Digitization of agriculture: innovative technologies and development models

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Abstract. No country can exist apart from others in the context of globalization and integration. All states integrated by foreign economic relations. Significant changes in the structure, organization, and geography of world trade have taken place in the past two decades. New significant exporters have appeared since the beginning of the early ninety. China is the world's largest exporter. Other countries are increasing their export capacity to become major global suppliers. The emergence of global economic chains has aggravated the competitive struggle between countries and transnational corporations for spheres of influence. The agro-industrial complex traditionally remains a priority and strategically important sector of the economy for Russia. The article discusses the full use of the export potential of the agro-industrial complex of the country and the key role of integration into the global economic space. The authors reveal a pool of promising technologies for the development of the agro-industrial complex of Russia, such as: Internet of Things, blockchain, robotics, unmanned aerial vehicles. The article forms a conclusion about the possibility of the practical application of each technology, as well as the need to develop a systematic and well-considered state approach for the introduction of a new generation of digital technologies and financial technologies in agriculture.

1. Introduction

Russia is steadily increasing its positions in the export of products of the agro-industrial complex on the world market. Saving the achieved results and becoming a leader in new product segments require the most efficient use of the opportunities offered by the market and accelerated technological development. According to UN forecasts, the world population will cross the border of 9 billion by 2050. The need for food resources is expected to double in the world.

World agricultural production has entered a period of global change. They are due to a combination of a number of key factors: global climate change, growth and change in consumption patterns associated with an increase in population and well-being.

The technological revolution, which has completely changed the structure of industrial production in recent decades, is coming to agriculture. The agro-industrial complex is becoming the focus of interests of global investors and an important tool of international politics. Changes occur in the market, in the organization of agricultural production, in the structure of consumption, and in the system of agro-innovations.

Key areas of change in the global agro-industrial complex: production, consumption, global market, innovation, farming.
The global market for agricultural raw materials and food is awaiting renewed price increases. The wave of mergers and acquisitions in the industry has led to a significant revitalization of the land market. Significant reduction in clean water has already affected not only China and India (water shortage is a traditional problem in these countries) but also the American Midwest, where the depletion of aquifers threatens to maintain high yields on irrigated land. Such problems as soil degradation, restriction of environmentally harmful farming methods require special attention. For example, agriculture is the source of 10% of CO2 emissions and more than 50% of other greenhouse gases, and 90%-95% of ammonia emissions in the European Union. 75% of agricultural land used is subject to erosion, with almost 20% losing more than 10 tons per hectare per year in EU countries.

As for the scientific world, there is a stormy discussion of such problems among scientists, for example, Aubry, S., Eigenmann, C. in their work "New challenges to digitization of genetic resources for food and agriculture" raise the problem of soil degradation and the use of outdated environmentally harmful tools for agriculture, and also proposes to carry out activities to ensure the digital revolution in agriculture [1]. Scientists Fernandez B and Herrera P in the study "Robust digital control for autonomous skid steered agricultural robots" offer to conduct agricultural robotization to assess the performance of industries, through modeling and analyzing big data [2]. Based on the analysis of the above and other relevant sources, we concluded that there are no specific strategies and measures that can be applied to improve the efficiency of domestic agriculture, therefore the main goal of this article is to develop scenarios for the development of the agricultural sector in Russia.

2. Materials and methods

Research methods used in the article: dialectic method of knowledge; logical and formal logical methods; method of comparison, generalization, systematization and synthesis (in the study of the essence of development strategies), systemic and integrated approaches, economic and statistical, grouping methods, graphical analysis (in assessing the characteristics of the functioning of the agro-industrial complex under conditions of increasing international competition), methods of expert diagnostics, forecasting (with determining directions for improving the strategy of the development of the agro-industrial complex in the context of increasing international competition).

Countries and interstate associations are currently stepping up work to develop a system of global trade agreements, increasing the promotion of products of national agro-industrial complex, enhancing the protection of their markets. Innovations in the agro-industrial sector are experiencing explosive growth. They will determine the new leaders of the agricultural market in the medium term. The volume of innovations in startups specializing in new agricultural technologies has grown more than 10 times in recent years. Big Data, robotics, artificial intelligence, and other technologies are becoming familiar not only on the industrial conveyor but also in agricultural production. The change process affects not only startups. Mergers and acquisitions are expected to continue in the “big six” agrotechnological companies. Another important global trend is the active development of centers for the development and implementation of advanced agricultural technologies as a new instrument of state support for the development of the agro-industrial complex [3].

