Modeling the Forecast of Economic Effects from the "Digital Earth" Project Results Application for Digitalization of the Russian Federation (on the Example of Agricultural Sector at the Macro Level)

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Abstract. The article examines the trends in the digital transformation of agriculture towards precision production of industry-specific products using precision agriculture technologies based on Earth remote sensing data. These technologies are shown to be evolving from digitalization of individual operations to digitalization of an interconnected system integrating all operations, including operations of related industries. The problems of effective implementation of digital technologies in the Russian Federation, as well as the ways of their solution using complex, integration technologies, are analyzed. The author's mathematical model is presented for forecasting the economic effect of the Earth remote sensing data utilization in precision agriculture technologies, which have become one of the main drivers of the rapid agriculture development throughout the world. Possible options are discussed of how this model can be utilized for the purpose of a scientifically grounded approach to the development of such technologies in a country.

1. Introduction

From the very beginning of the development of Earth remote sensing (ERS) technologies, they have been used in agriculture due to the spatial nature of its organization. At the early stages, the remote sensing results consisted of images only, which were not very much in demand since they required decoding, as well as being interpreted by highly qualified experts. While the management needed alternative solutions, retrospective, dynamics, forecasts. And to get this, the survey data had to be accumulated in some database (DB) with a dynamic series of observations. Only with the emergence of such databases in the form of geographic information systems (GIS), as well as modern imaging devices and carrier platforms, the remote sensing technologies started to be extensively used in agriculture. The most significant application of these technologies can be seen in precision agriculture (PA), which is now experiencing a real boom.

For example, in 2018, winter wheat was grown in the UK for the first time in the world on an area of one hectare without the direct participation of people, and with a significant yield of 70 kg per ha. All process operations from tillage to grain threshing were performed by robotic agricultural machines and units using ERS and PA technologies ["World First", 2020].
An analysis of this experience, as well as many other PA experiments in the world, shows that ERS data can solve various problems of plant growing, while ERS application requires a significant amount of additional data, both accumulated over a long time, as well as operational data, having appropriate integration with sensors, equipment and actuators installed on agricultural machinery.

Thus, the essence of PA is the integration of new agricultural technologies and high-precision positioning based on ERS technologies, as well as differentiated highly efficient and environmentally friendly agronomic activities in the fields based on detailed information on the chemical and physical properties of each field. It can be seen that in this case, the digital transformation of agriculture requires the combination of a huge amount of heterogeneous, multidimensional, diversified data with the appropriate technologies for its processing.

The transformation of agriculture into industrial production via digitalization has raised the challenge of developing methods for predicting the economic effect of investments in such a new asset as ERS technology, as well as creating the necessary conditions to ensure the effectiveness of these technologies based on a scientific analysis of readiness of the Russian Federation to implement PA and ERS. Therefore, this paper considers the abovementioned problems from the mathematical modeling point of view.

2. State and development trends of precision agriculture technologies in Russia

The great interest in precision agriculture (PA) in the developed countries is dictated by the increasingly complicated and expensive conventional technologies required to increasing the production efficiency and quality of agricultural products, which can be compared to the increasing level of mining complexity for each new bitcoin. In "Precision Agriculture", 2020, a reduction of up to 20% of resources such as fuel, seeds, and fertilizers per hectare is predicted. While, the upper threshold of conventional factors (plant breeding, improvement of energy efficiency of machinery, plant protection and nutrition), which affect the improvement of economic indicators, is not expected to be reached soon in the Russian Federation. Therefore, the digitalization of this industry must be seen as one of a number of other factors. Due to this, as well as the high cost of digital technologies, the difficulty to master them, as well as the lack of qualified personnel in the country, the so-called "social order" for the industry digitalization is insignificant, including PA technologies. Only a few domestic farms can embrace the integrated use of PA. And for the PA technologies to be integrated, the basic requirement of the digital economy shall be fulfilled — both information systems and data used for the digital transformation of agriculture shall be integrated.

Today, the country is dominated by a "task-based" method of software development and implementation, when separate "ready-made" software systems are purchased from various developers, which are neither functionally nor informationally connected.

Only for the last two years, heads of IT departments of agro-industrial enterprises began to ring the bells about the weak unification and regulation of accounting policies, patchwork business automation, introduction of heterogeneous software tools, databases, system software, as well as the lack of a unified regulatory and reference information. For example, significant attention was paid to this problem at the recent conference "ITAPK-2019: Theory and Practice of Agriculture Digitalization".

