

Impact of the complimentary nature of the digital resource on the accelerating dynamics of the agricultural sector

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Abstract—The paper is devoted to the study of the prospects for developing agriculture on the basis of the information revolution. The paper presents a number of reasons showing the increasing role of food production. The dynamics of the information technology sector is presented and new trends in the development of agriculture on the basis of the spreading cloud technologies and prioritized open information systems are highlighted, the formation of the Internet of Everything with Big Data, and the formation of relations for joint production and consumption of information. The paper substantiates the possibility of development of innovative processes in the agricultural sector due to the information technology, primarily on the basis of strengthening the interaction between the state, business, and science. The authors suggest the ways of improving management in the sectors of agriculture through modern information systems and the expanding basis for strategic planning, increasing the dynamics managerial decision making, which is necessary for the industries working with perishable products. The paper discusses the possibilities of reducing the cost of agricultural products with the help of information technology on the basis of the substitutional impact of the digital resource through the use of e-Commerce, e-advertising, and the use of mobile apps. The necessity of innovative digital policy in the agricultural sector, serving the promotion of digital technologies in rural areas, is substantiated. The role of the complementary nature of the information resource in the development of the agricultural sector is shown conceptually.

Keywords—*information technologies, information systems, agriculture, substitutional and complementary impact of the digital resource, food security, management improvement, innovations in the agricultural sector*

I. INTRODUCTION

The paper focuses on the studying the prospects of application of the achievements of the information economy in agriculture, and the relevance of this topic is proved by the set of theoretical and methodological, scientific and practical problems that this process encounters. The information revolution, which manifested itself as the rapid spread of the latest information technologies, influenced the rational organization and effective use of information. Ultimately, it changed the functioning of all spheres of the society: state structures and institutions, economic

and social spheres, science and culture. The number of “information-consuming” industries is growing, forming the digital economy, including the agricultural sector. It is necessary to investigate both the positive and negative consequences of the impact of information technologies on the functioning of the industry. In Russia, the development of the information economy is uneven and contradictory, some structural parts of the Russian information sector are characterized by greater dynamics, while others, on the contrary, lag behind. While having a number of problems, the Russian agriculture has a great potential for development, which is noted in the works of V. Goncharov, V. Korotchenya, L. Orlenko, V. Rastyannikov, etc. The introduction of information technologies will allow transforming the agrarian sector into a dynamic, intellectual, technologically advanced segment of the economy. The merger of the digital economy with agriculture will allow improving management, saving costs, enhancing innovation, and avoiding intermediaries. The aim of the work is to assess the impact of information technologies on the management and innovative nature of the development of agriculture on the basis of the substitutional and complementary nature of the digital resource.

II. OBJECTS AND METHODS OF THE RESEARCH

The object of the research was the functioning of the agro-industrial complex, including agriculture, in cooperation with the information and communication sector. The detailed object of the research was studying the prospects of developing innovations and management and reducing costs in agriculture with the help of information technologies. The objective of the research was to identify the realized and unrealized benefits from the use of information technologies in this economic segment, and to search for the directions of effective implementation of information technologies for innovative renewal of the agricultural sector, identifying the features of the digital agricultural policy. The methodology of addressing the research objectives is based on the principles of the dialectical-materialistic method of cognition, the application of the systemic, world-systemic and synergetic approaches, and the use of the method of formalized analysis. The dialectical-materialistic,

systemic, and world-systemic methods of cognition are used to study the digital economy in its sectoral version. The synergistic approach is needed for studying the diversified, penetrating nature of the modern information resource.

III. RESULTS AND DISCUSSION

A. *Reasons for the increasing role of food production*

Setting the global task of building a new global development model has changed the attitude to the sectors of the agro-industrial complex. The industrial society and the subsequent post-industrial society are known to have formed for and assigned to agriculture the role of the secondary “backward” sector of the economy, from which resources should naturally go to more productive economic segments. As a result, the share of agriculture has decreased sharply. The provided state aid and the dependence on external support only strengthened such common perception of this sector.

