Directions of Digital Technologies Development in the Supply Chain Management of the Russian Economy

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***Abstract*— The main objective of this paper is to investigate the digitalization and technologies impact on supply chain management of agricultural industry. This paper provides practical examples of supply chain digitalization, as well as its socio-economic and environmental effects. The absence of processes that are compatible with the high production requirements adopted in foreign markets can lead to crisis phenomena in domestic industries with high potential and rapid growth dynamics in agriculture industry. Agriculture in Russia is an integral part of the agro-industrial complex, and the program "Digitalization of its supply chain" should provide participants with the opportunity to use broadband, mobile, LPWAN communications, information technologies (small and big data, management platforms, etc.) of the domestic instrument industry (tags, controllers, sensors, control units) to improve significantly the efficiency of agriculture. The opportunities for modernizing the industry are huge. Food security of the country and the development of export potential, turn agriculture into a high-tech industry that can not only provide food for itself, but also many countries of the world through the global supply chain system, as well as create opportunities for the introduction of new innovative developments that have not exist before, stimulate management decisions that can provide the population with high-quality and safe products. According to expert estimates, during the season, the farmer has to make more than 40 different decisions in limited time intervals. Many of these solutions, which affect directly the production economy, are objects of digitalization in supply chain.**

Keywords*— *Digital technologies, digital transformations, supply chain management, cost reduction, e-commerce, control of production technology.

1. Introduction

The current level of digitalization of domestic agriculture is of serious concern: the lack of scientific and practical knowledge on innovative modern agricultural technologies and methodology, the lack of a global forecast for agricultural prices, the lack of an adequate number of information technology tools and equipment, as well as the underdevelopment of the logistics, storage and delivery system lead to high production costs [1-5]. Only a small number of agricultural producers have the financial capacity to purchase new equipment and use information technology (IT) equipment and platforms.

The Decree of the President of Russia "On national goals and strategic objectives for the development of the Russian Federation for the period up to 2024" dated 2018 sets the task of transforming priority sectors of the economy and social sphere, including agriculture, through the introduction of digital technologies and platform solutions [6].

According to the Ministry of Agriculture of Russia, "the use of digital technologies in agriculture allows to increase the profitability of agricultural production due to point optimization of costs and more efficient allocation of funds [7]. The introduction of the digital economy is calculated to reduce costs by at least 23% when implementing an integrated approach".

Our study is focused, first, on the analysis and classification of digital technologies application, focusing on their impact on supply chains transformation; second, on identifying the central factors of supply chains Digitalization in SCM, with the use of case studies of closed loop supply chains; third, on identifying the dominating trends in supply chains development and their transformation into ecosystems which coordinate the actions of all their participants and elements.

2. Materials and methods

SUPPLY CHAIN DIGITALIZATION

The business models of some companies (e.g. Google, Amazon, Alibaba, Airbnb, Uber) are fundamentally built on digital technologies. Other companies,

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whether they have existed for five, ten, twenty or even one hundred years, are forced to transform and embrace digital technologies in order to compete [8]. This process has various names such as digitization, digitalization or digital transformation. We will now define these terms in detail.

The work used system, comparative, economic and mathematical, and other research methods. Published works of scientific research institutions of the Russian Academy of Sciences and statistical materials at the federal level were used as materials.

3. Results

The volume of the information technology market in agriculture is rapidly developing. For example, if in 2006, according to the national agricultural census of 2006, 12.9% of agricultural organizations had the Internet, in 2016, as shown by the national agricultural census 2016 [9] - 61,2 %, i.e. in 10 years the Internet coverage of agricultural enterprises increased by 5 times. For comparison, the volume of production in agricultural organizations during this period increased by 1.75 times.

The goal of Digitalization in SCM of agriculture is to achieve a significant increase in the efficiency and sustainability of its operation [10]. This can be achieved through radical changes in the quality of management, both technological processes and decision-making processes at all levels of the hierarchy, based on modern methods of production and further use of information about the state of managed elements and subsystems, as well as the state of the economic environment of agriculture.

The expected socio-economic changes caused by the introduction of digital technologies in agriculture will be as follows:

- Growth of the contribution to the economy in 2024 - up to 5.9 billion rubles.
- Growth of export revenue in the perspective of 2025 to 45 billion dollars.

In addition, creating, dispatching, and aggregating data flows to create end-to-end chains from agricultural production to consumption with deep integration into related digital economy sectors as a tool for increasing agricultural productivity and maximizing the profits of industry enterprises will help:

- to improve the efficiency of agricultural production.
- to form new knowledge-intensive industries, involvement of workers of new professions in agricultural production.
- to increase income in rural areas.

