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State regulation of agriculture in the conditions of digitalisation of Ukraine's economy

Svitlana Stender*
PhD in Economics, Associate Professor
Higher Educational Institution "Podillia State University"
32316, 12 Shevchenko Str., Kamianets-Podilskyi, Ukraine
https://orcid.org/0000-0002-6234-1877

Valentyna Borkovska
PhD in Economics, Associate Professor
Higher Educational Institution "Podillia State University"
32316, 12 Shevchenko Str., Kamianets-Podilskyi, Ukraine
https://orcid.org/0000-0002-2983-2973

Inna Balla
PhD in Economics, Associate Professor
Higher Educational Institution "Podillia State University"
32316, 12 Shevchenko Str., Kamianets-Podilskyi, Ukraine
https://orcid.org/0000-0001-5041-9801

Abstract. Agriculture has a strategic role in providing food for the population. This causes significant government intervention in this sector, and therefore the development of high-quality approaches to this process remains relevant. This study aimed to provide recommendations for this process in Ukraine, particularly in the context of economic digitalisation. To achieve this, graphical analysis, modelling, abstraction, and the method of logical reasoning were used. The role of digital technologies in achieving more effective results in the context of improving the efficiency of agricultural development was described in detail in the paper. In addition, a conclusion was made about the necessity of cooperation between the state and enterprises in this area. This is primarily associated with the challenges that may arise in companies implementing such practices. Understanding the presence of these challenges, the likelihood of further implementation of such type of technologies in enterprises decreases. Several approaches were proposed in the paper to reduce the negative impact on agricultural companies. Given the consequences of the full-scale Russian invasion of Ukraine, particular attention was paid to non-financial approaches, as well as to the problems existing within the current legislative framework. Furthermore, separate conclusions were drawn based on statistical data regarding the development of science and education in Ukraine overall. The study's practical value lies in that the findings will enhance the efficiency of the state sector's functioning in Ukraine in agricultural regulation

Keywords: innovation; agricultural sector; technology implementation; regulatory framework; management and governance

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*Corresponding author

INTRODUCTION

Agriculture is one of the most important sectors of the Ukrainian economy, which is, in turn, a leading global producer of grains, sunflower oil, and other agricultural products. This sector also plays a crucial role in ensuring the country's food security and stockpiling food resources for the Ukrainian population. Additionally, agriculture serves as the primary economic driver for many rural communities, and its development contributes to job creation and maintaining the viability of rural areas.

Digitalisation, in turn, remains a critical component of the country's development across various spheres of life, including the economy, the social sector, and science (Nasirahmadi & Hensel, 2022; Abbasi *et al.*, 2022). It enables process automation, management optimisation, cost reduction and innovation acceleration, stimulating gross domestic product (GDP) growth, enhancing international competitiveness, fostering job creation and the development of small and medium-sized businesses, which are the primary source of employment in most countries, and stimulating innovation and scientific research (Zscheischler *et al.*, 2022). Another significant factor is the ability to improve people's quality of life through digital technologies, including enhanced access to education, healthcare, e-government services, e-commerce, and other services, which enable more effective resolution of social problems and reduction of social inequality.

Digitalisation can also be implemented in agriculture. Given the role of agriculture, ensuring the development of its digital component remains relevant. Considering the situation in the country (2024) related to Russian aggression, it is quite difficult to formulate such a policy that would be aimed at developing digitalisation in this sphere. Although the state and enterprises have the same goal in this context, especially considering that digitalisation has a positive impact not only on the economy but also on other components of the economy's functioning, they often cannot reach an agreement to ensure the effective implementation of this concept. Nevertheless, the search for such approaches remains relevant. Thus, A. Subeesh & C.R. Mehta (2021) conducted a comprehensive review of the role of artificial intelligence and the Internet of Things in agriculture, focusing on their contribution to digitalisation and automation. They described that these components play an important role in modernising agriculture through the automation and control of various types of agricultural activities. In addition, the researchers described the role of these technologies in ensuring food security and more effective management. The impact of digitalisation on the development of agriculture was also assessed by Y. Tang & M. Chen (2022). The researchers concluded that digitalization has a significant impact on agriculture, although they noted the existence of regional differences (the degree of this impact may vary depending on the territory). Particular attention was paid to the need for a high-quality workforce to ensure a high-quality transition to digital principles. However, neither of the above-mentioned studies provided recommendations for state policy in this area at the state level.

The significant role of technologies in agriculture was also highlighted by H. Panetto *et al*. (2020). They emphasised the increasing complexity of doing business in agriculture and the growing demand for innovative solutions. This indicates the need for more active involvement from the state to support digitalisation in such enterprises. The situation in Ukraine was studied by G. Duginets & K. Nizheyko (2023). The researchers paid particular attention to the need for more active involvement of research institutions in digitalisation processes, based on the evaluated experience of the European Union. Attention was also paid to the impact of digital technologies on the activities of farmers, including the potential benefits that can be obtained from this process. M. Nehrey (2023) and M. Marchenko (2023) focused on the potential for the development of the digitalisation of agriculture in Ukraine. The researchers noted that the successful implementation of digitalisation processes in this sector in the country will make it possible to achieve a significantly higher level of competitive advantage in the international market. In addition, it will make it possible to manage various processes at enterprises more effectively. However, it is worth noting that not much attention was paid to the possibility of interaction between the state and private enterprises.