At the end of the 20th and the 21st centuries, there were a number of reasons for the increased attention of the world community and national development programmes to food security, and the perception of the branches of the agro-industrial complex as a significant part of the real sector of the economy returned. The reasons for the new perception of their role include the following:

1. Food security is becoming an integral part of the global problems of our time. Food security is placed on a par with the need to ensure national and economic security. Hunger as a social phenomenon is believed to be a negative consequence of globalization. The unsolved problem of food security belongs to the series of “challenges” of social development. The essence of the challenges lies in the fact that failure to timely respond to the tasks set by the development of the society will lead it to degradation or complete disappearance. Food security and the survival of humanity are directly linked. According to most forecasts, including UN estimates, the growth of the world population and changes in consumer preferences will ensure an increase in demand for food by 70-100% until 2050, which will make agricultural production the most dynamic segment of the global economy [1].

2. The challenges of our time include social and economic inequality, which has a big role in modern research. Thomas Piketty’s ‘Capital in the 21st century’, where the problems of inequality are again raised, aroused common interest. In the UN report, the most important goals of the new millennium include a twofold reduction of poverty on Earth and a twofold reduction in the number of hungry people. 193 UN Member States and 23 international organizations were involved in the implementation of these goals, but the problems remain unresolved. Socio-economic inequality is primarily manifested in the lack of food for a certain part of the population, which makes this problem the most acute. Food consumption is directly dependent on income. In underdeveloped countries, the food consumer goods basket is mainly based on cereals, potatoes and bread, while in developed countries meat and fruit play a significant role. This is

a violation of physiological norms of consumption, which should depend on non-economic factors.

The agricultural sector itself can serve as a basis for deepening inequality between developed and developing national economies. The price gap between industrial and agricultural products and the high level of tariffs on exports from agricultural countries create unequal opportunities for gross income in these countries. In the long run, structural deformation is developing in the form of weak investment activity in countries that are predominantly agriculture-oriented.

3. The increased instability of the world economy and the cyclical shocks of the past period did not contribute to the elimination of food difficulties. The economic crisis of 2008 and the growing complexity of the geopolitical plan exacerbated the food problem. These days the reason for people’s unsatisfied need for food is not floods, drought, etc., but the increase in food prices [2].

4. In the modern economy, there are new reasons for the increasing role of agricultural sectors. Many countries are trying to replace hydrocarbon energy resources with biofuels obtained from food products, especially since this fuel is environmentally friendly. According to the development plans of the United States, by 2020 the share of bioethanol in the country’s fuel balance should amount to one fifth, while Sweden has set the objective is to fully switch to biofuels, and Brazil already satisfies half of its fuel demand with ethanol.

5. The modern model of economic development is focused on the resource-saving way of reproduction, on increasing the role of science, intellectual production, and innovative production. Long-term global forecasts contain the provision that most industries will move to a higher technological base, using highly qualified, creative labor resources. The next few decades will see a significant development of activities related to science, knowledge, information and communication technologies. So far, the share of the knowledge sector in developing countries, including Russia, is 15-20%, that is, its share is twice lower than in developed countries. However, according to forecasts, in the next 20 years, the share of the knowledge sector will double, and that of science, information and biotechnology will increase by three times. Especially high dynamics will occur in the sphere of intellectual services, whose share in the world GDP will increase by 10-15% [3]. Put on the intellectual track, agriculture will receive a new impetus for development.

B. *Information revolution and information economy*

The initial impetus for change was given by the information revolution. Since the end of the 20th century, the sector of information and communication technologies has occupied a special place in economic dynamics. World exports of its products have tripled since 1996 and now account for 10.8% of total world exports [4]. The annual growth of expenditures on information and communication products is quite stable and in the 2000s averaged 6.2% [5]. Sales of personal computers, mobile phones, tablets and laptops grew steadily until 2014; only in 2015, there was a negative trend in the sales of these products, but their

scale remained high enough, and in 2017, the positive growth trend returned. In 2016-2018, the emergence and expansion of cloud computing, big data, and convergent, mobile and social technologies gave a new nature to the information revolution.