Russia has a significant reserve for increasing the efficiency of agricultural production (by 3-5 times) and the potential for increasing the turnover of the industry due to the introduction of digital processes and technologies in crop and livestock production, increasing labor productivity and fully using the capabilities of modern digital platforms for management at the macro and local levels of production.

At the same time, we need to solve the following tasks:

- Creating digital methods, technologies, and technical tools for monitoring fields, collecting digital data on plants, animals, and beneficial microorganisms, digital methods for compiling and updating soil maps, and methods for updating and using breeding and genetic material.
- Introduction of digital tools for using information resources, platforms and technologies that improve the efficiency of agricultural production.
- Creation of technologies and technical means for automation, robotics and intelligent agricultural production.
- Development of information technologies for designing agrifood systems of various scales (agricultural organizations, agriculture of regions and the Russian Federation as a whole), taking into account new opportunities provided by the potential of the digital platform for agriculture.
- Development of systems for predicting the state of agrifood markets associated with geo-information systems (GIS).
- Development of tools for assessing the impact of agricultural policy options on market actors.
- Creating technologies that simplify the process of crediting and insuring agricultural production, reducing the time frame for providing public services (subsidies, subventions, etc.), taking into account the availability of objective digital data about the subject, and simplifying document management. The main task here will be to stimulate the introduction of digital technologies, therefore, the growth of turnover and productivity of economic entities;
- Use of financial and regulatory tools to smooth out seasonal downturns and information tools for managing the availability of exchange-traded goods in storage warehouses (grain, oil, sugar, milk powder, etc.);
- Improving the efficiency of interaction between participants and the state with the transition to digital format, integration of information resources and

convenient quick access to them for an unlimited authorized number of users (electronic transaction support, distributed registry technologies, electronic warehouse receipts, acts of acceptance of goods for processing, etc.);
- Development of the digital environment for remote agricultural education and the market for professional agricultural consulting;
- Increasing the attractiveness of working in agriculture, increasing the demand for information technology specialists in the agricultural sector, increasing the level of income in rural areas;
- Providing participants in agricultural production with access to the macro demand forecasting platform, agricultural machinery management platforms, weather forecasts and objective vegetation monitoring tools, production planning and management tools with elements of Big Data and AI, close integration of digital agriculture processes with platforms developed in the process of implementing the digital economy;
- Providing high-speed communication for rural areas, standardization of formats and protocol for data exchange between management information systems;
- Creating technologies and platforms to support decision-making for agricultural producers.

The objective tasks of digital transformation of agriculture in the near future should be [11, 12]:
- Formation of a basic set of processes and methodology for digital agriculture, in order to use effectively and efficiently available resources for the introduction of economically sound best available technologies and practices that increase the profitability of agricultural production, providing the ability to produce agricultural products in a cross-cutting digital environment "from field to counter";
- Launch of a platform for producers that contributes to the formation of dynamic seasonal KPI for crop management – "Effective hectare", and animal husbandry – "Effective head", allowing effective use of the resources available to the producer:
- Capacity of the machine and tractor fleet, personnel, profit, profitability and cost indicators, production cost values by industry, sales forecasts, purchase price futures for products within Russia and for exports of products;
- Development of functional requirements for domestic differential positioning equipment based on GLONASS/GNSS signals for digital and "precision farming systems";
- Implementation of objective monitoring and management platforms for transport and logistics infrastructure in agriculture;
- Creation of databases of agricultural technologies, machinery and equipment, soils and their properties, crops and varieties, fertilizers and plant protection products, diseases and pests, economic models of agricultural business and other data that affect the results of agricultural producers;
- Creating methods, algorithms and technologies for managing a "digital agricultural enterprise";
- Development of methods and algorithms for predicting the state of agroecosystems for creating adaptive technological maps of field operations and economic models;
- Development of technical and economic models for the use of equipment and aggregates for different land use conditions;
- Creating intelligent decision support systems for agricultural enterprises;
- Creating innovative farms as platforms for technology development and training;
- Implementation of "Internet of things" platforms (cyber-physical systems) for managing agricultural machinery, greenhouses, tools, flows of used materials, improving production energy efficiency, managing traceability systems, etc.;
- Ensuring international compatibility of applicable standards and protocols in order to replace foreign technologies that dominate the agricultural production market gradually;
- Mandatory localization of telemetry monitoring data;
- Application of technologies for digital analysis of soil structure, composition and condition, monitoring of crops to increase productivity and predictive analysis of crops, pests, etc.;
- Development of technical requirements and implementation of domestic equipment for differentiated application of fertilizers and chemicals for digital and precision farming systems based on digital soil maps showing the characteristics of the property in each section of the field;
- Creating a matrix of digital solutions for crop rotation formation for different regions of Russia, taking into account the specifics of production for the production of high-quality environmentally safe products based on best practices and using scientific potential;
- Approbation, analysis and implementation of digital technologies for managing conservation agriculture [13, 14] used at all stages of production (direct and strip seeding, differentiated fertilization, controlled transport of machinery (CTF), efficient harvesting and post-harvest logistics, etc.);