The purpose of this study was to formulate recommendations for state policy in the field of agriculture in the context of the digitalisation of the economy. The objectives of the study were: to build a model of the functioning of agricultural enterprises in the context of digitalisation and their interaction with the state; to analyse the economic consequences of digitalisation and to evaluate the regulatory framework of Ukraine in the field of agriculture and digitalisation.

MATERIALS AND METHODS

A certain source base was used in the writing of this article. The main part of it is statistical data provided by the State Statistics Service of Ukraine (Ukrstat,

n.d.). In addition, the content of the legislative framework was studied, namely Law of Ukraine No. 2297-VI (2022) and Law of Ukraine No. 2163-VIII (2024). However, it is important to note that as of 2024, not all information is publicly available, which causes some limitations in the study.

Nevertheless, it was decided to build a model to explain the need for government support for businesses in adopting digital technologies, how the profitability of such enterprises changes, and the consequences of these changes. Additionally, the model was expected to demonstrate the benefits to the government of supporting such enterprises and to describe the decision-making logic behind providing support. The model was constructed in the form of three graphs with the abscissa axis T (time) and the ordinate axis – I (income, for enterprises) or G (utility, for the state). The implementation of digitalisation as a whole project and its impact on business revenue were depicted in the figures. The entire time period was divided into stages to more clearly describe how changes occur within the business. The corresponding important indicators of revenue change over time were also reflected through appropriate markings. In addition, the changes that would occur in the company's operations in case of government assistance were analysed. For this purpose, it was assumed that the level of government support in such a case should be sufficient to prevent the company from reaching the point of unprofitability. It was also assumed that the company would be obliged to repay the assistance over time, namely during the period of receiving the highest level of income. The analysis itself was presented visually.

Subsequently, it was decided to analyse the retrospective benefits and losses for the government from helping such companies. For this purpose, the dependence G(T) was considered, where G – the utility of assisting such companies (by analogy with an investment project), and T – time. However, at the end of any project, there should be a benefit, which is presented in the form of an infinitely positive/negative part of the area. Thus, the total utility of the project can be represented as the difference between the sums of the areas above and below the graph. It was concluded that to find this, it is necessary to find the points of intersection of the graph with the T axis and to determine the sign of each part. Thus, the formula for finding the government's utility in aiding such companies is as follows:

$$G = \pm \int_0^a G(T) \pm \int_a^b G(T) \pm \ldots \pm \int_z^\infty G(T), \qquad (1)$$

where G – the benefit of the state from the company's assistance; a, b … – the corresponding points of intersection of the graph with the T-axis; G(T) – the formula for the dependence of the state's benefit on the company's assistance; if G(T) is positive at points between a certain interval (from 0 to a, from a to b …), then the sign before the integral is plus, and if it is negative, then minus.

It is important to note that the representation of the benefits of state-owned companies in the model is somewhat conditional, since the vertical axis within the model reflects utility rather than revenue. This utility is reflected in both social effects and environmental benefits. Therefore, their assessment requires rather complex evaluations. It is also worth noting some additional conditions for the model, specifically that the state will not try to find funds for the implementation of the project by creating new taxes or any similar action, but rather by foregoing alternatives. Also, for simplicity, the factor of discounting future cash flows/benefits from the project was not considered in detail, although this can be done when evaluating the schedule, reducing the weight of all future receipts compared to the initial ones: in this case, the schedule for an infinitely large period should approach zero.

The construction of the graphs was based on a theoretical understanding of how the enterprise functions and the probable impact of individual internal and external factors on it. A fairly large number of research methods were used to construct them, including the mathematical method, which made it possible to optimise the model by forming an equation for calculation and formalising the model; the graphical analysis method for evaluating the data that was formed within the framework of this model. A modelling graph was used to construct such a model. The Logical Reasoning method was used to form connections within the model, internal interaction. Abstraction was used to more effectively build a model by mentally highlighting the essential, most significant features, relationships, and aspects of the subject. In addition, the analysis method was used to study the impact of digital technologies on the development of agriculture, as well as its role in the state as a whole.

RESULTS

Supporting agricultural enterprises in adopting digital technologies plays a key role in increasing their efficiency, competitiveness and sustainability. This support can be financial, advisory or otherwise. The need for such support can be explained using the model shown in Figures 1, 2 and 3.

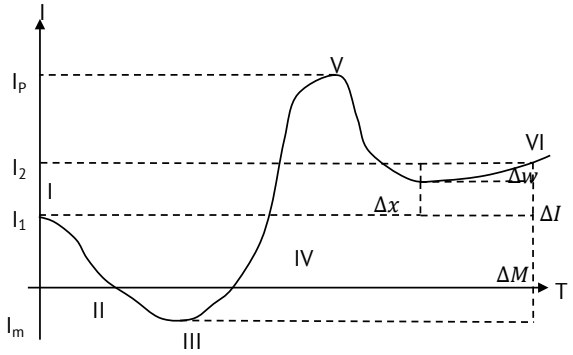

Figure 1. *Model of the implementation of digital technologies in enterprises*
Notes: *I, II, III, IV, V, VI – stages of implementation of digital technologies in enterprises; I – enterprise income; T – time; I1 – initial level of enterprise revenue; I2 – level of enterprise income after implementation of digital technologies; Im – minimum revenue level; Ip – peak profitability; Δx – difference between income before and after implementation of digital technologies; Δw – profit from further development of the enterprise; ΔI – total change in the level of enterprise revenue (Δx+Δw); ΔM – the amount of losses received due to the implementation of digital technologies at the enterprise in the short term*
Source: *compiled by the authors*

