Farm 4.0 as a driver for the development of the agro-industrial complex

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Abstract. As for production, many factories are indeed becoming unmanned, their production paradigm is changing. But man, still remains as the main creator, designer, engineer. For example, the agro–industrial complex is already part of the system of modern production, which a person can manage from anywhere on the planet, possessing the necessary amount of knowledge in the field of chemistry, biology, veterinary science, and so on. The demand for the technologies of the new industrial revolution will be formed not only by various groups of the population and the state, but also by the new ecosystems that we create. In an ecosystem, everything finds its place: producers, consumers, intermediaries, the state, and society as such. And if we look at demand, supply and infrastructure ecosystems as a whole, we will understand exactly what we can do in the next decade, from 2020 to 2030. In this regard, Farm 4.0 as a damper between consumer and producer is able to wrap drivers in windows of opportunity.

1 Introduction

Many people are accustomed to believe that the agro–industrial complex is the lowest–tech sector. However, even in Russia, it is a multi–sector, including not only the technological base of the XVIII–XX centuries, but also innovations of the XXI century.

In the current decade, a new technological revolution is unfolding, the main technologies of which are already well known to us – artificial intelligence, 3D printers, the Internet of Things, biotechnology, new materials, digital twins, etc. The new technological revolution is taking shape. And if in the early 2000s the expert community wondered whether it makes sense to invest in such technologies, now many countries have entered the race: who will master these technologies faster and find their application, create a new product or service with their help [1-4]. The ecosystem plays a major role here, allowing supply and demand to converge.

Individuals are intrigued by the introduction of products with innovative consumer benefits, whereas businesses are focused on cutting costs, streamlining production methods, and predicting individual needs more effectively. There is a growing societal and governmental push towards sustainability, including waste reduction and emissions control, as well as an emphasis on ethical practices, which is a prominent trend in today's market.

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Modern technology aligns with many of these standards: enabling remote control of entire factories while also being environmentally friendly. An intriguing comparison can be made to Michelangelo's sculpting process, where excess material is removed from a block. In contrast, a 3D printer eliminates the need for a block altogether by only producing what is necessary, leading to a zero-waste manufacturing approach. The question remains whether technology will ever match the creativity of the great masters. While humans still hold the upper hand in this realm, it is possible that significant advancements may occur within the next 5 to 10 years.

The combination of societal needs, government requirements, and business pressures has driven the development of a new wave of technologies that are reshaping the way goods are produced and distributed. This technological revolution is characterized by large-scale, comprehensive solutions that are transforming production processes, supply chains, and business operations.

What are the characteristics of the current era? The shift towards digitalization is becoming more prominent. In the midst of a pandemic, people have become increasingly comfortable utilizing video for meetings and social interactions. Looking ahead, it is anticipated that in the span of 2020 to 2030, neurointerfaces - cutting-edge technologies that merge advancements in medicine, biotechnology, artificial intelligence, and IT to establish a direct link between the brain and computer - will become widespread. Currently, they are predominantly used in rehabilitation and to a lesser extent in education. Just imagine being able to access information directly without having to watch a lecture or take notes. While this may appear to be a distant prospect, we are currently experiencing a time of significant transformation. It is possible that by the end of 2030, this technology will be as commonplace as video calling platforms such as Skype or Zoom.

Businesses are seeking to boost labor productivity, while consumers are looking for new and personalized products. The days of settling for what is readily available are long gone. Today, customization is key in every aspect of our lives, from health choices to dietary preferences, from fashion to transportation. All products and services are now tailored to individual needs and preferences [5-9].

Similar trends are occurring in the field of medicine, and they are likely on the right track: rather than focusing on a collective group of patients, the focus is shifting towards individualized care. However, the tools required for this approach must be able to gather and analyze a vast amount of data – encompassing big data, robust computing systems, and continuous monitoring.

The technologies of the latest industrial revolution are categorized into different groups, such as robotic complexes, design-related systems, monitoring systems, and the Internet of Things. Expert estimates suggest that the components of the Internet of Things, including systems, algorithms, and sensors, outnumber the global population. The advancements in the new industrial revolution aim to empower individuals to unleash their creative potential. For instance, the concept of a smart city, utilizing these technologies, transforms into an adaptive environment similar to a smart home. It tailors to the needs of its residents, offers sustainable and eco-friendly infrastructure, and promotes a healthy work-life balance, fostering personal growth [10-17].

One of the primary challenges we encounter is cybersecurity. We willingly disclose a significant portion of our personal information to various systems, making us vulnerable to cyberattacks. The likelihood of these attacks happening will only rise in the coming years. While some may only result in unauthorized access to personal accounts, the more severe threats involve breaching critical systems such as those in nuclear power plants. Russian businesses, as indicated by numerous surveys, are increasingly recognizing the importance of addressing cybersecurity risks. As they play a crucial role in the evolving industrial landscape, companies must confront the unavoidable dangers posed by cyber threats.

