Evaluating the digitalization potential of agro-industrial sector of Russia

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Abstract. Best practices of farmers using modern digital technologies demonstrate high results achieved both in crop production and in animal husbandry. Efficiency is expressed in increasing the yield, labor productivity, reducing costs, and what is more, in preserving soil fertility and protecting the environment. However, the need to digitize managerial and analytical processes based on Big Data, Data Science implementation and the ability to interpret the obtained analytical material and make qualified decisions based on a scientific approach are often missed the memo. In light of this, the purpose of the study was to analyze the readiness of various company unit categories employed in the agro-industrial complex of Russia to use big data and process it. Based on the results obtained, a matrix for determining the potential for the transition of companies to the use and analytics of Big Data was built. According to the results of which, it can be argued that, on average, about 45% of the analyzed companies have a high potential for the transition to digital development, and an average level of potential is 24%. In the context of the categories of farms, the results for the surveyed agricultural cooperatives, traders and exporters are higher than the average indicators.

1. Introduction
Under the new technological paradigm, the rates of development of all social institutions are accelerating. If in our paper 2019 we discussed about successfully implemented programs of information and communication technologies in Russia, such as systems for provision of state and municipal services in electronic form, remote individual and collective citizen appeals: State information system of housing and communal services, State Services, the taxpayer's account and others, then in 2020, due to the coronavirus pandemic, digital technologies have become guides in all essential fields and services [1].

Thus, solving the problems of transforming priority sectors of the economy and the social matters through introduction of digital technologies and platform services have become not only a goal for specialists in certain industries, but also a prerequisite for the further existence of both a single business process and the entire life support chain.

Digital technologies not only have a strong impact on our lives, but also play a significant role in solving global problems, such as: preserving soil quality, providing food and clean water, energy,
thereby ensuring the achievement of the 17 United Nations Sustainable Goals development (SDGs). Scientists have established the most popular digital technologies for solving these problems – the Internet of Things, explainable artificial intelligence and Big Data [2]. In recent literature, smart technologies are seen as game-changing tools, whereby their integration will benefit three pillars of interrelated areas: sustainable food production, access to clean and safe drinking water, and green energy production and use [3, 4].

As part of new initiatives being developed by the Ministry of Agriculture of the Russian Federation, digital twins are planned to appear by 2024 – these will be models of farms with a full set of tools – from weather forecasting to the selection of production capacities and personnel. Also, within the framework of the information systems being created, it is planned to organize traceability of 90% of grain and its processed products by 2024; animal products will be monitored by the breeding animals management information system, which, in turn, will ensure collection and analysis of data on 100% of breeding animals. The Ministry of Agriculture of the Russian Federation notes that in crop production, it is primarily important to implement a digital register of agricultural lands with the function of online harvest prediction, taking into account the vegetative index. In animal husbandry, it is planned to collect information for the genetic selection feed supplies, information on animal diseases. Thus, by 2024, it is predicted that the implemented digital infrastructure will increase the productivity of industries by 15-20%.

According to the survey results conducted by the working group of the Ministry of Agriculture of the Russian Federation, the following technologies are considered the most in demand in crop production in more than 1,700 agricultural organizations:

1) digital mapping and crop yield planning;
2) variable rate application;
3) monitoring the state of seeds by remote sensing;
4) yield class monitoring;
5) differential spraying.

The farmers highlighted the following as the main directions in animal husbandry:

1) herd health monitoring;
2) animal products quality monitoring;
3) identification and monitoring of individual animals at livestock breeding complexes, meeting their individual needs;
4) production process electronic database;
5) automatic regulation of microclimate and monitoring for harmful gases [5].

