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Human role in the modern robotic reproduction development

Abstract. Digitalization of the economy and the fourth industrial revolution are accompanied by the blurring of the boundaries between physical, digital and biological technologies. At the same time, one of the key tasks is to create fundamentally new jobs and develop human capital as a key competitive advantage of countries that embody such economic transformations.

The requirements for qualification in production vary significantly depending on the degree of digitalization and the level of development of circular principles. The introduction of any new technology means that employees will face certain challenges that create additional requirements for their skills and competencies. With regard to the human resources, our study of this issue reveals the trends in digitalization and robotization of production, generating the reduction of jobs, stagnation of wages and the growth of wage inequality on the one hand, and on the other, creating fundamentally new popular and highly paid professions.

The paper is devoted to the study of the role and place of a man in the development of modern robotic production, as well as the transformation of professional competencies and requirements on the basis of flexible interaction of virtual and physical production systems that provide full adaptation of products and form new operating models.

The analysis of the scale and dynamics of robotic reproduction as a key factor of such changes is carried out. Problems and prospects of industrial and service robots application are considered. The new knowledge about the role of the man in the management of modern intellectual systems is obtained.

It has been concluded that the transformation of human capital and its adaptation to the challenges of digitalization and robotization of the economy remain unresolved, associated with the need to change the level of qualification and the digital competence development. The solution of investigated problems will be facilitated by an active impact on the labour market, lifelong learning based on more flexible educational systems, and additional income support.

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Роль людини в розвитку сучасного роботизованого відтворення

Анотація. Цифровізація економіки й четверта промислова революція супроводжуються стиранням кордонів між фізичними, цифровими й біологічними технологіями. При цьому одним із головних завдань є створення принципово нових робочих місць і розвиток людського капіталу як ключової конкурентної переваги країн, що втілюють такі економічні трансформації.

Вимоги до кваліфікації на виробництві істотно змінюються в залежності від ступеня його цифровізації та рівня розвитку циркулярних принципів. Упровадження будь-якої нової технології означає, що працівники зіткнуться з певними викликами у зв'язку з виникненням додаткових вимог шодо їх навичок і компетенцій. Відносно людських ресурсів вивчення даної проблематики дозволить виявити тенденції, які створюють цифровізація та роботизація виробництва, породжуючи з одного боку скорочення числа зайнятих і зростання диференціації в оплаті праці, а з другого – створюючи принципово нові затребувані й високооплачувані професії.

Стаття присвячена дослідженню ролі та місця людини в розвитку сучасного роботизованого виробництва, а також процесу трансформації професійних компетенцій і вимог на основі гнучкої взаємодії віртуальних і фізичних систем виробництва, які забезпечують повну адаптацію продуктів і формування нових операційних моделей. Здійснено аналіз масштабів і динаміки роботизації відтворення як ключового чинника таких змін. Розглянуто проблеми та перспективи застосування промислових і сервісних роботів. Основні результати дослідження полягають в отриманні нових знань про роль людини в управлінні сучасними інтелектуальними системами.

Авторами зроблено висновок про те, що трансформація людського капіталу та його адаптація до викликів цифровізації та роботизації економіки залишаються проблемами невирішеними, що пов'язано з необхідністю зміни рівня кваліфікації та розвитку цифрової компетенції працівників. Вирішенню досліджених проблем сприятиме активний вплив на ринок праці, навчання протягом усього життя на основі більш гнучких освітніх систем, а також підтримка додаткового доходу.

Ключові слова: роботизація відтворення; роботизація; цифрова економіка; індустрія 4.0; конкурентоспроможність людини; цифрові професійні компетенції; менеджмент інтелектуальних систем.

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Роль человека в развитии современного роботизированного воспроизводства

Аннотация. Цифровизация экономики и четвертая промышленная революция сопровождаются стиранием границ между физическими, цифровыми и биологическими технологиями. При этом одной из ключевых задач является создание принципиально новых рабочих мест и развитие человеческого капитала как ключевого конкурентного преимущества стран, воплощающих подобные экономические трансформации.

