Evaluation of digital maturity for agricultural organizations based on DMPTSC analysis

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Abstract. It is impossible to perceive modern agricultural production without information and communication technologies. The authors analyze the modern state of agriculture in Russia and provide data confirming that agricultural organizations are the main producers of goods. The paper describes the departmental project "Digital Agriculture", which is designed to increase the efficiency of agricultural production based on the introduction of digital technologies. The digital gap in rural areas is proved based on indicators of the use of information and communication technologies in urban and rural areas. The term "digital maturity" is defined in the aspect of digital transformation of agricultural organizations. The paper proposes the methodology to assess the digital maturity by groups of factors. A survey of the heads of large agricultural organizations was conducted according to the DMPTSC analysis, and measures were proposed to increase the efficiency of digital transformation of agricultural enterprises.

1 Introduction

Agriculture is one of the most dynamic sectors of the national economy. It provides the population with food, and processing enterprises with the necessary raw materials. One of the functions of agriculture is to ensure the country's food security. Agricultural production mainly includes crop and livestock industries, which are concentrated in three categories of farms: agricultural organizations, population farms and peasant farms.

Over 20 years agricultural production in Russia has grown significantly in all categories of farms (Figure 1).

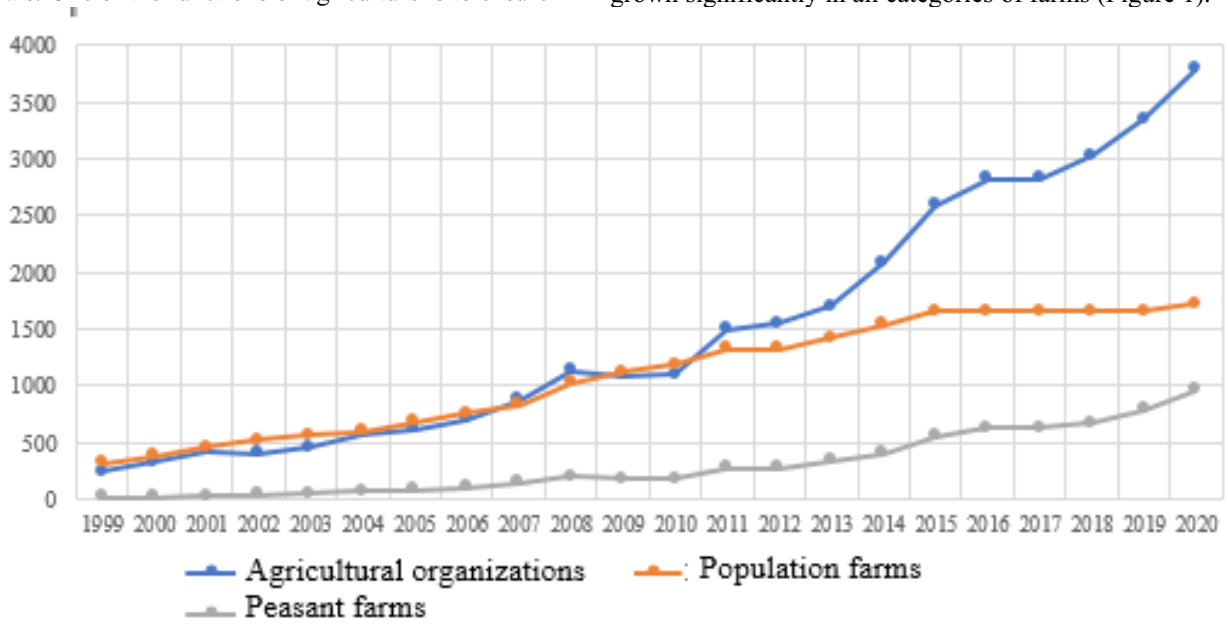

Fig. 1. Agricultural products by categories of farms in actual operating prices, bln rub.

The data shows that from 1999 to 2020 the volume of agricultural production in all categories of farms increased 11 times. Peasant farms demonstrate the highest growth rates (by 62 times), since this entrepreneurial activity appeared only in the early 90s of the 20th century and was strongly supported by the state in the late 2000s. At the same time, in 2020, 58.5% of agricultural products were produced in agricultural organizations, 26.6% – in population farms, and 14.9% – in peasant farms. Thus, agricultural organizations should become priority enterprises that should improve their

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efficiency through innovation and information technology.

The shift to a digital economy is seen as a key driver of the economic growth [1]. First of all, agricultural organizations must actively introduce modern digital technologies into their activities.

