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DIGITAL TECHNOLOGIES IN AGRICULTURAL ENTERPRISE MANAGEMENT

Abstract. The article investigates the theoretical and practical principles of using digital technologies in the management of agricultural enterprises. The dynamics of Ukraine's position in the world ranking of digital competitiveness is analyzed, the leading countries in digital transformation of economic systems are identified in order to study the progressive experience of digitalization of the economy, its spheres, agriculture in particular. The evolution of technologies and business ideas in agriculture, which can be represented as a two — factor model of development, is studied. The comparative analysis of approaches to conducting agrarian business is carried out. It is noted that almost all large holdings in Ukraine are now actively investing and implementing digital solutions, it can also be seen that at all levels of agricultural production the country already has its leaders with extensive experience in implementing digital technologies. It is hypothesized that an important indicator of the development of digitalization are digital technologies formed with world experience. They can be divided into eight main areas of activity: FMS (farm management systems); data collection and aggregation (for precision farming), forecasting; marketplaces; robotic equipment and drones; sensors; reasonable irrigation; animal husbandry; next generation farms. Based on world experience, the peculiarities of the application of certain digital technologies in certain areas of agriculture are considered and assumptions are made about the possibility of their use in the realities of domestic agricultural production. It is concluded that the path or vector of digitalization in agriculture can be represented as three stages for agricultural holdings and two stages (without the last) for relatively small farmers: the first stage characterizes the agricultural company with efficient business processes (here must be implemented and fully integrated internal accounting systems). and a single digital back office); the second stage of development is a digital technology company (it uses innovative technologies such as precision farming, artificial intelligence (AI), computer vision (CV), machine learning (ML), etc.); the third stage is the ecosystem of the agricultural holding (a whole infrastructure of innovations has already been built here).

Keywords: digitalization, digital technologies, agriculture, digitalization of agricultural production, digital infrastructure of agricultural enterprise.

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ЦИФРОВІ ТЕХНОЛОГІЇ В УПРАВЛІННІ СІЛЬСЬКОГОСПОДАРСЬКИМ ПІДПРИЄМСТВОМ

Анотація. Досліджено теоретичні та практичні засади використання цифрових технологій в управлінні сільськогосподарським підприємством. Проаналізовано динаміку позиції України у світовому рейтингу цифрової конкурентоспроможності, визначено країн — лідерів із цифрової трансформації економічних систем з метою дослідження прогресивного досвіду цифровізації економіки, її сфер, сільського господарства зокрема. Досліджено еволюцію технологій і бізнес-ідей у сільському господарстві, яку можна представити у формі двофакторної моделі розвитку. Здійснено порівняльний аналіз підходів до ведення аграрного бізнесу. Зауважено, що практично всі великі холдинги України зараз активно інвестують і впроваджують цифрові рішення, також можна свідчити про те, що на всіх рівнях сільгоспвиробництва країни вже є свої лідери з великим досвідом упровадження digital-технологій. Висунуто гіпотезу, що важливим індикатором розвитку цифровізації є цифрові технології, що сформувались із світовим досвідом. Їх можна розділити на вісім основних напрямів діяльності: FMS (системи управління фермою); збір та агрегація даних (для точного землеробства), прогнозування; маркетинг; роботизована техніка і дрони; сенсори; розумне зрошення; тваринництво; ферми наступного покоління. На основі світового досвіду розглянуто особливості застосування окремих цифрових технологій в окремих сферах сільського господарства і здійснено припущення щодо можливості використання їх у реаліях вітчизняного сільськогосподарського виробництва. Підсумовано, що шлях або вектор цифровізації в АПК можна представити у формі трьох ступенів для агрохолдингів та двох ступенів (без останньої) для відносно невеликих сільгоспвиробників: перший ступінь характеризує агрокомпанію з ефективними бізнес-процесами (тут повинні бути впроваджені і повністю інтегровані внутрішні системи обліку і єдиний цифровий бек-офіс); другий ступінь розвитку — це вже цифрова технологічна компанія [вона використовує інноваційні технології, такі як точне землеробство, штучний інтелект (AI), комп'ютерний зір (CV), машинне навчання (ML) та ін.); третій ступінь — це екосистема агрохолдингу (тут уже збудована ціла інфраструктура інновацій].

Ключові слова: цифровізація, цифрові технології, сільське господарство, цифровізація сільськогосподарського виробництва, цифрова інфраструктура сільськогосподарського підприємства.