Требования к квалификации на производстве существенно меняются в зависимости от степени его цифровизации и уровня развития циркулярных принципов. Внедрение любой новой технологии означает, что работники столкнутся с определенными вызовами, формирующими дополнительные требования к их навыкам и компетенциям. В отношении человеческих ресурсов изучение данной проблематики позволит выявить тенденции, которые оказывает цифровизации и роботизация производства, порождая с одной стороны сокращение числа занятых и рост дифференциации в оплате труда, а с другой – создавая принципиально новые востребованные и высокооплачиваемые профессии.

Статья посвящена исследованию роли и места человека в развитии современного роботизированного производства, а также процесса трансформации профессиональных компетенций и требований на основе гибкого взаимодействия виртуальных и физических систем производства, обеспечивающих полную адаптацию продуктов и формирование новых операционных моделей.

Осуществлен анализ масштабов и динамики роботизации воспроизводства как ключевого фактора таких изменений. Рассмотрены проблемы и перспективы применения промышленных и сервисных роботов. Основные результаты исследования состоят в получении новых знаний о роли человека в управлении современными интеллектуальными системами.

Авторами был сделан вывод о том, что трансформация человеческого капитала и его адаптация к вызовам цифровизации и роботизации экономики остаются проблемами нерешенными, что связано с необходимостью изменения уровня квалификации и развития цифровой компетенции работников. Решению исследованных проблем будет способствовать активное влияние на рынок труда, обучение в течение всей жизни на основе более гибких образовательных систем, а также поддержка дополнительного дохода.

Ключевые слова: роботизированное воспроизводство; роботизация; цифровая экономика; индустрия 4.0; конкурентоспособность человека; цифровые профессиональные компетенции; менеджмент интеллектуальных систем.

1. Introduction

The global economy has entered an era of profound structural changes caused by modern technological advances and high speed automation of production processes.

The idea of new technological revolution received an impetus for active discussion following the agenda of the World Economic Forum in Davos where Germany's strategic plans to increase the competitiveness of its industry were presented several years ago. One of the initiatives under the High-Tech Strategy 2020 Action Plan of Germany was called Industry 4.0. In order to continue the policy of innovative development in Germany, an industrial strategy has been developed until 2030, aimed at supporting key industries. First of all, they include: automobile and aircraft industry, chemical industry, electrical engineering, optics, production of medical devices (Federal Ministry for Economic Affairs and Energy of Germany, 2019).

New global trend in technological development is associated with the transition to cyber-physical systems from embedded systems. The specifics of cyber-physical systems is associated with the fact that they help organize the interaction of the virtual and physical worlds. The use of such technologies is aimed at ensuring the interfacing of smart objects with each other through the Internet, networks, and data arrays. Digital processes will allow the production of products with increased customization, energy and resource efficiency. Industry 4.0 will bring the production process closer to the consumer: a high level of personalization of the product will enable the consumer to be included in the production process as a participant or co-creator (co-producer, co-designer).

These processes will have important consequences for the global economy, the economies of individual countries, corporations and individuals, leading to greater efficiency and productivity of production, higher speeds. Digital transformation requires radical change. A world in which everything is interconnected will become not only more interactive and flexible, but also more complex. Any action in the value chain will trigger responses. To be successful, it is important to adapt quickly. Speed is a determinative success factor in the modern world.

Industry 4.0 will use automated platforms that provide flexible control of production processes, their optimization and autonomous adaptation to external influences. Automation will help reduce interest in unskilled workers, lower their pay levels.

Modern technologies provide a constant interaction of the digital and real world. The formation of a networked and globally integrated economy is an everyday reality. So, almost half of German manufacturing companies use Industry 4.0 applications, tailored to individual customer requirements. In addition, factories of the future are able to quickly change the operating mode of production and quickly respond to failures in the work of suppliers. Full transparency of production processes allows you to make optimal decisions and create new business models. Modern technologies allow you to integrate complex production systems into the IT infrastructure or implement completely new business models based on interaction with the cloud, Big Data or predictive analytics tools.