In recent years, all kinds of digital technologies have been increasingly used in agriculture abroad [2, 115]. For example, the *Food and Farm 2020* European Internet project developed in Europe ensures the compatibility of gages and sensors used by agricultural machinery. In the United States, about 70% of agricultural enterprises have digitalized their production [3, 281].

Currently, our country is implementing the *Digital Agriculture* project developed by the Ministry of Agriculture of the Russian Federation. According to the project, as a result of the industry digitalization, the investments in economic activities should increase to 5.9 billion rubles and revenue volumes – to 45 billion rubles by 2024. The departmental project includes three stages (Figure 1).

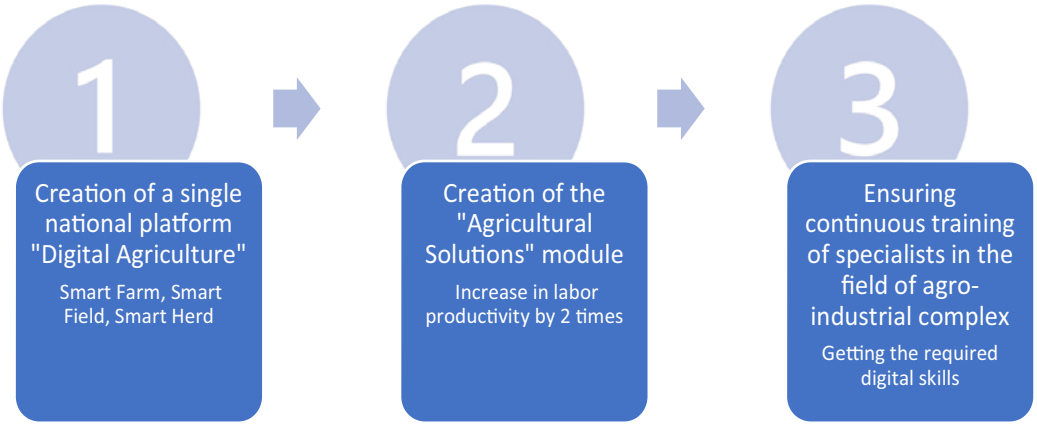

Fig. 2. "Digital Agriculture" stages.

Currently, Russia's digital agriculture is developing in five main areas indicated by the Ministry of Agriculture: effective hectare, smart contracts, agroexport "from field to port", agroindustrial solutions for agribusiness and "Land of Knowledge" [3, p. 00055]. Before starting to digitalize production activities, it is important to assess the readiness of the enterprise for digital transformation. This is a multilevel study that includes the analysis of the growth factors of an organization through the introduction of information and communication technologies. Thus, the digital transformation of agricultural organizations should begin with the assessment of digital maturity [4, 1].

Digital maturity is assessed in terms of the readiness of the organizational culture of an enterprise and its personnel for transformation, the current state of work with information and the effectiveness of production management. The assessment of digital maturity should contribute to the necessary action plans for the functioning of the enterprise in the digital economy and its transition to a fundamentally new level of development.

There is currently a so-called digital gap between urban and rural population. It is expressed in a substantial difference in access to digital technologies and in the level of digital competencies. In turn, this has an impact on economic activities in rural areas, i.e. employees of agricultural organizations have less knowledge, abilities and skills that are relevant in the digital economy (Fig. 3).

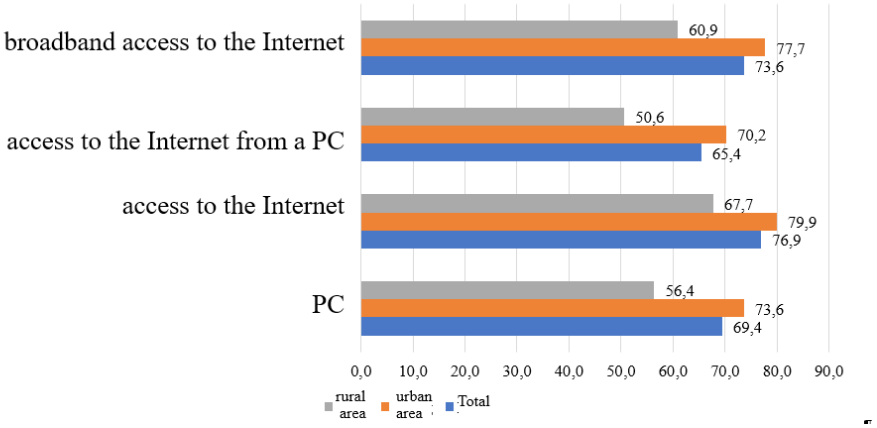

Fig. 3. Use of information and communication technologies in urban and rural areas in 2019, %.