The trend for farms is the growth of niche markets with high added value. The key technological innovations are aquaponics, the widespread introduction of IT, biological pest control, and the development of small-scale mechanization. Interestingly, the utilitarian quad bike has become the best-selling farm machine on the UK market in recent years.

3. Result and Discussions

The widespread adoption of digital technologies is a key trend in the global economy of the last decade. The use of georeferencing systems, integrated fleet management, precision farming is becoming the industry standard in agriculture. But as the cross-sectoral analysis shows - the real digital revolution is still ahead in world agriculture.

IT companies, media, finance, and insurance are world leaders in the implementation of digital technologies [5]. The digitalization level is significantly lower in real production and logistics.
Agriculture closes the list. The main limiting factor is the peculiarities of agricultural production. However, a number of current trends indicate that this situation will radically change in the coming years. The development and production of robotic agricultural machinery are now at the forefront of innovation. In general, there are 3 stages of development and introduction of digital technologies in agriculture:

- Pilot technologies: the technologies of the plant are beginning to be introduced from the mid-2000s, monitoring the state of agricultural equipment and the like [6].
- Market saturation: the number of digital technologies and industry standards in agriculture has reached a critical mass at present. Almost all manufacturers of equipment, companies from China and India offer their own programs and solutions that optimize the use of machinery and equipment. There are several solutions associated with precision farming. A variety of options are available for using geodata for crop forecasting, agricultural work optimization, logistics management, and others. Additional pressure on the user provides the arrival of a new generation of agricultural technologies - the Internet of things and the blockchain.
- Integration is the key trend of the future: companies that can offer common standards and solutions that combine existing developments in the field of digital agrotechnologies and eliminate the problem of choice and associated risks will become the leaders in the digitalization of agriculture.

According to the study Accenture (one of the leading consulting companies in the field of innovation), a possible solution to the problem of the development of digital technologies in world agriculture lies in the creation of integrated cloud services. Such services will take over data from digital units of agricultural equipment and ensure the compatibility of various formats and protocols. In addition, the only service can provide the most efficient use of data that is useful to all agricultural companies in the whole region - remote sensing of the earth, hyperspectral aerial survey, weather forecast data, etc [7].

An additional advantage of this cloud service will be marketing and logistic support for farmers. Access to information will reduce the risks of overproduction of agricultural crops, provide access to real prices for agricultural products, and reduce the cost of intermediary services, simplify the construction of transport chains. According to Accenture, the effect of introducing unified cloud services for agriculture can be a doubling of the profit from a hectare. The creation of such services will provide the prerequisites for a significant acceleration of the digitalization of agriculture.

 Accelerated introduction of a new generation of digital technologies for the agro-industrial sector is an effective way to use the organizational advantages of the agricultural development model. In addition, it will significantly improve the efficiency of investments in the agro-industrial complex, increase the return on each invested ruble. Creating a unified state cloud service can be an essential element of non-financial government support for agriculture [8].

In our opinion, the use of a systematic and well-considered state approach for the introduction of a new generation of digital technologies in agriculture should be an important and promising component of the agribusiness development strategy.

New ambitious tasks of agricultural development require further development of the system of agro-finance and bringing it to a new qualitative level. As development priorities can be identified:

- Reducing the timing of the decision on the provision of project financing in the agricultural industry.
- Ensuring more flexible financing conditions appropriate to the specifics of the agricultural business, which is significantly affected by climate risks.
- Further simplification of access to bank and leasing financing for small agribusiness.
- Reducing bank interest rates on loans; expanding access to government support.

Importantly, such technologies are being introduced not only in the USA, EU Canada, and other developed countries of the world. Successful experience in introducing modern financial technologies focused on small agribusiness and farmers exists in a number of actively growing African countries: South Africa, Kenya, Nigeria, Tanzania. International support, the weakness of "traditional" financial institutions have created a good climate for new products from the field of financial technologies in
these countries. The use of a comprehensive automated scoring system - assessing the creditworthiness of farmers and agricultural entrepreneurs in Kenya is of considerable interest. The advantage of this system is wide access to credit funds and a high level of repayment [10].

Modern financial technology is the basis of the scoring system used. It combines highly efficient data retrieval algorithms, processing large amounts of information, making decisions based on neural networks.