Digitalization is driving the rapid development of robotics as a key element of Industry 4.0. It is assumed that robots will be more compact and mobile, cognitive and networked. Moreover, subsequent «robotic» generations of people will perceive robots and their abilities as services that can be ordered over the Internet and configured with a click of the mouse.

Robots appear in various forms and configurations and can cooperate with humans. Sensitive colleagues robots «Cobots» have a sense of touch, it is important for building a cyber-physical world, a promising direction for the development of which is a combination of Industry 4.0 and the Internet of things IoT. According to the research firm ABI Research (2019), the cobot market will expand from USD 95 million in 2015 to USD 1 billion by 2020.

With cobots carrying various payloads, it is possible to solve a wide range of problems: from automating complex assembly tasks, for example, cars, to manipulating flexible parts; from assembling small parts in mobile phones to capping bottles. Such robots are easy to move from place to place and reprogrammed to perform various tasks. Built-in sensors allow people and cars to work together safely: if an unexpected contact occurs, the cobot can reduce speed and prevent injuries. Thus, additional costs for ensuring safety at work are not required. Moreover, cobots are indispensable as data aggregators; through them, real-time information for IT systems can be systematized and disseminated. This will optimize production processes and make them more autonomous from human participation (The International Federation of Robotics, 2019).

Collaborative robots, mobile assistance systems, autonomously driven vehicles and intelligent, digital automation solutions will reduce the burden on people.

And this will lead to the fact that in intellectual production:

- fewer people will be required;
- labour power can be used much more productively;
- employees will be freed from performing routine tasks due to the ability to monitor production processes and manage them through networks;
- more attention to professional development and more creative assignments (see, for example, Frey & Osborne, 2017).

2. Brief Literature Review

Zemtsov (2017), Gunina et al. (2019), Logunova, Kapkaev and Isaeva (2019), Aymaletdinov et al. (2018) devote their research to identifying, analyzing and resolving the problems of transforming the role and place of a man in the digital ecosystems.

The theoretical aspects of the digital economy formation and production robotics are studied in the works by de Reuver, Sørensen and Basole (2018). Zajko, Pezoldt and Brighton (2015), and Kallio (2016).

Oppenheimer (1997), Florida (2002), Å. Olsson and T. Olsson (2010), Priporas, Stylos,and Fotiadis (2017), Zingheim and Schuster (2008) devote their studies to the problems of modern professional competencies changing and the labour requirements transforming, as well as their impact on the labour productivity.

The main provisions on the impact of digitalization and robotization on the labour market, used by the authors in the formation of the conceptual framework of the article, have been developed by a number of specialists, namely: Ford (2015), Arntz, Gregory and Zierahn (2016), Brynjolfsson and Mitchell (2017), Frey and Osborne (2017).

3. The Purpose of the paper is to study the role and place of a man in the development of modern robotic reproduction, as well as the process of professional competencies and requirements transforming based on the flexible interaction of virtual and physical production systems, ensuring full adaptation of products and new operating models formation.

4. Results

In modern robotics, two large segments of robots are distinguished - the industrial and service ones. According to the International Federation of Robotics (IFR, 2019), global robot installations in 2018 amounted to USD 16.5 billion (without software and peripherals), showing a 6% increase a year. Moreover, a similar situation, characterized by increasing growth rates developed amid the crisis in economic and trade relations between the two largest players in the global market - the United States and China (or the PRC).

Most actively robots are used in industries such as automotive (about 30% of the total number of installed robotic systems), electrical engineering and electronics (25%), metalworking and mechanical engineering (10%), plastics and chemical products (5%), and food and drinks (3%) (ABI Research, 2019).

Due to the active dynamics of the technological innovations introduction, there is a growing demand for industrial robots. In 2005 and 2008, the average annual volume of robots sold globally amounted to about 115 thousand units. In 2016, the milestone of 300 thousand installed systems per year was overcome. In 2017, the number of installations increased to almost 400 thousand. Predicted values for the short term indicate a further increase in industrial robotics (Figure 1) (ABI Research, 2019).

