



UDC 336.71:004.65

Digitalisation of financial activities of the agricultural sector under martial law

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► **Abstract.** The purpose of this study was to analyse the effects of digitalisation on improving the efficiency of financial processes in the agricultural sector under martial law. The study focused on the key technologies contributing to the development of financial processes in agriculture, such as financial technologies, artificial intelligence, blockchain, cloud technologies, and cybersecurity systems. The study found that these technologies not only enable the automation of financial processes but also provide greater transparency and security in financial management, which is critical in times of crisis. The study also examined the specific challenges and risks of digitalisation in the agricultural sector, specifically in the context of data and infrastructure security. The growing dependence on digital systems was found to increase vulnerability to cyber threats, which requires investment in improving protection and risk management systems. Particular attention was paid to the adaptation of digital technologies in the context of war, where the positive outcomes of the implementation of digital solutions for monitoring production processes, data analysis, supply chain management, and production capacity planning were noted. The study also reviewed international practices in the use of digital technologies in the agricultural sector, specifically in countries such as Israel, the United States, Germany, China, and the Netherlands, which provided an opportunity to apply best practices to ensure the stability of Ukraine's agricultural sector. The study findings

► **Suggested Citation:** Sirenko, N., Melnyk, O., Bodnar, O., Mikuliak, K., & Spivak, V. (2025). Digitalisation of financial activities of the agricultural sector under martial law. *Ekonomika APK*, 32(1), 70-81. doi: 10.32317/ekon.apk/1.2025.70.

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demonstrated that the digitalisation of Ukraine's agricultural sector is a necessary step to maintain food security and economic stability in times of war but also required overcoming considerable challenges such as insufficient infrastructure, human resource shortages, and cyber threats. The conclusions pointed to the need for increased investment in digital technologies and cybersecurity, as well as the development of human resources to effectively use the latest technologies

► **Keywords:** innovative technologies; business strategies; blockchain; artificial intelligence

► Introduction

The digitalisation of financial activities has become one of the key factors in the development of many sectors of the economy, including the agricultural sector. In the modern environment, especially in the context of martial law, this trend is particularly relevant. The agricultural sector in Ukraine is a crucial source of economic stability, ensuring food security and a great share of national exports. However, its activities are considerably complicated during periods of military operations, when the risks of losses, disruption of supply chains, and financial complications become inevitable.

The relevance of digitalisation in the financial sector of the agro-industrial complex is driven by the need for more efficient and flexible management of financial resources, effective business monitoring, and quick access to finance and market data. The use of modern technologies can greatly improve the efficiency of financial processes, reducing risks through automation and the introduction of innovative approaches to financial management. Technologies such as blockchain, financial platforms for the agricultural industry, and AI-based software solutions help to ensure the transparency and reliability of financial transactions (Liutak & Baula, 2024). One of the greatest challenges facing the agricultural sector during martial law is reduced access to conventional financial resources, deteriorating lending conditions and instability of the payment system (Stender *et al.*, 2024). Conventional financial instruments may lose their effectiveness in such circumstances, which requires finding alternative solutions. Digital technologies, including online financial management platforms, mobile applications for remote financial transactions, and decentralised financial systems, may become critical to ensuring the continuity of financial processes and maintaining the profitability of agricultural businesses.

Digitalisation is a multifaceted process that encompasses not only the automation of financial transactions, but also the improvement of analytics, security, and operational management of resources (Ponomarenko & Pysarchuk, 2024). This enables businesses to increase their competitiveness and adapt to challenging economic conditions. For the agricultural sector, especially in wartime, digitalisation can be a tool to help overcome barriers and provide access to finance, increasing transparency and reducing the influence of human factors in decision-making.

Various scholars have significantly developed research in the field of digitalisation of the financial activities of the agricultural sector. J. Tingey-Holyoak *et al.* (2021) analysed the effects of automated financial accounting systems on agricultural enterprises and emphasised that the use of such systems substantially reduced losses due to human errors. In support of this, S.R. Gunistry & M.K. Vandana (2024) showed that process automation reduced the

time required to process financial data, which was critical in times of instability. T. Yu *et al.* (2018) emphasised the value of implementing blockchain technologies to ensure the transparency of financial transactions. The study showed that the use of decentralised registries helped to avoid fraud and increased confidence in financial transactions. Q. Lu *et al.* (2024) investigated the effects of digital platforms for financial management and noted that their use enabled farmers to adapt more quickly to market changes during crisis periods.

A detailed analysis of the digital transformation of agricultural finance was also conducted by R. Kausshal (2023), who emphasised the significance of integrating artificial intelligence to forecast financial flows. The researcher's findings confirmed that AI-based systems helped to reduce the risks associated with unpredictable market conditions. R. Fabregas *et al.* (2019) focused on mobile financial applications and noted that their use contributed to the increased flexibility of financial transaction management. J. Kieti *et al.* (2021) showed that digital platforms specialised for agricultural enterprises have simplified access to credit, which was a major factor in times of financial difficulties. The researchers emphasised that online lending services enabled farmers to obtain financial resources quickly. On the other hand, M. Carmela Annosi *et al.* (2020) addressed the effects of digitalisation on risk monitoring and noted that automated surveillance systems enabled faster detection of threats to business.