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Introduction. The state and development of agriculture in domestic economies was significantly influenced by the revolution of technological systems, each of which increased the level of efficiency, productivity, and, accordingly, profitability to a previously unattainable level. Experts' forecasts for the coming years converge on the point that the digital revolution in agriculture will be a catalyst that will allow the agricultural sector to meet the needs of future generations. In other words, the digital revolution of agriculture will fully meet the requirements of sustainable development. Digitization will have the ability to transform all parts of the value chain of agricultural products. The resource management of any element of this chain can be built on the principles of optimization, individual approach, reasonableness and predictability. The operation of the system in real time will be ensured by establishing a hyper-connection with the information system.

Within the production and distribution chains it will be possible to ensure full control and coordination, to create optimal models of management of agricultural lands, crops and animals. Digital agriculture will be an environment for creating systems that are characterized by high productivity, predictability and the ability to adapt to change, including those that provoke a changing climate. This, in turn, can help increase food security, profitability and the resilience of the national economy.

In the context of the goals of sustainable development, digital agriculture is able to provide society with economic benefits by increasing productivity, efficient use of financial resources and

market opportunities, by expanding communications and greater inclusion — social and cultural benefits, by optimizing resource use and adapting to change. climate — environmental benefits.

Analysis of research and problem statement. Issues of conditions, models and principles of digital transformation of business process management are covered in studies of both foreign and domestic scientists, including S. Veretyuk [4], O. Dannikov [6], L. Kit [7], S. Kolyadenko [8], O. Pizhuk [13], V. Pilinsky [4], K. Sichkarenko [6] and others.

Unsolved aspect of the problem. At the same time, the issues of digitalization of business processes of certain spheres of the national economy, in particular agriculture, use of modern advanced progressive world experience of digital transformation of business models of business structures management remain in the field of scientific interests.

The purpose of the article. The aim of the article is to study and systematize the progressive experience in the digital transformation of business models of agricultural enterprises in order to increase the efficiency of their activities.

Research results. Characterizing the current state of digitalization of Ukraine’s economy, in particular in the field of agriculture, experts use analytical data from international rankings. One of the indicative authoritative international rankings that characterizes the digital competitiveness of countries is the Digital Competitiveness Index — IMD (WDC) analyzes and evaluates the ability of countries to adopt and study digital technologies that lead to transformation in government practice and business models. society as a whole. As in the case of IMD’s global competitiveness ranking, it is assumed that the digital transformation takes place primarily at the level of enterprises (private or public), but it also occurs in government and society. Based on research, the WDC ranking methodology determines digital competitiveness based on three main factors [1]:

1) knowledge (know-how, the need to discover, develop, understand and build new technologies), in turn, is revealed through: talent; training and education; scientific concentration.

2) technology (general context that allows the development of digital technologies), in turn, is revealed through: regulatory framework; capital; technological framework.

3) future readiness (the level of readiness of the country to use the results of digital transformation), in turn, is revealed through: adaptive attitude; business agility; IT integration.

The assessment of the dynamics and place of Ukraine in the Digital Competitiveness Ranking is shown in *Fig. 1*.

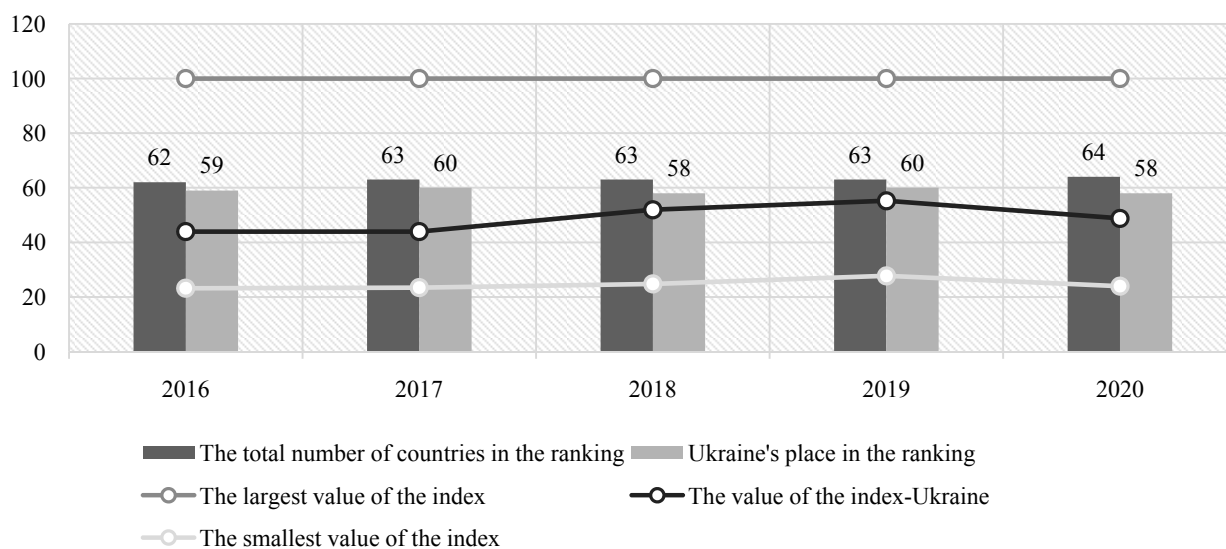


Fig. 1. Assessment of the dynamics and place of Ukraine in the Digital Competitiveness Ranking

Source: based on data [1].