It is also impossible to ignore the environmental component of the issue. According to researchers, 30% of global greenhouse gas emissions are from agriculture [6]. In this regard, scientists propose new approaches to climate optimization of agriculture through the coordinated actions of farmers, researchers, the private sector, civil society and politicians [7]. Also proposed are the theories of changing the approach to the applied agrochemicals (replacing them with plant growth-promoting microorganisms) [8], investigated the effect of agro-waste derived biochar and vermicompost on soil quality and yield in [9], models are proposed for quantifying the impact of land management practices on soil GHG fluxes [10]. The initiatives are aimed at improving the efficiency of the use of agricultural resources.

However, when turning theoretical calculations and desires into practical deeds, it appears that not all is going smoothly in practice. Agriculture is fraught with many problems and risks, which are both traditional (insufficient financial resources and a shortage of highly qualified personnel) and specific (for example, the lack of digital infrastructure in rural areas). According to the research conducted, in 2018, 76.6% (on average) of Russian households had access to the Internet [11].

In papers concerned with the digitalization of the agro-industrial complex, scientists also highlight the following problems that prevent modern development of agriculture: lack of awareness of consumers about the possibilities of digital technologies [12], high cost of introducing digital technologies into production and the lack of skills and competencies among workers for working with
digital technologies [13], lack of material and technical resources in the scientific sphere [14], difficult introduction of digital technologies by small and medium-sized farms, which will lead to a gap in the capabilities of various farms categories in the future [15], strain on liquidity associated with the significant risks (amount of loan charges in the agricultural business for modernization of the production process through digitalization are limited) [16], etc.

The farmers of neighboring countries also face similar problems: Okenova A. O. notes the lack of financial capabilities of a number of manufacturers in the Republic of Kyrgyzstan for the purchase of new equipment and for the use of IT equipment and platforms [17], Amanalieva M. O. in its works asks about the impact of digitalization on the work load of the population of the nearest and remote regions of the Republic of Kyrgyzstan [18], the Kazakhstan scientists focus on the introduction and use of digital technologies only in conjunction with the growth of the actual economy and transition to its innovative model [19].

At the same time, the need to use modern digital solutions in the agricultural sector is irrefutable. Lots of foreign scientists’ works are also devoted to digitalization issues: introduction of the digital innovation process in agri-cooperatives [20], analyze the actual and possible impacts of digital technologies, which they might generate in the rural domains [21], or the (potential) economic impacts of digitalized supply chains [22, 23], and relation between demand, supply and patterns of use of information [24, 25].

Thus, transition to a brand new way of working is fraught with many difficulties. As the authors note, until recent years, the use of information technology in agriculture was limited to the use of computers and software, mostly for financial management [26]. Also, in the studies conducted, it is noted that the volume of internal costs for research and development in agriculture in Russia, according to data for 2018, is 13 times less than similar costs in industrial production [27]. However, integration of digital development is impossible without involvement of artificial intelligence, systematization of large databases and possibility of their processing and use. Therefore, the purpose of the study was to identify companies in the Volga Federal District of the Russian Federation that are potentially ready (morally and financially) to use and analyze big data.

Agriculture 4.0 is comprised of different already operational or developing technologies such as robotics, nanotechnology, synthetic protein, cellular agriculture, gene editing technology, artificial intelligence, blockchain, and machine learning, which may have pervasive effects on future agriculture and food systems [28]. Researchers confirm that digitalization of agriculture can provide new solutions to such complex problems as the need to produce large volumes of food, given limited resources and in a changing climate [29].

2. Materials and methods

To determine the level of readiness of agricultural producers, processors and other AIC market participants to use a large amount of information, a database, make management decisions based on the analytical studies, a survey was conducted of more than 500 companies from three constituent entities of the Volga Federal District of the Russian Federation: the Chuvash Republic, the Ulyanovsk region and Mari El Republic.

The survey of organizations was conducted from May 2020 to April 2021, so seasonal factors that could potentially affect performance can be excluded.

Among the selected companies, the interviewer clarified the level of using Big Data in the process of doing business and recorded the answers received. If enterprises stated that they did not take advantage of this opportunity, the interviewer specified the reasons; if companies implemented Data Science, then the forms of work organization were clarified (figure 1).