Another trend in global agro-industry is protected soil technology [11]. It ensures the high efficiency of agricultural production and, in general, makes it possible to solve one of the main problems of investment in agriculture - the significant impact of adverse environmental factors.

Protected soil agriculture requires access to modern technologies: computer control of nutrient solutions, temperature and humidity of the environment, etc [12]. Israel is an example of the active use of natural competitive advantages for the development of agricultural production of protected soil. This country now not only exports vegetables grown in greenhouses but is also the largest supplier of agricultural technologies in the world.

The next step in the development of agricultural production of protected soil allowed for the implementation of new technologies: LED light sources with an optimal emission spectrum for photosynthesis and aeroponics[13].

From a practical point of view, the use of aeroponic technologies led to the creation of “vertical farms” - a new format for the production of agricultural products.

Placing vertical farms directly in the city, next to a shop or restaurant significantly reduces the cost of transporting products, preserving freshness, etc. Such farms allow using any free space or even make them mobile, based on a truck.

The rapid growth of the global market for agricultural unmanned aerial vehicles confirms the effectiveness of their use. The use of agrotechnologies based on the use of UAVs is becoming one of the key factors of competitiveness. This is especially true for Russia, where agriculture sets ambitious goals for entering the world market.

Export-oriented AIC of Russia creates an excellent domestic market for agricultural aircraft. Today, their use is not widespread in Russia, but it can increase significantly in the future. The possibilities of the domestic market of Russia are sufficient for the formation on its basis of one of the world leaders in the agro UAV market. This is a very promising direction given the high market growth rates (up to 30% per year).

So, the competitiveness of agricultural products is now determined by the efficiency of its production and the use of advanced technologies. They create favorable conditions for the development of the domestic agro-industrial complex.

In our opinion, the use of a systemic and well-considered state approach for the introduction of a new generation of digital technologies and financial technologies in agriculture should become an important and promising component of the development strategy of the Russian agro-industrial complex.

We also suggested that the use of protected ground farming technologies (for example, vertical farms) could contribute to Russia's entry into the world leaders in the use of modern agricultural technologies. Production of equipment for vertical farms will contribute to the development of the domestic high-tech AIC due to the rapid growth of this market.

4. Conclusion
Currently, a new technological wave is unfolding in the global economy, which will be characterized by the development of robotics; biotechnologies based on modern achievements of molecular biology and genetic engineering; nanotechnology; artificial intelligence systems. The relevance of flexible automation of production and the use of renewable energy sources is increasing. Biotechnology will be the basis for the development of agriculture[14].

All this creates prerequisites for the formation of a new structure of the markets for the means of production and the products of the agro-industrial complex. Russia has significant potential for the
development of agriculture at the global level. This is due to such strengths as favorable agronomic conditions, the availability of diversified infrastructure, and the presence of able-bodied human capital. However, the main restrictions on the development of the agro-industrial complex remain low wages, high corruption, significant inflation, import dependence, the use of outdated production methods and technologies, and the imperfection of the financial and credit system.

So, innovations are now experiencing explosive growth in the AIC. They will determine the new leaders of the agricultural market in the medium term. The volume of innovations in startups specializing in new agricultural technologies has grown more than 10 times in recent years. In our opinion, the use of a systematic and well-thought-out state approach for the introduction of a new generation of digital technologies and financial technologies in agriculture should become an important and promising component of the development strategy of the agricultural sector of Russia. We also suggested that the use of such technologies of protected ground protection as vertical farms may contribute to Russia’s entry into the world leaders in the application of modern agricultural technologies. Production of equipment for vertical farms will contribute to the development of the domestic high-tech AIC due to the rapid growth of this market. The market of agricultural unmanned aerial vehicles (UAVs) can be distinguished by one of the new directions of the technological development of the AIC. The possibilities of the domestic market of Russia are sufficient to form on its basis one of the world leaders in the agro UAV market.

We have identified two main scenarios for the development of the Russian agricultural sector in 2030. According to the first, the main drivers of agricultural development will be: a gradual revival of the economy, import substitution, and the further development of traditional export niches.

Improving conditions for investment will be due to the effects of stimulating monetary and fiscal policies [15].

The second scenario “Global Breakthrough” provides for the development and implementation of scientific and technological policy in the field of agriculture. The main objective of the scientific and technological development of the agro-industrial complex of Russia is to ensure the competitiveness of products in the external and internal markets through the creation, distribution, and application of the latest achievements of science and technology.

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