The total number of countries included in the digital competitiveness ranking is 64 in 2020. The maximum value of the index of this rating in the last rating year is 100.00, the minimum — 23.99. Ukraine’s rating position is below the average value, amounting to 48,807, which

corresponds to a rating of 58. At the same time, the rating position rose by 2 points compared to 2019.

According to the latest rating in 2020, the top five leading countries in digital competitiveness include: the United States (100.00), Singapore (99.37), Sweden (96.07), Denmark (95.23) and Switzerland (94.65), while the rating score of Ukraine is 48.81. According to the average rating indicator of the studied period, the leading position is occupied by Singapore. The fastest rate of increase in digital competitiveness in 2020 compared to 2018 according to the rating is observed in Ukraine (excluding other rating positions). In other words, Ukraine’s digital competitiveness is inferior to other countries. In order to increase the level of digital competitiveness of Ukraine, it is advisable to study the experience of digitalization of economic systems and models of the leading countries in the ranking, in particular, this applies to the development of solutions in the field of digitalization of agriculture.

Digital solutions are increasingly penetrating all segments of agriculture. To achieve growth in the profitability of agribusiness, it is extremely important to make maximum use of innovative technologies. The same companies that in the near future will be able to combine their business into a single system based on a digital platform, will become the undisputed market leaders.

The evolution of technologies and business ideas in agriculture can be represented as a two-factor model of development (Fig. 2). The horizontal axis is time, and here we can conditionally distinguish three stages-approach to agribusiness: the traditional way, digital agriculture and ecosystems of market participants. The vertical axis is a complexity of technological development, it can be used mainly for breeding and seed production as the main drivers of yield growth [2; 5].

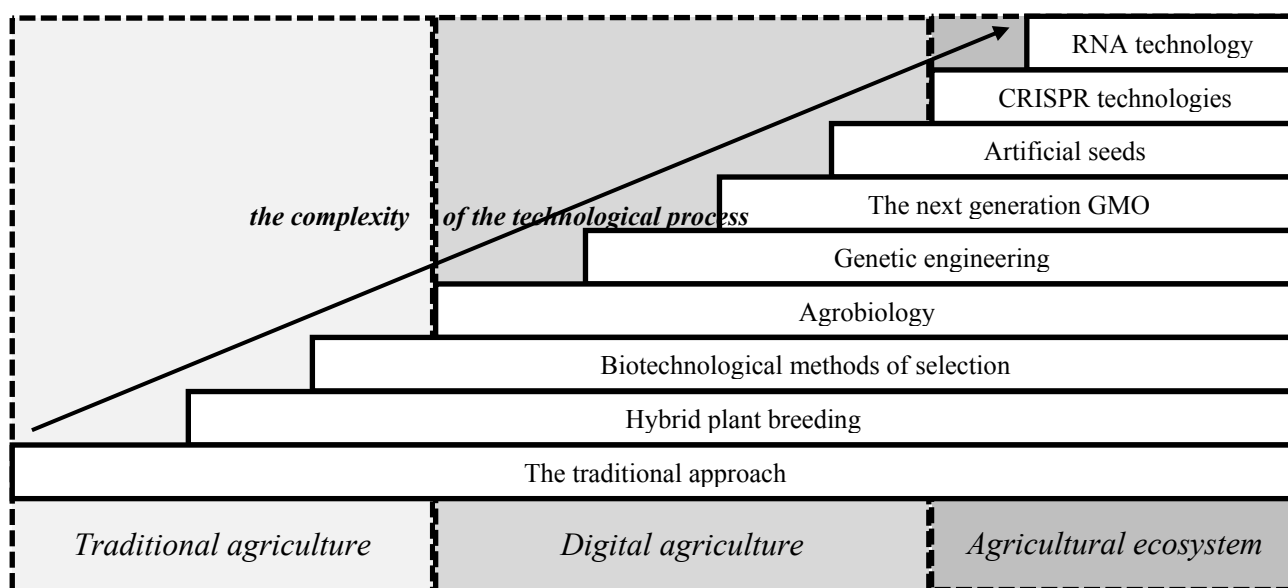


Fig. 2. Evolution of the technological basis of business models of agricultural enterprises

Source: compiled according to data [2; 5].