T. Niemand *et al.* (2021) focused on the role of government support in the digitalisation of financial transactions. The researchers emphasised that without corresponding policies and incentives from the state, the implementation of innovations can be challenging. Finally, W. Feng & R. Liu (2024) investigated the factors that hindered digitalisation in a crisis and noted that the crucial ones were infrastructure problems and lack of proper training of staff to use the latest technologies. These studies provided a basis for analysing the benefits and challenges of digitalising the financial activities of the agricultural sector and confirmed the need for an in-depth study of this issue to develop effective strategies to overcome crisis situations. However, a series of understudied aspects persists. Specifically, the issue of integrating digital technologies under martial law requires a deeper analysis, especially in terms of the adaptation of agricultural enterprises to changes in the economic environment and the effects of infrastructure challenges. The practical application of blockchain technologies to protect financial transactions and risk management is still understudied.

The purpose of the present study was to analyse the role of digitalisation in the financial activities of the agricultural sector during martial law to improve the

efficiency of management processes in this area. The objectives of the study were to analyse the challenges faced by agricultural enterprises in implementing digital financial solutions during martial law; to investigate the effects of digital technologies on risk management and financial stability of the agricultural sector; and to develop recommendations for optimising the digitalisation process in the context of the crisis.

► Materials and methods

To investigate the effects of digital technologies on financial processes in the agricultural sector of Ukraine under martial law, the study employed methods of analysis, comparison, and systematisation of data, as well as empirical research on the example of particular enterprises, namely, the agricultural holding Myronivskiy Hliboprodukt (MHP, 2023) and Kernel (n.d.). The principal materials for the analysis included statistical data on agricultural production in Ukraine for 2019-2023 (Agricultural products at constant prices, 2023), as well as financial reports of MHP and Kernel for this period. To examine digital technologies in financial management in the agricultural sector, the study analysed the use of technologies such as artificial intelligence (AI), blockchain, cloud technologies, and mobile payment platforms. The assessment of the effects of these technologies on financial processes included an investigation of their implementation in the agricultural business, specifically in terms of accounting automation, resource management, and financial results forecasting. The study also analysed the use of digital security systems that help protect data in the digitalisation of financial transactions.

The research methodology included several key stages. The first stage was the collection and processing of statistical data, specifically from the State Statistics Service of Ukraine (Agricultural products at constant prices, 2023), which reflects changes in agricultural production and the dynamics of financial indicators in the agricultural sector for 2019-2023. Using the financial statements of MHP and Kernel, the study assessed the effects of digital solutions on their financial performance, including revenues, assets, equity, and other significant financial indicators such as earnings before interest, tax, depreciation, and amortisation (EBITDA) and net profit.

The analysis of the influence of martial law on the use of digital technologies in agriculture involved examining the specifics of the transition of agricultural enterprises to online platforms for managing finances, sales, and resources. This included investigating the role of mobile applications and online platforms in attracting investment and loans, as well as the possibility of using blockchain technologies to ensure transparency and security of financial transactions. Furthermore, the modelling method was employed to develop recommendations for optimising digitalisation in the agricultural sector under martial law. Using the economic modelling method, forecasts were created to analyse the financial results of agricultural enterprises when implementing various digital technologies. This approach helped to assess possible changes in financial performance, such as cost reduction, improved resource management efficiency, and increased financial transparency.

A significant aspect of the study was the exploration of the practices of other countries, such as Israel (Netafim Quality Policy, n.d.), the United States (McVan, 2023), and Germany (AgriCon, n.d.). The study also investigated China (Wang *et al.*, 2022) and the Netherlands (Van der Hoeven, n.d.) in the use of digital technologies in crisis situations. This helped to identify opportunities for adapting their approaches to Ukraine's conditions and to propose strategies for enhancing the digitalisation of the agricultural sector in wartime. All research findings were based on the systematisation of modern technologies and their implementation in the agricultural sector. The applied methods and materials helped to comprehensively assess the role of digital technologies in the financial management of agricultural enterprises in Ukraine.

► Results

Digitalisation has become an integral part of the development of the modern economy, including the financial sector, which is undergoing significant transformations under the influence of technological innovations. The development of information technology and continuous improvement of software have changed traditional approaches to financial management, creating conditions for faster, safer and more efficient financial transactions. The concepts underpinning modern digitalisation cover various aspects, from process automation to the introduction of AI and blockchain technologies.