The theory of the information economy claims that large-scale production should be abandoned, and that human activity should be implemented in small firms located close to the housing of workers. Working in rural areas is consistent with this hypothesis. The new global resources – information and knowledge – can provide significant assistance to the development of the agricultural sector. According to official data, an average American farmer works to meet the demand of 75 US residents, while the rest of the countries, as a rule, are still far from such estimates. The intervention of information in the development of intellectual methods for developing agriculture is a powerful reserve for the growth of agricultural countries.

C. Conditions of development of agriculture in Russia

In Russia, the situation concerning the conditions for the development of agriculture is difficult. On the one hand, the general economic conditions have been complicated, the reasons for which were geopolitical difficulties, the fall of the ruble, a sharp rise in prices, a new wave of “capital flight”, the aggravation of cyclical fluctuations in development, the accumulation of corporate debts and the formation of the budget deficit. On the other hand, the development of national agricultural production and the refusal to import food have become not just a desirable phenomenon, but a necessity. The problem of replacing the materials and components due to import restrictions and the sanctions applied emerged. The indicator of production dependence on imports, calculated as the share of imports in the costs of raw materials, is of particular importance. In some areas, for example, in the production of meat and meat products, processing of fish and seafood, fruits and vegetables, this estimate has reached 20%, 28% and 33%, respectively [6].

During the previous decades, the Russian economy was characterized by an increase in imports of food products. In 2000-2013, the cost of imported food and raw materials for agriculture increased by almost 6 times, and later the trend was strengthened due to the sanctions imposed [7]. The fall of the ruble has led to the fact that the cost of Russian products in dollars falls, and the cost imported products, measured in rubles, increases.

The increasing geopolitical difficulties were a catalyst for the positive dynamics of the Russian agricultural sector and associated processing industries, but dependence on imports remains a significant obstacle to their development [8]. At the same time, positive changes are evident, for example, it follows from the data of Rosstat that the commodity volume of imports of agricultural products for many types of goods has decreased, and that of import substitution has increased [9]. In modern conditions the level of Russia’s self-sufficiency in all types of production which got under import restriction (grain crops, potatoes, poultry meat, pork) has grown.

In 2016, the country ranked 46th out of 113 countries in the food security rating. At the same time, there is a need to eliminate the shortcomings that have accumulated in agriculture in recent decades. The active onset of market relations has dealt a new blow to Russian agricultural production. Dependence on natural conditions makes agriculture a very vulnerable part of the economy in need of support, in particular from the state. However, in the neoliberal model of development, the agricultural sector is forced to develop independently. The effect of the “price scissors”, that is, different rates in the growth of prices of agricultural and industrial goods, was inevitable. Producers suffer losses, while a huge number of speculative operations are carried out, bringing benefits to intermediaries. The principles of perfect competition are violated, as the freedom to enter the food market is hampered by formal norms: quotas and licenses. There are additional informal barriers in the form of extortion by officials and racketeering by criminal structures. Over the years of market reforms, the consumption of the main food products in Russia has halved. The reasons for the apparent abundance of products in retail outlets are not the increase in their supply, but their price inaccessibility for a large part of the population, which is especially evident for meat products.

The search for the ways of turning the agricultural sector into a competitive segment of the Russian economy leads to the conclusion that it is necessary to involve it in the system of the knowledge economy. Studies lead to the conclusion that the solution of the issue of import substitution in agriculture requires the transformation of agricultural production into a modern technological mode. From a technological point of view, the Russian agricultural sector currently belongs to the classical labor-saving type. While Canada and Australia use one worker per 100 hectares of land, Russia uses 5 workers for the same amount of work. Yet, with such a distribution of factors of production, the amount of applied fixed assets per employee in Russia is almost ten times less than in the countries mentioned above [10].

In addition, the state of agricultural production assets can be estimated as quite low. Half of the active fixed assets has been lost in the period of the perestroika, and the number combine harvesters, tractors, potato harvesters, etc. fell by 6-10 times during years of the reforms [11]. As a result, the remaining part of the equipment carries a large operational load. Even among the CIS countries, Russia ranks only seventh in terms of efficiency of agricultural production.

