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Parameters of Economic Design of the Ecosystem of the Digital Economy of Small Agricultural Formation

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Abstract : The aim of this study is a scientific, practical and methodological analysis of the economic design of a smart digital dairy farm created by deploying one of the ready-made digital solutions for managing the M2M network, combining robotic milking systems (RMS) with automation tools for the herd management process, on the basis of an existing agricultural enterprise specializing in the production of whole milk. The result of the analytical study of the parameters of the economic design of a smart dairy farm should be the identification of the specifics of the digital transformation of small agricultural formations during their integration into the ecosystem of the digital economy and the construction of digital business ecosystems necessary for the integrated management of agricultural production in the conditions of small agricultural forms. Real small agricultural enterprises of the region were used as a testing ground for testing advanced scientific and production experience and the implementation of ERP systems of domestic production. As a result, the necessary data were obtained and analyzed, an adequate assessment of their economic efficiency was carried out from the point of view of prospects for obtaining the necessary scientific and production experience and developing practical recommendations for the implementation of modern digital technologies in small-scale agricultural production. To achieve the stated goals, general scientific and highly specialized economic research methods were used, including observation, survey, questionnaire, numerical-analytical and statistical methods, expert assessment method, as well as a method of comprehensive assessment of economic activity. The result of the study was the receipt of numerical values of economic parameters for designing a digital ecosystem within a small agricultural formation to create a smart farm for the production of raw milk and the development of a concept for deploying a digital ecosystem based on existing and promising digital platforms, as well as ready-made solutions using the example of 1C : Enterprise 8. ERP "Agro-industrial complex 2".

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As the experience of introducing high-tech technologies into agro-industrial production in different countries shows, the main channel for implementing the results of R&D in agriculture is digitalization . The process of agricultural production today is already inseparable from digital and information technologies, turning agro-industrial production into a global information technology structure that combines both the features of a modern agro-industrial enterprise and a business ecosystem aimed not only at a quantitative increase in the volume of manufactured products, but also a radical increase in their quality and safety, the most efficient use of the transport and logistics resources available to the agricultural producer , the creation of conditions for storing and processing products and the fastest possible delivery to the end consumer. This set of tasks can no longer be effectively implemented within the framework of the third (industrial) technological structure, and urgently requires the earliest possible implementation of solutions characteristic of the next - fourth stage of the industrial revolution, called in relation to the agricultural sector AIC 4.0 (Pushpa , Gowri and Ramachander , 2024).

The needs of the fourth technological order impose very strict requirements not only and not so much on the material, technical and technological adaptation of agricultural producers, but on the transformation of the ideology of agro-industrial production in the context of its transformation from a low-profit, rather risky and unattractive from the point of view of investors sector of the economy into a modern technological business built on ultra-modern digital platforms and solutions, characterized by a high level of labor culture (Bohnsack , Rennings , Block , 2024). It seems that the achievement of these and many other ambitious indicators put forward by the needs of the agro-industrial complex 4.0 is possible only within the framework of the formation of a kind of digital economy ecosystem in the agro-industrial sector, on the successful integration of individual agricultural producers (and their associations) into which the future of the Russian agro-industrial complex as a whole, its competitiveness and ability to withstand external sanctions pressure will depend.

Understanding the urgent need for digital transformation of the domestic agro-industrial complex and its entry into the fourth (digital) technological stage is not only in the scientific and expert community. The same idea, repeatedly expressed by the Russian leadership, was enshrined in a number of program documents of the Russian Federation, which laid the conceptual foundations for the digital transformation of agriculture and its transfer to a fundamentally different technological basis.

It should be noted that there is no unity on most conceptual issues concerning both the terminological and semantic paradigm of digitalization in either world or domestic science. The views of scientists are sometimes diametrically opposed even on the most basic fundamental concepts, such as " digitalization ," "digital economy," "digital ecosystems," etc. In general, this state of affairs can be explained by the still relative novelty of digital narratives in world scientific thought, as well as the difference in approaches to terminology that takes place in various areas of scientific knowledge (Singh , Kolar and Abraham , 2024).

