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Digitalization of manufacturing in Russia, Belarus and the European Union

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Abstract. Digitalization of manufacturing industries is becoming the engine of digital transformation of the entire economy. The essence of the digitalization process in the context of the deployment of the Fourth Industrial Revolution is the process of penetration of information communication and computer technologies into the mechanisms and business processes of the real sector of the economy. A key component of the digital transformation of manufacturing industries is the introduction of cyber-physical systems. In order to assess the level of digital transformation of the national economy, new concepts are introduced: the index of development of cyber physical systems, proposed to reflect the processes of neo-industrialization - Industry 4.0 and the index of transformation of a business model, indicating the dynamics of the processes of Industry 3.0. A set of measures has been proposed to reduce the risks of displacing the domestic economy to the "margins" of world leaders in the international division of labor and in the new technological environment and to increase the profitability of enterprises in the real sector of the economy.

1. Introduction

In modern conditions of the development of world economic relations and the growing global competition of national socio-economic systems, a significant effect from the introduction of digital technologies at the macroeconomic level can be obtained in the manufacturing industry due to its high complexity and the technological lag of Russia from advanced countries. Here, a major breakthrough in the field of efficiency gains is possible in all parts of the value chain - from intensifying the development and launch of new products on the market, synchronizing the production and supply chain of components to significantly increasing efficiency at every stage of the reproduction process from planning, production, quality control to the level after-sales service of the final product. Thanks to the modernization of Russian engineering based on the principles of Industry 4.0, labor productivity can be significantly increased in this industry, reducing the gap with the most industrialized countries [1].

The Russian economy as a whole is still far behind in terms of digitalization of the developed countries of the world. According to McKinsey consulting company, the share of the digital economy in Russia barely reaches 4%, while in the USA - 11%, China - 10%, EU countries - 8%, Czech Republic, Brazil - 6%, India – 5.5% [1, 2].
In terms of digitalization, the most important sectors for Russia - mining, manufacturing and transport - lag behind the EU most of all. International experience shows that it is difficult for industries lagging behind in digitalization to subsequently bridge the gap with leading industries. This is due to the fact that companies with a low digital culture are unattractive for relevant specialists. In addition, lagging companies lack the skills and resources to develop, implement, and deploy large-scale new digital tools, products, and services, which reduces their competitiveness.

2. Materials and methods

The purpose of this study is to develop a generalized digitalization index of manufacturing enterprises to assess the digitalization level of the manufacturing industry of the national economy as a complex socio-economic system. To achieve this goal, the following tasks:

- to analyze the level of digitalization of the economy of the leading countries of the world on the example of the EU and the key areas of digital modernization of industry in Russia and Belarus;
- identify current trends and promising areas of digital transformation of the domestic economy, taking into account the identified specific features of the international experience of neo-industrial development.

The study used the methods of factor, historical, statistical, comparative and system analysis, the method of expert assessments, which allowed the authors to solve the tasks.

3. Results

The essence of the digitalization process in the context of the deployment of the Fourth Industrial Revolution is the process of penetration of info-communication and computer technologies into technologies and business processes of the real sector of the economy. Accordingly, the competitiveness ratings of national economies should be transformed. New approaches based on digital technologies cannot but be based on indicators of industrial digitalization. At present, digitalization already covers the enterprises of the aviation, automobile, shipbuilding, food industries, nuclear energy, and the space and rocket complex of Russia [3, 4]. Digital product doubles are created; production processes are duplicated in a virtual environment. The transition to a distributed product creation model begins. Digitalization services companies are booming. For example, one of the leaders in digitalization in industry in Russia - the company "Digital" - began working two years ago as a startup, in which only a few people were employed. Now its staff is more than 500 people, revenue for 2018 amounted to 1.7 billion rubles. Twice growth is planned for 2019.

At the same time, the main organizations involved in ranking competitiveness continue to adhere to a post-industrial methodology that underestimates the role of digital transformation of industry.