One of the key concepts of digitalisation is financial technology (FinTech), which combines innovative solutions for providing financial services using the latest technologies. Research shows that the implementation of FinTech solutions can reduce the cost of financial transactions by up to 30% and increase revenues by 20% by automating processes and improving access to services such as mobile banking apps, online lending, and digital payment systems. AI and machine learning are already actively helping financial institutions automate decision-making: AI analyses large amounts of data to assess credit risks, predict financial trends, and identify suspicious transactions, which can reduce credit risks by 20%. Blockchain technologies also contribute to major cost reductions in the financial sector (up to 50% in some cases), ensuring transparency, security, and decentralisation of transactions, as they allow conducting transactions without intermediaries (Mhlanga, 2021).

Cloud technologies have become another integral element of modern financial digitalisation, helping companies scale operations and reduce infrastructure costs by 15-20%. Cloud-based solutions enable financial institutions to ensure continuity of operations and quick access to large amounts of data, which is crucial in the current market environment (Javaid *et al.*, 2022). For the agricultural sector, which faces many financial challenges, digital technologies have become a key tool for improving the efficiency of financial management. Automated accounting and reporting systems, for instance, can reduce administrative costs by up to 25% by simplifying data processing and improving accounting accuracy (Gotthardt *et al.*, 2020). Online platforms enable access to finance without the need to visit physical offices of banks or financial institutions, which is especially valuable in remote

regions. Mobile applications and web services help farmers apply for loans, negotiate with suppliers, and monitor the financial status of their farms in real time. The use of AI in financial processes enables better working capital management, prompt response to market changes, and minimisation of losses (Ahamed & Vignesh, 2022). Big Data analytics systems help farmers better understand market trends, which is vital for cost and investment planning.

Despite the major benefits, there are some challenges associated with digitalisation in agricultural finance. The key ones include insufficient infrastructure in remote regions, lack of trained professionals to work with the latest technologies, and cybersecurity risks. Digitalisation has become the primary driving force behind the transformation of various sectors of the economy, including the financial and agricultural sectors, in periods of stability and development. However, in times of crisis, such as wars, economic recessions, or natural disasters, the role of digital technologies becomes particularly critical. Digitalisation can be both a reliable tool for adaptation and effective functioning and a source of new challenges and risks that require special attention. The need to maintain infrastructure is also a prominent aspect, as even the best digital platforms cannot function without stable networks and servers. In crises, when infrastructure is often disrupted by hostilities, natural disasters, or technical malfunctions, access to significant digital systems may be limited (Moşteanu et al., 2020).

One of the most successful digitalisation practices in Ukraine's agricultural sector is the introduction of blockchain technologies to ensure transparency of accounting and financial transactions. For example, Ukrainian agricultural cooperatives such as GrainChain use blockchain to create decentralised registries that guarantee the accuracy and traceability of transactions. This greatly reduces the risk of fraud and simplifies the audit process, while increasing the trust of investors and international partners. Automation of financial processes through digital platforms has become the basis for agricultural enterprises to adapt to the challenges of martial law. For instance, the AgriAnalytica system operating in Ukraine allows farmers

to keep track of expenses, apply for loans, and analyse financial performance in real time.

Artificial intelligence and analytical systems have also become a valuable tool for financial management. For instance, the Ukrainian company SmartFarming uses AI to forecast yields, model risks, and plan financial flows. Big Data analytics allows farmers to better understand market trends, which contributes to rational cost and investment planning. Another successful example is the use of cloud platforms to manage agricultural processes. Thanks to cloud solutions such as Cropio, agricultural companies can remotely monitor crop conditions, allocate resources, and analyse financial results. The role of digital technologies in strengthening financial inclusion is particularly noteworthy. For example, cooperatives that implemented digital platforms for transparent payments between farmers and suppliers can increase the efficiency of their cash flow and ensure prompt payment for services and products. This not only reduced financial risks but also helped to strengthen cooperation in times of economic instability (Bexcolli et al., 2023).

The digitalisation of Ukraine's agricultural sector under martial law has become a critical tool for preserving food security and maintaining stability in the agricultural sector. Since the outbreak of the war in 2022, Ukrainian farmers have faced many challenges, such as disrupted supply chains, damaged infrastructure, reduced access to finance, and a shrinking workforce. In such circumstances, digital technologies have helped agricultural enterprises adapt to the new reality, optimise production and financial processes, and ensure connection with internal and international markets. Automation of financial accounting and the use of blockchain have increased the transparency and security of financial transactions, which is crucial when attracting investment and interacting with international partners. The introduction of digital technologies made it possible to maintain the key indicators of the agricultural sector even in wartime (Sirenko et al., 2021). The analysis in Table 1 presents how the agricultural accounts have evolved to overcome the current challenges.