At the end of 2019, Ministry of Agriculture developed the concept of the "Digital Agriculture" national platform, providing a list of its sub-platforms: a sub-platform for collecting agro-industrial sector statistical data, a sub-platform for providing information support and services, a sub-platform for digital land use and land management, a sub-platform for storing and distributing information materials, a sub-platform for the traceability of agricultural products, a sub-platform for agrometeorological forecasting, a service for multifactor operational monitoring, diagnosis and proactive modeling of the development of diseases in agricultural crops. This approach to the creation of digital platform (DP) for the agricultural sector, being an aggregation of these sub-platforms, excludes their integration on a truly integrated single DP of the agro-industrial complex.

The introduction of ERS technologies has just started in the Russian Federation, while the Russian ERS segment is insignificant, therefore, ground-based systems for receiving, processing, storing and
transmitting data from ERS sources are also insufficiently developed and consist of heterogeneous departmental unconnected centers with outdated software and hardware, incapable of receiving and processing large amounts of data from ERS sources [Nosenko, Loshkarev, 2020]. The solution lies in an integrated approach to solving the ERS data integration problem, in coordinating the operation of all the initial and output data created by various integration centers in a single digital platform (DP), in coordinated use of such data being sent to potential users, taking into account the ontological models of their databases.

3. Problem definition for mathematical modeling of forecasting the economic effect of ERS data utilization in precision agriculture technologies

At the dawn of computerization, ICT effectiveness was assessed using the Cobb-Douglas production functions apparatus, in which computer capital and labor in this sector were included as separate factors [Akaev, Rudskoy, 2017; Erik Brynjolfsson, 2002]. In the middle of the last century, the use of the Cobb-Douglas production function was justified due to the fulfillment of the main stringent requirements of mathematical statistics — the data should reflect the results, either of a one-time survey of a sufficient number of homogeneous objects, or the results of a survey of the same object for long periods of time, with the objects (object) staying in fairly similar conditions during the survey.

Currently, due to the significant dynamics of the entire technological structure of society, it is almost impossible to ensure such conditions. The main obstacle when using the methods based on economic and statistical dependences is the need to observe the condition of homogeneity of the considered object set, which is very difficult to ensure. In such a situation, statistical methods are usually complemented or replaced, with the latter happening more often, with corrective calculations based on expert assessment and qualitative analysis.

Therefore, with abundant forecasts of digital technology effectiveness, their results significantly differ from each other, while not having any mathematical confirmation.

So, according to Gartner forecasts, the total economic effect from the introduction of the Internet of Things in all economic sectors on a global scale will amount to $1.9 trillion by 2020. Agriculture accounts for 4%, i.e., approximately $76 billion ["Smart Farming", 2020; "Rural Digitalization", 2020] Roland Berger estimates smart farming market value at €4.5 billion by 2020. GoldmanSachs estimates that cumulative crop productivity growth from precision agriculture solutions could grow 70% and generate $800 billion in additional production by 2050. The market for precision agriculture solutions for growers and developers will generate $240 billion by 2050.

Following such promising forecasts by J’son & Partners Consulting, the Analytical Center of the Ministry of Agriculture of the Russian Federation, without taking into account the problems of digital transformation of the agricultural sector, has even more promising plans by 2024 — improvement in labor productivity at agricultural enterprises by 2 times, reduction of the unit costs of enterprises for business administration by 1.5 times, the total economic effect of digitalization in the amount of 4.8 trillion rubles per year or 5.6% of the Russian Federation's GDP growth [Akhmetov, 2019; "Rural Digitalization", 2019].

Such forecasts of the digital technology efficiency not supported by mathematical models are simply explained by the desire of domestic forecasters to receive certain preferences and investments, and to seize the sales market if talking of Western companies.

Since we have proposed to use mathematical modeling to forecast the economic effect of ERS data utilization, let us consider the necessary initial requirements for such a statement.

Based on the definition of precision agriculture as a system consisting of closely interconnected subsystems in the form of new technologies for the production of crops, as well as software and hardware for high-precision positioning during the agricultural operations, and a complex of technical and agrochemical means corresponding to these requirements, it can be concluded that the introduction of PA should be based on a system approach. Mistakes of haphazard implementation are
reported in "How to Start", 2019. For instance, it is indicated that the process of converting existing equipment for differentiated fertilization is rather complicated and expensive. A more efficient solution is to acquire new equipment.

