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QUALITY OF DIGITAL AGRARIAN PRODUCT: CONTRIBUTION TO FOOD SECURITY AND SPECIFICS OF MANAGEMENT

Abstract: *In the 21st century, food security is connected not only with the availability of arable land, traditions in agricultural production, or labour resources. Its growth in the conditions of quick climate change is possible in the case of the effective use of digital agrarian products. The digital readiness of farmers and farm employees for the transition to digital (including intellectual) technologies is often a barrier to an increase in the efficiency of agricultural production and crop protection from climate influences.*

Management of the quality of digital agrarian products involves IT companies considering all features of this sector's functioning, as well as the capabilities and potential of farms. Integration of certain digital agrarian products into agricultural production and promotion and sales of agrarian products are implemented in different countries given the existing practices, approaches and participation of the government and private sector in this process.

The goal of this paper was to identify the consumer parameters of the quality of digital agrarian products as the basis of food security. The novel aspect of this paper is due to the determination of the specifics of managing the quality of digital agrarian products in countries with centrist and market regulations.

Keywords: *digital agrarian products, quality management, food security, precise farming, systems of remote sensing of areas, remote cultivation of agricultural land, climate change.*

1. Introduction

Domination of the agrarian sector in the economy in the late 20th – early 21st centuries was a sign of the country's being a developing or underdeveloped one. Economically developed countries achieved the goals of food security with highly efficient means and methods of agricultural production, using imported products as well. Some developing countries, which specialised then in agriculture, began demonstrating a quick growth of productiveness by the 2020s, which was due to digital technologies. The digital economy allowed them to ensure the development of agrarian products' value-added, which is connected with the achievement of

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advantages in the optimisation of expenditures, reduction of the need for labour resources, increase in consumer qualities, and growth of export (Paraušić et al., 2023). These countries satisfy most of their food demands and export products with high value-added. Because of various difficulties, other developing countries still specialise in commodity agricultural production. This does not facilitate the achievement of food security, due to complex climate conditions, and does not allow them to reach good results in world markets (due to fluctuations in agricultural product prices).

New digital technologies cover various sectors of the economy, including agriculture. Digitalization in this sphere began later than in industry. This situation was mainly caused by opposition to technological changes from farms. Insufficient level of education, the experience of previous generations, and rather optimal climate conditions allowed individual farmers and farms to integrate opportunities presented by progress. Certain economically developed countries did not demonstrate a significant increase in intellectualisation of the agrarian sector in the 20th century. For example, the share of farm owners with higher education in Spain was 2 % as of year-end 2013 (Sadjadi & Fernández, 2023). Accordingly, the country's agrarian sector did not demonstrate technological transformations in the 2010s, and, as of now, it receives subsidies from the EU. The growth of knowledge and skills in the management of processes in agriculture ensures its productiveness, influences the quality of life of human resources and allows involving them in the work in this sector. Studying the directions of using digital technologies to raise the productiveness of agrarian products is an important practical task of agrarian economic science. Thus, the quality of digital agrarian products, which influences the productiveness of processes, is the main task of modern companies which develop innovative technologies in the sphere of agricultural production management.

The goal of this research was to determine consumer parameters of the quality of digital agrarian products as the basis of food security. For this, we established the indicators of the quality of digital agrarian products which influence the effectiveness of agriculture and characterised the specifics of management of agricultural products with the use of digital technologies.

2. Methodological basis of the research

We reached the designated tasks based on the selected methodological basis, which includes the following:

- Research sample: agrarian sectors of China and Brazil. These countries were chosen because of the high intensity of growth of agricultural production and dissemination of agrarian digital products among their farms;
- Scientific & practical and methodological materials, which were used to determine the main provisions and conclusions.

Analysis of the theoretical and empirical studies within the considered problematics demonstrated the following.

Sadjadi and Fernández (2023) presented a complex analysis of problems and features of Spain's agriculture in the post-COVID period. The authors considered the importance of farms' adopting modern digital technologies which ensure an increase in the potential of supporting food security. An important scientific contribution of this research is the systematisation of problems and barriers to implementing digital technologies in the agricultural processes of the country.

Abiri et al. (2023) considered the formation of digital agrarian technologies in the context of the reduction of threats to food security. The authors identified the types of

agrarian digital technologies which became the most widespread in agriculture and were studied at the theoretical and empirical levels. These are the Internet of Things and machine learning. The scholars also determine the types of digital agrarian technologies with good perspectives for use; these include wireless sensor networks and cyber-physical systems.