If we consider the country aspect, we can distinguish five countries that occupy leading positions in the introduction of industrial robots. They are China, Japan, USA, Republic of Korea and Germany. These five countries account for more than 70% of global turnover. The analysis shows that the European and North American robotics markets are growing significantly amid stagnation in the Asian countries. So, for the sixth year in a row, growth has been observed in the European market for 12% in dynamics from 2013 to 2018. The United States is showing tremendous growth rates: in 2018, more than 20 thousand robots were installed, which is 20% more than in 2017 (ABI Research, 2019).

The largest market for industrial robots since 2013 is the PRC, which accounts for 36% of the total number of installed robots in 2017 and 2018. In 2018, more than 150 thousand devices were installed. And this is more than the number of installed robots in Europe and America for the same period combined (ABI Research, 2019).

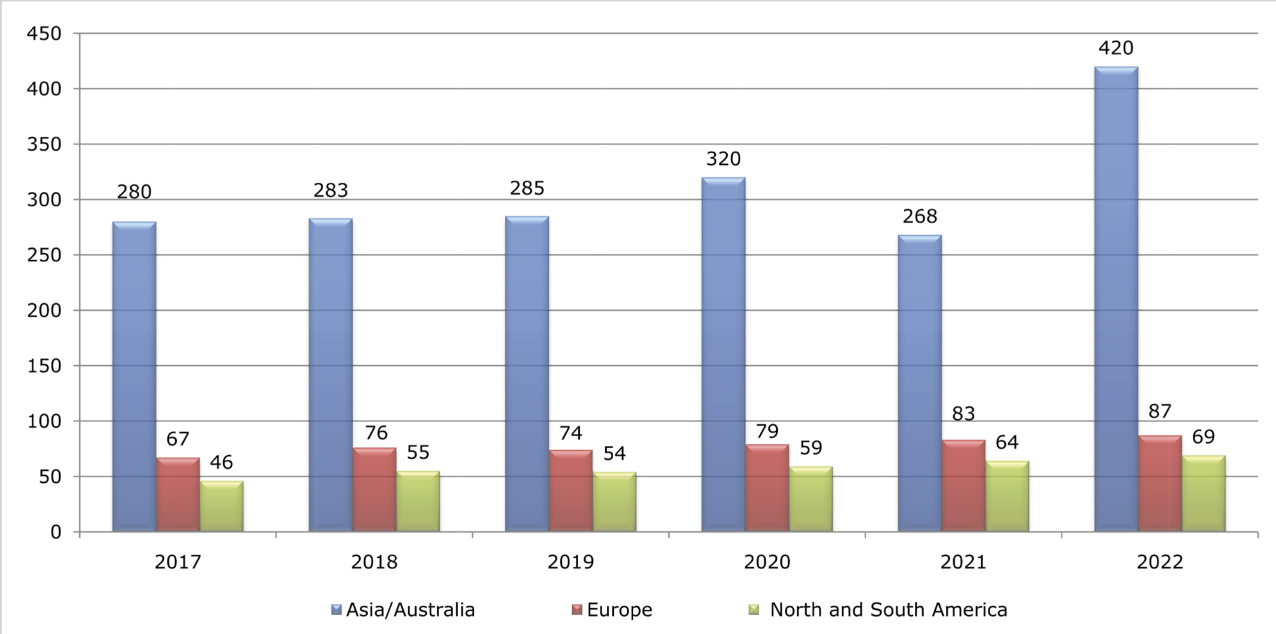

Figure 1:
Annual installations of industrial robots, thousand units
Source: ABI Research (2019)

Demonstrating the highest pace of digitalization, China can be positioned as a country with best practices in this area today. In China, the state program «Made in China 2025» is being implemented, aimed at supporting key technologies in leading sectors of the economy. The People's Republic of China declared its ambition to become a world leader in the field of artificial intelligence by 2030. For the purpose of investing in national high-tech production, the China New Era Technology Fund was founded in 2018 with the capitalization of USD 15 billion (ABI Research, 2019).