The next challenge pertains to infrastructure. Voice assistants are now prevalent in numerous locations, with voice bots often being the ones responding at the other end of the line. Additionally, during phone conversations, individuals may not discern between the voices of an actual person and a bot, despite ongoing advancements in the development of comprehensive dialog systems globally.

When considering a comprehensive transition, numerous artificial intelligence and robotization systems have faced the challenge of integrating disparate components. For instance, digitizing a shopping mall may prove more difficult than starting from scratch due to disconnected systems. A smart elevator may not align with video cameras installed decades ago, and the overall complex may struggle to blend into the surrounding ecological environment despite its individual components being present. The integration of systems poses significant challenges that must be addressed [18-23].

In terms of manufacturing, numerous factories are transitioning to unmanned operations, transforming their production methods. However, humans continue to play a crucial role as the primary creators, designers, and engineers. For instance, the agro-industrial sector is now integrated into the contemporary production system, allowing individuals to oversee operations from any location worldwide, provided they possess expertise in fields such as chemistry, biology, and veterinary science.

The technologies of the new industrial revolution will be shaped by a diverse range of stakeholders, including different population groups, governments, and the ecosystems we establish. Within these ecosystems, all parties - producers, consumers, intermediaries, the state, and society - have their roles to play [24-28]. By examining the interconnected ecosystems of demand, supply, and infrastructure, we can gain insight into the opportunities that lie ahead from 2020 to 2030. What will be the key global trends in future agribusiness, considering the demand, supply, and infrastructure aspects?

2 Research methodology

The rise of digital technology and the need for efficient products are driving the agro-industrial complex towards complete digitalization. This trend is evident in almost every sector of the industry, including agriculture and livestock farming in Russia. While larger agricultural companies are embracing digitalization to stay competitive globally, even smaller farmers are utilizing user-friendly mobile interfaces to optimize their yields and manage soil fertilization.

What impact will digitalization have on our agricultural industry? Will we see a decrease in employment opportunities if all combines are operated without human intervention? This scenario is becoming increasingly common. It is crucial to consider what tasks combine harvesters should focus on and what new roles they may need to adapt to. Ultimately, understanding the changing demands of the population and envisioning the future of the agricultural sector are key priorities.

As the global population steadily increases, the demand for food will remain constant. Projections from the United Nations suggest that by 2050, Earth's population will reach nearly 9.7 billion, and by 2100, it will exceed 11 billion. Ensuring that everyone is adequately fed will be a critical challenge. Fortunately, advancements in various technologies offer promising solutions. Genetic modification techniques can significantly boost productivity and make agriculture more resilient to changing climates. Digital logistics innovations and farm productivity-enhancing technologies also play crucial roles in meeting the growing demand for food.

The rise of vertical farming in urban areas is becoming increasingly prevalent. This innovative approach to agriculture is gaining popularity due to its minimal transportation distances, cost-effectiveness, and constant availability of fresh produce. If all traditional

horizontal farms were to transition to vertical farming, how would this shift impact our competitive edge?

The advancements in automation and artificial intelligence have the potential to remove the need for human labor in tasks that rely on following algorithms or coordinating between systems. Yet, the impact of technology on human resources policies goes beyond just job cuts for companies [29-35].

The fast pace at which digital technologies, artificial intelligence, robotics, automation, and virtualization are advancing begs the question of whether robots and algorithms could eventually replace humans. The debate on this issue remains divided, with researchers Carl Frey and Michael Osborne finding in 2013 that nearly half of all occupations in the United States are highly vulnerable to being taken over by artificial intelligence, robotics, and automation within the next two decades. Additionally, a study conducted by the authors in collaboration with Citibank across over 50 OECD countries suggests that machine algorithms and neurotechnology could potentially replace humans in more than half of all occupations.

In traditional career paths, the scope of responsibilities associated with the digital landscape is growing at a fast pace. This includes handling big data, digital communication, coding, and creating websites and apps. As a result, novel roles are emerging to cater to these new tasks. By 2022, advancements in technology are predicted to result in the elimination of 75 million jobs globally, while simultaneously generating 133 million fresh opportunities.

Figure 1 displays the distribution of automated labor across different economic sectors.