Zhu et al. (2024) analysed digital technologies used to prevent the emergence and fight pests and crop diseases. The authors used the experience of Chinese farms to consider modifications of drones applied for these goals. An important aspect of this work is the identification of algorithms of AI technologies built-in remote sensing systems.

Michels et al. (2021) dwelt on coverage and directions of using drones in German precise farming, based on the empirical study of the functioning of farms in various states of Germany. According to scholars, the growth of demand for digital agrarian products (including systems of process management based on drones) in Germany depends on farmers' awareness of their advantages and possible efficiency in management.

Quan et al. (2023) assessed the time and economic effects of Chinese farms from the application of the systems of pesticide use in precise farming. The researchers determined the optimal areas of agricultural land required for obtaining advantages and showed that for micro-farms, with areas below 20 hectares, the use of digitalization did not bring a significant increase in revenue.

Kazambayeva et al. (2023) substantiated the need for the use of systemic analysis in the processes of assessment of the indicators of effectiveness of agricultural production given the factor of climate transformations and market fluctuations. The authors justly noted the necessity for systemic determination of environmental, natural, socioeconomic, and technological factors of sustainable development of agriculture. The focus on the technological component showed the importance of this research in the context of ensuring the quality of digital agrarian products.

Bocean (2024) performed a comprehensive assessment of an increase in the efficiency of agricultural production depending on the emergence and dissemination of new digital technologies. The author conducted an empirical study by the example of the agrarian sector of the EU, using exhaustive statistical and analytical data. The work demonstrated the direct connection between these variables and focused on the high efficiency of production in the EU countries due to the similar level of digital knowledge and skills of employees of the member states.

3. Experimental setting and methods

We selected methods and approaches that are most optimal for determining the connection between the consumer quality of digital technologies and their effectiveness in the agrarian sector.

Frame analysis was used to establish the frameworks of functioning of the agrarian sector in the considered countries, which allowed revealing whether there is a focus on digitalization. The statistical analysis enabled us to identify the key indicators of the effectiveness of manifesting consumer parameters of agrarian digital products' quality.

The integrated approach was utilised to perform a comprehensive assessment of the specifics of agricultural product management in the conditions of the use of leading digital agrarian products.

We also used comparative analysis to determine the dynamics of the level of yield of cereals and the volumes of value-added of fisheries, forestry, and agriculture. We selected the volume of GDP from the activities of three sectors because there is no data on agriculture in isolation. The

dynamics of this indicator are necessary for determining the effectiveness of the influence of the growth of digital agrarian product quality on them.

4. Results

The modern development of digital agrarian products depends on the offer from IT companies and demand from the participants of the agrarian sectors, as well as parties interested in the growth of food security (countries and international organisations). Based on the assessment of scientific and analytical literature, we determined the list and features of the management of digital agrarian products that are present in the market.

1) Systems of remote sensing of areas. This digital product may have different modifications, namely as follows:

- Systems that collect, systematise, and process the data on farms with the help of unmanned aerial vehicles (drones). The advantage of these digital products is their difference in the context of the collection and recording of data. Data received with the help of these systems differ from data obtained from video cameras or satellites. This is because, apart from the resolution of images, it is possible to determine temperature indicators, indicators of air pollution, and soil samples. These systems may contain a large number of sensors, e.g., hyperspectral, multispectral, heat, etc. (Abiri et al., 2023). Data from drones are more precise and informative. The functional capabilities of these systems depend on the drone's modification. More complex types of drones are those of the helicopter type (one rotor), fixed-wing drones (plane type), and drones with vertical take-off and landing. Simpler drones have more rotors and lower cost. The most popular drones have four or six rotors, they are the simplest in exploitation.

In China, remote sensing with the help of drones involves the use of these systems within software installed on farms' PCs and digital apps on smartphones and tablets. The first option is used for general monitoring of the process of remote sensing and transfer of data for systematisation, processing, and analysis of the data obtained; the second option is used in field conditions by farm personnel. The main goal of using these digital products at Chinese farms is to collect images of farms and crops and assessment of the state of crops (Zhu et al., 2024).

- Systems that process data from digital satellites (if there is an agreement with companies that provide high-quality satellite images of areas on a constant basis) or computer vision sensors installed on farms.