According to calculations, the transition to metatechnology would increase agricultural production by 4.5 times. The intensification of innovative activity in the agricultural sector could help to solve the problem of restoring the processes of concentration and specialization, replacing labor-intensive technologies with labor-saving ones, and lead to an increase in labor productivity.

Assessing the conditions for the development of agriculture in Russia, it is impossible to bypass the data on the potential of the industry. Our country owns 10% of the world’s arable land and 55% of the fertile lands

of the entire planet; this amounts 0.82 hectares of agricultural land per person (while the global norm is 0.14 hectares), but up to 40 million hectares are not currently used productively [12]. Theoretically, a national economy with the resource potential of this level should not only provide its population with food, but also be the largest supplier of agricultural products in the world markets.

In the future, agriculture in combination with the food industry can and should take the place of the leading segments of the Russian economy. The growing positive dynamics of the agricultural sector could ensure the multiplicative growth of small towns in the European part of Russia, Siberia and the Far East, contribute to the expansion of the economic space, and increase the comfort zone of the Russian population.

D. Necessity and directions for application of information technologies in agriculture

In view of the huge demand of the product sector for new growth reserves, on the one hand, and the existence of significant reasons for their limitations, on the other hand, information technologies are an effective additional source of development. They can contribute to the development of the agricultural sector through reducing costs, accumulation of funds for modernization, and direct innovative participation. Information resources can act as resources-substitutes in management, employment, trade, and advertising. Improving management through information technology, replacing traditional workers with remote workers, savings on trade costs through e-Commerce and advertising costs through the expansion of Internet advertising, and using mobile devices for employees' information alerts will lead to enterprises' large-scale savings and the emergence of new sources of modernization.

In the majority of analytical estimates, the general level of informatization of the enterprises of the agro-industrial complex is recognized as insufficient. The lack of application of information technologies is claimed to be due to a number of reasons as follows:

- low efficiency of economic entities;
- lack of government involvement in the process of formation of the material and technical base and lack of its organizational influence on systemic informatization;
- weakness of the information infrastructure of the Russian agricultural enterprises.

Integrated information systems of enterprise management cannot be used by small and medium-sized agricultural enterprises due to the high cost of equipment, especially since the cost of installing the system is usually several times higher than that of the system itself.

In the developed countries the whole production chain of the branches of the agricultural complex is built on the basis of intensive and effective methods of management, which are implemented through the introduction of new technologies in production processes; first of all, the information and

technological base is improved for managing the material and financial resources, working with staff, and searching for potential buyers of products. New information technologies offer special computer programs which, by means of mathematical models and methods of processing information, serve for transferring the information about modern methods of processing agricultural products and about the special branch of knowledge concerning the relevant areas of agriculture and food industry [13].

Almost all firms of the agro-industrial complex participate in information exchange through their own websites, functioning in both the real and the virtual economy. Management at the microeconomic level involves such steps as the collection of information, its analysis, and the choice of management decisions, followed by the transfer of tasks to the object of management. The use of information technologies in the management mechanism makes it more perfect, as the basic elements of management, decision-making and communication, are carried out faster, better, and the time gap between them practically disappears. The raw materials and the final product of agriculture are perishable products, so in this industry it is extremely important to have a high degree of dynamism of management decisions and to eliminate the unnecessary management links and bureaucratic delays. Participation in the relations of the information economy provides the basis for a broader development of strategic management in the agro-industrial complex.

The development of the strategy for developing information systems at the enterprises of the agro-industrial complex is not limited to the acquisition of computer equipment; in the modern conditions, it primarily means solving production tasks with the help of information technologies. The tasks include increasing the level of automation of business processes, introducing quality management systems and improving productivity. The information strategy available in the enterprise should match its strategic objectives, namely:

- the information strategy should be developed on the basis of its business strategy;
- the information strategy should be included in the basic documents of the enterprise;
- the information strategy should be long-term (developed for the period of at least one year).

The information resource used at the micro-level of the enterprises of the agro-industrial complex is a substitute for the traditional factors of production, that is, it can replace the material resources, reducing the enterprise's production costs. In the studies on the specifics of management in the food production sectors, attention is drawn to the high importance of the problem of resource saving as an important management task [14].