The domestic economic doctrine is characterized by a maximally expansive approach to the interpretation of the term "digital ecosystem", according to which it is "a complex of electronic platforms that integrate a full range of data on the dynamics of information flows and the potential for digital development of various spheres of human socio-economic activity" (Popova , Lata and Melikhov , 2023). Among representatives of the expert community and practitioners, the more widespread point of view is that digital ecosystems are a kind of cyber -space in which various platforms and services of a particular company (group of companies) function through seamless integration, allowing users and partners to quickly resolve issues of internal corporate interaction that arise in the process of using the ecosystem and satisfying the needs of users for digital services, while ensuring transparency of the digital ecosystem, efficiency of service provision and maximum speed of solving emerging problems (Ivanova , Ovchinnikov , Lata & Korabelnikov , 2020).

This understanding of digital ecosystems in general and digital ecosystems of agribusiness in particular implies the need for the broadest possible integration of all subjects of the agricultural structure into existing and prospective ecosystems of the agricultural economy, since the positive effect of using digital technologies in the process of agricultural production is the more significant, the greater the degree of involvement in the digital infrastructure of partners and users and, accordingly, the more obvious the positive impact of the network effect becomes: reducing costs due to scaling up production and increasing the efficiency of labor and capital resources. In this regard, the purpose of this study is a methodological and scientific-practical analysis of the specifics of digital ecosystems of small agribusiness and the development of practical recommendations for the implementation of modern digital technologies in small agricultural production.

Milk production under conditions of complete or partial refusal to use in the diet of farm animals of certain components of artificial origin, including feed additives obtained using technologies of genetically modified growth stimulants, as well as the use of herbicides and insecticides in the production of feed, has received the name of "organic production" in modern agricultural science.

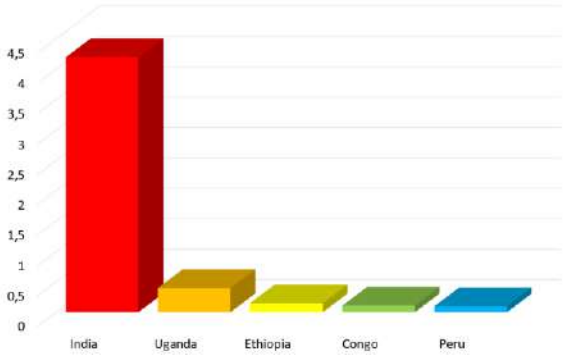

Figure 1: Top five countries by number of organic farms (million units).

According to data published by the Research and Information Center for Organic Agriculture (FiBL), in 2023 there were 4.3 million organic producers in the world, the vast majority of whom are concentrated in India. They are followed by such countries as Uganda, Ethiopia, Congo and a number of other countries whose agriculture is at a very low level of technological development, but, at the same time, demonstrates a fairly high potential in the field of organic production. The world market for organic products, according to FiBL , reached 136.4 billion euros in 2023 and continued to grow actively in the following 2024. The highest growth rates of the organic market were recorded in the European Union. In terms of total sales, the US market retains its leading position (59.0 billion euros), followed by Germany (16.1 billion euros) and China (12.6 billion euros). (Research Institute of Organic Agriculture)

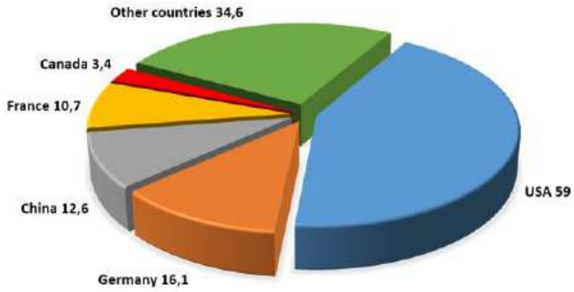

Figure 2: Global organic market capacity (EUR billion).