Study of the global robotics market shows that the average density of robots in the manufacturing industry of industrialized countries is about 99 robots for every ten thousand employees. The highest density of robots is demonstrated by the European countries - about 114 units per ten thousand employees, the USA - 99 units, Asia and Australia - 91 units (ABI Research, 2019).

Unlike industrial robots, service robotics covers a wider range of applications. These are automated guided vehicle (AGV), unmanned aerial vehicles (UAV), exoskeletons, medical robots used in surgery, therapy and rehabilitation, as well as service robots for personal and home use and others.

Sales of professional service robots are growing. So, the number of professional robots sold in 2018 increased by 61% and reached 271 thousand units. For comparison, in 2017, sales amounted to 168 thousand, which is 32% higher compared to the previous year (ABI Research, 2019).

Sales of power exoskeletons that reduce the power load on a person increased from 6,700 units in 2017 to 7,300 units in 2018. This type of robots has a high growth potential: the total number of units sold in 2018 amounted to about 7 thousand (ABI Research, 2019).

Service robots for personal and home use are produced for the mass market for domestic use (cleaning robots, vacuum cleaners, lawn mowers, etc.), as well as for entertainment and educational purposes. The growth dynamics of robots used in everyday life increased to 16.3 million units in 2018. The growth was 59%. Market growth in value terms was USD 3.66 billion (ABI Research, 2019).

Requirements for qualifications in production also vary significantly depending on the degree of digitalization and the level of manufacturability. The introduction of any new technology means that employees, one way or another, will face certain challenges that form additional requirements for their skills and competencies.

At the same time, the digital transformation of socio-economic systems not only acts as a driver for the development of new industries, but also contributes to fundamental transformations of all spheres of human life (Smorodinskaya, 2015). Under the influence of the advanced achievements of science and technology, the regional systems of health care, education, the labour market are being transformed, and the quality of the human capital of the territories is changing as a result.

Along with a change in the competencies of human capital, the demand from the labour market is changing. Digitalization and robotization of production have a multidirectional effect on it. On the one hand, production robotization leads to the release of labour resources, differentiation in wages is growing, and wages are stagnating. On the other hand, these processes create demand for new professions and highly paid specialists.

According to the forecasts, digital manufacturing technologies and the widespread introduction of robotics will deprive more than five million people of their jobs. The most significant reductions will affect office, administrative employees, as well as production personnel of individual industries. At the same time, compensation for the indicated losses is expected due to the two-million growth of engineering, financial and computer professionals (Arntz, Gregory, & Zierahn, 2016).

It must be emphasized that the reduction in the share of human labour amid the introduction of all-round robotics will be maximally manifested in the developing countries that lack breakthrough technologies, compensated by available labour. Ultimately, many large enterprises will be returned to the US and the EU, and developing countries will lose an important industrial resource.

In this regard, digital skills are becoming an integral part of professional skills both in the field of education, science, and in industry. The implementation of breakthrough technological projects in the context of digitalization creates a demand for specialists who have a set of specific competencies:

- full understanding of the scope of activity, as well as competence in related matters;
- understanding of the opportunities and risks associated with the use of new technologies;
- knowledge of project management methods and teamwork skills;
- ability to solve problems and implement turnkey projects;
- database skills; knowledge of big data tools and visualization tools;
- adaptability and ability to work in conditions of uncertainty;
- knowledge of the basics of cyber-security;
- development of emotional intelligence and systemic thinking;
- ability to continuous learning, etc. (National Academies of Sciences, Engineering, and Medicine, 2017).

In the context of digital transformations of economic systems, the problem of ownership of key digital competencies is relevant for the vast majority of professions. Thus, digital competencies are necessary for marketers to optimize advertising management and predict emotional response to it. In jurisprudence, digital skills will automate the analysis of materials, as well as simplify preparation for litigation. For modern engineers, professional digital competencies are already an integral part of the skill set required by the employer (Kapkaev & Isaeva, 2019). In addition, the demand for data specialists is expected to grow rapidly in most industries, which will facilitate the acquisition of this profession of intersectoral nature.