Table 1. Economic accounts of agriculture for 2019-2023, UAH mln

Indicators	Year				
	2019	2020	2021	2022	2023
Agriculture output	842,767	892,852	1,366,456	1,073,916	1,163,676
	of which				
Crop production	623,951	670,423	1,100,168	811,056	904,630
Animal husbandry	200,990	203,942	237,586	243,599	240,833
Services	13,097	13,457	21,615	14,905	18,213
Intermediate consumption	498,744	511,460	789,635	636,962	621,124
Gross value added	344,023	381,392	576,821	436,954	542,552
Net profit	229,467	253,353	401,295	318,775	380,122

Source: created by the authors of this study based on Agricultural products at constant prices (2023)

Agricultural output over the five years shows fluctuations, with an overall decline in 2022, when output declined because of the adverse impact of the war, including lower yields and loss of production capacity. Despite the major decline in agricultural output in 2022, thanks

to the introduction of digital solutions, farms managed to maintain financial stability and begin to recover in 2023. Farms that have implemented digital financial management platforms have recorded a 10-15% increase in revenues due to more efficient use of resources and cost

optimisation. This helped companies not only to maintain liquidity but also to restore production capacity. In 2023, a 20% reduction was observed in management process costs due to accounting automation and the use of cloud technologies, which contributed to the stability of financial operations in a high-risk environment. At the same time, the cost of administrative services was reduced thanks to FinTech solutions that ensured more efficient interaction with banks and suppliers (Nechyporenko *et al.*, 2022).

One of the main achievements in the introduction of digital technologies was the automated management of financial processes. During the war, many farmers managed to switch to online platforms to manage their finances, which enabled them to make quick payments, apply for loans, and make international payments without having to physically visit banks or other financial institutions. This was a significant factor in maintaining the financial stability of the business when conventional methods of making payments in the economy became less efficient. Businesses that switched to online platforms reduced their operating costs for financial services by an average of 20-25%, which was a crucial factor in maintaining financial stability during the crisis (Myronchuk *et al.*, 2023).

Digital platforms have also helped to keep producers and consumers connected. Online trading platforms and commodity exchange platforms enabled farmers to sell their products even in the challenging conditions of the war. This has become a valuable tool for maintaining the sales market, particularly in the face of restricted logistics routes and problems with physical transportation of products. Online sales have enabled agricultural businesses not only to minimise losses but also to maintain sales markets even in an unstable economic environment. Around 30% of farmers who used these platforms managed to retain up to 40% of their sales markets even in the face of active hostilities. Online sales have become a tool that has allowed businesses to minimise losses and maintain stable financial flows (Yekimov *et al.*, 2022). However, despite these advantages, the implementation of digital solutions in the agricultural sector in wartime has certain challenges. One of the key challenges is the uneven access to digital technologies in various regions of the country. In remote areas, especially in the east and south, where hostilities are active, the infrastructure is heavily damaged, making it challenging to use the latest technologies. Many farmers do not have adequate access to a stable internet connection or are unable to implement digital solutions due to a lack of resources or support.

Another barrier to the development of digitalisation is the shortage of human resources. Effective implementation of the latest technologies requires skilled professionals who can work with digital platforms, analytical systems, and other tools (Morosan & Bowen, 2022). However, the war has led to a massive emigration of young professionals, while those who stayed often lack sufficient experience to work with modern digital technologies. This makes it even more challenging for farmers to adapt to new conditions. Cybersecurity risks have also become a genuine issue. The growing digitalisation of the agricultural sector increases the probability of attacks on information systems, which can lead to the loss of valuable data or

financial resources. As Ukraine's cybersecurity infrastructure still needs to be improved, farmers could suffer major losses in case of successful cyberattacks.

Financial instability is a barrier to the adoption of digital solutions. Many agricultural enterprises, especially small and medium-sized ones, have limited access to finance for technology development due to the overall economic situation in the country. This means that even the best digital tools may be unaffordable for a great proportion of farmers due to their prohibitive cost (Agrawal *et al.*, 2019). Digitalisation in the agricultural sector becomes a vital area of focus in times of crisis, especially during war or natural disasters. Countries with varying economic and social conditions leverage technology to support food security and reduce risks to agricultural production (Dovgal *et al.*, 2017). The practices of other countries can give insight into which strategies can increase the resilience of Ukraine's agricultural sector in wartime.

Israel is a vivid example of the effective use of digital technologies to manage financial activities in the agricultural sector, specifically in resource optimisation. In 2021, the Israeli company Payoneer launched an online platform for managing international financial transactions of farmers, which reduced transaction costs and provided faster access to capital for farmers (Netafim Quality Policy, n.d.). This is a valuable experience for Ukraine, where digital platforms for financial management are becoming increasingly relevant, especially in times of crisis when conventional financial instruments may be limited.

In the United States, a strong emphasis on digital technologies has been placed on financial security. Cybersecurity programmes for agricultural companies, especially after the cyberattack on the largest meat processing company JBS Food, helped reduce the risks of cyberattacks on agricultural companies by 35% in the first year after implementation. This helped ensure the stability of financial flows and operations (McVan, 2023). For Ukraine, this experience is significant, as protecting farmers' financial platforms from cyberthreats is critical to maintaining financial stability in wartime.