The implementation of the principles and methodology of organic production can be most clearly illustrated by the example of a livestock farm that implements the so-called " loose housing" system. The main advantage of this method of keeping animals is the absence of crowding of the herd and the predominance of natural green fodder in the diet in combination with nutrient mixtures that do not contain hormones, growth stimulants, chemical preservatives, etc. Under such conditions, dairy cows experience almost no stress, which has a positive effect on the growth of the volume and quality of the products obtained. In particular, the fat content of milk increases by at least 2-2.5% and its bacterial content decreases , which makes it possible to obtain "organic" and, under certain conditions, "environmentally friendly" products, which have enjoyed steady demand in the European and world markets over the past decade (Ayaz , Ammad-Uddin , Sharif , Mansour , & Aggoune , 2019).

However, this is far from exhausting the positive impact of organic production on the entire agricultural sector. The refusal to use chemical and biological components of artificial origin, herbicides, insecticides, as well as genetically modified elements and artificial growth stimulants in animal diets in agricultural production gives a synergistic effect in the context of an overall increase in the environmental safety of agricultural production. In addition, the uniform distribution of livestock throughout the pasture and, consequently, significantly less " trampling " helps to reduce the time it takes to restore pasture lands and increase their fertility (Popova , Lata , Kleiman , & Melikhov , 2023).

However, along with the obvious advantages of organic production, there are also a number of objective difficulties that hinder the widespread introduction of this technology. The most significant factor hindering the development of "organics" is the high financial and resource entry threshold, due to a number of objective reasons of both organizational, economic and purely economic nature. Even in such relatively economically prosperous countries as Germany, the Netherlands, France, Denmark, farms introducing organic milk production technologies are provided with state support aimed at compensating for the costs associated with the decline in production during the transition period (Adhiatma , Fachrunnisa , Nurhidayati , Rahayu , 2023).

It seems that one of the most effective algorithms for reducing costs during the transition to organic production and achieving a positive economic effect is the creation of a comprehensive “smart dairy farm” integrated into the existing regional ecosystem of the digital economy, by deploying within the farm one of the ready-made digital solutions for managing the M2M (Machine - to - Machine) network , combining robotic milking systems (RMS) with automation tools for the herd management process.

Digital modeling of a smart dairy farm involves integrating into a single IoT network a sequence of technological stages of whole milk production within a small agricultural formation: organizing loose housing of productive animals on relatively large pasture areas using automated control and herd management systems; using automated milking in combination with modern technologies for cooling and storing raw milk; analyzing milk quality and monitoring animal productivity and health (Fountas , Espejo-Garcia , Kasimati , etc. , 2020)

According to the authors of this study, in the conditions of a small agricultural enterprise in terms of the number of employees, this problem can have a positive solution only and exclusively in the conditions of labor differentiation with the use of robotic milking systems (RMS) and the implementation of solutions for the deployment of a full-fledged digital production management ecosystem. The use of innovative labor organization methods in a small agricultural enterprise, the use by farmers of modern information and computer technologies, digital management and other organizational, economic and technological innovations necessary for the creation of a smart farm should contribute to the innovative and scientific-technological development of the agricultural sector, and, in addition, represent an economically effective business project (Popova , Lata , & Melikhov , 2022).