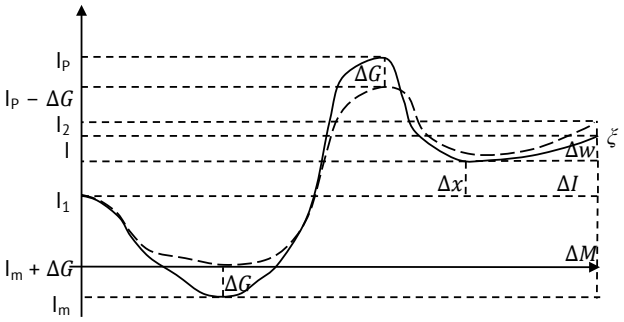

Figure 2. *Model of the implementation of digital technologies in enterprises in the case of state support*
Notes: *ΔG – the amount of assistance/return of funds from/to the state; ξ – the amount of excess profit received as a result of the implementation of digital technologies at the enterprise*
Source: *compiled by the authors*

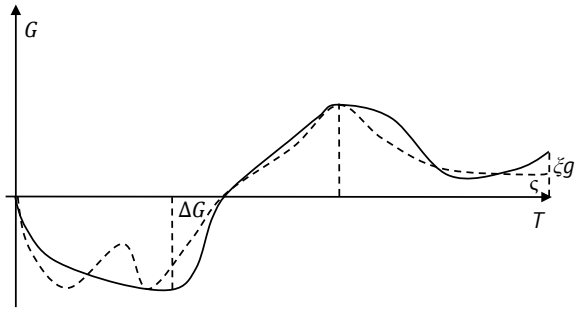

Figure 3. *Impact of support on the state*
Notes: *ξg – benefit received from helping the enterprise to implement new technologies; ς – benefit received from the alternative project*
Source: *compiled by the authors*

Figures 1, 2 and 3 show in detail why the state should be interested in helping enterprises (including agriculture) to implement new (digital) technologies. Nevertheless, it is worth describing in more detail the logic depicted in these figures. Thus, Figure 1 shows how the company's revenues look (change) during the period of implementation of digital technologies. At stage I, the company is just starting to implement technologies, as a result of which it receives a gradual decrease in profitability (stage II), which can even lead to losses for a certain period. At stage III, the company is at the lowest point in terms of income level (lower than the initial one by the indicator ΔM, where the risk of bankruptcy is the highest). The risks that the company bears at this stage are different, depending on both the financial condition of the company at stage I and the complexity of the process itself, as well as the company's preparedness for it. Thus, the enterprise may not feel the process of implementing digital technologies at all, or, at least, not get into the loss zone. At stage IV, there is a recovery of profitability, to the peak level V, which is associated with the effect of introducing new technologies and maximising profitability from it at the first stages (until it is implemented by competitors, demand does not fall, consumers do not get used to it). After that, profitability falls to a new level (I_2), which is already higher than the initial one (I_1) by the level Δx. In the future, the company continues to develop normally (stage VI), receiving a new growth rate, which should be higher than those observed in previous periods due to the effect of introducing new technologies (Δw), and therefore the total change in income for this period is equal to ΔI (in this case, this is Δx + Δw).

Thus, the implementation of digital technologies increases the company's income level in the medium and long term. However, in the short term, the company makes losses due to the significant difficulties associated with the implementation of these technologies. These difficulties are related to: the cost of technologies, the complexity of their implementation, maintenance and application, and the need for highly qualified personnel. This leads to the fact that not all companies are ready to implement such technologies, which in fact has a negative impact on the development of the country and these companies in the medium and long term. Therefore, in this case, the introduction of state support is becoming relevant. The change in the company's income level over time, taking into account the factor of state support, is shown in Figure 2. In this case, the maximum loss of the company is reduced by the amount of ΔG, which is the amount of state support. At the same time, the decrease in income in this case reaches the level of ΔM - ΔG, and the point of income level becomes equal to I_m - ΔG. In Figure 2, the level of state revenue is such that it does not allow the company to incur losses during the process of implementing digital technologies, since although in this case the company may agree to such an initiative, in reality, the volumes may be fundamentally different. Similarly, the same happens with the level of maximum profitability, which decreases by the amount of state support (the assumption is that the support amounts should be repaid over time on an interest-free basis) and becomes equal to I_p - ΔG. However, due to the benefit received from the use of state funds at the initial stage, the level of income that the company receives in the future becomes higher than that which would have been received without state assistance. This excess profit reaches the level of ξ. Thus, the state not only stimulates enterprises to implement digital technologies, but also allows them to increase their income, and therefore can also receive more benefits for itself, at least due to an increase in tax revenues.

How this process looks from the point of view of the state can be seen in Figure 3. The state has a certain amount of budget revenue, which it distributes among various projects from which it expects to receive a certain benefit. However, for the state, this benefit manifests itself not only in economic terms but also in other components – ecological and social. Thus, it is a derivative of the company's income and its activities, and is denoted in Figure 3 as ξ_g. On the other hand, the state will also receive benefits from the implementation of alternative projects: Figure 3 shows a variant of a set of projects that require state support, the benefit from the implementation of which is equal to ς. Thus, the total result obtained by the state can be depicted on the graph as the sum/difference of the area of the figures obtained as a result of the implementation of one or another project. It should be understood that the result may be negative, in which case the provision of such assistance is not necessary. Figure 3 is constructed in such a way that supporting enterprises in the implementation of digital technologies is beneficial, but the situation may also be the other way around.

