological aspects of production, control of manufacturing systems and NC-based machinery, analysis and accumulation of digital technologies, optimized production costs, processes and procedures for data collection and processing.

Stages prior to the start of a project for digital transformation in manufacturing, infrastructure or public services require preliminary evaluation of feasibility and expediency of digital transformation based on digital technologies applied within the project and the degree of their penetration into the national economy. It necessitates determining goals and objectives to be achieved by the project and development of the mechanisms and procedures required as well as identifying and calculating the indicators for evaluating the project effectiveness and efficiency given interests of all stakeholders, forecasting for the industry development, collecting and processing data on projects and measures in digital transformation within a certain area, analyzing business goals set by entities in manufacturing and infrastructure or by government institutions in each individual area and in general.

The tools applied within the field are re-engineering, digitization and restructuring, i.e. those implying profound transformation of all production processes and related infrastructure. Measuring the level of digitization requires developing a complex system for monitoring with an established at the state level set of indicators and methodology of their measuring and calculation, which is assumed to necessitate identifying an integral indicator to evaluate the effects and efficiency of a project for digitization of the national economy. Integral evaluation of the digital transformation effectiveness by generalizing effects of

synergy with payback periods of 10 to 15 years for effective scaling and replication of digital technologies is to account for the given integral index for the whole composition of technologies applied in manufacturing, infrastructure and public services for the population. The existing index-based approaches for evaluating the level of digitization in national economies (Aheleroff et al., 2020) and societies include infrastructure and cost criteria, levels of involvement into digital activities, range of information systems, integration of digital technologies, transformation of economy and digitization of public services. Effectiveness of digital transformation is determined on the basis of specific features of projects to be implemented and of the effects they are to bring about. Among those we can name the criterion of public effectiveness in terms of digitization at the individual and the national levels. Development of the project requires choosing the approach which will allow achieving strategic goals set.

Evaluation of potential integration in the production process of a promising product, allocation of human and intellectual resources with other factors and evaluation of possible risks (Kuteynikov et al., 2019) are the key to digitization of economy which involves digital technologies of Industry 4.0, digital twins (Kritzinger et al., 2018; Qi & Tao, 2018), machine learning, industrial Internet-Of-Things, distributed registries and big data.

The general scheme of digital transformation evaluates the level of digital maturity, digital technologies and digital control. Standardization of production processes, additive manufacturing, simulation modeling, machine learning, industrial Internet-Of-Things, in their turn, allow a set of indicators to evaluate the opportunities for integrating digital technologies and digitized documenting.

The demands for increased effectiveness and efficiency of project management and provision of services using digital technologies are added by increased expectations of customers in terms of being provided more innovative and operative services with a simultaneous requirement for products to increase competitive advantages as compared with other products in global markets and for incentives to promote economic growth.

Elaboration and integration of digital transformation strategy for achieving the goals of the economy and society digitization imply contributions by digital technologies into manufacturing, infrastructure and public services to establish the attitudes of trust within the public to digital services promoting openness in the society and integration of stakeholders in development of innovative approaches to attain sustainable economic growth. Current approaches to increasing productivity in manufacturing, infrastructure and public services require continuous effort aimed at digitization resulting in increased digital well-being of businesses and allocation of resources in accordance with priorities in the national strategic development. Prioritized sectors and industries in terms of digitization today are machine building, energy, including energy efficiency, circular economy (Molchanova, 2020), construction, textiles, small and medium-size businesses, retailing (Meyer et al., 2018), agriculture (Esch et al., 2020; Richter et al., 2019), transport and logistics (Dubovik et al., 2018), health services, education, while information and communication technologies and finance, possessing negligent digital riskiness levels, are characterized by much higher rates of digital transformation as compared to the former. This condition determines the necessity for the state to establish legal measures and incentives for the above sectors and industries and to effect investments of state funds into the prioritized areas.

Factors restricting digital transformation comprise those rooted in the lack of relevant competences with entrepreneurs, investors, managers and employees, with the crucial one rendering major influence on digital transformation being investments in digital technologies. It is here that government has to put effort to increase investments in digitization making it top-priority. Study of successful examples in innovation-based digital transformation (Esch et al., 2020; Habanik et al., 2019; Kolla et al., 2019; Molchanova, 2019; Piskun et al., 2019; Tolstykh et al., 2018) reveals prerequisites for effective projecting in digital transformation and these are to be accounted for when developing strategy for digital government and implementing programs and projects of digital transformation. Private investors are to be given incentives to increase investments in infrastructure for digital networks in distant territories through granting tax benefits and other types of subsidies. Modern digital environment offers more opportunities for cooperation among stakeholders to establish priorities in policies, cooperative effort in development and provision of social services, supported by new structures of organization and governance and new mechanisms of funding innovative digital projects.

Integration of digital technologies in manufacturing, infrastructure and public services allows integrating digital technologies-based applications to search for solutions in the areas of digital transformation, security, data protection while gaining benefits from digital transformation at all levels and in all aspects of society. Support for start-ups and further commercialization and scaling will provide additional gains in innovative activities within the national economy and in employment creating new jobs across the nation.

Digital transformations promotes innovation in the service sector generated by ever increasing spread of mobile Internet, Internet-Of-Things, big data and other advanced technologies, in the manufacturing sector main benefits come from less time-consuming processes of production (Eder et al., 2018), automation, optimization of human resources, intelligent systems, computer-aided design and manufacturing, digital twins (Kritzinger et al., 2018), neural networks and artificial intelligence.