2) Systems of remote cultivation of agricultural land. Here drones equipped by drones that spray fertilizers and apply pesticides are used (Michels et al., 2021). These drones are controlled by operators, and the volume of fertilizers and pesticides is strictly regulated by sensors, which prevents environmental damage and damage to the quality and safety of crops. In this case, food security is ensured, which consists of the provision of food products and retaining their quality (Niewczas-Dobrowolska, 2022).

Chinese farms have been using these systems since 2010. By 2020, around 70,000 drones were used to ensure crop protection on the territory of 14.5 million hectares (Zhu et al., 2024). The economic effect and saving time from the application of this system depend on the processed areas. Saving time due to these equals to 14-15 hours per one hectare. The average growth of income due to the implementation of this system was assessed at $433-438 per hectare of agricultural land as of early 2024 (Quan et al., 2023).

An important aspect of using this system of remote cultivation of agricultural land is the precision of the volume of sprayed pesticide used by the robot; it is determined by the AI technology of big data analytics. Determination of the volume of pesticides and fertilizers required for crops is

performed based on the data that are provided during the farm's registration in the system about the following parameters: area of crops; date of planting; type of pesticides and fertilizers, etc. Information about the following threats to the health of cultivated plants (pests, diseases, climate features) is already in the system. It is determined based on the farm's geolocation and analysis of big data on the specifics of these indicators for the given territory. The most optimal volume of spraying fertilizers from one drone is 22.5 litres per hectare. It is safer than 30 litres per hectare and more effective compared to volumes of 7.5 or 15 litres per hectare (Shan et al., 2022).

Like in China, Brazil is peculiar for a quick development of these systems based on robotized drones. Over 2020-2023, 8,000 drones were imported into the country. According to the forecast data, the number of drones used in agriculture will reach 90,000 by 2026 (AgroPages, 2023).

Time-saving due to farmers' applying these systems to spray pesticides in Brazil is rather significant. The time needed for this process with the help of a drone is 3 hours per hectare. A farm employees need twice or thrice more time (Croplife, 2024).

3) Systems of informing farmers about climate change, threats to crop health, and corresponding measures and procedures in agricultural production. These systems also belong to digital agrarian products of precise farming.

These information systems are based on the AI technology of analysis of big databases. They are integrated into digital applications, which are compatible with smartphones and tablets.

In most provinces of China that have agricultural land, programmes for farmers' support are financed by the central government and regional authorities. Companies that manage local meteorological stations install climate sensors and soil and plant sensors on farm territories. Within local agrarian digital systems, information received by these sensors is compared to information received after processing images from national meteorological satellites Fengyun (Xinhuanet, 2018). With certain periodicity, required for the implementation of the main agricultural processes, and in case of forecasting emergency climate situations, these systems generate messages and recommendations for farmers regarding the necessity for certain measures. This facilitates the government and regional and local authorities accepting responsibility for yield and support of the necessary level of food security. This system has been functioning in China since 2015, it supports the work of micro and small agrarian businesses in the country. The importance of this system is predetermined by the fact that most arable land (more than 70 %) is processed by small farms, which employ around 90 % of all labour resources that work in this sector (Wei, 2023). Accordingly, digital support of agriculture's effectiveness is required by the government to reach goals of sustainable development connected with decent work, fighting poverty, and prevention of hunger.

Brazil also supports small farms using the systems of informing about climate change and possible diseases of plants. Unlike China, Brazil uses this measure also for private companies that develop agrarian digital products and companies that work in the sphere of sustainable development. An example is the Brazilian start-up Agrosmart, which supports more than 100,000 farms on the territory of Latin America (Bains, 2023). The start-up Agrosmart was started in 2014 to inform farmers about climate and soil conditions through a digital platform. The digital platform functions in the following form: sensors of soil quality are installed on farms – they transfer information about the indicators with the set periodicity; the data about soil quality go into the information system; management of a collection of information about soils and plant quality is conducted with the help of drones; the information system receives data from the

company that deals with satellite footage of territories; analysis of big databases, received from these sources, is performed; based on machine learning and neural networks, forecasts are developed and data are systematised about soils, order of planting, and harvesting; the data and detailed recommendations are transferred to farms and individual farmers.

Activities of the digital platform Agrosmart facilitate the effectiveness of the functioning of Brazilian farms and contribute to the achievement of social and environmental goals of sustainable development. The company that manages the start-up creates and implements successful sustainable practices that help farms achieve the designated goals. The perspectives of the start-up's activities are connected with the attraction of financing for Brazilian farms that are oriented towards sustainable digital transition.