Thus, it was possible to find out to what extent enterprises are ready to introduce Data Science into production, and if not, what factors hinder this process.
Theoretical basis for the study was the development of domestic and foreign scientists. System and logical approaches were used for processing and analysis of the information received: monographic, economic and statistical methods, as well as the methods of expert assessments and scientific abstraction were used as the research ones.

Statistical and economic method allows to describe the studied phenomenon in its entirety on the basis of mass digital data, so the authors used it to analyze the current status and trends in agricultural production.

Computational and constructive method helps to identify a set of long-term solutions to the problem. It was used to set the direction for the long-term development of agricultural cooperation to address the challenge of sustainable development in rural areas.

Using traditional research tools that are based on qualitative analysis of the most important publications in the field, as well as on statistical analysis, we shaped our own opinion.

3. Results and discussion

The survey involved various categories of farms whose activities are directly or indirectly related to the agro-industrial complex, namely: agricultural machinery dealers, processors of agricultural products, agricultural cooperatives, agricultural producers (organizations and farmers), traders and exporters. Also, the enterprises were at different levels of remoteness from the centers of the analyzed subjects. Traditionally, agricultural enterprises and cooperatives are registered in municipal districts. And companies related to trade are usually registered in the capitals of the constituent entities of the Russian Federation. The survey involved enterprises of three constituent entities of the Russian Federation: the Mari El Republic (163 organizations), the Ulyanovsk region (139), the Chuvash Republic (203). Most of the respondents are representatives of the processing industry (32-43% depending on the constituent entity) and agricultural producers (32-36%), i.e. these two groups account for about 70% of the respondents. The following economic entities also took part in the monitoring: traders (wholesale trade of the AIC products) (with an average share of monitoring of about 12%), agricultural machinery dealers (8%), agricultural cooperatives and exporters (about 5% for each category) (figure 2).

It is worth noting that 44 surveyed enterprises during the year of the survey made a decision to liquidate the agricultural businesses or completely ceased to exist (8.5% of respondents).
Figure 2. Structure of the surveyed companies by category in terms of the constituent entities of the Russian Federationa.

aPrepared by the author based on a survey of more than 500 organizations in three constituent entities of the Volga Federal District of the Russian Federation, 2020-2021.

If we classify the surveyed enterprises by size, then the largest number in the monitoring is micro and small organizations, which account for about 85% on average of three constituent entities. If we consider separately by region, then in the monitoring of the Ulyanovsk region, small enterprises (45% of respondents) occupy a larger share, and in the Mari El Republics and Chuvashia, these are micro-enterprises, the share of which in the total list of respondents is 53% and 49%, respectively (in the Ulyanovsk region – 38%). Medium-sized enterprise and non-SMEs account for an average of 8% of the surveyed organizations in each area (figure 3).

Figure 3. Structure of the surveyed companies by size in terms of the constituent entities of the Russian Federationa.

aPrepared by the author based on a survey of more than 500 organizations in three constituent entities of the Volga Federal District of the Russian Federation, 2020-2021.

As part of the survey, the respondents were asked whether there is a need for additional information, data or analytics to enter new market channels, for market research, including
international ones, for developing foreign economic activity, possessing current information about the
state of industries, etc. About 24% of companies refused immediately without explaining the reasons.
In terms of the constituent entities of the Russian Federation, the situation is as follows: in the
Ulyanovsk region and the Mari El Republic, most of the organizations that refused any information at
once – 26% and 25%, respectively, the least of all such enterprises in the Chuvash Republic – about
21% (figure 4).

![Figure 4](image)

**Figure 4.** Structure of the responses of companies received during the survey, in terms of
the constituent entities of the Russian Federation⁴.

⁴Prepared by the author based on a survey of more than 500 organizations in three constituent
entities of the Volga Federal District of the Russian Federation, 2020-2021.