2 Materials and methods

In January 2022, the authors conducted a survey among the heads of agricultural organizations and

experts in the industry on the degree of readiness of enterprises for digital transformation. The survey was based on the DMPTSC analysis.

The DMPTSC analysis is the author's methodology that includes 6 groups of factors of digital maturity of agricultural organizations:

1. Data Utilization (D – Data)
2. Process Management (M – Management)
3. Product Management (P – Product)
4. Personnel Policy (S – Skills)
5. Use of end-to-end technologies (T – Technology)
6. Organizational Structure (C – Culture).

The analysis establishes the degree of influence of each factor from 1 to 3 points, where 1 – minimum degree of influence and 3 – maximum degree. Then, the heads of organizations and experts had to evaluate four indicators of digital maturity in each factor on a five-point scale (Fig. 3). After the survey, the author calculated a real estimate of the influence of factors using the following formula:

$$D_i = \frac{\overline{Э} \times I_i}{\sum I}$$

where D_i – real estimate of the impact of the digital maturity indicator,

$\overline{Э}$ – average value of expert assessments of the digital maturity indicator, points

I_i – degree of influence of the indicator on the efficiency of digital transformation, points.

Data Utilization (D – Data)

Assessment of data inventory quality	Assessment of data collection, analysis and visualization	Assessment of the efficiency of decision-making based on data	Assessment of data security

Use of end-to-end technologies (T – Technology)

Assessment of product management efficiency	Assessment of the degree of introduction of the customer-centric approach	Assessment of the level of design thinking	Assessment of the efficiency of the product management flexible approach

Process Management (M – Management)

Assessment of the efficiency of current process management	Assessment of the process inventory quality	Assessment of the degree of document development regulating the process	Assessment of process control quality

Product Management (P – Product)

Assessment of the degree of end-to-end technologies use	Assessment of employee competencies when utilizing end-to-end technologies	Assessment of regulatory support of the end-to-end technologies	Assessment of the level of customer satisfaction with services based on the end-to-end technologies

Personnel Policy (S – Skills)

Assessment of the degree of baseline competencies development	Assessment of the degree of personal competencies development	Assessment of the degree of professional competencies development	Assessment of the efficiency of digital transformation managers

Organizational Structure (C – Culture)

Assessment of the current state of the organizational culture	Assessment of the degree of staff opposition to organizational changes	Assessment of the quality of regular management	Assessment of the feedback degree

Fig. 4. Indicators of the DMPTSC analysis of digital maturity of agricultural organizations.

Specialists of the AIC Food Program and teachers of Kazan SAU participated in the digital maturity survey. The agricultural organization AIC Food Program is engaged in the breeding of dairy cattle and the production of raw milk. At the beginning of 2021, the organization employed 701 people. Over the past five years, investments in fixed assets in the group of companies amounted to more than 5 billion rubles. The group's enterprises are actively introducing digital technologies. So, for example, the "Herd Management" program reduced the service period from 145 to 109 days, reduced the disease rate from 12 to 2, and increased the pregnancy ratio from 18% to 28% by year. After the introduction of herd management and feeding systems, we were able to increase the milk yield from 26.5 to 34 kilograms of milk per dairy cow [5].

Table 1. Results of the DMPTSC analysis of the AIC Food Program.