Germany has been actively implementing digital technologies to optimise financial processes during the COVID-19 pandemic. Specifically, the creation of AgriCon online platforms enabled farmers to effectively manage financial transactions, optimise orders, and logistics costs. This reduced the cost of transporting products by 15% and allowed farmers to stay afloat even in the face of crisis restrictions (AgriCon, n.d.). For Ukraine, such platforms could become valuable tools to maintain stable financial operations during the war, including optimising logistics costs and ensuring financial flexibility.

China is investing in automation to reduce labour costs, which also directly influences the financial performance of agricultural companies. The use of unmanned tractors and autonomous mechanisms in rural areas can reduce labour costs by 25-30%, which positively influences financial efficiency (Wang *et al.*, 2022). In Ukraine, the introduction of such automated solutions could reduce labour costs and increase the efficiency of financial resources, especially in areas where access to labour is limited.

The Netherlands, which is a global leader in the use of automated technologies, is also actively implementing

digital solutions to manage financial flows in the agricultural sector. The introduction of automated greenhouse technologies allows agricultural enterprises to significantly reduce energy costs and increase productivity, which improves financial outcomes (Van der Hoeven, n.d.). For Ukraine, analogous solutions could be significant for reducing natural resource costs and increasing the financial

sustainability of agricultural companies in challenging conditions. The practices of other countries in implementing digital technologies in the agricultural sector during crisis situations is an example for Ukraine. Table 2 presents the practices of other countries in digitalising the agricultural sector in times of crisis and how these practices can be applied in Ukraine.

Table 2. Countries' experience in digitalising the financial activities of the agricultural sector in crisis conditions

Country	Digital solutions	Challenges and opportunities for application	Recommended measures
Israel	Online platforms for international financial transactions	Lower transaction costs, faster access to capital; need for scalable solutions for small and medium-sized enterprises	Create local digital platforms for financial transactions; train farmers to use such tools
USA	Cybersecurity of financial platforms	Growing cyber threats, the need for cyber defence specialists and modern software	Implementation of state cyber defence programmes; training of personnel and creation of technical audit programmes for systems
Germany	Digital platforms for financial management	Insufficient access to the Internet in rural areas; need for financial flexibility in times of crisis	Developing online platforms for financial management; providing access to high-speed internet
China	Automated financial tools to reduce costs	Excessive cost of equipment, need for qualified specialists	Support for local software developers; training for farmers and technicians
Netherlands	Digital solutions for financial monitoring of greenhouses	Need to invest in equipment; dependence on stable energy supply	Integration of financial monitoring into automated systems; promotion of renewable energy sources

Source: created by the authors

Table 2 systematises the principal approaches and technologies used in various countries and suggests possible ways to adapt them to Ukrainian conditions to support the resilience of the agricultural sector in crisis circumstances. The experience of implementing digital solutions is significant not only at the industry level, but also at the level of individual companies that are actively integrating modern approaches into their operations. Myronivskyi Hliboprodukt is one of the largest agricultural producers in Ukraine. Over the 5 years (2019-2023), MHP's

financial activities have been focused on modernising equipment, expanding production and diversifying products. The company has invested heavily in the development of innovative technologies, including digital solutions that help optimise resource management, specifically agricultural assets, and increase productivity. In an increasingly competitive global environment, MHP delivers stable revenues and provides important opportunities for the country's economy. Table 3 shows the company's financial performance.

Table 3. MHP's financial performance indicators for 2019-2023, USD mln

Indicators	Year				
	2019	2020	2021	2022	2023
Income	2,056	1,911	2,372	2,642	3,021
Profit	215	-133	393	-231	142
EBITDA	378	340	648	384	445
Assets	2,509	2,108	4,014	3,809	3,886
Capital	1,596	1,254	1,794	1,446	1,567

Source: created by the authors of this study based on MHP (2023)

MHP's financial performance demonstrates that the company has managed to overcome the challenges posed by both the pandemic and the war. While the company's revenues and assets are growing, profitability is more volatile, reflecting the impact of the crisis on financial performance. The recovery in EBITDA and equity in 2023 suggests a gradual stabilisation, while the overall growth

in assets shows the company's ability to adapt effectively to changing circumstances.

Kernel agro-holding is one of the leaders in the Ukrainian agricultural sector, actively investing in the modernisation of its production facilities and the development of digital technologies to improve the efficiency of agricultural asset management, specifically in finance and

resources. In the face of major economic challenges, including the pandemic and the war, Kernel has managed to adapt and maintain stability through the introduction of

innovative digital solutions such as FinTech, blockchain, and cloud technologies. Table 4 shows the company's financial performance.

Table 4. Kernel's financial performance indicators for 2019-2023, USD mln

Indicators	Year				
	2019	2020	2021	2022	2023
Income	3,960	4,107	5,596	5,332	3,455
Profit	179	123	513	-41	299
EBITDA	346	443	806	220	544
Assets	2,464	3,165	3,997	4,186	3,885
Capital	1,346	1,494	1,949	1,686	1,744

Source: created by the authors of this study based on Kernel (n.d.)