The companies, who continued communication, noted that there was no need for additional
information and resources due to the fact that they already use public reports – 30% of the surveyed
organizations. In terms of the constituent entities, most of those, who use statistical information posted
on various official resources, are in the Ulyanovsk region (43%), the least such companies are in the
Mari El Republic (30%) and Chuvashia (31%).

Furthermore, 24% of respondents said that at the time of the call, additional information is not
relevant. The reasons were different. For example, off season and stockout; busyness and no time due
to the sowing/harvesting campaign; remote work associated with the coronavirus pandemic; yet they
are in no hurry to enter new markets, since they believe that there are many unfavorable factors, etc.
Stating such reasons, most of the organizations of the Mari El Republic (31%) refused. Companies of
the Chuvash Republic (24%) and the Ulyanovsk region (18%) refused less than the organizations in
the Mari El Republic.

Slightly more than 20% of respondents receive the necessary information from their sources:
contacts are established, there is no need for additional information. This answer option is distributed
approximately equally in terms of the constituent entities.

Further, about the same proportion of enterprises that do not have free financial resources to
provide additional analytical information and enterprises that already use paid services of analytical
agencies: 8% and 5%, respectively. It is noteworthy that in the Ulyanovsk region only 1% of
enterprises that do not have the funds to obtain additional information and analytical study, in the
Chuvash Republic and Mari El Republic, there are 10% and 11%, respectively. At the same time, the
share of companies that have already signed contracts for analytical services in the Ulyanovsk region
is 10%, in the Chuvash Republic – 6% and in Mari El Republic – 1%. 4% of respondents have their
own analytical department, 3% of organizations want to bargain over the cost of analytical work and about 2% of respondents say that there is no trust in official data sources.

Based on the survey results, a matrix was created for determining the potential for transition of the analyzed objects to the use and analytics of big data (hereinafter referred to as the Matrix). Assignment of companies to a particular group was determined by the responses received from them. Such answers as already signed contracts, use reports from open access, have an analytical department - were assessed as high potential for transition to digital development, as they demonstrated availability of dedicated analytical personnel capable of interpreting the received amount of information; or contracts have already been signed to obtain prepared analytical material or data package for further strategic or operational management decision.

Those companies that made decisions intuitively based on information received from personal contacts with counterparties, but were not experts or specialists in a particular industry; or took interest in the possibility of applying an analytical approach to solving certain problems facing the organization - in the Matrix they are classified as companies with a middle potential for transition to digitalization.

Companies that were not ready to work with big data and analytics were attributed to the third group with weak potential.

When constructing the Matrix, the following answers of the respondents were excluded, namely: 1) “without explanation”, since the answer is not relevant and it is possible to assume that, if the call would be at a more convenient time and/or to a more competent employee (for example, company secretary secretaries took the responsibility for rejecting the offered opportunities), then a more detailed answer could be obtained; 2) “no trust in official sources,” since such answer does not make it possible to assess the level of potential according to the study criteria (table 1).

| Potential level | Mari El Republic (%) | Ulyanovsk Region (%) | Chuvash Republic (%) | Answer category |
|-----------------|----------------------|----------------------|----------------------|----------------|
| High            | 32                   | 60                   | 42                   | 1. Already signed contracts |
|                 |                      |                      |                      | 2. Use reports from open access |
|                 |                      |                      |                      | 3. Have an analytical department |
|                 |                      |                      |                      | 1. Use own contacts |
|                 |                      |                      |                      | 2. Reduce the price |
| Middle          | 26                   | 21                   | 24                   | 1. No free funds |
|                 |                      |                      |                      | 2. No information needed now |
| Weak            | 42                   | 19                   | 35                   |                      |
| Total           | 100                  | 100                  | 100                  | x |

*Prepared by the author based on a survey of more than 500 organizations in three constituent entities of the Volga Federal District of the Russian Federation, 2020-2021. For the study, operating companies were selected with a positive financial result at the end of 2020 financial year. In the selected companies, an interviewer clarified the level of use of analytical research based on big data and recorded the answers received.