While the model generally explains the basic principles of this approach, some other scenarios are also worth considering. For example, assistance can be non-reimbursable or, on the contrary, take the form of a loan. Moreover, it can be non-financial in nature: even assistance in the form of recommendations can significantly facilitate the process of implementing innovative technologies at enterprises. It is worth considering each of these options in more detail. Suppose the option of helping the company is such that it does not involve its return. In this case, the losses incurred by the state will be permanent, but the benefits that it will

receive from the activities of such an enterprise should be comparatively greater. If, however, assistance is provided in the form of a loan, the state can also receive financial benefits from this kind of investment, but this will create an additional burden on the enterprise. Thus, one should expect a relatively lower level of utility to be obtained from the operation of such a company.

A separate type of support that should be evaluated is non-financial assistance. It may include recommendations or advice provided to such companies on the digitalisation of their enterprises. However, the principles for forming such support programs are usually quite large-scale, prepared in advance and aimed at providing recommendations to all similar companies at once. In this case, assistance to the enterprise is part of a large-scale program, and therefore it is not correct to make calculations, since it is necessary to carry out more global assessments that can evaluate the combined result of all potential companies that plan to implement digital technologies, with an assessment of the estimated costs of such support. To understand and assess the situation in the context of the digitalization of agriculture in Ukraine, an analysis of statistical data from the agricultural sector was carried out (Table 1).

Table 1. *Costs of conducting various scientific research in Ukraine, considering inflation, and expenditure structure*

Years	Expenditure on research and development	Fundamental scientific research	Applied scientific research	Scientific and technical (experimental) developments
2010	8,107	2,175	1,589	4,343
2011	8,139	2,104	1,734	4,301
2012	9,024	2,505	1,938	4,580
2013	9,769	2,572	1,965	5,232
2014	7,240	1,871	1,437	3,932
2015	5,860	1,310	1,044	3,506
2016	5,463	1,055	1,214	3,195
2017	5,575	1,219	1,318	3,038
2018	6,366	1,426	1,354	3,586
2019	6,291	1,364	1,325	3,601
2020	5,910	1,479	1,379	3,053
2021	6,604	1,627	1,510	3,467
2022	4,268	1,018	1,204	2,047
Years	**Expenditure on research and development, %**	**Fundamental scientific research, %**	**Applied scientific research, %**	**Scientific and technical (experimental) developments, %**
2010	100	26.8	19.6	53.6
2011	100	25.9	21.3	52.8
2012	100	27.8	21.5	50.8
2013	100	26.3	20.1	53.6
2014	100	25.8	19.8	54.3
2015	100	22.4	17.8	59.8
2016	100	19.3	22.2	58.5
2017	100	21.9	23.6	54.5
2018	100	22.4	21.3	56.3
2019	100	21.7	21.1	57.3
2020	100	25	23.3	51.7
2021	100	24.6	22.9	52.5
2022	100	23.8	28.2	48

Source: *compiled by the authors based on data Ukrstat (n.d.)*

Table 1 shows that the largest share of expenditures on research work is occupied by scientific and technical (experimental) developments. However, it is worth noting that, despite the nominal increase in expenditures on scientific work, taking into account inflation, the volume of expenditures is decreasing, which indicates negative trends in the development of the scientific sphere in Ukraine.

The volume of support for the digitalization of the agricultural sector can be partially estimated by evaluating the volume of state support for the sector (Fig. 4).

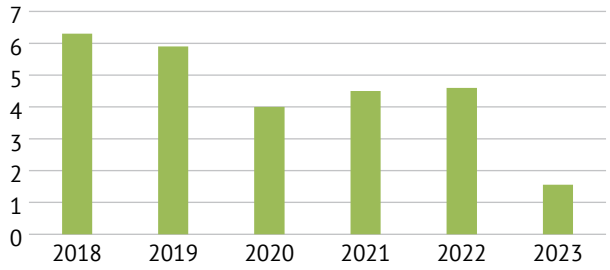

Figure 4. *Government support for agriculture in Ukraine, 2018-2023, billion UAH*
Source: *compiled by the authors based on Support for agriculture… (2023)*

As can be seen from Figure 4, the volume of government support for agriculture in Ukraine has been gradually decreasing over time, due to the onset of the COVID-19 crisis in 2020 and subsequently, the full-scale Russian invasion of Ukraine in 2022. In 2023, the volume of government support is the lowest, however, it is worth noting that it is provided not only from the state budget but also from individual international organizations, which is not considered in this figure. This trend is quite natural, given the problems in the country caused by the war. Nevertheless, the state should make more efforts supporting public sector enterprises if it intends to achieve better results in this direction. However, likely, this can only be done after the end of the war.

The digital economy interacts with agriculture through the introduction of technologies that enable more efficient production and management activities. For example, digital technologies such as sensors, drones, data analytics, and artificial intelligence are helping farmers manage their farms (Annosi *et al.*, 2020; Shoushtarian & Negahban-Azar, 2020). Precision irrigation and fertilization systems, for instance, ensure that crops receive the right amount of water and nutrients at the right time, leading to improved crop growth and yields (Bonvoisin *et al.*, 2020; Trivedi *et al.*, 2021). Digital technologies are also helping farmers anticipate and manage risks such as pests, diseases, and weather conditions. Sensors and monitoring systems can detect problems early on, enabling timely interventions that minimise crop losses (Lajoie-O'Malley *et al.*, 2020; Jiang *et al.*, 2022). They help to improve the management of the agricultural supply chain, and producers, in turn, can interact directly with potential buyers, optimising the processes of storage, transportation and sales. Furthermore, the digital economy is fostering innovation in agriculture (Lioutas *et al.*, 2021; Kukk *et al.*, 2022). Innovative startups and companies are developing new digital solutions for agricultural needs, leading to continuous improvement in the industry. Overall, innovative technologies in the context of digitalisation are contributing to increased efficiency, quality, and sustainability in agriculture. This results in enhanced production potential and competitiveness.