Based on the analysis of the following sources [Novitsky, 2019; "Application of GIS", 2019; "Satellite monitoring", 2019], it can be argued that for each specific farm, the greatest efficiency of PA utilization is achieved when the complex of ESR technologies is present, including technical and software tools integrated, and designed in the form of the following ESR technologies.

Instruments and sensors for precision agriculture:
- parallel driving systems;
- samplers and soil analysis;
- differential application systems;
- yield sensors.

Agricultural land monitoring:
- monitoring the boundaries of work sites of fields;
- agrochemical monitoring of fields;
- yield mapping;
- terrain conditions analysis.

Machinery monitoring:
- automated data collection based on space navigation;
- operational accounting of agricultural activities and machinery movement.

Means of data transmission to the structural divisions of the economy.

Considering the main requirement of the digital economy — the integration of both information systems and information, a unified ontological information model of crop production shall be developed for all agricultural enterprises in the Russian Federation to address the aforementioned. In the Russian Federation, the conceptual issues of such an approach were studied using calculations based on the model of optimal information system synthesis [Medennikov, 1993] in the framework of the "Agriculture Electronization" task of the Comprehensive Program of Scientific and Technological Processes of the CMEA member countries with subsequent scientific substantiation in scientific papers [Yereshko, Kulba, Medennikov, 2018]. Thus, a unified ontological information model of crop production was developed, and 240 functional management tasks were defined with a unified description of algorithms for most agricultural companies.

As is commonly known, the production of a certain quality and quantity of agricultural products requires observing strict resource proportions due to process requirements and the product specifics [Vasilenko, 1989]. As a result, the production factors form an integral system of agricultural production. These requirements were confirmed in a formalized form in the so-called theory of complementarity [Milgrom, Roberts, 1990]. The results showed that ICT investments are more effective with the high level of the other two complementary assets — organizational and human capital.

Finally, we will define one more initial requirement for the development of a mathematical model for forecasting the economic effect of ESR data utilization.

Sometimes the cost of just one sensor exceeds the cost of a tractor produced in the Russian Federation [www.at.farm, 2020]. Due to the poverty of most farms in the Russian Federation, the advantages of PA and ESR technologies can be used by only a small number of them — by large companies ["Rural Digitization", 2020]. Therefore, the model shall address the size of farms.

4. Mathematical model of forecasting the economic effect of ERS data utilization in precision agriculture technologies

The above considerations are presented as a series of postulates.

4.1 Let us assume that only profitable enterprises will be engaged in PA implementation.

4.2 All farms are divided into groups determined in accordance with the specialization of economic activities, for example, based on the Russian National Classifier of Types of Economic Activity
Depending on the total volume of product turnover, all farms are divided by profitability classes with a step of 5 million rubles for a more detailed analysis of the farm digital transformation level based on the research by the well-known Western consulting company Gartner, which distinguishes three groups of companies in terms of information technology (IT) costs, expressed as a percentage of the company’s turnover [”Where we’re going”, 2020]. In accordance with this methodology, let us assume that the expenditures of the agricultural enterprises of the Russian Federation on IT are about 0.5% of their turnover.

Let us assume that the tasks to be automated are ranked in order of importance (in the order they are acquired) for each group of farms. This assumption is based on the results of informatization process monitoring for the 300 best agricultural enterprises, as well as the analysis of the Russian Federation software market.

Let us assume that the expenditures of enterprises for digital transformation are focused on PA implementation, that is, the expenditures of other industries are not considered. This is necessary to maintain the generality of the research objective in the conditions of model complications when SPs are broken down by industry.

Let us introduce the following notation.