Thus, according to the Matrix we constructed, 60% of the surveyed farms in the Ulyanovsk region have a high potential for transition to digital development, 42% – in the Chuvash Republic and 32% – in the Mari El Republic. Middle level is characteristic of 21-26% of farms, depending on the chosen entity.

In terms of the constituent entities, the potential is higher than the averaged data for the following categories of companies: in the Mari El Republic – agricultural machinery dealers (40% of respondents have high potential), agricultural producers (40%) and traders (33%); in the Ulyanovsk region - agricultural cooperatives (83%), traders (69%) and exporters (67%); in the Chuvash Republic – agricultural cooperatives (67%), exporters (60%), traders (58%) and processors (44%).
According to the results of the study, among the selected categories of farms, the potential for using Big Data and Data Science is higher among agricultural cooperatives, traders and exporters. The results of processors and agricultural organizations are slightly worse.

Accordingly, it should be noted that the level of digitalization of organizations in the agro-industrial sector differs not only in the territories of their location, but also in the types of activities. These observations make it possible to more accurately determine the reasons for the lag in digitalization in some farms in the agricultural sector. While most of the works consider the problem that has arisen only from the point of view of high investment costs [30, 31].

It is worth noting that the researchers also add that there may be differences between farmers cultivating traditional staple crops and farmers cultivating exotic plant species [32].

4. Conclusion
The use of big data in work, its processing and analysis, for establishing production chains and making strategic decisions is one of the areas of agriculture digitalization. However, according to a survey by the Ministry of Agriculture of the Russian Federation, farms at this stage are more tuned in to the introduction of technologies in certain industries - in crop and animal production, but are not yet fully ready for an integrated approach to systematization and use of data. However, in terms of the constituent entities, a different situation has been occurred. According to the survey findings, the farms of the Ulyanovsk region have a higher potential for transition to the use and analytics of big data (60% of companies have high potential), in other analyzed entities the values are significantly lower.

In realities of modern life, the efficiency and competitiveness of companies' activities are predetermined by the transition to the use of advanced technologies. It should be kept in mind that those companies that earlier and faster than others will be able to implement modern agro-management will succeed more than others.

Thus, according to the National Research University “Higher School of Economics” forecast, provided that the basic problems of agriculture are quickly resolved and an effective, modern scientific and technical policy in the agro-industrial complex is implemented, Russia can become a global supplier of food by 2030, moreover, high-quality, organic, healthy food – on a par with the USA, the European Union and Brazil.

Based on the results of the study, the following conclusions can be drawn:
1. Traditionally, it is believed that the closer a company is to the capital of a subject, the more advanced it is. However, according to our data, this is not always the case. For example, agricultural cooperatives are for the most part removed from urban agglomerations, but show the maximum desire for digitalization.

2. The level of aspiration of individual companies to digitalization also depends on the level of development of the subject as a whole. Those companies that conduct their business in regions that are traditionally more successful and industrially developed are more susceptible to changes and new technologies - for example, the results of surveys in the Ulyanovsk region.

In the framework of the study, the authors obtained good results. However, it is worth improving them further by expanding the ongoing research, since 500 organizations of different economic categories within three constituent entities of the Russian Federation are extremely small for the unconditional approval of certain relationships. We also plan to cover with our survey all the constituent entities of the Volga Federal District of the Russian Federation - these are 14 constituent entities, in order to obtain a consolidated answer to one of the most pressing issues of our time in the whole district. It is also necessary to analyze how much the size of the farm (namely, large holdings and small forms of business) influences the desire to introduce digital technologies in the management of the farm's activities.

The knowledge gained will provide comprehensive answers to the questions of the lag in the digitalization of individual enterprises and the leadership of others, which is an extremely important indicator in reducing the lag in the development of enterprises in the agricultural sector, since it is this industry that is responsible for providing food to the population. In addition, digitalization in the
modern world is also responsible for improving decisions to reduce the environmental burden. Therefore, the authors consider it extremely important to continue the disclosure of the chosen topic.

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