The choice of the organizational and legal form of such an agricultural enterprise in today's Russian legal reality is quite obvious: it can be a peasant (farm) enterprise created by registering its head as an individual entrepreneur (IE), or a peasant (farm) enterprise created in the form of a legal entity. It should be noted that Russian civil legislation also provides for other organizational and legal forms of economic activity in the field of agricultural production, in particular, agricultural cooperation, business partnerships and companies, etc. However, the choice of such a form in the context of this study is not of fundamental importance, since Russian law does not contain any specific features that significantly distinguish the process of digitalization of certain entities of the agricultural structure . We will consider a peasant (farm) enterprise as a testing ground for testing technologies for deploying an IoT network for dairy production, but the concept of a smart dairy farm can also be implemented within the framework of other agricultural formations (Lata , Korabelnikov , Melikhov , 2023). A conceptual model of such production can be graphically represented as follows:

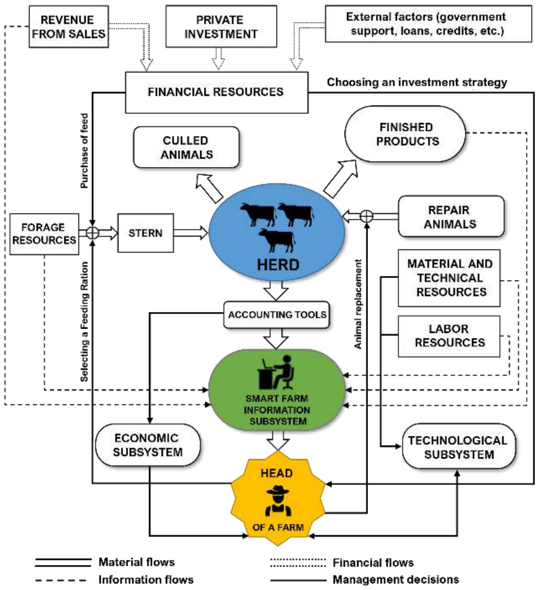

Figure 3: Schematic diagram of the deployment of a smart dairy farm based on a peasant (farm) enterprise.

The study of the economic efficiency of the introduction of robotic milking systems and automated herd management by organizing an IoT network in a small agricultural enterprise has already been considered by the authors on the pages of this publication. The need for further scientific and practical study of the topic of the creation and operation of innovative digital agro-industrial formations is due to a number of factors of both a purely economic and political nature, which, in particular, include the need for the earliest possible replacement of import-dependent technologies currently used in the domestic agro-industrial complex. The relevance of the economic study of the processes of automation and robotization of agriculture is also mediated by the acute shortage of qualified personnel, which is most acutely felt in the livestock segment of agricultural production (Jacobides , Cennamo , Gawer , 2018).

The Internet of Things technology, widely known in the expert community as M2M, is a system for transmitting information from device to device without human intervention. Such interaction becomes possible by equipping “machines” with a variety of sensors, turning them into “smart” devices that can interact with each other without any intermediate information nodes (Ying , Wang , Lei , ets , 2022). The use of M2M technology is the most promising direction for creating digital solutions and platforms for automating production process management, regardless of its industry specifics. The Internet of Things can turn any production or network of interconnected devices and mechanisms into a “smart” one by equipping them with the above-mentioned sensors and combining them into an IoT network. Agricultural production is no exception in this sense, although it has its own specifics.

The realities of the modern Russian IT market are largely determined by the consequences of economic sanctions, as a result of which a number of players left the Russian market, who in the recent past offered ready-made solutions for deploying IoT networks , equipping production chain components with M2M hardware elements, and also offered digital services in the form of access to their own cloud services, remote administration systems, etc. It should be noted that the consequences of the departure of manufacturers of digital solutions for the agricultural sector from the Russian market did not produce any noticeable effect on the functioning of the Russian agro-industrial complex, as evidenced by the steady growth of gross agricultural production in the Russian Federation and the volume of its export to foreign markets. However, for some Russian agricultural producers who relied on "Western partners", their refusal to cooperate became an unpleasant "surprise" and a reason to search for alternative ways of supplying the hardware component of the technology, including through "parallel import" of such components from states that did not join the anti-Russian sanctions.