In the area of digitalisation, the state and companies engage in a complex interplay with several key aspects (Mihailova, 2020; Zhong *et al.*, 2022). The government's role encompasses providing incentives such as tax exemptions and grants for research and development, establishing essential infrastructure like communication networks and data centres, and promoting digital education to cultivate a skilled workforce (Prause *et al.*, 2020). Additionally, it safeguards citizen interests and human rights, ensures adherence to compatibility and security standards, and regulates the sector to enforce data protection and privacy regulations. State-driven innovation is crucial for advancing digital technologies and enhancing a nation's global competitiveness. Financial support such as grants, subsidies, and investments serve as a key instrument to stimulate digital technology research and development, benefiting both startups and established companies (Shepherd *et al.*, 2020; Rijswijk *et al.*, 2021). Moreover, reducing the tax burden, creating educational programmes for digital skills, especially targeting young people, and engaging in public procurement can further promote digital innovation.

A promising approach in this context is public-private partnership, which is essentially a form of cooperation between the state and private companies aimed at achieving common goals and solving specific tasks in the agricultural sector. This form of cooperation provides more opportunities to invest in new agricultural technologies and digitalization solutions (Sridhar *et al.*, 2023). Collaboration with the private sector allows for faster implementation of innovative solutions such as agricultural sensors, monitoring systems, data analysis, machine learning and other technologies that improve the efficiency and productivity of the industry. In some cases, this improves the ability to scale up and enter new markets.

As of 2024, Ukrainian companies are taking steps to introduce the latest technologies in the agricultural market. For example, Myronivsky Hliboproduct has implemented a large-scale SAP digital technology project aimed at improving the quality of management in key business sectors (Approach to digital…, 2023). The SAP system portfolio includes various modules for enterprise resource management, customer relations, procurement, master data, human resources, and poultry management; the company expected to achieve concrete results in terms of increased profits through its implementation. The implementation is still ongoing,

so it is difficult to say how effective this initiative has been. Nevertheless, it is reasonable to assume that it will lead to an overall increase in the efficiency of the company's internal operations.

Regulating agriculture in the digital economy necessitates a comprehensive approach and the adoption of modern technologies, particularly in the context of Ukraine's current situation, which is characterized by a decline in innovation. Therefore, the government should invest in establishing digital infrastructure for rural areas, ensuring access to high-speed internet and other digital technologies. This includes providing financial incentives and support to farmers who adopt digital technologies such as agricultural drones, IoT devices, and farm management systems. Furthermore, it is important to provide access to training and advisory services on digital technologies for agriculture and to develop appropriate regulations to govern the use of digital technologies in agriculture, including data, privacy and cybersecurity. Monitoring and evaluating the effectiveness of digital technology implementation in agriculture is also important to identify successful practices and areas for further support. Moreover, engaging the private sector in developing digital solutions for agriculture through partnerships and investments is critical.

Regulating agriculture in the context of digitalisation entails the utilisation of digital technologies and policies aimed at fostering innovation, enhancing productivity, and ensuring the sustainability of the industry. This encompasses establishing a legal framework, stimulating innovation practices, and ensuring data protection and privacy. Implementing appropriate norms and legislation is a crucial aspect of regulating agriculture in the digital era. Clear rules regarding the collection, storage, and processing of data, particularly the personal data of farmers and other agricultural stakeholders, must be established. This should include requirements for storing data in a secure environment and restricting access to third parties without data owners' consent. Ukraine has certain legislative acts related to data processing and personal data protection. The primary law in this sphere is Law of Ukraine No. 2297-VI (2022), which regulates relations associated with the processing and protection of personal data, aiming to protect the fundamental rights and freedoms of individuals and citizens, including the right to privacy in the context of personal data processing. Nevertheless, this law has certain shortcomings, including a lack of strictness and clarity in the legal framework, leading to non-compliance by companies with data processing and storage regulations. This is less relevant to agricultural companies specifically, as they deal less extensively with personal data. In the context of digitalisation, cybersecurity has become a more pressing issue. To safeguard against cyberattacks, cybersecurity standards for farms and digital solution providers must be established. The full-scale Russian invasion of Ukraine further highlights this urgency. Ukraine has Law of Ukraine No. 2163-VIII (2024), but the law is relatively new, making it difficult to definitively assess its effectiveness.

Given the current war situation in Ukraine, where a significant portion of funding comes from partners The direct costs of the war are also enormous, including both payments to the military and the need for constant infrastructure repair. Thus, a likely way out of the situation is to establish more direct interactions with the state to facilitate the digitalisation process at enterprises. The maximum amount of assistance should be provided in the form of recommendations or any other services that do not require significant financial injections. Providing monetary assistance for such purposes may be practically impossible in the current budgetary circumstances.

DISCUSSION

The study revealed that digital technologies in agriculture have led to significant positive outcomes. This underscores the need for governments worldwide to actively promote the adoption of such technologies among businesses. The Ukrainian government is no exception, and they have taken some steps in this direction, as evidenced by some of the nascent legislative frameworks. However, as of 2024, these measures are insufficient to maximise the promotion of economic digitalisation in the country. Supporting companies in this endeavour, as suggested in the study's model, would be an effective strategy. Nevertheless, the ongoing war in the country complicates the implementation of such initiatives, as available funds are primarily directed towards military needs or social support. Therefore, providing consultative advice from the government is an effective measure in cases where direct financial allocation is not feasible or challenging.

