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The Impact of Digitalisation on Employment in Agriculture in Ukraine and Slovakia

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ABSTRACT

The digital transformation is strategically important for the agricultural sector development, food security and employment in the agricultural sector and related industries. The study aimed to assess the impact of digitalisation on employment in agriculture in Ukraine and Slovakia. The study found that Ukraine and Slovakia have successfully implemented digital technologies in agriculture, which has led to positive results for agricultural production and sector competitiveness. Both countries use digital platforms to collect, process, and analyse data, contributing to efficient resource management and making agriculture more accurate and productive. However, Ukraine has a low correlation between the number of people employed in agriculture and investments in digital transformation, possibly due to the specifics of agriculture and infrastructure constraints. In Slovakia, however, the level of dependence is moderate, indicating more efficient use of digital tools in agriculture. For the further development of digital agriculture in both countries, it is crucial to consider the specifics of infrastructure, financing, and farmers' readiness to implement digital solutions. Attention should also be paid to simplifying bureaucratic procedures and supporting research and innovation, which will help to increase the benefits of the digital transformation of agriculture and further improve the productivity and competitiveness of the sector.

KEYWORDS: Agrarian structure, digitization, work organization, investment, employment.

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El impacto de la digitalización en el empleo agrícola en Ucrania y Eslovaquia

RESUMEN

La transformación digital es estratégicamente importante para el desarrollo del sector agrícola, la seguridad alimentaria y el empleo en el sector agrícola y las industrias relacionadas. El estudio tiene como objetivo evaluar el impacto de la digitalización en el empleo en la agricultura en Ucrania y Eslovaquia. El estudio encontró que Ucrania y Eslovaquia han implementado con éxito tecnologías digitales en la agricultura, lo que ha dado resultados positivos para la producción agrícola y la competitividad del sector. Ambos países utilizan plataformas digitales para recopilar, procesar y analizar datos, contribuyendo a una gestión eficiente de los recursos y haciendo que la agricultura sea más precisa y productiva. Sin embargo, Ucrania tiene una baja correlación entre el número de personas empleadas en la agricultura y las inversiones en transformación digital, posiblemente debido a las limitaciones específicas de la agricultura y la infraestructura. En Eslovaquia, sin embargo, el nivel de dependencia es moderado, lo que indica un uso más eficiente de las herramientas digitales en la agricultura. Para un mayor desarrollo de la agricultura digital en ambos países, es crucial considerar los aspectos específicos de la infraestructura, el financiamiento y la preparación de los agricultores para implementar soluciones digitales. También debe prestarse atención a simplificar los procedimientos burocráticos y apoyar la investigación y la innovación, lo que ayudará a aumentar los beneficios de la transformación digital de la agricultura y mejorar aún más la productividad y la competitividad del sector.

PALABRAS CLAVE: Estructura agraria, digitalización, organización del trabajo, inversión, empleo.

Introduction

The digitalisation of agriculture is critical in changing the employment structure and increasing productivity in rural areas of the EU, Ukraine, Slovakia, and other countries. Here are some of the common factors that are driving these changes:

1.   Introducing modern technologies and digital solutions in agriculture increases farmers' productivity. New technologies, such as drones, automated tractors, and monitoring systems, help to optimise production processes and reduce the need for manual labour.

2.   The digitalisation of agriculture will increase the skills requirements for farmers and agricultural workers. This may lead to an increased demand for education and training in digital technologies.

3.   Consumer habits are changing, which may lead to a decline in employment in traditional agricultural activities, such as manual recording and improvement, in favour of more automated methods.

4.   Thanks to technology and digitalisation, farmers can improve the quality of their products, open up new markets and increase export opportunities.

5.   Modern agricultural technologies can reduce the negative impact of agriculture on the environment, leading to more sustainable employment and the development of environmentally friendly industries.

Overall, the digitalisation of agriculture helps to increase productivity and create new opportunities in rural areas of the EU and Ukraine. However, this process also requires employees' training investments in infrastructure to ensure the successful integration of digital technologies in agriculture.

The introduction of modern digital technologies in agriculture contributes to the automation and mechanisation of production processes, optimisation of resource use, integration of e-commerce and increased efficiency of production management. Modern digital technologies are changing employment structure, increasing the demand for IT specialists and creating new opportunities in agro-technology and start-up development. However, to achieve the full potential of agricultural digitalisation, infrastructure, education, and training of highly skilled professionals are needed (Angin et al., 2020; Bahn et al., 2021).