Efficiency, being a key factor to digital transformation in manufacturing, infrastructure and public services, creates incentives for increased competition within the economy, allowing for reductions in overhead expenses and savings from re-allocation of human resources thus becoming intrinsic to the state strategy in digitization by integrating new ways and methods of learning and digital technologies in educational and training programs. Digital technologies are to play a crucial role in digital transformation of health service (Gopal et al., 2019) through application of electronic servicing, scaling and expansion of data sharing.

Creation of public goods and modernization of public sector through integration of digital technologies and improved productivity and production efficiency rates can be regarded both a stage in and the ultimate goal of digital transformation in the national economy. Many industrial enterprises undergoing digital transformation reveal a gradual transition from intermittent to continuous optimization of business processes and operations with aggregation of the data and functions provided for by functioning within the single digital platform of the project. Operational and managerial processes are added by technologies of machine learning and creation of digital twins for technological and business processes and products.

6. Findings

The problems related to low levels in application of digital technologies and lack of competences for scaling required to enter the global markets can be solved by developing modern digital platforms for research and developments in the field of digital technologies, by implementing state regulated mechanisms to create incentives for companies who provide for commercially feasible projects of end-to-end technologies. The problem of scaling in relation to projects in digital transformation can be solved with mechanisms of preferential lending, compensating for logistics-related expenses, for spending on participation in trade exhibitions and fairs, and for obtaining certificates, creating incentives for establishing partnerships and joint ventures with private and public initiative to develop innovative application and services (Akarkin & Yasinovskaya, 2019). According to the report by the World Economic Forum, by availability, range of application and influence on economy and public relations Russia is among most active users of these technologies (Tolstykh et al., 2018).

That the strategy chosen by the Russian Government in acceleration of overall digitization and digitization of economy in particular is extremely effective happened to be proven by extraordinary recent events – the outbreak of COVID-19 pandemic, which necessitated such aspects of digitization as remote work of company employees using information systems, platforms and networking, organization and control of measures to prevent epidemic conditions, social security provisions with digital services and the like.

Resulting from digital technologies integration and inducing increases in the productivity and efficiency rates in manufacturing, infrastructure and public services, digital transformation is to be given foundations in the form of human capital development, increased numbers of investments in digital projects and start-ups, reduced periods of new products entering markets with further scaling, lowering production costs and overhead expenses, improved efficiency rates of investments in digital economy, higher levels of customer satisfaction, improved quality of products and services, increased information and digital security and higher labor productivity rates.

This implies modeling, creating digital environment, developing new business models (Molchanova, 2019) and platform-based solutions, establishing new approaches to operating and processing data in integrating and improving processes for adding value to products and services, radical transformation of the system of management with digital technologies, acquiring new competences in digital technologies and digital environment by company employees and increased demands for research and developments with application of tools for digital transformation.

Digital transformation requires investments in manufacturing automation, in solutions based on artificial intelligence, automation of intra-company logistics, of quality control measures and procedures, investments in analytical solutions, in digital control of manufacturing and production planning, investments in intelligent warehousing and storing.

Economic development of territories within the Russian Federation depends to a large extent on integration of innovative products and technologies (Piskun et al., 2019). Increased outputs in manufacturing, with fastest growth rates by innovation-intensive enterprises, provide for economic growth of territories and allow raising the standards of living by creating higher levels of quantities of demand for goods and services. Digital transformation added by increased growth in R&D is to solve – in the long run

– the problem of heavy reliance of national industry on foreign technologies and of creating demand for domestically developed high-tech products bridging the current divide between high-tech developers and the market.

Many manufacturing enterprises through digital transformation can increase the rates of energy efficiency and the efficiency of operating and capital expenses, of reliability of operative control, of adaptivity of capital construction and technical and technological re-equipment of manufacturing facilities, of optimizing the logistics of purchase procedures and processes, of establishing a system of automated control based on application of artificial intelligence, of monitoring risks and evaluating the investment efficiency, of labor productivity while allowing for increases in human capital by the company personnel obtaining new competences in digital technologies. High-tech industries are the primary drivers inducing increased economic potential of territories and promoting further transformation of economy and economic growth (Zheng et al., 2020), these conditions necessitating additional forms of support by the government of digitization-related activities.

7. Conclusion

Digital transformation and effective mechanism of management and administration can provide for successful modernization of industrial sector and for innovations in public service sector, increasing efficiency and management quality while establishing digitized approach to the environment and care for safety and security of sensitive data.

Implications of acquiring digital skills and competences for sustainable economic and social development of a nation (Habanić et al., 2019), the necessity for improved methods of funding and support, establishment of preferences for public sector through digital infrastructure and digital platforms, application of digital technologies to optimize and coordinate federal and local administration – all these imply prioritizing digital transformation of modern society.

Highly-efficient and productive public sector is deemed integral to highly-efficient national economy. Digital technologies, social networking, mobile devices, cloud computing provide opportunities for integrating individuals, businesses and public bodies to jointly establish shared strategic priorities, Special emphasis should be given to the fact that under conditions of digitized economy efficiency is impossible to be separated from other outcomes in social policies.

Transition to digital government can be effected with:

- crowd-sourcing;
- scaled environment;
- intelligent data processing;
- deep learning;
- big data;
- hybrid clouds;
- data-centric approach to system organization;
- modern ecosystems of social services;
- interoperability in public services.

Creation of digital environment necessitates unification of tools and methods for digital transformation, development of up-to-date mechanisms to provide for systemic approach and information coverage for all sectors involved: manufacturing, infrastructure and public services; development of a knowledge base in industrial digital technologies, a unified registrar of digital products and legal provisions for regulations in intellectual property in the Russian Federation, it also requires integration of digital technologies and customer preferences when determining the strategies in development and state policies in digitization to maintain the levels of public trust to government agencies and to provide high-level servicing by private and public sectors.

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