In the current study, considerable attention was paid to describing the role of agriculture, in particular for Ukraine. A similar assessment was conducted by J. MacPherson *et al.* (2022), who noted that the potential of digital agriculture in addressing sustainable development challenges hinges on its integration into existing policies and how future conditions and regulatory frameworks shape its implementation. Overall, the authors formulated recommendations aimed at integrating digital technologies in agriculture to facilitate a gradual transformation in this direction. They further called for the use of the latest technologies in other

areas of activity, not just agriculture. These recommendations remain relevant for Ukraine as well.

M.-H. Ehlers *et al*. (2021) also examined the characteristics of the agricultural sector in the context of digitalisation. They emphasised that digitalisation can increase the precision of policy instruments, but its impact on other parameters, such as freedom of action, cost distribution, and data domains, can be ambiguous. The authors described the significant role of digitalisation in developing flexible policy instruments in this sector. In this regard, the researchers formulated specific recommendations for politicians: they consisted of using digitalisation methods for more flexible use of traditional agricultural policy instruments, as well as to reduce costs in this context. However, this can also lead to a conflict of interest, primarily because not all interested parties may want such changes. All of this remains relevant in the context of Ukraine as well.

The benefits of digitalisation for agricultural companies were explored by A.M. Ciruela-Lorenzo *et al*. (2020). Their work highlights the transformative impact of digitalisation on the agricultural sector. It has been shown that these technologies contribute to economic stability by increasing operational efficiency and creating new customer engagement opportunities. However, challenges such as poor rural internet infrastructure, low technological literacy among farmers, and the scale of agricultural operations were also described. In this context, the authors emphasized the need for agricultural cooperatives to adopt digital technologies, diversify their activities, innovate, collaborate, and use digital tools to remain competitive. S. Fielke *et al*. (2020) noted that digitalisation leads to increased transparency, diversification, and ongoing restructuring of agricultural management. Additionally, attention was drawn to the growing focus on identifying opportunities to use digital technologies to improve sustainability in agricultural enterprises. In contrast, in Ukraine, significantly less attention is paid to such issues due to the complex situation in the country, primarily associated with the consequences of Russia's full-scale invasion.

It is noteworthy that digitalisation and the introduction of new technologies in agriculture allow for more effective achievement of sustainable development goals. While in Ukraine any such goals are relegated to the background, in the world as a whole, this is a rather important component of long-term state policy. In this context, digitalisation as a method of achieving sustainability of agro-food systems was studied by R.A. Bahn *et al*. (2021). The researchers noted that the use of digital transformation in the agro-food system allows for an increase in the potential of this sphere, and increases productivity and resource efficiency. However, they also drew attention to the fact that, despite all the advantages, problems may arise in this process, and the result may actually be negative. The researchers identified political priorities for digital transformation in agriculture, which should include, first of all, both financial support and training. The conducted study offered similar recommendations on how to promote digitalization in agriculture in the country. It is also worth noting that in any case, achieving sustainable development goals will become one of the important goals of state policy in Ukraine, at least after the end of the war.

This study also considered the components of a state policy that should be formed to achieve better goals in the context of the introduction of digital technologies. The formulation of more long-term goals in this context would be important for Ukraine. On the other hand, the question arises of how much this is possible at all in wartime conditions. This is why the political leadership should learn to act flexibly, in accordance with changing world events, in order to be able to appropriately and most effectively respond to any challenges.

CONCLUSIONS

The integration of digital technologies into the agricultural sector has brought significant advancements in efficiency, productivity, and sustainability. Innovative technologies such as sensors, drones, big data analytics capabilities, and artificial intelligence have revolutionised agricultural practices, enabling farmers to make data-driven decisions and optimise various aspects of their operations. This has led to increased yields, improved resource management, and enhanced product quality.

However, as presented in the study, successful implementation of digital technologies in agriculture requires cooperation between the state and the private sector. The government plays a crucial role in providing support and incentives to encourage innovation and adoption of digital solutions. This includes financial support through grants, subsidies, and investments in research and development, as well as the development and maintenance of appropriate infrastructure: in particular, the study showed a downward trend in support for the agricultural sector in the country, first due to the effects of the COVID-19 crisis and then to the outbreak of the full-scale invasion. The study showed that as of 2024, taking into account inflation, the costs of performing various types of research in Ukraine are gradually decreasing. Although not accounting for inflation, the level of expenditure on such work has increased. However, examining the real indicators reveals that research costs have nearly halved compared to 2010. At the same time, structurally more funds have begun to be allocated to applied scientific research. Thus, the

state is currently facing the task of finding new sources of funding to improve the efficiency of the scientific research apparatus.

Some difficulties related to the legislative framework for the digitalisation process in Ukraine were considered, which, however, are difficult to resolve given the full-scale Russian invasion. Discounting of cash flows was not used in the evaluations. In addition, rather limited attention was paid to the analysis of the impact of the war on this process, due to the difficulty of evaluating this factor. Nevertheless, the analysis of this component remains relevant for future research. In addition, it is important to find opportunities for innovation in other types of enterprises.

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CONFLICT OF INTEREST

None.