Start-ups that are similar to Agrosmart function due to financing from private national and regional investors and global venture funds. The dynamics of attraction of financing in this sphere changed over 2017-2022. The volume of financing of start-ups and companies that develop and service agrarian digital products in the world equalled $3.3 billion in 2017, $2.3 billion in 2018, $1.96 billion in 2019, $6.6 billion in 2020, $17.8 in 2021, and $8 billion in 2022 (Bains, 2023). The growth of financing in this direction in 2020 was due to the agricultural sector's striving towards fighting challenges caused by the COVID-19 pandemic, creating conditions for the management of processes with the minimization of the use of human labour. Further growth of the indicator in 2021 was due to new participants entering the market; they work in the sphere of development of digital platforms, software, and apps that facilitate the sustainable development of the agrarian sector. These market actors appeared in many countries, but most of the deals on financing start-ups in this sector accounted for developed and quickly developing countries, including Brazil, China, and India. The considered start-up Agrosmart attracted $5.9 million in investments in 2019, while in 2022 this sum equalled $9 million. The platforms's activities allowed the participating farms to retain high yields and achieve the Sustainable Development Goals in the sphere of energy efficiency and water saving. As of year-end 2022, the farms were able to save 20 % of energy and 60 % of water with an increase in the volumes of agricultural production (Bains, 2023).

Focusing on global trends, China demonstrates the attraction of private (up until recently, government capital dominated) capital to invest in the sustainable development of agriculture and agrarian digital technologies. 2024 saw the adoption of national measures for the creation of a safe and attractive investment climate for foreign investors (Zhou, 2024). Within these measures, directions and centres of responsibility for the protection of rights and interests of foreign investors in China, protection of intellectual property, and elimination of monopoly at the national investment market were determined. China creates conditions for raising the level of international integration in capital markets. Also, preconditions for attracting international corporations in the country, including those working in the sphere of IT, are formed.

4) Platforms for online trade of agrarian products.

These digital products are to raise the effectiveness of promotion and sales of agrarian products. They include different functions, which ensure the setting of online stores and online payments, logistics, processing of orders, transportation, and stock management. This is a traditional list of functions peculiar to international platforms of this type; it is most widespread in the USA, Canada, and other developed countries (Galle, 2024). Payment for the services of digital trading platforms, on

which farms and individual farmers can open their stores, is performed as per set tariffs. Functional capabilities and support depend on the pricing category of the package of services. These digital platforms are developed by the initiative of digital business, which determines demand from farms.

In developing countries, not all farmers have access to private digital trading platforms. This is true, especially for small farms and individual farmers. These countries start creating online trading platforms at which farmers can sell – without intermediaries – their products, in direct contact with the consumer. This is seen in countries of Africa and certain developing countries of Asia. Large banking systems are also involved in the financing of this category of digital products. African countries have started creating online trade platforms, which impose payment for their services. However, it is much lower compared to American or European prices. The appearance of this digital product raises the profit of farms, which is low due to high transaction costs. In 2023, citizens of South Africa spend around 50 % of their incomes on food. This indicator was observed in the USA 150 years ago. As of now, Americans spend 10 % of their incomes on food (Nedbank, 2023). It is expected that a gradual transition to direct trading of agricultural products in this region will allow eliminating of intermediaries, reducing unproductive transportation, and ensuring higher quality of products due to the prevention of unnecessary movements of the product.

Until 2024, the Chinese government used to finance the digital online trade of agricultural products, supporting the growth of the agrarian sector. The country's strategic course towards an increase in the rural population's living standards, green transition, and growth of agricultural products' quality led to the development and implementation of the new national policy in this sphere. In March 2024, nine ministries developed programme recommendations to optimise Chinese farms' transition from traditional agricultural production to modern agricultural production which is based on digital technologies. Though this process has been taking place in China for the last ten years, it is rather fragmentary and does not take into account the needs of certain regions with difficult climate conditions.

In March 2024, these ministries adopted a programme plan for support of the development of digital trading of agrarian products. This plan envisages the formation of districts for online trading of the sector's products (100 structural centres). 1,000 digital trading platforms will be created. Personnel in the sphere of digital agriculture (10,000 employees) will be trained (Wfpchinacoe, 2024b). According to the plan, the new policy of the country in support of digital trading of agrarian products will allow raising farmers' incomes, ensuring the growth of product quality, and ensuring the exchange of experience in the use of agrarian digital technologies between the farmers from different regions. Personnel training is a part of the country's focus on an increase in the digital readiness of human resources to digital changes and possibilities of the emergence of new requirements for the profession.