- \( i \) – the task number implementing PA control function in the form of a software package (SP), \( i \in I \), \( I = \sum I_i \);
- \( l \) – PA technology index, \( l \in L \);
- \( j \) – farm group specialization index, e.g., according to RNCE, \( j \in J \);
- \( I_j \) – task sequence required by farms from group \( j \), \( i \in I = \bigcup I_j \);
- \( k \) – farm yield class index, \( k \in K \);
- \( n_{jk} \) – number of farms from group \( j \) in yield class \( k \), \( n_{jk} \in N \);
- \( a_{ijkl} \) – investments in equipment, personnel training, reorganization of the management system per one hectare of land required to solve the \( i \)-th problem of the \( m \)-th enterprise of the \( j \)-th group of the \( l \)-th PA technology, \( m \in N_k \);
- \( q_{ijl} \) – the annual cost of equipment maintenance per hectare of land required to solve the \( i \)-th problem of the \( j \)-th group of the \( l \)-th PA technology;
- \( t \) – current year number;
- \( S_m \) – area of land of the \( m \)-th enterprise;
- \( p_{ijl} \) – the cost of the software required to solve the \( i \)-th problem of the \( j \)-th group of the \( l \)-th PA technology;
- \( b_{ijl} \) – the cost of software deployment required to solve the \( i \)-th problem of the \( j \)-th group of the \( l \)-th PA technology;
- \( r_{ijl} \) – the annual cost of software support required to solve the \( i \)-th problem of the \( j \)-th group of the \( l \)-th PA technology;
- \( f_{ijl} \) – the annual cost of images (per hectare) required for the \( j \)-th group of the \( l \)-th PA technology;
- \( h_{ijl} \) – the annual cost of image decoding (per hectare) required for the \( j \)-th group of the \( l \)-th PA technology;
- \( d_{jk}^t \) – the amount of funds allocated for the implementation of PA technologies in group \( j \) of yield class \( k \) in the \( t \)-th year;
\(d_{jkl}^t\) - the amount of funds allocated for the implementation of PA technologies in the group \(j\) of yield class \(k\) in the \(t\)-th year of the \(l\)-th PA technology;

\(I_{jk}^t\) - the number of SPs deployed in the group \(j\) of the yield class \(k\) by the \(t\)-th year, including the \(t\)-th year;

\(I_{jkl}^t\) - the number of SPs deployed in the group \(j\) of the yield class \(k\) by the \(t\)-th year, including the \(t\)-th year of the \(l\)-th PA technology;

\(MO_{jk}^t\) - the volume of investments in equipment, personnel training, reorganization of the management system into a group \(j\) of yield class \(k\) by the \(t\)-th year, including the \(t\)-th year;

\(MO_{jkl}^t\) - the volume of investments in equipment, personnel training, reorganization of the management system into a group \(j\) of yield class \(k\) by the \(t\)-th year, including the \(t\)-th year of the \(l\)-th PA technology;

\(Z_{jk}^t\) - the expenditure of enterprises for digital transformation in the \(t\)-th year of the group \(j\) of yield class \(k\).

Let us introduce the value \(g_{jk}^t = 1\), if \(\sum_{t=r_{jkl}^t}^{t_{jkl}^t} p_{jk} > 0\), then \(0\);

Then the acquisition costs for SP, equipment, ESR images, their support and implementation, as well as personnel training, reorganization of the management system into a group \(j\) of yield class \(k\) by the \(t\)-th year of the \(l\)-th PA technology will have the following form:

\[
\Delta d_{jkl}^t = n_{jk} \sum_{i=r_{jkl}^t}^{t_{jkl}^t} p_{jk} + n_{jk} \sum_{i=r_{jkl}^t}^{t_{jkl}^t} (b_{jk} + r_{jk}) + \sum_{m=1}^{t_{jkl}^t} g_{jk} S_{m}\]

\[
+ n_{jk} \sum_{m=1}^{t_{jkl}^t} q_{jk} S_{m} + \sum_{m=1}^{t_{jkl}^t} g_{jk} (f_{jk} + h_{jk}) S_{m} .
\]

The costs of SP support, equipment maintenance, purchasing ESR images, operating by the beginning of the \(t\)-th year will have the following form:

\[
d_{jkl}^{t-1} = n_{jk} \sum_{i=1}^{t_{jkl}^t} (b_{jk} + r_{jk}) + n_{jk} \sum_{i=1}^{t_{jkl}^t} q_{jk} S_{m} + \sum_{m=1}^{t_{jkl}^t} g_{jk} (f_{jk} + h_{jk}) S_{m} .
\]

Then, taking into account the condition that the expenditure of enterprises for digital transformation is focused on PA implementation, the expression \(Z_{jk}^t\) will have the following form:

\[
\Delta Z_{jk}^t = (d_{jkl}^{t-1} + \Delta d_{jkl}^t), \quad \text{where} \quad d_{jkl}^{t-1} = \sum_{i=1}^{t_{jkl}^t} d_{jkl}^{t-1}, \quad \Delta d_{jkl}^t = \sum_{i=1}^{t_{jkl}^t} \Delta d_{jkl}^t.
\]

The financial constraints can be described as

\[
d_{jkl}^{t-1} + \Delta d_{jkl}^t \leq D_{jkl} .
\]

The incurred costs efficiency criterion for the digital transformation of enterprises in the \(t\)-th year of the group \(j\) of yield class \(k\) is defined with the condition that the allocated funds are spent in the maximum volume: \(\max Z_{jk}^t\) when the above constraints are met.