REFERENCES

[1] Abbasi, R., Martinez, P., & Ahmad, R. (2022). The digitization of agricultural industry – a systematic literature review on agriculture 4.0. *Smart Agricultural Technology*, 2, article number 100042. doi: 10.1016/j.atech.2022.100042.

[2] Annosi, M.C., Brunetta, F., Capo, F., & Heideveld, L. (2020). Digitalization in the agri-food industry: The relationship between technology and sustainable development. *Management Decision*, 58(8), 1737-1757. doi: 10.1108/MD-09-2019-1328.

[3] Approach to digital transformation: The experience of MHP. (2023). Retrieved from https://forbes.ua/ru/innovations/pidkhid-do-tsifrovoi-transformatsii-dosvid-mkhp-27122023-18159.

[4] Bahn, R.A., Yehya, A.A.K., & Zurayk, R. (2021). Digitalization for sustainable agri-food systems: Potential, status, and risks for the MENA region. *Sustainability*, 13(6), article number 3223. doi: 10.3390/su13063223.

[5] Bonvoisin, T., Utyasheva, L., Knipe, D., Gunnell, D., & Eddleston, M. (2020). Suicide by pesticide poisoning in India: A review of pesticide regulations and their impact on suicide trends. *BMC Public Health*, 20, article number 251. doi: 10.1186/s12889-020-8339-z.

[6] Ciruela-Lorenzo, A.M., Del-Aguila-Obra, A.R., Padilla-Meléndez, A., & Plaza-Angulo, J.J. (2020). Digitalization of agri-cooperatives in the smart agriculture context. Proposal of a digital diagnosis tool. *Sustainability*, 12(4), article number 1325. doi: 10.3390/su12041325.

[7] Duginets, G., & Nizheyko, K. (2023). Digitization of the EU agricultural sector: Experience for Ukraine. *Economy and Society*, 56. doi: 10.32782/2524-0072/2023-56-148.

[8] Ehlers, M.-H., Huber, R., & Finger, R. (2021). Agricultural policy in the era of digitalisation. *Food Policy*, 100, article number 102019. doi: 10.1016/j.foodpol.2020.102019.

[9] Fielke, S., Taylor, B., & Jakku, E. (2020). The digitalisation of agricultural knowledge and advice networks: A state-of-the-art review. *Agricultural Systems*, 180, article number 102763. doi: 10.1016/j.agsy.2019.102763.

[10] Jiang, S., Zhou, J., & Qiu, S. (2022). Digital agriculture and urbanization: Mechanism and empirical research. *Technological Forecasting and Social Change*, 180, article number 121724. doi: 10.1016/j.techfore.2022.121724.

[11] Kukk, M., Põder, A., & Viira, A.-H. (2022). The role of public policies in the digitalisation of the agri-food sector. A systematic review. *NJAS: Impact in Agricultural and Life Sciences*, 94(1), 217-248. doi: 10.1080/27685241.2022.2147870.

[12] Lajoie-O'Malley, A., Bronson, K., van der Burg, S., & Klerkx, L. (2020). The future(s) of digital agriculture and sustainable food systems: An analysis of high-level policy documents. *Ecosystem Services*, 45, article number 101183. doi: 10.1016/j.ecoser.2020.101183.

[13] Law of Ukraine No. 2163-VIII "On the Main Principles of Ensuring Cyber Security of Ukraine". (2024, January). Retrieved from https://zakon.rada.gov.ua/laws/show/2163-19/ed20240101#Text.

[14] Law of Ukraine No. 2297-VI "On Protection of Personal Data". (2022, October). Retrieved from https://zakon.rada.gov.ua/laws/show/2297-17#Text.

[15] Lioutas, E.D., Charatsari, C., & De Rosa, M. (2021). Digitalization of agriculture: A way to solve the food problem or a trolley dilemma? *Technology in Society*, 67, article number 101744. doi: 10.1016/j.techsoc.2021.101744.

[16] MacPherson, J., Voglhuber-Slavinsky, A., Olbrisch, M., Schöbel, P., Dönitz, E., Mouratiadou, I., & Helming, K. (2022). Future agricultural systems and the role of digitalization for achieving sustainability goals. A review. *Agronomy for Sustainable Development*, 42, article number 70. doi: 10.1007/s13593-022-00792-6.

[17] Marchenko, M. (2023). Digitalization of business management processes of agricultural enterprises. *Galician Economic Journal*, 81(2), 133-139. doi: 10.33108/galicianvisnyk_tntu2023.02.133.