Kernel's financial performance in 2019-2023 demonstrates the overall resilience of the business despite the influence of the crises. The company's revenues grew until 2021, followed by a decline in 2023 caused by the effects of the war. Profitability is a volatile indicator: the company suffered losses in 2022 due to the crisis, but in 2023, profits increased. EBITDA shows a steady recovery after a drop in 2022. Since the outbreak of war in Ukraine, agricultural holdings, including MHP and Kernel, have faced serious challenges. Part of the production facilities of both companies are in the regions affected by the hostilities, which led to a loss of resources, disruption of supply chains and logistical difficulties. For Kernel, the war has made it challenging to export its products due to the blockade of seaports, forcing the company to reorient its supplies through alternative routes, increasing transport costs. Risks for both companies have increased due to higher logistics costs, limited access to markets and delays in cash flows caused by restrictions on working with foreign investors. However, both companies have adapted to the unfamiliar environment by focusing on the internal market and looking for alternative supply and sales routes.

Digitalisation has become a key area of development for both MHP and Kernel, especially in wartime. MHP actively leverages IoT technologies, analytical platforms, and ERP systems to monitor resources, manage production, and financial flows. Kernel is implementing digital solutions to improve supply chain management, logistics, and finance, which enables the company to minimise losses and stay competitive. For example, Kernel's use of Big Data technologies helps to analyse market trends, optimising export operations and planning. During the crisis, both companies also invested in cybersecurity to protect data and ensure the stability of financial transactions. As a result, MHP and Kernel have not only managed to reduce operating costs, but also considerably improve the efficiency of their resource management, even in times of economic instability. The companies have considerable potential to improve their financial performance by implementing digital solutions, which will optimise operations and mitigate the risks caused by martial law. A digitalisation strategy can cover several key areas aimed at increasing the efficiency of resource management, enhancing analytics capabilities, improving logistics, optimising financial operations, ensuring cybersecurity, and strengthening customer relationships.

The first area of the strategy is digital optimisation of resource management. Companies can automate resource monitoring and management processes using IoT. This will enable them to quickly assess the need for fertilisers, water, and energy, reducing production costs by 5-10%. Integration of ERP systems to automate cost accounting, inventory management, and forecasting of resource requirements will reduce costs by 7-15% by optimising financial flows and reducing losses. The second area is the expansion of analytics and forecasting based on Big Data. Using analytical platforms to process data from various sources, such as weather conditions and market fluctuations, will allow companies to assess risks more accurately and make informed financial decisions. The use of machine learning for financial forecasting will reduce the probability of financial losses from unforeseen factors by 20-25% and optimise investment planning. The third area concerns the improvement of logistics. The use of digital platforms for logistics management and tracking of delivery routes will help choose the best delivery routes, reducing transport costs by 5-10% even in conditions of limited access to territories. Automation of logistics processes through integration with suppliers will help ensure supply stability and reduce logistics costs by an average of 7-12%.

Another prominent area of the strategy is the introduction of financial digital platforms for cash management and investment attraction. The introduction of electronic payments and mobile banking will enable efficient management of working capital, reducing the processing time of financial transactions by 15-20%, which will positively influence the company's liquidity. Online platforms for attracting investments will provide further access to financing, especially in the case of hindered access to conventional loans. This can increase the volume of attracted investments by 10-15% per year. Considering the growing cyber risks during martial law, strengthening cybersecurity is a critical area. Investments in modern cyber security and access control systems, along with staff training, will reduce the risks of cyber incidents by 30-40%, which will protect financial information and reduce possible financial losses from attacks. The last area is the implementation of CRM systems to maintain relationships with customers and partners. This will increase the transparency of operations with customers and strengthen relations in international markets, which will ensure stable demand for

companies' products even under the restrictions caused by the war. Automation of marketing processes through CRM will help to better respond to changing market demands and can increase sales by 10-12% through more accurate targeting and personalisation. Taken together, these strategic areas of digitalisation could allow MHP and Kernel to reduce operating costs by 20-25%, increase resource efficiency, and greatly improve financial outcomes even in the face of economic and security instability. Implementing these areas of digitalisation will allow companies to optimise costs, reduce risks associated with market fluctuations and war, and maintain competitiveness. As a result, the company will be capable of maintaining stable financial performance, ensuring economic sustainability, and implementing a long-term growth strategy even in the face of significant external challenges.