Another way to solve the problem of import dependence in the deployment and use of IoT networks is cooperation with domestic manufacturers who are now able to offer solutions for the digitalization of the domestic agricultural sector. The development of domestic M2M is necessary not only and not even so much to meet the needs of agricultural producers in the deployment of IoT networks, but to create conditions for the integration of individual digital platforms into the regional and then federal ecosystems of the digital economy based on hardware and digital platforms of domestic production (Lata , Korabelnikov , Melikhov , 2023).

3 DIGITAL ECOSYSTEM "SMART FARM"

Integrated environments and ready-made solutions for building a digital ecosystem for a small agricultural enterprise producing raw milk are widely represented on the global and Russian digital markets. The so-called CRM, SCM, ERP and ERP2 systems, offered until recently by both domestic and foreign developers , have gained the greatest popularity among Russian agricultural holdings and smaller agricultural structures . However, after the introduction of restrictive measures against the Russian Federation, most foreign software manufacturers left the Russian market, completely stopping sales of their products and continuing only technical support for those already purchased. The most popular ERP solutions on the Russian market before the introduction of restrictions were the developments of 1C, Galaktika, SAP , Microsoft , Kompas and others (Abashkin , Abdrakhmanova , Vishnevsky , 2024).

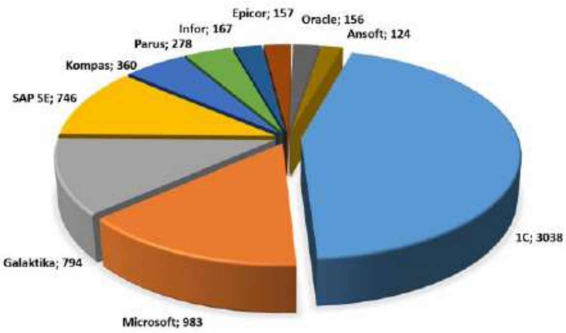

Figure 4: Number of ERP projects implemented on the Russian market in 2022.

As we can see, the leaders of the Russian ERP solutions market are 1C and Galaktika, which together sold over 55% of their products on the market. Among foreign players, before the sanctions were imposed, the most significant positions were occupied by Microsoft and SAP. However, after their departure in 2022, foreign companies are rapidly losing the Russian market, since their participation is limited to technical support for their clients without the possibility of them receiving new products. At the same time, domestic software manufacturers continue to expand both the range of their products and the quality of services provided. It should be noted that among Russian developers, 1C occupies a dominant position, whose share in the ERP systems market continues to grow.

The ERP system 1C :ERP "Enterprise Management" was first introduced in 2013, becoming the next step in the evolution of the 1C:UPP configuration. In 2020, the second generation of this software product was released under the index 1C :ERP "Enterprise Management 2" (current version 2.5.21.111). The main The advantage of the ERP system of the 1C company is its versatility, allowing the program to be used at enterprises in a wide variety of fields, including enterprises in the agro-industrial complex. The functionality of 1C :ERP covers almost all the main business processes of the enterprise, allowing monitoring of key indicators, building coordinated interaction between various departments, setting up various algorithms for assessing the efficiency of work, both of the organization as a whole, and with detailing by departments and individual employees.

1C :ERP "Enterprise Management 2", like all other products of the company, is essentially a digital platform representing an object-integrated environment for deploying a digital ecosystem of an enterprise of any complexity, regardless of its organizational and legal form, industry affiliation and production specifics. However, the company, based on the 1C :Enterprise 8 platform, has released a ready-made solution 1C:Enterprise 8. ERP "Agro-industrial complex", aimed at both creating a digital ecosystem of the industry level and automating the management of a separate agro-industrial enterprise in the areas of activity "Crop production" and "Livestock farming", including the creation of a digital smart farm for meat and dairy production, as well as a digital pig-breeding enterprise (Popova , Lata , Melikhov , 2023).