- Integration of analytical digital tools and regulatory solutions to combat "cross-border", control and monitoring of land use using big data analysis;
- Application of technologies for digital analysis of soil structure, composition and condition, monitoring of crops to increase productivity and predictive analysis of crops, pests, etc.;
- Integration of information systems of the Federal Service for Veterinary and Phytosanitary Surveillance and veterinary services into a public-private digital platform for seamless integration of control and supervision systems into business management systems of economic entities for the purpose of identification and traceability of animals and for inclusion in end-to-end digital chains of the full production cycle of animal products.
- Digitalization in SCM of livestock production and use of "digital herd" technologies, implementation of life cycle and traceability processes to ensure high quality, including for export of livestock products ("green corridors");
- Work on standardization of formats and protocols for data exchange between production management information systems in order to increase the competition of digital solution providers with priority to domestic software developers while maintaining compatibility with global standards;
- Development of digital technologies of domestic breeding and accelerated breeding of new plant varieties and animal breeds adapted to specific soil and climatic conditions of the regions, with a high potential for yield, weight gain and resistance to diseases and damage by pests with the creation of breeding and seed-growing centers in the regions;
- Assistance in the development and implementation of new educational programs and training standards in the system of higher and secondary professional education on innovative technologies of digital agriculture (including the use of direct seeding, precision farming technology, biotechnology, etc.), including advanced training courses for agricultural enterprises, providing a set of measures for the transfer of knowledge and dissemination of technologies of saving agriculture and biotechnologies in agricultural production;
- Creating a cross-cutting platform for monitoring agricultural production processes to ensure the operation of social nutrition systems in Russia;
- Creating data sets and procedures for creating information systems for bidding, purchasing, and managing export and import of agricultural products;
- Integration of information systems of market participants and the state into a distributed and open "metasystem" that provides integration of knowledge bases on innovative technologies for environmental and economic efficiency of agriculture across all working systems, including traceability systems, data on seed and genetic stock, data of fertilizer suppliers, etc.

Implementation of the program will contribute to the development of a new agricultural technology policy of the Russian Federation and growth in related industries: ICT (information and communication technologies), production of innovative agricultural machinery and equipment for precision farming, biological preparations (plant protection products, stimulants and fertilizers), optimization of the use of mineral fertilizers and chemical plant protection products, reducing environmental impact, and development of breeding and seed centers, introduction of new educational standards in training programs in agricultural universities and colleges, as well as in advanced training courses, professional service of agricultural consultants, optimization of the life cycle of the agricultural industry through Digitalization in SCM of processes.

At the current stage of economic development, Digitalization in SCM in agriculture provides an opportunity to create complex automated production and logistics chains that cover retail chains, wholesale trade companies, logistics, agricultural producers and their suppliers in a single process with adaptive management. In turn, the Digitalization in SCM of commodity flows and production makes it possible to accumulate systematically trade parties for the export of agricultural products.

The digital transformation scenario assumes a systematic, accelerated digitization of agricultural production and integration with the digital economy program areas [15-18]. This dictates the need for inclusive use of logistics cargo transportation, stimulating domestic consumption, developing product exports, and building platforms that provide end-to-end digital solutions for generating added value and ensuring the competitiveness of Russian business.

The scenario implies a step-by-step development of Digitalization in SCM of domestic agriculture in production cycles. Taking into account the ""horizontal nature" of the transformed industry as a whole, this will ensure the creation of life-cycle chains for production and sales of products:

It is assumed that at the first stage (2018 - 2021) of digital technology implementation, methods for stimulating the introduction of digital technologies by

agricultural producers (the "give & take" model 3) are piloted, objective data from market participants is collected and analyzed, and data necessary for digital farming is reintegrated and enriched by state information sources. Piloting takes place on a prototype of the public-private platform "digital agriculture" with the participation of the information system of the Analytical Center of the Ministry of Agriculture of Russia and other systems.

The issues of developing "Internet of things" platforms for managing agricultural machinery and equipment, integrating data into corporate governance systems, developing "digital field" commercial applications, and others should be considered from the point of view of providing a favorable regime for creating a highly competitive environment.