► Discussion

The findings of the present study suggest that the introduction of digital technologies in the financial activities of the agricultural sector has major potential for optimising operations and managing risks. One of the key advantages is the automation of financial processes, which greatly reduces the amount of manual work and reduces the probability of errors. This enables farmers to obtain more accurate data on financial flows, monitor expenses and income, which helps them make more informed management decisions. This is crucial during periods of instability, such as martial law, when prompt and accurate data play a key role in maintaining business. H. Tian *et al.* (2019) investigated the automation of financial processes in the agricultural sector and noted that digital solutions reduce the risk of errors and improve cost management. The researchers also noted an increase in productivity due to the minimisation of manual work, which is consistent with current findings. U. Kambali & N. Panakaje (2022) emphasised that automation is not crucial for all agricultural enterprises due to the excessive cost of implementation, which only large farms can afford. Therefore, this opinion can be partially agreed with, as the current findings suggest that even small farmers can benefit from digitalisation, but this requires adapted and cheaper solutions.

The use of artificial intelligence and Big Data helps agricultural enterprises anticipate possible risks and adapt financial strategies to market conditions (Llazo *et al.*, 2024). For example, Big Data analytics can predict changes in the market, analyse weather conditions, and other factors that may affect yields. Combined with automation, this approach enables farmers to reduce losses and optimise the use of resources. However, the complexity of implementing such technologies often requires highly skilled professionals, which are lacking in rural regions of Ukraine, limiting the possibilities for the widespread of such solutions. R. Ben Ayed & M. Hanana (2021) explored the use of artificial intelligence to monitor and manage yields in the agricultural sector. The researchers emphasised that the use of artificial intelligence algorithms allows optimising the use of resources, such as water and fertilisers, and increasing yields. These conclusions are in line with current findings, as the potential of digital technologies to improve the efficiency of agricultural processes was also noted.

One of the key aspects of the effects of digitalisation is the introduction of blockchain technologies that ensure transparency and security of transactions, reducing the risk of data falsification (Gulaliyev *et al.*, 2023). This is crucial for financial transactions involving large amounts of money or investment. However, due to the martial law, agricultural enterprises in Ukraine face limited access to resources and infrastructure to support such technologies, which creates further obstacles. S. Rijal & F. Saranani (2023) focused on the use of blockchain technologies to ensure transparency of financial transactions. The researchers pointed out that blockchain avoids data fraud and increases trust in financial transactions, especially when attracting investment. This is consistent with current findings, which also highlighted the significance of transparency in crises. However, the researchers believe that blockchain is too complicated to implement due to the unstable infrastructure and may be relevant only for large enterprises. The present study suggested that blockchain can also be used by medium and small farmers, provided that the platforms are simplified. H. Zhou *et al.* (2019) focused on Big Data analysis in risk forecasting. The researchers concluded that although the use of big data helps to adapt financial strategies, its practical implementation in crisis conditions is limited due to unstable infrastructure and lack of qualified personnel. The current findings also addressed the problem of a lack of specialists in rural areas, which confirms the conclusions of H. Zhou *et al.* However, the development of distance learning and government support may reduce this drawback in the future.

The martial law has also brought major challenges to the infrastructure of the agricultural sector. Due to the partial destruction of transport routes and logistics networks, farmers are forced to adapt their processes to the new conditions. In this context, digital platforms for selling and purchasing products are becoming indispensable to keep producers and consumers connected. Thanks to online trading, farmers can minimise losses while maintaining the ability to sell their products even when they have limited access to conventional markets. This is especially significant in times of economic instability when direct access to financial and logistical resources may be limited. K. Sermuksnyte-Alesiuniene *et al.* (2021) investigated the effects of digital solutions on logistics optimisation in crisis conditions and argued that online trading allows farmers to circumvent problems with physical access to markets. This is in line with current findings that digital platforms help to keep producers and consumers connected, even when conventional logistics are unavailable. M. Remondino & A. Zanin (2022) noted that digital platforms also have their limitations, specifically, the risk of unstable Internet access in remote regions. It is worth agreeing with this observation, although the development of mobile internet and government support can help overcome these limitations.

Cybersecurity is another critical aspect of digitalisation in crises. The growing dependence on digital solutions creates new vulnerabilities for the agricultural sector (Mukambaeva *et al.*, 2024). The risk of cyberattacks and hacking is becoming a reality for many farms, especially in the context of armed conflict. The US practices in managing cybersecurity in agriculture, which has become a

priority after cyberattacks on large agricultural companies, could be useful for Ukraine. Successful adaptation of practices from other countries will help to enhance the security of Ukrainian farmers working with digital platforms. S. Rotz *et al.* (2019) emphasised the value of cybersecurity in the agricultural sector due to the growing dependence on digital technologies. The researchers also argued that agricultural companies must invest heavily in cyber defence, as the risk of cyberattacks increases under martial law. The researchers noted that farmers should develop their own cybersecurity standards, which is different from the approach of using existing solutions. K. Demestichas *et al.* (2020) also focused on cybersecurity risks but suggested that international practices and off-the-shelf solutions for the agricultural sector should be used, which is in line with the findings of the present study.