Today, the 1C:ERP Agro-industrial Complex Solution provides automation of almost the entire range of business processes within an agricultural enterprise with a crop or livestock focus, namely: accounting and planning in crop production; accounting of motor transport and fuel and lubricants; accounting of work and finished products; production accounting of productive animals on a dairy farm and pig farm ; cartography; agricultural monitoring ; sales management; warehouse and stock management; interaction with suppliers and customers and much more. As we can see, the use of this solution from 1C covers almost all existing and prospective business tasks that need to be solved in the course of an agricultural enterprise's activities.

To summarize, we can conclude that the industry solution 1C :Enterprise 8. ERP "Agro-industrial complex" allows you to build a full-fledged digital business ecosystem, including subsystems for production management, field mapping, creation of technological maps of crops, components of industry management, integration with geolocation systems , space monitoring and much more. As the experience of using the ERP ecosystem Agro-industrial complex shows, this software is capable of integrating almost all modern subsystems of digital management, production management, logistics, storage and sale of agricultural products.

4 PARAMETERS OF ECONOMIC DESIGN OF SMART FARM DIGITAL ECOSYSTEM

The economic efficiency assessment of the ERP Agro-industrial complex implementation can be carried out using investment analysis methods, which determine a number of basic economic values that characterize the economic performance of an innovative project, the implementation of which was carried out through investment. Such values are traditionally considered to be the terms of normal and discounted payback of investments; net present value of the investor; the coefficient of return on investment of the investment project; internal rate of return; the index of return on investment. The calculation of the indicators will be based on the data obtained as a result of testing the industry solution ERP Agro-industrial complex in agricultural formations of the Volgograd region with a calculation horizon of 5 years. In those cases where numerical data are not available, an interpolation model was used, as well as an expert assessment. The discount factor, according to the methodological guidelines developed by the Government of the Russian Federation for investment projects in the field of agriculture was taken as r = 20. The approximate investment cost of the project is given in Table 1.

Table 1: Investments in the creation of a digital ecosystem for a dairy farm based on “1C :Enterprise 8. ERP Agro-industrial complex”.

Name	2024	2025	2026	2027	2028
Fixed assets (thousand rubles)					
1C: ERP Agro-industrial complex 2. Client license for 300 rubles. Electronic delivery	2 136	-	-	-	-
PC Intel i5 12400 16Gb x 30	1,950	-	-	-	-
Office equipment	650	-	-	-	-
Training of personnel during product installation	200				
Installation of equipment (including redevelopment of premises)	150				
Organizational expenses	50	-	-	-	-
Current expenses					
Remuneration	-	820	840	870	900
Technical support	-	120	120	120	120
Electricity	-	100	100	100	100
Consumables	-	50	50	50	50
Transportation costs	-	25	25	25	25
Information service	-	35	35	35	35
Communication, including Internet payment	-	12	12	1 2	12
Other expenses	-	10	10	10	10
Total	5 136	1 172	1 192	1 222	1 252

Analysis of financial and accounting statements of a number of agricultural enterprises of the Volgograd region that participated in the implementation of the investment project for the deployment of a ready-made industry solution ERP Agro-industrial complex shows that the use of a digital ecosystem allows to achieve improvement of the following financial indicators: net profit growth was 25% (compared to the previous year), enterprise assets grew by 19% on average, capital and reserves increased by 8%. Forecast modeling of the profitability of an agricultural enterprise with an average annual profit level of 20 to 50 million rubles, taking into account the fact that the profit growth of such an enterprise over the past 5 years averages from 35 to 45 percent (approximately 8-10% per year), shows that digitalization of agricultural production management on average gives at least a 10 percent increase in net profit. The main sources of this growth are the reduction of costs associated with labor costs, optimization of production processes, reduction of transportation, overhead and other expenses, reduction of expenses on fuel and lubricants, electricity and heat energy, etc. Taking into account all these factors, the investment analysis of the implementation of the ERP solution for the agro-industrial complex is based on the indicators of the annual increasing cash flow from the implementation of the digital solution in the range from 2 to 5 million rubles with a discount rate of 20%.