In traditional agriculture, a high dependence on the human factor is clearly expressed. There are such factors as relatively low yields with relatively high production costs. And the factor of success, as a rule, is a good price situation.

In digital agriculture, there is a clear focus on the efficiency of each operation. Digitalization of agricultural machinery, sensors, unmanned aerial vehicles and other digital elements help to achieve this. Thus management of production processes is automated. Production shows a relatively high yield at a relatively low cost [13].

The third approach in Ukraine is just beginning to emerge — the creation of ecosystems of market participants, new businesses and partnerships. It is expressed not just in the use of certain digital solutions, but in the cooperation of entire digital platforms of many market participants. In this case, we are talking about the sale of not only products but also services (eg, transport,

logistics, sales, etc.). Not only classic agricultural holdings, but also IT giants will be included in the competition here.

Domestic farmers are mastering digital technologies by leaps and bounds. Almost all large holdings in Ukraine are now actively investing and implementing digital solutions. It is also safe to say that at all levels of agricultural production the country already has its leaders with extensive experience in implementing digital technologies, and we see a clear upward trend. This process is mutual: on the one hand, new solutions for various areas of agricultural activity regularly appear, and on the other hand, enterprises come to understand that the introduction of digital technologies is necessary for sustainable development. The scenario that in 10 years, other things being equal, more than 80% of domestic agricultural enterprises will use digital solutions in their work [5, p. 36].

In Ukraine, there is an active development of almost the entire range of elements of precision farming, but at the moment the most popular are satellite positioning technologies, GIS-systems and systems for monitoring and control of equipment and quality of work performed. The market of ERP-systems for agriculture, control and accounting systems in various branches of agricultural production, the market of specialized data and programs for their storage and processing for making the right and timely decisions is also rapidly developing.

Changing demand is a difficult issue, because domestic farmers are forced to learn new technologies abruptly, rather than smoothly and progressively. Such rapid development does not always allow to competently adapt new digital solutions, to understand the applied aspects and to determine their practical benefits. However, everything goes to the fact that over time, the decision-making process and the equipment itself in agriculture will be even more automated — the farmer will become the operator of various monitoring systems.

Another important indicator of the development of digitalization is digital technologies formed with world experience. They can be divided into eight main areas of activity: FMS (farm management systems); data collection and aggregation (for precision farming), forecasting; marketplaces; robotic equipment and drones; sensors; reasonable irrigation; animal husbandry; next generation farms (mostly vertical greenhouses).

A large number of technology companies that have grown from startups respond to the main demand of farmers — data collection, aggregation and analysis. The decisions of American companies declare the use of new and very effective technologies — artificial intelligence, computer vision and machine learning. Some domestic companies are also trying to use these technologies, especially on an industrial scale — to analyze NDVI images (map of photosynthetic active biomass) of tens of thousands of hectares of arable land, counting the number of apples on thousands of hectares of orchards. This allows you to timely and accurately address the problems of poor seedlings, insufficient green mass, identify foci of disease and pests, predict with a high degree of accuracy the harvest and, as a result, more accurately plan harvesting, transport, storage and / or work.

Digital technologies in animal husbandry are based on the analysis of data from sensors and sensors. However, these are probably the least «useful» of the technologies: they often work only with a certain set of data, while dairy complexes have a common practice of using system integrators that cover all areas of digitization that work with the entire set of farm-generated data.

In the United States, urban vertical greenhouses are being actively developed, allowing developers and farmers to find synergies and meet the demands of the western urban population for greening. Soon the new generation of digital technologies will include not only vertical production, but also new methods of growing live ingredients (aquaculture, insects, algae, microbes) [2; 3].

Irrigation is an effective way to increase yields, and smart irrigation is even more effective. Therefore, this area of digital technology is also not left out. Of course, the greatest demand for them is observed in areas with arid climates, but in Ukraine, smart irrigation technologies, albeit «self-written», without the software of Western startups, are already used.

Such a group of digital management technologies as agromarketplaces on a global scale is still poorly developed, except, perhaps, one case — Indigo — a biotechnology company that organized agromarketplace in the United States, through which transactions worth hundreds of

millions of dollars. The situation is that agromarkets are not created by farmers themselves, but by other market players. In many countries, including Africa, such as Kenya, there are large enough electronic platforms for trade in agricultural products. In India, the online food trading platform (eNAM) has been launched by the Ministry of Agriculture. However, this is a new trend, as agricultural products, in contrast to industrial and consumer goods, generally have less clear specifications and pricing system. But it is worth remembering that marketplaces have other positive effects. For shareholders and top management it is first of all transparency and efficiency of receiving data on structure, volume, sales prices, optimization of document flow, convenience for buyers. Currently, none of the largest domestic agricultural producers has a full-fledged marketplace, although many of them make purchases through their own electronic platforms.