Changes in the number and structure of jobs are not the only significant consequences of the digital transformation of the economy. The development of technology will provoke a gap between income from labour and capital, which will lead to an increase in inequality among workers. The owners of intellectual and physical capital (developers, shareholders, investors) will get the maximum benefit from the upcoming changes. Workers with a low level of education and skills will not be in demand over time, due to the replacement of this kind of work with robotic resources (Zemtsov, 2017; Aimaletdinov et al., 2018).

In this context, it is obvious that the government already needs to take actions to restructure the education system and train specialists, to modernize the infrastructure, creating new jobs. In the regulatory field, it is also necessary to introduce new progressive tax legislation (Pitaykina & Vlazneva, 2018; Volodin, Pitaykina, & Vlazneva, 2018).

In the foreseeable future, new technologies will help to overcome the current biological limitations:

- devices on the human body that are part of the Internet of things will transmit information generated by their own emotions, increasing their manageability;
- exoskeletons and brain - related prosthetics will increase person's physical strength and endurance, and will also be useful in providing an adequate level of life activity for people with certain physical limitations;
- sensors and computers built into the human body will improve hearing, vision, and will also make household immersion in virtual and augmented realities possible;
- nootropic drugs will transform the working and educational processes, improving human cognitive abilities (The International Federation of Robotics, 2019).

Robotization penetrating deeper into human life will soon expand its horizons and will be integrated into new industries and activities. Robots will be involved in the organization of medical and social care, delivery services, harvesting and the provision of a range of services, which will be facilitated by the introduction of the Internet of things with the connection of third-generation robotic systems with artificial intelligence. Using terabytes of information received from the network, such robots will be able to automate business processes, the sphere of education, maintenance and the provision of certain types of work and services (Atkinson, 2017).

In this context, the question arises of increasing the competitiveness of a person in an augmented economy, preserving his rights and freedoms (Volodin, Pitaykina, & Vlazneva, 2018). Given the high cost of augmented technologies, not everyone can afford this kind of transformation, while losing competitive advantages, particularly in the labour market. It is also likely that network add-ons may be targeted by hacker attacks aimed at controlling a person (Pitaykina, 2018).

Today, there are some areas with minimal risks of enhancing the role of robotization:
- research and creative activities;
- development of robots and software;
- interactions based on personal contact, feelings and empathy (medicine, education, social services);
- work in adaptive and emergency conditions, requiring responsible and prompt decisions;
- entrepreneurship and management, associated with risk and the need to bear various kinds of responsibilities;
- mentoring activities related to the transfer of knowledge, experience and based on the ability to convince.

5. Conclusions

The risks of robot implementation are obvious. They are associated with potential unemployment, rising inequality and exclusion from the economy of certain categories of citizens. Another negative consequence is the increased polarization of the population of the regions in such parameters as education, competence, age and gender. Elderly people of working age do not react so flexibly to environmental changes and are less inclined to master new technologies. With regard to the polarization of society by gender, this trend is explained by the excess of the proportion of men over the share of women employed in potentially less robotic industries. Differences in adaptation to the robotic circular reproduction of regions will provoke the emergence of zones of special social tension, an increase in inter-regional migration flows, as well as a decrease in the stability of the economy of individual territories.

Nevertheless, digitalization and robotization will solve a number of socio-economic problems:
- provide additional opportunities for the implementation of labour and business activities;
- improve the quality of social services provided;
- improve the system of acquiring professional competencies;
- create fundamentally new conditions for conducting socially significant scientific research;
- strengthen communication between key institutional units, etc.

The transformation of human capital and its adaptation to the challenges of digitalization and robotization of the economy remain unresolved, associated with the need to change the level of qualification and the development of digital competence. The solution of these problems will be facilitated by an active impact on the labour market, lifelong learning based on more flexible educational systems, as well as additional income support. Identified features should be taken into account and subjected to additional scientific research in the part of overcoming possible threats and minimizing risks associated with digitalization and robotization of the key sectors of economy.

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