[18] Mihailova, M. (2020). The state of agriculture in Bulgaria – PESTLE analysis. *Bulgarian Journal of Agricultural Science*, 26(5), 935-943.
[19] Nasirahmadi, A., & Hensel, O. (2022). Toward the next generation of digitalization in agriculture based on digital twin paradigm. *Sensors*, 22(2), article number 498. doi: 10.3390/s22020498.
[20] Nehrey, M. (2023). Digital transformation of the agricultural sector: Prospects, challenges and solutions. *Scientific Papers NaUKMA. Economics*, 8(1), 94-100. doi: 10.18523/2519-4739.2023.8.1.94-100.
[21] Panetto, H., Lezoche, M., Hernandez Hormazabal, J.E., Diaz, M.D.M.E.A., & Kacprzyk, J. (2020). Special issue on Agri-Food 4.0 and digitalization in agriculture supply chains – new directions, challenges and applications. *Computers in Industry*, 116, article number 103188. doi: 10.1016/j.compind.2020.103188.
[22] Prause, L., Hackfort, S., & Lindgren, M. (2020). Digitalization and the third food regime. *Agriculture and Human Values*, 38, 641-655. doi: 10.1007/s10460-020-10161-2.
[23] Rijswijk, K., *et al*. (2021). Digital transformation of agriculture and rural areas: A socio-cyber-physical system framework to support responsibilisation. *Journal of Rural Studies*, 85, 79-90. doi: 10.1016/j.jrurstud.2021.05.003.
[24] Shepherd, M., Turner, J.A., Small, B., & Wheeler, D. (2020). Priorities for science to overcome hurdles thwarting the full promise of the 'digital agriculture' revolution. *Journal of the Science of Food and Agriculture*, 100(14), 5083-5092. doi: 10.1002/jsfa.9346.
[25] Shoushtarian, F., & Negahban-Azar, M. (2020). Worldwide regulations and guidelines for agricultural water reuse: A critical review. *Water*, 12(4), article number 971. doi: 10.3390/w12040971.
[26] Sridhar, A., Balakrishnan, A., Jacob, M.M., Sillanpää, M., & Dayanandan, N. (2023). Global impact of COVID-19 on agriculture: Role of sustainable agriculture and digital farming. *Environmental Science and Pollution Research*, 30, 42509-42525. doi: 10.1007/s11356-022-19358-w.
[27] Subeesh, A., & Mehta, C.R. (2021). Automation and digitization of agriculture using artificial intelligence and internet of things. *Artificial Intelligence in Agriculture*, 5, 278-291. doi: 10.1016/j.aiia.2021.11.004.
[28] Support for agriculture in 2023: What farmers can expect. (2023). Retrieved from https://www.growhow.in.ua/pidtrymka-apk-u-2023-rotsi-na-shcho-mozhut-rozrakhovuvaty-ahrarii/.
[29] Tang, Y., & Chen, M. (2022). The impact of agricultural digitization on the high-quality development of agriculture: An empirical test based on provincial panel data. *Land*, 11(12), article number 2152. doi: 10.3390/land11122152.
[30] Trivedi, P., Mattupalli, C., Eversole, K., & Leach, J.E. (2021). Enabling sustainable agriculture through understanding and enhancement of microbiomes. *New Phytologist*, 230(6), 2129-2147. doi: 10.1111/nph.17319.
[31] Ukrstat. (n.d.). *Expenditure on research and development by type of work by region*. Retrieved from https://ukrstat.gov.ua/operativ/operativ2021/ni/ni_vvndrvr_reg.html.
[32] Zhong, R., He, Q., & Qi, Y. (2022). Digital economy, agricultural technological progress, and agricultural carbon intensity: Evidence from China. *International Journal of Environmental Research and Public Health*, 19(11), article number 6488. doi: 10.3390/ijerph19116488.
[33] Zscheischler, J., Brunsch, R., Rogga, S., & Scholz, R.W. (2022). Perceived risks and vulnerabilities of employing digitalization and digital data in agriculture – socially robust orientations from a transdisciplinary process. *Journal of Cleaner Production*, 385, article number 132034. doi: 10.1016/j.jclepro.2022.132034.

Державне регулювання сільського господарства в умовах цифровізації економіки України

Світлана Стендер
Кандидат економічних наук, доцент
Заклад вищої освіти «Подільський державний університет»
32316, вул. Шевченка, 12, м. Кам'янець-Подільський, Україна
https://orcid.org/0000-0002-6234-1877

Валентина Борковська
Кандидат економічних наук, доцент
Заклад вищої освіти «Подільський державний університет»
32316, вул. Шевченка, 12, м. Кам'янець-Подільський, Україна
https://orcid.org/0000-0002-2983-2973

Інна Балла
Кандидат економічних наук, доцент
Заклад вищої освіти «Подільський державний університет»
32316, вул. Шевченка, 12, м. Кам'янець-Подільський, Україна
https://orcid.org/0000-0001-5041-9801

Анотація. Сільське господарство грає стратегічну роль у забезпеченні населення продовольством. Це стає причиною значного втручання в даний сектор держави, а отже й формування якісних підходів до цього процесу залишається актуальним. В рамках даного дослідження метою стало надання рекомендацій до цього процесу в Україні, зокрема, на процеси в розрізі цифровізації економіки. Для цього було використано графічний аналіз, моделювання, абстрагування та метод логічних міркувань. В рамках роботи було детально описано роль цифрових технологій для досягнення більш ефективних результатів в контексті підвищення ефективності розвитку сільського господарства. Крім того, було зроблено висновок стосовно потреби взаємодії між державою та підприємствами в цьому напрямі. Пов'язано це, в першу чергу, зі складнощами, що можуть виникнути в компаніях, які будуть запроваджувати подібні практики. Розуміючи їхню наявність, менш вірогідним є подальше впровадження такого виду технологій на підприємствах. В роботі було запропоновано декілька підходів, що можуть бути використані для зниження негативного впливу на сільськогосподарські компанії. Зважаючи на наслідки повномасштабного вторгнення Росії в Україну, особлива увага була приділена нефінансовим підходам, а також проблемам, що існують в рамках актуальної законодавчої бази. Крім того, окремі висновки були сформовані на основі статистичних даних про розвиток науки та освіти в Україні в цілому. Практична цінність дослідження полягає в тому, що отримані результати дозволять підвищити ефективність функціонування державного сектору в Україні у сфері регулювання сільського господарства

Ключові слова: інновації; аграрний сектор; впровадження технологій; нормативно-законодавча база; менеджмент та управління