	Degree of impact	Expert 1	Expert 2	Expert 3	Expert 4	Real estimate
Data Utilization (D – Data)						
Assessment of data inventory quality	3	5	4	5	3	**0.18**
Assessment of data collection, analysis and visualization	2	4	5	5	4	**0.16**
Assessment of the efficiency of decision-making based on data	3	4	5	5	3	**0.18**
Assessment of data security	2	4	5	5	4	**0.16**
Process Management (M – Management)						
Assessment of the efficiency of current process management	2	4	4	5	5	**0.20**
Assessment of the process inventory quality	2	5	5	5	3	**0.12**
Assessment of the degree of document development regulating the process	1	5	5	5	3	**0.06**
Assessment of process control quality	2	4	5	5	4	**0.16**
Use of end-to-end technologies (T – Technology)						
Assessment of product management efficiency	2	4	4	5	4	**0.16**
Assessment of the degree of introduction of the customer-centric approach	2	4	4	5	3	**0.12**
Assessment of the level of design thinking	1	4	4	5	4	**0.08**
Assessment of the efficiency of the product management flexible approach	2	4	4	5	5	**0.20**
Product Management (P – Product)						
Assessment of the degree of end-to-end technologies use	3	4	4	5	4	**0.24**
Assessment of employee competencies when utilizing end-to-end technologies	3	4	4	5	4	**0.24**
Assessment of regulatory support of the end-to-end technologies	2	4	4	5	5	**0.20**
Assessment of the level of customer satisfaction with services based on the end-to-end technologies	2	5	4	5	3	**0.12**
Digital Competencies (S – Skills)						
Assessment of the degree of baseline competencies development	2	4	5	5	3	**0.12**
Assessment of the degree of personal competencies development	1	5	4	5	3	**0.06**
Assessment of the degree of professional competencies development	3	4	4	5	4	**0.24**
Assessment of the efficiency of digital transformation managers	2	4	4	5	3	**0.12**
Organizational Structure (C – Culture)						
Assessment of the current state of the organizational culture	2	5	4	5	4	**0.16**
Assessment of the degree of staff opposition to organizational changes	2	5	4	5	5	**0.20**
Assessment of the quality of regular management	3	4	4	5	3	**0.18**
Assessment of the feedback degree	2	4	4	5	4	**0.16**

3 Results and Discussion

The data shows that people responsible for the digital transformation in AIC Food Program should pay special attention to the following aspects during its implementation:

1. Data collection, analysis and visualization. The most important at the initial stage of digitalization of any organization is the high-quality receipt and processing of primary data from various sources. In this case, it becomes important to establish contacts with stakeholders, the feedback of which serves valuable information for the agricultural organization. Stakeholders include consumers, suppliers, competitors and employees. Moreover, the more data, the more difficult it is to highlight the main aspects [6, p. 10]. Therefore, the leaders of transformation must have the skills to visualize them.
2. The development of documents regulating digital transformation is a complex and capacious stage of digitalization. It must take into account the interests of all concerned. It should contain indicators of the efficiency of digital transformations and algorithms for their implementation based on the peculiarities of agricultural production in the Agro-Industrial Complex Food Program.

3. The rate of production intensification and the growth of labor productivity depend on the level of development of the technical potential of agricultural production [7, p. 48]. The principles of design thinking when using end-to-end technologies are poorly developed in the studied organization. It is possible to significantly increase the competitiveness and attractiveness of products using this methodology to solve technical and business problems.
4. The assessment of customer satisfaction when receiving end-to-end services is the job of the marketing department. Such feedback can be obtained when delivering or transferring marketable products, as a result of monitoring social networks, or when directly communicating with the customers of an organization. The obtained data make it possible to adjust the quality characteristics of the produced goods.
5. The digital competencies of employees are the most important factor in the efficiency of digital transformations. The transition of the agricultural sector to an innovative development model is largely determined by the readiness of personnel to perceive and introduce modern technologies into agricultural production [7, p. 148]. The employees of the AIC Food Program must have not only basic and professional skills, but also develop personal ones. Soft skills are personality skills that can help employees work with other people and develop relationships with customers and partners.
6. Without changing the current state of organizational culture in the studied group of companies, the efficiency of digital transformation can decrease sharply. When determining the degree of development of the organizational culture, it is necessary to adhere to the principles of spiral dynamics. According to the authors, a culture of power with its mobilization nature prevails in the AIC Food Program. In a digital economy, when there is a continuous change in the external and internal environment of an organization, there must be a synthesis culture in which there is no clear hierarchy, and employees work in project teams created to address a specific task.

4 Conclusion

Information and telecommunication technologies are not only an integral part of the daily life of a modern person, but also a necessary technological platform for modern business processes [4, p. 00050]. The introduction of these technologies in the agricultural organization requires the consideration of all factors of the macro- and micro-environment. The DMPTSC digital maturity analysis proposed by the authors takes into account almost all aspects of digitalization and is the initial stage that evaluates the degree of readiness of the organization for deep digital transformations.

The conducted digital maturity study of the AIC Food Program based on the DMPTSC analysis reflects the current state of the organization and identifies the main areas that the digitalization specialists need to pay attention to during the digital transformation.

It is necessary to increase production volumes not by all means, but only by those that are economically feasible [10]. This methodology can be used to evaluate large agricultural organizations that are starting to introduce digital tools into their production and whose managers want to change the management principles using information and communication technologies.

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