There are many institutions in the world that deal with competitiveness ratings. Here are just a few key organizations and their products:

- Institute of Management (IMD), Switzerland - "World Competitiveness Yearbook (WCY IMD)";
- World Economic Forum (WEF) - "Global Competitiveness Report (GCR WEF)";
- UN (UH / HDRO) - "Human Development Index";
- The World Bank (World bank) - "Worldwide Governance Indicators (WGI)"; "Doing Business";
- UNCTAD (UNCTAD) - "International Trade, Investment and Development of Countries (International Trade, Investment and Development)"
- Swiss Institute of Economics (KOF Swiss Economics Institute) - "KOF Index of Globalization" (KOF Index of Globalization).
In all of these universal ratings, the issues of industrial digitalization are practically not considered. Part of these issues is two other popular ratings. The Networked Readiness Index (NRI) of countries is compiled annually by the World Economic Forum international organization in conjunction with the INSEAD International Business School. The index reflects the level of readiness of countries for the widespread use of ICT for socio-economic development.

According to the authors, the international rating I-DESI (International Digital Economy and Society Index), first published by the European Commission in 2016, can be considered the most appropriate international rating for analyzing the development of the digital economy in the framework of the neo-industrial model. The index I-DESI index, developed on the basis of the DESI index for member countries of the European Union, evaluates the effectiveness of both individual countries of the European Union and the European Union as a whole compared with Australia, Brazil, Canada, China, Iceland, Israel, Japan, South Korea, Mexico, New Zealand, Norway, Russia, Switzerland, Turkey and the United States of America. The index I-DESI index uses data from various recognized international sources, such as the Organization for Economic Co-operation and Development, the United Data Organization, the International Telecommunication Union and others [5 - 7].

If Russia is in the middle of the list in terms of human capital, then the use of the Internet and the integration of digital technologies in business leave much to be desired. And in terms of broadband infrastructure ranks last.

It should be noted that in general, all these most popular rating products, focusing on universal or digital indicators of competitiveness, significantly underestimate the role of factors and indicators of business digitalization, including manufacturing. Meanwhile, the modern statistical base already applies a set of tools for measuring digitalization processes in industrial production, which becomes the vector and driver of the entire digital economy. Thus, the OECD countries statistical portal contains a special section called "Information and Communication Technologies in Business", where you can set selection parameters that include a country, a group of countries and industries, for example, a processing industry, and a list of several dozen specific indicators reflecting digitalization processes.

4. Discussion
To assess the digitalization level of the manufacturing industry on the basis of this information, the authors developed the Digitalization Index of Manufacturing Enterprises, consisting of two sub-indices:

The index of development of cyber physical systems. When constructing the Cyber physical Systems Development Index, we selected indicators that most accurately reflect the possibilities of using digital technologies to transform the manufacturing process in manufacturing industries. The composition of this index includes the following elements:

- Businesses using broadband Internet access for at least 100 Mbps,
- Companies using EDI, Electronic data interchange,
- Enterprises using automatic object identification (RFID) technologies,
- Enterprises using cloud services,
- Including for the operation of own software,
- Enterprises using ERP,
- Big Data Enterprises.

Broadband Internet and electronic data exchange, cloud services and big data are attributes of the "industrial" use of digital streams. These components of digitalization began to develop due to the need to process large flows of information generated during the operation of a complex of devices that equip modern equipment.

The set of indicators included in the Cyber Physical Systems Development Index allows us to track how technologically equipped enterprises are to build digital display formats for production organization in real time.
The transformation model of a business model consists of the following elements:

- Businesses with a website for ordering,
- Enterprises using CRM,
- Companies that exchange electronic information with suppliers and customers,
- Companies receiving orders on computer networks,
- Companies placing orders using computer networks,
- Enterprises using cloud services for CRM systems,
- Businesses using social media.