By solving the optimization problem using the simulation modeling, the following values will be found: \(I_{jk}^t\), \(I_{jkl}^t\), \(MO_{jk}^t\), \(MO_{jkl}^t\), as well as ESR image costs per year \(t\): \(fh_{jk}^t = \sum_{m=1}^{t_{jkl}^t} g_{jk}^{t-1} (f_{jk} + h_{jk}) S_{m} .
\]

We obtain the following integral values by summing over the time of digital transformation for the entire period \((\omega, T)\)

\[
I_{jk}^T = \sum_{t=1}^{T} I_{jk}^t - \text{the number of SPs deployed in the } j\text{-th group of } k\text{-th yield class for the considered period,}
\]
\[ I^T_{jkl} = \sum_l I^T_{jkl} \] - the number of SPs deployed in the \( j \)-th group of \( k \)-th yield class of the \( l \)-th PA technology for the considered period,

\[ MO^T_{jkl} = \sum_l MO^T_{jkl} \] - the volume of investments in equipment, personnel training, reorganization of the management system into the \( j \)-th group of \( k \)-th yield class for the considered period,

\[ MO^T_{jkl} = \sum_l MO^T_{jkl} \] - the volume of investments in equipment, personnel training, reorganization of the management system into the \( j \)-th group of \( k \)-th yield class of the \( l \)-th PA technology for the considered period,

\[ fh^T_{jkl} = \sum_l fh^T_{jkl} \] - the ESR image costs for the considered period.

The obtained integral values allow to perform analytical calculations of the level of agricultural sector digital transformation in terms of the PA control functions: 

\[ w^i = (\sum \frac{I^T_{jkl}}{I}) \times 100\% \], of industry affiliation: 

\[ w^i = (\sum \frac{I^T_{jkl}}{I}) \times 100\% \], of farm yield class 

\[ w^i = (\sum \frac{I^T_{jkl}}{I}) \times 100\% \], of PA technology: 

\[ w^i = (\sum \frac{I^T_{jkl}}{I}) \times 100\% \].

For instance, further, we are interested in the digital transformation level of agriculture in the context of informatization of PA management functions: 

\[ w^i = (\sum \frac{I^T_{jkl}}{I}) \times 100\% \].

If now we take the world's advanced economy with a 100% digital transformation level and PA technology utilization indicator \( w^i \) based on ESR data as a standard, then the value \( IND = \frac{w^i}{w^i} \) will determine the forecast economic efficiency index for the Russian Federation in terms of the effects of the "Digital Earth" project results on the example of the agricultural sector.

5. Practical significance

The developed model was used to perform a series of numerical experiments to study the mechanisms of influence on the digitalization processes in agricultural sector. As an example, the result is provided for two scenarios, which are the most valuable from the point of view of the declared paper topic.

In the first scenario, the agricultural sector digitalization is carried out only at the expense of enterprises without state support and without taking into account the costs of machinery, PA equipment and ESC images due to lack of data. The information assets (SPs and PCs) are acquired at market prices and all SPs are purchased in the first year. The necessary information on enterprises was obtained from the Spark database and a survey of the 300 best agricultural enterprises ["Spark", 2020].

Calculations for this scenario showed that the agriculture digitalization level is as follows for different SP groups. Accounting and financial accounting — 32.4%, enterprise management — 24%, organizational management — 17.7%, technology management — 9.3%, overall level — 12.8%. Due to the lack of funds in the first two groups of enterprises in terms of product sales, enterprises of these groups are excluded from the digitalization process.

The second scenario differs from the first in that the state invests in the SP development based on their types, which significantly reduces their cost for enterprises. The rest of the parameters remained unchanged. In this case, the agriculture digitalization level is as follows for different SP groups. Accounting and financial accounting — 62.8%, enterprise management — 37.7%, organizational management — 37.4%, technology management — 19.9%, overall level — 23.6% (increased by 10.8% compared to with the first scenario). The calculations show that in this case, due to the lack of funds in the first enterprise group, which is assumed by product sales, these enterprises are excluded from the digitalization process, while the enterprises of the second group are actively involved in the digitalization process spending 522,480 thousand rubles on it. However, even in this case, the overall digitalization level is still insufficient.
6. Conclusion
In market conditions, the need is gradually recognized to form a certain cloud-based unified information space for digital interaction of participants in the agriculture value chain [9-Voronezh]. The author's mathematical model for forecasting the economic effect of ESR data utilization in PA technologies allows performing numerical experiments covering various scenarios for the development of digital transformation of the industry — from implicitly market conditions to the state-supported creation of a unified information web environment for digital interaction of agro-industrial complex entities, including a digital PA sub-platform based on ESR.