At the first stage of digital transformations in agriculture, its participants together with the Ministry of Agriculture of the Russian Federation form and ensure the process of determining dynamic seasonal KPI for agricultural sectors [19].

At this stage, it is necessary to create a National Union for Digital Transformation of Agriculture, which will act as a Competence Center that provides access to all interested participants in the agro-industrial market. The Union is also responsible for the development of Euro-Asian contacts in the field of Digitalization in SCM of agriculture.

The key task of the Union should be studying the effectiveness of digital technologies and coordinating pilot implementations at enterprises in the regions of Russia. The Union will need an open directory of available technologies and provide recommendations to the Russian industrial complex for the production, localization, development and import substitution of technologies of paramount importance. The Union will provide:

- classification of tasks and identification of problems in the field of implementation of cyber-physical systems (Internet of things), big data analysis, integration of business management systems and traceability systems and other information systems used in agriculture;
- ranking tasks by importance and identifying specific problems related to the Digitalization in SCM of the industry, including legal regulation;
- formulation of solutions in the interests of the industry;
- consolidation of opinions of market participants and preparation of draft regulatory documents, and their coordination with representatives of state authorities.

The Union will work on interaction with state and municipal authorities on the use of digital technologies and adaptation of legislation, as well as on coordination with other areas of the digital economy.

The Union will conduct analytical research aimed at digital development of agriculture, analysis of global trends, disclosure of export opportunities and development of recommendations to support domestic producers of digital solutions for the agro-industrial complex.

The second stage (2021 - 2024) affects large and medium-sized agricultural enterprises. At this stage, the approved technologies should be scaled up by economic entities, including using incentive measures, by shifting state support in favor of enterprises that implement Digitalization in SCM processes and technologies using methods of objective control over production. This, in turn, will allow agricultural producers to integrate into the global space, using global standards for compliance with quality requirements and traceability of products.

At the second stage, digitization of selection technologies, seed stock, genetic fund of livestock producers, and genomic selection will be implemented, intelligent decision support systems for agricultural enterprises will be created and tested in the pilot territories, intelligent decision support systems for agricultural enterprises will be created and tested in the pilot territories, and a digital plan for ensuring food security will be formed separately.

At the second stage, it will be necessary to build digital chains to support logistics of supply and sales of products with parallel processes of Digitalization in SCM of transport and logistics, exchange of information received from vehicles with operators of digital platforms, interested Federal authorities, and creation of digital logistics nodes.

At the second stage, it is also necessary to launch technological and organizational bases for distance learning and professional development of employees of the agro-industrial complex with access to the most advanced technologies in the field of agriculture and product processing.

It is also necessary to provide assistance to Russian scientific institutions working in the agricultural sector in launching a system of scientific advice, producers on technologies for growing crops, animals and processing products.

At the third stage (2022-2024), it is necessary to create an end-to-end system of information support in the field of agriculture, it will be necessary to digitize all

cycles of agricultural production, which will reduce the cost of production and increase the availability of products, including by minimizing the participation of intermediaries in sales chains. There will be digital fragmentation (division of labor) and "uberisation" of farms (for example, the owner of cattle and dairy production is responsible only for feeding, walking and milking, the supply of feed, medicines, slaughter, export of products is carried out by specialized companies).

At all the above stages, private digital production management platforms, cloud and edge 6 systems for managing cyber-physical systems and the Internet of things, and predictive platforms for information support for solving individual production tasks will be implemented. A fundamental feature of the digital platforms being implemented in agriculture is their openness and deep integration into the metasystem, which provides support for the life cycle of the entire industry and quality control in the framework of a risk-based approach based on data analysis and predictive models [20, 21]. The prototype of the metasystem can be the public-private platform "digital agriculture", which continues its development from the first stage. Here it will be necessary to establish a reasonable balance between the openness of data and the confidentiality of data of business participants

"Smart" agriculture", according to the world rating of the potential positive effect of global technologies, ranks 1st place in the world. Digitalization in SCM of Russian agriculture will require an active phase of investment in agro-industrial companies.

A significant part of the process is Digitalization in SCM - the introduction of the Internet of things, the development of applied mathematics, consulting and data processing - these are tasks that can only be implemented with private funding.

The first and second stages will need to be implemented, including by attracting investment from private and institutional investors. In general, Russia will have to pass the stage of attracting investments in digital agricultural technologies similar to the United States (2010-2012), Europe and Asia (active investment attraction is currently taking place). At the third stage, the active phase of mergers and acquisitions of digital market participants in agriculture is obvious.