The transformation model of the business model incorporates those indicators that reflect the digitalization of not the main production, but auxiliary business processes of the enterprise. This includes information and communication technologies used to communicate with customers, consumers, suppliers, as well as creating a media image of the company. We assume that this index reflects the concept of "cybernetic digitalization" inherent in the previous Third Industrial Revolution, the era of automated control systems (ACS), in contrast to the current cyber physical digitalization, which combines production and digital technologies.

Cybernetic systems (ACS), in contrast to cyber physical:

- existed primarily in the field of managing the results of manufacturing activities;
- did not participate in the management of the entire product life cycle;
- did not provide predictive analytics and management in real time;
- were not the "Internet of things".

The era of cybernetic systems, corresponding to the fifth technological mode and the Third industrial revolution, has exhausted itself by the end of the 2000. Since the 2010, the era of cyber physical systems has begun. But at the same time, the processes of cyber physical and cybernetic digitalization will go on in parallel for a long time, therefore, when rating and assessing national competitiveness, both processes must be taken into account [8].

The data on the dynamics of some indicators forming the sub indexes of cyber physical and cybernetic digitalization of 28 EU countries are given below.

It should be noted a steady increase in the index of cyber physical digitalization. This fact confirms the hypothesis of the transition to the Fourth Industrial Revolution, the digitalization of manufacturing industries. Data on the most industrialized countries of Western Europe look much more convincing. For example, the share of German manufacturing enterprises using RFID increased from 2009 to 2017 from 4.98 to 26.37%, that is, more than five times. The same indicator for the UK – 2.14 and 11.85%; France – 2.25 and 14.14%.

An assessment of data reflecting cyber digitalization indicators in the EU countries attests to the attenuation of these processes, i.e. on the exhaustion of the potential of the fifth technological order related to the informatization of auxiliary areas of activity.

The dynamics of gross value added by industry (table) [9] reflect the actual stabilization of indicators responsible for the digitalization of auxiliary activities of manufacturing enterprises. They realized that using their own website, placing and receiving orders through computer networks, it was no longer possible to increase competitiveness. Cybernetic digitalization technologies have lost their effectiveness and have reached the limits of effective profitability.

We see that in the EU countries as a whole, manufacturing and the production of machinery and equipment are growing faster than the information and communication industry. However, the Information Technology and Services sector is a leader in growth rates in almost all of the countries cited. This means that since 2010, information and communication technologies have become more in demand in the manufacturing industry, and not in the information industry itself.
Table 1. The growth rate of gross value added by industry, in national currency, at current prices, 2010/2016.

| Countries       | Manufacturing industry | including machinery and equipment | Information and Communication | including telecommunication | Information Technology and Services |
|-----------------|------------------------|-----------------------------------|-------------------------------|----------------------------|-------------------------------------|
| Italy           | 1,075                  | 1,199                             | 0,883                         | 0,681                      | 1,15                                |
| Germany         | 1,259                  | 1,243                             | 1,299                         | 0,993                      | 1,502                               |
| France          | -                      | 1,191                             | 1,114                         | 0,846                      | 1,278                               |
| Poland          | 1,494                  | 1,119                             | 1,353                         | 0,953                      | 2,145                               |
| United Kingdom  | 1.2                    | 1,117                             | 1,208                         | 1,227                      | 1,251                               |
| EU (28 countries)| 1,215                  | 1,287                             | 1,202                         | 0,939                      | 1,428                               |
| Japan           | 1,087                  | 1,277                             | 1,051                         | -                          | -                                   |
| Korea           | 1,249                  | 1,325                             | 1,25                          | -                          | -                                   |
| USA             | 1,195                  | 1,164                             | 1,293                         | 1,095                      | 1,544                               |

In general, the analysis carried out confirms the main thesis: the developed countries of the world are moving to neo-industrial development, the main content of which is cyber-physical digitalization of manufacturing industries [10].