7. References
[1] The world's first robotic farm Hands Free Hectare grew crops without the participation of people [electronic resource] URL: https://incrussia.ru/news/pervaya-robotizirovannaya-ferma-hands-free-hectare/ (date of treatment 05/16/2020)
[2] Precision farming: principle of work and and prospects [electronic resource] URL: https://xn--80ajqpcpbhkds4a4g.xn--p1ai/articles/tochnoe-zemledelie/ (date of treatment 05/16/2020)
[3] Nosenko Yu I, Loshkarev P A ETRIS ERS - problems, solutions, prospects (part 1) [electronic resource] URL: http: //geomatica.ru/clauses/304/ (date of access 22.02.2020)
[4] Akaev A A, Rudskoy A I 2017 Convergent ICTs as a Key Factor of Technological Progress in the Coming Decades and Their Impact on World Economic Development International Journal of Open Information Technologies ISSN: 2307-8162 vol 5 1 pp 1-18
[5] Erik Brynjolfsson, Lorin Hitt, Shinkyu Yang 2002 Intangible Assets: Computers and Organizational Capital Brookings Papers on Economic Activity Vol 2 1
[6] "Smart Farming": Review of leading manufacturers and technologies [electronic resource] URL: http://geoline-tech.com/smartfarm/ (date of access 04/09/2020)
[7] The digitalization of agriculture in Russia lacks data [Electronic resource] URL: http://www.iksmedia.ru/news/5533967-Czifrovizaci-selskogo- xozyajstva.html#ixzz6KBD7IYEP (date of treatment 04/25/2020)
[8] Akhmetov V Ya, Galikeev R N 2019 Prospects for the socio-economic development of rural areas in the context of digitalization of the economy The Eurasian Scientific Journal 6(11) Available at: https://esj.today/PDF/03ECVN619.pdf (in Russian) DOI: 10.15862 / 03ECVN619
[9] Digitization of agriculture in Russia: stages, results, plans TAdviser: IT in the agro-industrial complex of Russia [Electronic resource] Access mode: https://geometricrussia.ru/a219060-tsifrovizatsiya-selskogo-hozyajstva.html (date accessed: 20.09.2019)
[10] How to start introducing precision farming at an enterprise [Electronic resource] URL: https://smartfarming.ua/-ru-blog/kak-nachat-vednyrat-tochnoe-zemledelie-na-predpriyati (date of access 04/09/2019)
[11] Novitsky I Precision farming: principle of operation and prospects [electronic resource] URL: https://xn--80ajqpcpbhkds4a4g.xn--p1ai/articles/tochnoe-zemledelie/ (access date 04/09/2019)
[12] The use of GIS to ensure the technology of "precision farming" [Electronic resource] URL: https://gisinfo.ru/item/65.htm (date of access 04/09/2019)
[13] Satellite monitoring in agriculturehttps [Electronic resource] URL: aggeek.net/ru-blog/sputnikovyi-monitoring-v-selskom-hozyajstve (date of access 04/09/2019)
[14] Medennikov V I 1993 Theoretical aspects of the synthesis of structures of computer management of agro-industrial production Agrarian science 2 pp 16-18
[15] Ereshko F I, Kulba V V, Medennikov V I 2018 Integration of the digital platform of the agro-industrial complex with digital platforms of related industries agro-industrial complex: economics, management 10 pp 34-46
[16] Vasilenko Yu V, Danchuk G D 1989 Analysis of the use of production potential Economy of agricultural and processing enterprises 12 pp 3-42
[17] Milgrom P, Roberts J 1990 The economics of modern manufacturing: Technology, strategy, and organization The American Economic Review pp 511-528 [Electronic resource] URL: www.at.farm (date of access 04/22/2020)

[18] Where the automation wave is heading [Electronic resource] URL: https://1-sys.ru/ (date of access 04/09/2020)

[19] Spark [Electronic resource] URL: http://www.spark-interfax.ru/ (date of access 09.04.2020)

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