Without discounting, the payback period of the investment project was determined by the formula:

$$DPP = \min_{n}\left(\sum_{t=1}^{n} CF_i/(1+r)^i - CI\right) \geq 0 \qquad (1)$$

where *CFi* is the cash flow in the i-th period of time; *CI* – initial cost of investment.

The dependence of the increasing cash flow on time is a linear function, which explains a fairly optimistic forecast of the payback period of investments: the full cost of the initial investment, taking into account the costs incurred by the investor in the initial period, will be returned between the second and third years of the project implementation. Note that this forecast does not take into account the depreciation of the value of the capital invested by the investor throughout the entire period of the project implementation. Taking into account discounting, the payback point will be reached in the fourth year of the project implementation. The potential efficiency of cash investments in the proposed innovative project, as well as the amount of cash flow throughout the calculation horizon, taking into account discounting, is determined using the NPV indicator - the net present value of the investor for the entire period of the project implementation. In the economic model we are considering, this indicator is calculated using the formula:

$$NPV = \sum_{t=1}^{n} CF_i/(1+r)^i - CI \qquad (2)$$

At a discount rate of 20%. the value of net present value with a 5-year calculation horizon takes the value NPV = 1,783 thousand rubles. Thus, the net present value of the investor, given the assumptions made in the economic model, will be quite a significant amount compared to the size of the initial investment.

5 CONCLUSIONS

In summing up the results of the conducted research, it is necessary to emphasize that the experience of technologically advanced agricultural enterprises indicates that the growth of the main production and economic indicators of agricultural formations of the region is achieved by activating scientific and technical activities by building digital ecosystems of agribusiness based on object-oriented digital platforms, or by implementing ready-made solutions offered on the ERP systems market. It is also obvious to the authors that the development and implementation of digital business ecosystems is a powerful tool stimulating the development of not only individual agricultural formations , but also the Russian agro-industrial complex as a whole. In addition, as the calculations carried out by the authors show, the use of digital platforms and ecosystems for automation and production management within a relatively small agricultural enterprise can be not only of purely scientific interest, but also represent a fairly profitable business project with an acceptable level of economic return. However, the degree of readiness of a particular agricultural enterprise for digital transformation will be of great importance here.

When assessing the digital development of agricultural formations and their potential readiness to transition to the next technological order, it is important to identify factors that characterize the ability of subjects of the Russian agricultural structure to implement technological innovations, apply new methods of organizing labor, use the achievements of scientific and technological progress, digital and innovative technologies. For this purpose, the authors of this study have developed and proposed for discussion in the scientific community an integral indicator for assessing digital potential: the digital development index (DDI), which characterizes the degree of digital development of an industry, company or individual agricultural enterprise.

Currently, the innovative scenario for the transformation of regional agricultural formations in line with digitalization and the inclusion of small business entities in digital business ecosystems depends on a number of conditions:

firstly, the presence of innovative goal-setting in the subject of the agricultural structure, expressed in the awareness of the inevitability of digital transformation as a necessary condition for further development;

secondly, the ability to carry out scientific and industrial modernization mainly through internal resources;

thirdly, the availability of targeted government support, focused on innovation -oriented enterprises that are actively implementing digital technologies in their practical activities;

fourthly, the priority of economic motivation, mediating the desire of agricultural enterprises to intensify their production and reduce costs through the use of digital innovations and advanced production experience;

fifthly, the introduction into the economic structure of not only large, but also medium and small agricultural forms of an effective mechanism for their integration into digital ecosystems.

One of the ways to solve the above-mentioned problems is to create industry digital business ecosystems based on ready-made solutions created by domestic developers. The most effective and universal tool for creating the above-mentioned digital ecosystems of agribusiness is the ERP system Agro-industrial complex, offered on the market by the leading developer of software for production management and automation in the Russian Federation, 1C. The platform for developing the ERP Agro-industrial complex was the widely known and long-presented on the market software package 1C:Enterprise 8.

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