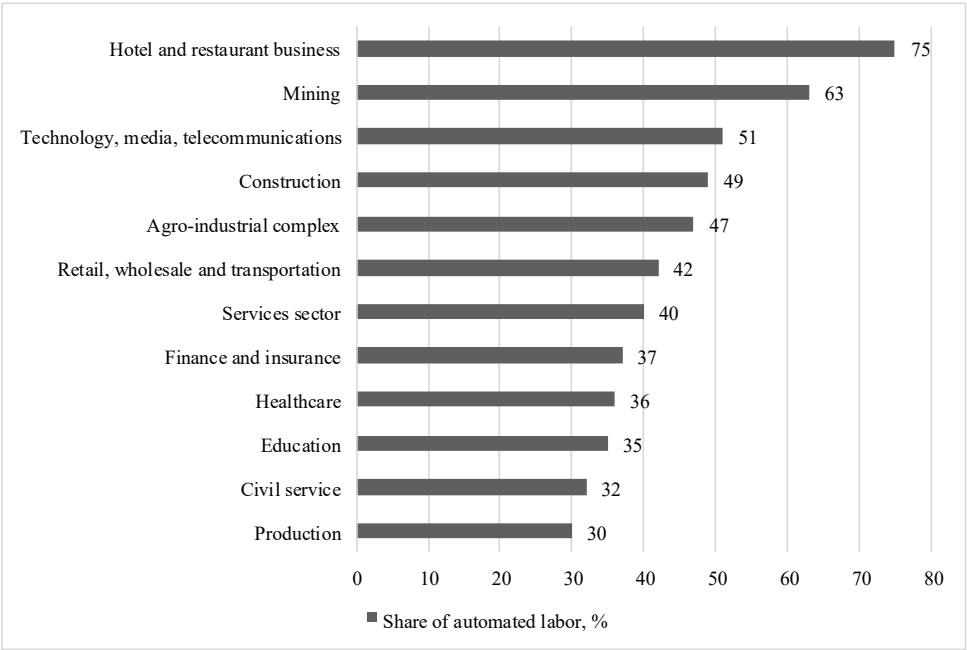

Fig. 1. The proportion of automated labor in various economic sectors as determined by the author using sources [2, 8].

Overall, the agro-industrial complex is expected to reach an average automation level of 47%, primarily due to the existing high automation levels and the costly nature of technology implementation. Among different industries, the hotel and restaurant sector is

deemed most susceptible to automation, with around 75% of processes likely to be automated. This is followed by the mining industry at 63% and the financial sector at 37%.

With the rise of digitalization and increasing demand for a variety of products, it is crucial to analyze the shifting population and its demographics. Recently, there has been a significant trend towards healthy living, prompting a potential transformation in agriculture. Rather than drastically changing the industry, the focus should be on meeting the evolving consumer demands. Estimates suggest that the market for functional foods, which enhance speed, intelligence, and resilience, will reach approximately $300 billion this year, showcasing its immense potential. Looking ahead, the agricultural sector, including agribusiness, will need to adapt to cater to the needs of consumers. This includes the aging population, expected to triple in the near future, as well as the younger generation pursuing active and healthy lifestyles with specific dietary requirements. Additionally, there is a growing emphasis on the circular economy, aiming for minimal emissions and sustainable practices. It is hoped that agriculture will align with these principles to support a more environmentally friendly economy.

How will the intersection of digitalization and the consumer's desire for functional products shape the future? The transformation brought about by digitalization and innovative materials is reshaping how businesses operate and how value is distributed. Will the agricultural giants of today still dominate the industry in a decade, or will we see a shift towards IT companies leading the way, much like in the sharing economy

Figure 2 displays the hierarchy of influence of essential technologies and trends in the agro-industrial sector.

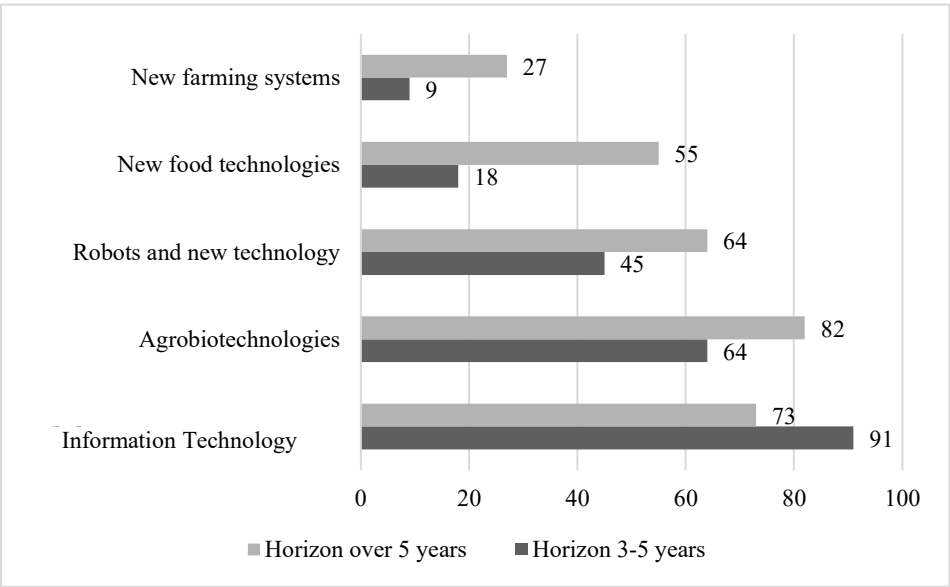

Fig. 2. Assessment of the influence of significant technologies and trends on the agricultural and industrial sectors [3, 5].