Information acts as a basic resource in any production, and the functioning of the classical factors of production (labor, land, and capital) is impossible without the connection of information flows. Any production, including the production on land, is

organized by means of the information on possible combinations of resources, conditions of optimization of production, management measures, forms of stimulation, etc. Thus, information as an complimentary resource can contribute to the efficiency of the existing factors of production. The new model of the economy is based on the fact that physical capital as a factor of production may increase its productive power through the transition to a higher

level of quality management based on information technology. Due to its nature, the information resource may be used not only as a substitute resource, but also as complementary to the traditional factors of production. Ultimately, the performance of the company will increase due to the positive changes in the quality of management; this impact is reflected in the chart (Fig. 1) with the shift of the isoquant.

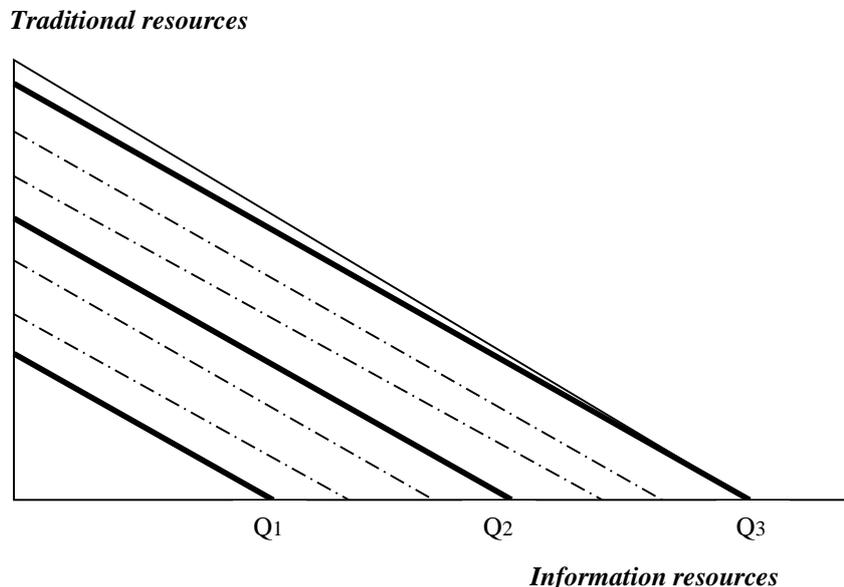


Fig. 1. Changes in the performance of the enterprise's production activity due to information resources. Drawn by the authors based on: [15].

Rational use of information support at the enterprise leads to improved efficiency, accelerated rate of production, increased quality of manufactured products, and improved consistency of actions. Information technologies allow tracking the progress of certain operations to notice possible problems timely and fix them before they cause significant harm to production.

Agriculture is the initial basis for informatization of the agro-industrial sectors. The agricultural sector is highly dependent on the changing environment: climate, precipitation and temperature changes. The need for the introduction of information technologies in agriculture is largely due to the need to reduce external risks. Processing of large amounts of information on the impact of various factors will improve the efficiency of management decisions related to the production of agricultural enterprises, to help them adapt to unexpected changes in the conditions of production.

The Russian information policy should be focused on the use of intelligent technologies in agriculture, as stated in the Strategy for the development of the information society in Russia for the period 2017 – 2030 [16].

The specifics of agricultural sector demands taking into account the short shelf life of products. For this reason, an important role is given to the speed with which the goods will be delivered to the place of consumption, storage or processing. Another problem of the agricultural sector is the rise in prices due to the huge number of intermediaries, only getting rid of them will solve the problem of reducing food prices. The

introduction of digital technologies, bringing a multiple increase in the speed of information transfer, can affect the solution of these problems. State digital policy in rural areas and assistance to farmers in creating websites and blogs will lead to a fall in the number of intermediaries in transactions on agricultural products. Agrarian digital policy should be focused on the formation of distance learning programs for specialists in rural areas, to ensure computer literacy of the population of villages [17]. It is necessary to help the rural population with modern digital technology, the development of mobile communication, the promotion of the Internet. The use of Internet advertising and e-Commerce should be expanded in order to revitalize the market for environmentally friendly agricultural products. The country's innovation policy should include a special component related to the agricultural sector, including the field of information technology. It will contribute to the spread of advanced farming methods, the introduction of electronic equipment in animal husbandry, and the emergence of technologies for sensing land.