Before the adoption of this strategic plan, Chinese farmers used the advantages of digital trading platforms (working directly with consumers, without intermediaries) and interacted with other farmers to exchange experience and knowledge (Wfpchinacoe, 2024a).

Despite the implementation of parts of the strategic plan in 2024, there are still differences between regions by the indicator of the effectiveness of using agrarian digital products, the productiveness of farm activities, and the level of revenues from agricultural product sales. Farms in the eastern part of the country have higher indicators of using digital trading platforms, compared to the farms from Western and

Central China. This difference is explained by the following factors: farms in Eastern China are located near the coast, which provides more attractive opportunities for the transportation of products; these farms have sustainable practices of precise farming and livestock, due to a higher level of knowledge and experience of the management and employees; convenient location of these farms makes them more attractive for investors.

In Brazil, unlike China, online platforms for agricultural product trading are created and managed by private businesses. They are rather effective, similar to other mentioned digital agrarian products that are presented in the market.

5. Discussion

The analysis we performed demonstrated active dissemination of digital agrarian products at farms in China and Brazil. Though each country has its specific features of ensuring the quality of agrarian digital products by IT companies, their key direction is connected with an increase in demand from consumers and support of food security. Similar to Brazil, China is a quickly developing country. China supports a centrist approach, which is peculiar for certain liberalism in the attraction of private capital and management of critically important sectors, including the digital economy and agriculture. Brazil is characterised by the domination of the market regulation of the quality of agrarian digital products.

To confirm the influence of improvement of the quality of digital agrarian products, we elaborated on the dynamics of the volumes of value-added from fisheries, forestry, and agriculture and the level of cereal yield in China and Brazil (Table 1).

Table 1. Dynamics of the level of cereal yield and volumes of value-added from fisheries, forestry, and agriculture in China and Brazil

Country/ Indicator	Value						
	2016	2017	2018	2019	2020	2021	2022
China							
Cereal yield (kg per hectare)	6.019	6.111	6.122	6.264	6.296	6.317	6.38
Agriculture, forestry, and fishing, value-added, $ billion	905.1	918.8	978.6	1,020	1,130	1,290	1,310
Brazil							
Cereal yield (kg per hectare)	4.18	5.2	4.8	5.3	5.26	4.5	4.9
Agriculture, forestry, and fishing, value-added, $ billion	87.8	94.9	85	79	84.3	109.6	112.6

Source: Compiled by the authors based on the World Bank (2024a) and the World Bank (2024b)

Analysis of the presented dynamics of indicators (Table 1) showed that due to effective management of the quality of digital agrarian products, China was able to achieve stable growth. This might be also due to the government's active participation in support of the digitalization of the studied sector and improvement of the policy of dissemination of digital technologies. As for Brazil, we may note changes in the indicators and growth in 2022. This was connected with the improvement of cooperation between developing companies, digital platforms, and consumers of digital agrarian products (farms).

6. Conclusions

Summing up the results obtained, it is possible to state that the quality of digital agrarian products depends on financing, expectations, and demand from consumers, as well as the country’s course towards support or increase in food security and

agrarian sector's readiness for the integration of digital technologies. The expedience of consideration of these factors was proven in the course of the analysis of the management of digital agrarian products by the example of China and Brazil.

At present, there is uncertainty in the markets of agricultural production, connected with cataclysms, climate change, and growth of demand which does not allow exporting food products to other countries. Given this, it is expedient to raise the level of productiveness and volumes of production in the agrarian sector. This goal could be achieved due to the improvement of agrarian technologies and through the dissemination of intellectual digital technologies, which ensure the growth of production without an increase in arable land. The use of AI will allow ensuring the growth of food security at the national and international levels and reducing the level of climate change caused by agricultural production. Thus, it would be possible to reach the goal of sustainable development of agri-food systems (Kazambayeva et al., 2023).

To raise the efficiency of agriculture, it is possible to create centres for mastering digital agrarian products, which will allow raising the readiness of farm personnel for work with new technologies and equipment. Activities of such centres could be financed by the central and regional authorities and international organisations. Also, developing companies that deal with digital agrarian products and consumers could join efforts for this. This could be implemented in case of the absence of the government's participation in support of innovative digital transformations in the agrarian sector and improvement of food security.

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