The digitalization processes of manufacturing in the Republic of Belarus, on the one hand, have a solid foundation, but on the other, they clearly do not correspond to the tasks and logic of the Fourth Industrial Revolution unfolding. Today in Belarus about 115 thousand specialists are employed in the field of software development and IT tasks in other sectors. About a third of specialists work in the High-Tech Park (HTP), established in 2005. Some of the IT companies with Belarusian roots, as well as their products are widely known in Europe and the world.

In 2005, the IT industry was in its infancy and was formed by many small disparate companies. At the same time, the outflow of qualified personnel abroad became a key problem, since the immigration policy of the European Union, USA, Canada, Australia contributed to the priority entry of IT specialists into these countries.

Talking about the prospects for the development of the IT sector in Belarus, two scenarios can be distinguished: 1) expand the export of services, focusing on outsourcing; 2) integrate the industry with industrial and other sectors of the economy, switching to the development of Internet of things and industry 4.0 technologies, that is, switch to digitalization of the manufacturing industry itself in line with the neo-industrial development model [11].

The problem is that the IT sector has significantly outpaced the "rest of the economy" not only in terms of salaries, but also in the quality of management, the development of self-government institutions, and the degree of integration into the global economy. In order to create products and turnkey solutions in the field of the Internet of Things, it is necessary to produce not only software, but also the equipment itself, as well as access to financing and distribution channels by world standards. Most Belarusian enterprises do not yet have this.

The considered examples are, rather, exceptions to the rule: the IT sector continues to exist separately from the industrial sector, focusing on exports. But even in this case, it plays a very significant role in maintaining the financial stability of the Belarusian economy.

Thus, the processes of digital transformation of the manufacturing industry in the Republic of Belarus, on the one hand, have a strong foundation, but on the other hand, do not fully correspond to the tasks and trends of the unfolding Fourth Industrial Revolution.

5. Conclusion
As a result of the study, it is necessary to draw the following conclusions. Developed countries of the world on the basis of the principles of the "Industry 4.0" concept are moving towards neo-industrial
development, the main content of which is cyber-physical digitalization of manufacturing industries. To assess the digitalization level of the manufacturing industry on the basis of the analysis, the authors developed a comprehensive index of digitalization of manufacturing enterprises, consisting of two sub-indices: the index of development of cyber physical systems and the index of transformation of the business model. Thus, the current trends and risks of the development of the socio-economic system of Russia associated with the formation of a new VI technological structure, neo-industrialization and Industry 4.0 are contained in the process of lagging modernization of manufacturing industries. Neo-industrialization in economically developed countries consists in reconfiguring production chains, based on the integration of new information technologies (BigData, blockchain, self-learning neural networks) and the actual processing technologies for raw materials and semi-finished products. The result of this process, called cyber physical systems, is the main technological and organizational advantage of the new generation industry.

The importance of the strategic path for the development of the Digital Economy in our country is beyond doubt. At the same time, the practical creation of institutional prerequisites for it is late and carries the risks of shifting our country to the "backyard" of world leaders in the international division of labor and in the context of a new technological structure.

In order to prevent this from happening, a number of efforts are required. We single out the most significant of them:

- providing technology transfer and experience of their application from the so-called. international centers of excellence in digital technology;
- selection and launch of significant projects to introduce digital technologies into the practice of companies and organizations on the conditions of state co-financing from budgets of all levels;
- the provision of preferential tax regimes to those business entities that have invested in digital economy technologies;
- to carry out the training of specialists whose qualifications will make it possible to manage projects of digitalization of technological processes of Russian enterprises in severe environmental conditions;
- providing consulting assistance to Russian enterprises and their associations on the creation of such digitalization management tools as "Digital Model of Business Maturity", "Center of Excellence / Design Thinking", "Structure of the IT Function Model", "Digital Solutions System", "The structure of digital architecture", "A model that provides transparency of IT costs" and more.

The proposed set of measures will make it possible to increase the profitability of enterprises in the real sector of the economy at one time and will ensure an increase in the share of innovative products in the volume of production of enterprises in non-primary industries.

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