Decision makers need more data. If digitization is properly implemented, it can be used to capture data collection and analyze results throughout the production cycle. The collection of this data is due to the automation of process registration, which, in turn, partially replaces manual labor. And the first obstacle to the development of these trends is the human factor, as employees often show resistance and fears associated with the transition to digital solutions. However, over the past few years, demand for them has grown by about 25% [11, p. 202].

For example, in pig farming, genetic companies are increasingly using accurate digital data to ensure the most accurate genetic selection. But before you start implementing certain solutions, you need to determine why you need it, what can be changed using these technologies, and what data will be most interesting. For example, to regulate feed consumption during gestation, sows can be switched to group housing instead of individual cells, and then electronic feeding systems can be a means of data collection. They will provide an opportunity to collect information on the weight of the animal, the amount of food consumed, which will allow daily analysis of the dynamics of changes that will occur with each animal.

Thus, the path or vector of digitization in the agro-industrial complex can be represented as three stages for agricultural holdings and two stages (without the latter) for relatively small farmers (Fig. 3).

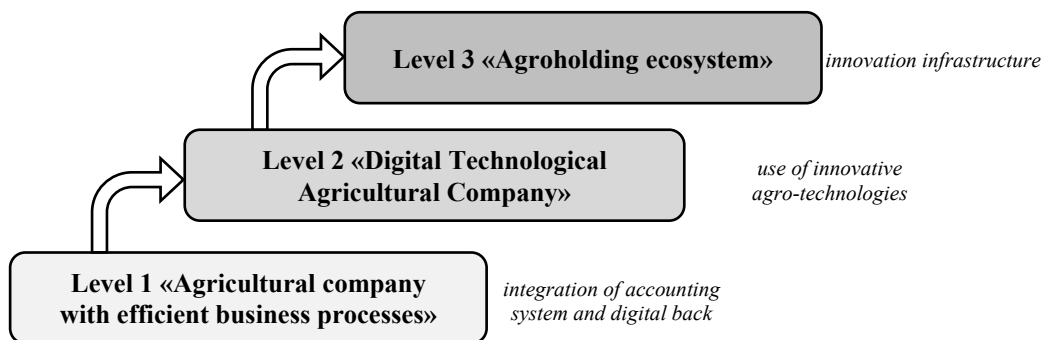


Fig. 3. Vectorization of digitalization in the agro-industrial complex

Source: compiled according to data [2; 5].

1. The first stage characterizes an agricultural company with efficient business processes. Internal accounting systems and a single digital back office should be implemented and fully integrated here. The construction of dashboards (info panels showing the values of the most important business indicators in real time) and the accumulation of a database of production performance indicators should be used.

2. The second stage of development is already a digital technology company. It uses innovative technologies such as precision farming, artificial intelligence (AI), computer vision (CV), machine learning (ML) and others. Supply chains in such production are built online, sales are omnichannel (carried out both offline and online). Various innovations are constantly being implemented.

3. The third stage is the ecosystem of the agricultural holding. A whole infrastructure of innovations has already been built here. Market participants are integrated into a single system

based on the digital platform of the agricultural holding. And the sale of digital solutions / services in the agro-industrial complex exists as a separate business.

Conclusions. Thus, in the coming years, the digitalization of the agricultural sector will cause significant changes in agriculture and production of this industry. It can ensure the production of economic, environmental and social benefits, but at the same time provoke a number of problems. Uneven access to digital technologies and services means the risk of a digital divide. Small farmers and other rural people run the risk of not keeping up with the transformation, not only in terms of computer literacy and access to digital resources, but also in terms of productivity and various aspects of economic and social integration. To get the result, the introduction of technology is not enough. Social, economic and political systems will have to provide the basic and accompanying conditions that will enable the digitization of agriculture. To achieve an increase in business profitability, it is highly desirable for agricultural enterprises to fully master the second step of the path proposed above. For true leadership in the industry in 7—10 years should strive to take the third step. But right now, many domestic agricultural companies are facing the tasks of the first two stages of development. However, not all industry representatives are confident in the positive economic effect of digitalization. In this regard, it is extremely difficult to find evidence or convincing calculations of the economic effect of certain measures related to it.

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