In Russia, numerous agricultural conglomerates are incorporating cutting-edge virtual reality technologies. A viral image from the end of 2019 showcased a cow in the Moscow region adorned with augmented reality glasses, displaying captivating visuals of lush meadows and fertile pastures. This innovative approach raises questions about its purpose. In today's dairy industry, a single cow is monitored for 20–25 parameters daily, surpassing the data collected by a person wearing a health tracking bracelet. Researchers have

identified a crucial area for enhancing cow performance: their emotional well-being. Surprisingly, a cow's mood has emerged as a significant economic factor. Extensive scientific research is underway to determine ways to improve a cow's happiness and productivity.

Utilizing augmented reality glasses to view images of meadows and pastures has shown to significantly boost milk production, especially during test phases. This innovative approach is gaining traction in Russia, where many livestock production combines have been automated to ensure high-quality meat products. While some may believe that traditional farming methods are still prevalent in rural areas, the modern agro-industrial complex in Russia is a blend of 18th and 19th-century techniques and cutting-edge digital tools of the 21st century. Farmers today can still wear rubber boots and navigate muddy fields while using smartphones to control drones and monitor their operations, showcasing the integration of traditional practices with modern technology.

The upcoming developments in the agro-industrial sector.

Hence, the future of the agro-industrial complex will be shaped by global trends such as digitalization and robotization. These trends may result in job displacement but also offer new opportunities in fields like engineering, programming, and design that appeal to the younger generation. Additionally, there is a shift in demand due to a growing and active aging population, leading to changes in the types of products needed [36-43]. Russia has made significant progress in meeting domestic demand with domestic resources, which is crucial for national food security.

Just a few years ago, the idea of artificial meat seemed like science fiction to many. However, in a short span of 3–4 years, the cost of lab-grown meat has plummeted by over 30,000 times. In Moscow, adventurous diners can now sample this innovative food in select restaurants. Beyond Meat, a company leading the charge in producing cruelty-free meat alternatives, is at the forefront of this revolution. Embracing these new technologies is crucial in addressing global food shortages, despite some hesitations from the public. While fears and skepticism may exist, it's clear that advancing technology in the agricultural sector is a necessary step forward. Throughout history, genetics and breeding have played a vital role in feeding humanity, but it's essential to ensure that these advancements are carefully monitored and regulated.

Innovative technologies are revolutionizing our physical capabilities, giving rise to the emerging field of human enhancement in medicine. Personalized nutrition, based on individual genetics and goals, known as functional nutrition, is becoming increasingly important and can significantly impact one's performance. Looking ahead to the future, some experts predict that by 2100, humans may transition entirely to digital existence, potentially achieving immortality. This technological singularity could arrive as soon as 2050, raising questions about the necessity of traditional agriculture. The future of the agro-industrial complex hangs in the balance as we contemplate the implications of a fully digital and immortal society.

3 Conclusion

Ultimately, the farmer plays a crucial role in Russia, not just in terms of employment and food production. Various entities, such as banks, work to support farmers and improve their quality of life. However, in order to assist them effectively, it is essential to focus on the future. When farmers are fully occupied with agricultural tasks, they may struggle to plan ahead even just a few years. This is where strategic planners and forecasters come into play, helping farmers anticipate future needs, adopt new technologies, and explore innovative business models. Perhaps one day, farmers will be able to use drones and virtual reality

technology to monitor their livestock while enjoying a glass of fresh milk in the countryside.

When considering the future of the agro–industrial complex in the next 20–50 years, the field of futurology becomes essential. Let's pose a thought-provoking scenario: what if humans no longer need to consume food? Imagine a world where pills or powders containing essential vitamins and amino acids replace traditional meals. While this may seem far-fetched, such innovations already exist in various forms. Instead of enjoying a steak or avocado salad, individuals could simply obtain all necessary nutrients from a tube or convenient package. Will this new way of nourishment bring satisfaction? Perhaps food will serve a different purpose, such as fuel for the body or energy for machines. The looming question for the next few decades is whether traditional foods will still be consumed, leading the agribusiness industry towards a major transformation.

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