The analysis of digital technologies advancement in the agricultural sector allows concluding that the impact of the information resource in agriculture is mostly of a substitutional nature, since this industry has not used all the reserves of intensification. For this reason, the increase in the complementary nature of the use of information resources should be a direct task of digital policy in the agricultural field. There are already some achievements, in particular, electronic equipment allows using special sensors to check animals' food and the presence of pesticides in products; the

technology for sensing land opens up new opportunities for competent farming.

Intellectual development of Russian agriculture will create a new raw material basis for the food industry, will help to change the situation with the price of supplies, and will reduce the import dependence of the industry.

A most important factor in the economic development of the agro-industrial sector, including improving the competitiveness of goods and services in this segment of the economy, is innovative development, based on the functioning of the regional policy of innovative development within the framework of the state innovation policy. The main supplier of the final food product is the food industry, and agriculture largely depends on its effectiveness. This sector shows contradictory assessments of the results of innovation. On the one hand, among all the industries, innovations in the food industry are considered the most significant and complete. This is due to the active turnover in the industry, stable demand for essential products, and a high degree of competitiveness in the industry's markets. Many enterprises in this sector managed to use this advantage to accumulate funds for the renewal of fixed assets and the search for new market niches. An additional factor in the success of innovations is consumers' rapid response to changes in the range and quality of products. On the other hand, there are quite opposite assessments, in particular, there is an opinion about the lack of innovative activity in the food industry.

One of the factors of increasing the innovation activity in the food industry is the need for interaction of all the participants of the innovation process: credit institutions, the state, knowledge and research institutions, regional authorities, and food engineering industries, including agriculture. The necessary tool for their integration is the openness of the participants of the innovation mechanism. Information technology is a necessary tool to solve the problem of consolidation of participants. The following trends in their development will contribute to this.

The information technology revolution has caused the prevalence of the value of open data over the private data. When most of the information is closed, there are difficulties with the processing of information and its further dissemination. Open data eliminate discrimination in access to information. The Internet of Everything, Big Data and cloud technologies contribute to the unity of the economic space. Modern innovative technologies have the property of complex intelligent systems that can purposefully accept exchange flows and process them in accordance with their tasks.

In agriculture, digitization is facing many problems. Only large companies can afford to automate corporate reporting based on unique integration solutions for information transfer from one information platform to another. The question of staffing enterprises with IT specialists is still open. Only a few segments of the industry have their own information strategy. The main unsolved problem is that there are no effective communication links between users and developers of

the IT systems. The reason lies in the development of information systems based on the needs of the average enterprises, and not in accordance with the orders of individual enterprises. The status of information services at agrarian enterprises is not defined, there is no consensus on their place in development and decision-making process. Often, the functions of information departments are very blurred, they are engaged both in fixing personal computers and software configuration, and in planning the company's development. The issue of financing the information departments at agricultural enterprises is being discussed. Training information departments' staff is a dynamic component of the industry's development.

IV. CONCLUSION

Information technologies have already changed the nature of management, the mechanisms of innovation, and the marketing strategy of agriculture due to reducing managerial, transactional and material costs. However, not all enterprises in the industry are actively involved in the digital economy, both for financial and organizational reasons. Differentiation of the industry's enterprises by the use of information technology is such that the economic entities that are not engaged in the production of basic food products are the most advanced. The following ways of improving the situation may be suggested: to study the possibilities of marketing innovations carried out with the help of Internet advertising and e-Commerce; to apply information systems and strategic management more widely, to develop a special digital agricultural policy, to pay attention to ensuring the adequacy of financing of and granting the status to information departments of agricultural firms, to increase the training of specialists for maintaining IT systems, and to adapt the mechanisms of functioning of information systems to the conditions of particular firms.

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