The main investment in the deployment and maintenance of technological equipment for digital agriculture will fall on the shoulders of business. The role of business is to introduce reliable, accessible, secure and cost-effective communications, computing power, information systems and services, and digital platforms created with priority use of domestic technologies that contribute to the development of agricultural production.

The role of the state and planning in the large-scale development of digital agriculture will grow significantly by providing favorable fiscal and regulatory regimes, as well as by creating a "heavy" infrastructure that requires the longest possible investment:

1. the established (incentive) rate of Bank lending, depending on the degree of Digitalization in SCM, expressed in the presence of mechanisms for obtaining objective data from the creditable economy;
2. providing access to online satellite sensing data and digital GIS substrates in maximum detail;
3. direct participation of the state in solving international issues related to increasing the volume of export products;
4. improving the state's legal regulation of food quality, information space, and simplifying the use and maintenance of the Register of UAV and drones;c
5. deployment of state weather radars and integration with private weather stations of economic entities that provide the most accurate local weather forecast using data analysis. Processing thousands of data sources can be handled by the Russian leaders of the Internet technologies (such as Yandex or Mail.ru);
6. the created digital transport and logistics systems together with wholesale distribution centers (RCS, Agrohabs) of agricultural products will become part of the agricultural production ecosystem. The state and private business will become partners in the construction of this infrastructure that meets the needs of agriculture within the framework of the "Digital transport and logistics" program.

Business in order to digitalize agriculture expects the state to participate in the following areas:

- formation of methodology for planning, forecasting, monitoring and reporting in the implementation of agricultural development programs;
- reducing the costs of organizations when reporting and interacting with control and supervisory authorities in a digital automated format. Native integration of reporting is in real-time mode. Maintaining traditional reporting methods for businesses that do not support digital production tracking formats;
- improving decision-making efficiency by switching to electronic exchange of documents (information), automating procedures and processes, and using automated decision support systems;

- ensuring coordination of activities of federal and regional executive authorities, local self-government bodies and interaction with business representatives on issues of agricultural development;
- providing effective projects that can be scaled up in the regions of the Russian Federation, for example, the "social nutrition" project: creating a food basket using digital traceable food production chains;
- creating a system of educational programs that provide retraining, modern literacy of specialists, and the formation of personnel competence for digital agriculture;
- rapid adaptation of legislation to the technological requirements necessary for the intensive implementation of digital agriculture;
- ensuring coordination of regional and federal executive authorities in the application of digital technologies implemented in rural regions;
- encouraging agricultural producers to implement digital technologies using state support;
- assistance to telecommunications companies in expanding their coverage area on agricultural land;
- maximum implementation of electronic document management, reporting, automation of public services and decision-making systems.

The implementation of the outlined concept of digital transformations in agriculture will increase the share of enterprises using digital technologies from 1 to 60%, and the export of products will increase from 25 to 45 billion dollars. The number of jobs related to information technology will increase from 1% to 20%.

Table 1 – Quantitative indicators of the digital transformation in SCM

Indicators	2018	2021	2024
Share of agribusiness enterprises using Internet of things, precision agriculture, digital herds, and smart greenhouses	< 1%	20%	60%
Share of coverage of agricultural land by various communication technologies	< 10 %	30%	70 %
Share of agricultural enterprises equipped with objective control tools and transmitting data for receiving subsidies in electronic form	< 10 %	50%	100 %
Quantity (volume) of products sold on electronic platforms	< 1 mln	3 mln	7 mln
Number of private weather stations on agricultural land	less 10 %	50%	80 %
Number of cargoes of medium and large agribusiness companies moved within the framework of the EEC (EEU) with connection to the "Transport and logistics" platform	25 billion $	30 billion $	45 billion $
Export	<1%	8 %	20 %
% jobs related to information technology, data processing and cyber-physical systems (Internet of things) in rural areas			

Indeed, the achievement of such indicators will not be possible without state support and a well-organized organizational mechanism for the introduction of digital technologies.

4. Conclusions

These technologies change supply chains and drive new ways to create value. However, not all companies chose this path of digitalization due to significant investment costs, and thus risk becoming laggards. The implementation of the main components of the digital transformation of SCM concept will allow the real sector of the economy, which is strategically important for Russia, to be involved in the digital economy. It should be noted that all over the world, the service sector is subject to digital transformations. The implementation of this concept will also help to remove a number of contradictions in the agro-industrial complex, such as the disparity in prices for agricultural products, and will help to reduce production costs. The system of education in agricultural universities and the system of retraining will undergo significant transformations. They will not only focus on the use of digital technologies of SCM in the educational process, but will also have to demonstrate them.

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