It is worth noting the positive experience of other countries that actively use digital solutions in the agricultural sector. For example, Israeli systems for water management or Chinese automated tractors for soil cultivation have become indispensable elements of resilience in crisis situations. For Ukraine, these practices can serve as a basis for developing its own solutions, which will help reduce dependence on labour and improve resource management in remote or hazardous areas. A. Ferrari *et al.* (2020) investigated the influence of digital technologies on the socio-economic development of rural communities. The researchers concluded that digitalisation contributes to improving the quality of life in rural areas by creating new jobs and improving access to educational and financial resources. The researchers also noted that digitalisation promotes greater integration of rural communities into the national and international economy, which is consistent with present findings. However, in contrast, A. Ferrari *et al.* paid more attention to cultural barriers that may hinder the rapid adoption of digital technologies in remote villages, where residents may be less ready for innovative approaches. In summary, digitalisation of the agricultural sector is a crucial area for Ukraine, especially in times of crisis. However, systematic investments in infrastructure, cybersecurity, and human resources development are required to fully exploit the potential of digital technologies. Adopting international practices and adapting it to Ukrainian conditions will contribute to the stability of the agricultural sector and increase its efficiency in the face of instability.

► Conclusions

The study highlighted the significance of digital technologies for the financial activities of the agricultural sector, especially in times of crisis, including in Ukraine. The use

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of blockchain technologies ensures transparency and security of financial transactions, which is critical for large transactions. Cloud technologies can reduce infrastructure costs, while maintaining access to large amounts of data and allowing operations to scale.

Digitalisation in the agricultural sector facilitates the automation of financial accounting, which reduces costs and increases efficiency. In Ukraine, this is particularly relevant under martial law, when conventional management methods are becoming less effective. Online platforms for financing, lending, and insurance enable farmers to operate without having to physically visit banks, which is essential for remote regions. Specifically, the introduction of online platforms has reportedly reduced the cost of processing financial transactions by 20-30%.

The practices of other countries demonstrated the effectiveness of digitalisation of financial activities in the agricultural sector. Israel is implementing platforms for managing international financial transactions that reduce costs and provide access to capital. The US focuses on cyber security of financial platforms, reducing the risk of attacks and ensuring the stability of financial flows. In Germany, online platforms are optimising logistics costs to support farmers in crises. China is investing in automation, reducing labour costs, while the Netherlands is using technology to reduce resource consumption and increase productivity. These practices can be useful for Ukraine to reduce costs and improve the financial sustainability of farmers.

Strategic areas of digitalisation can allow MHP and Kernel to reduce operating costs by 20-25%, increase resource efficiency, and markedly improve financial outcomes even in the face of economic and security instability. Overall, digital technologies such as automated accounting systems, online platforms for financial transactions, precision farming technologies, and blockchain help to improve the efficiency of the agricultural business. The limitations of the present study included the lack of available data on the internal processes of agricultural companies and the limited ability to assess the long-term effects of digitalisation in the context of the military crisis. Further research could be aimed at analysing the effectiveness of concrete digital solutions in the agricultural sector and examining their impact on the financial sustainability of enterprises in crises.

► Acknowledgements

None.

► Conflict of interest

None.

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► **Анотація.** Дане дослідження було направлене на аналіз впливу цифровізації на підвищення ефективності фінансових процесів в аграрному секторі в умовах воєнного стану. Акцентовано увагу на основних технологіях, що сприяють розвитку фінансових процесів у сільському господарстві, таких як фінансові технології, штучний інтелект, блокчейн, хмарні технології та системи кібербезпеки. Виявлено, що ці технології не тільки дозволяють автоматизувати фінансові процеси, але й забезпечують більшу прозорість та безпеку в управлінні фінансами, що є критично важливим під час кризових умов. У роботі також розглядалися специфічні виклики та ризики цифровізації в аграрному секторі, зокрема, у контексті безпеки даних та інфраструктури. Виявлено, що зростаюча залежність від цифрових систем збільшує вразливість до кіберзагроз, що потребує інвестицій у вдосконалення систем захисту та управління ризиками. Особливу увагу приділено адаптації цифрових технологій в умовах війни, де відзначено позитивні результати впровадження цифрових рішень для моніторингу виробничих процесів, аналізу даних, управління ланцюгами постачання та планування виробничих потужностей. У роботі також вивчено міжнародний досвід використання цифрових технологій у аграрному секторі, зокрема в таких країнах, як Ізраїль, США, Німеччина, Китай та Нідерланди, що надає можливість застосувати найкращі практики для забезпечення стабільності аграрного сектору України. Результати дослідження демонструють, що цифровізація аграрного сектору України є необхідним кроком для підтримки продовольчої безпеки та економічної стабільності в умовах війни, але також вимагає подолання значних викликів, таких як недостатня інфраструктура, кадровий дефіцит та кіберзагрози. Висновки вказують на необхідність посилення інвестицій у цифрові технології та кібербезпеку, а також розвиток кадрового потенціалу для ефективного використання новітніх технологій

► **Ключові слова:** інноваційні технології; бізнес-стратегії; блокчейн; штучний інтелект