In the EU, digitalisation has become essential for increasing agricultural productivity and improving the quality of life of rural populations. With the help of modern technologies such as agrarian sensors, automation systems, artificial intelligence and data analytics, farms can produce more efficiently and manage resources more effectively (Ozdogan et al., 2017).

Ukraine and Slovakia, as two different countries, have their peculiarities in developing digital technologies in agriculture. Agrarian characteristics, such as the size and structure of agriculture, financial capacities, market requirements and legislative support, determine these differences. With its vast agricultural production, Ukraine faces great

challenges in optimisation and modernisation, while Slovakia, with its more limited agriculture, can focus on high-quality products and efficiency. Given these differences, both countries are developing digital technologies in agriculture according to their needs and strategies.

Ukraine has significant potential in agricultural production but faces challenges in implementing digital innovations due to financial and infrastructural constraints. While the EU member Slovakia has greater access to financial resources and developed technological infrastructure, which facilitates faster adoption of digital solutions in agriculture, Ukraine, in turn, has significant potential for agricultural development. However, Ukraine lacks infrastructure and access to many resources, which limits the speed and scale of digital innovation. Hence, both countries have advantages and challenges in developing digital technologies in agriculture, and they can mutually benefit from each other's experience and support to achieve common goals (Dobrovodska et al., 2019; Tretyak et al., 2022).

The study of the impact of digitalisation on agriculture in Ukraine and Slovakia in the context of general trends in the EU has several relevant aspects. First, it is a regional approach to analysis, which allows us to compare the impact of digital transformation on agriculture in countries with different levels of economic development. This makes the study relevant for regional policymakers and investors looking for appropriate approaches to digital rural development.

There is a growing interest in digital solutions in agriculture, where digital transformation has become a vital tool for food security and crisis response, particularly in the context of the full-scale war in Ukraine, where food security and humanitarian concerns have become significant challenges for agriculture. The study offers practical information and ideas that can contribute to developing digital agriculture and preserving employment in rural areas.

The study aims to assess the impact of digitalisation on agricultural employment in Ukraine and Slovakia. The study aims to identify familiar and different trends in the impact of digitalisation on the agricultural sector in these regions.

Specific research objectives include:

1.   Analysis of the introduction of digital technologies in agriculture in Ukraine, the EU and Slovakia.

2.	Study of the impact of digitalisation on the changing structure of employment in the rural sector.

3.	Assessment of the impact of digitalisation on agricultural productivity and competitiveness.

4.	Identification of factors that facilitate or impede the digital transformation of agriculture in the studied regions.

5.	Consideration of possible prospects and recommendations for further development of digital agriculture.

1. Literature Review

Many scholars think digital tools, such as agricultural sensors, automation systems and data analytics, can significantly increase agricultural productivity. This means producing more crops per unit of inputs and resources (according to Ostapchuk et al. (2021), Arıcıoglu et al. (2020)).

Agriculture that uses digital solutions becomes more competitive in the global market. More accurate predictions of yields and improved product quality can make agricultural products more attractive to consumers (according to a study by Fountas et al. (2020)).

In addition, introducing digital technologies such as autonomous tractors, drones, and agricultural software can help increase productivity and reduce the need for manual work. This reduces the necessary workforce and opens up opportunities for automation and robotisation of routine tasks in agriculture. Such innovations can significantly increase production efficiency and reduce costs, which are critical factors for the sustainability and development of agriculture in the modern world. In addition, developing digital infrastructure in rural areas can also create new jobs in information technology, programming, digital equipment maintenance, and other related fields (Dueñas et al., 2021).

Berawi et al. (2020) claim that digital technologies can improve the competitiveness of small and medium-sized enterprises in rural areas, leading to increased production and business expansion.

However, according to Kova et al. (2019), introducing digital technologies may require retraining workers. New equipment and software related to digital technologies may require specific skills and knowledge (Skrypchuk, 2023).

Wilson et al. (2018) and Xiong at al. (2020) believe that introducing robotic systems and automation can reduce the physical burden on agricultural workers, which can be particularly beneficial for older workers or disabled ones.

Wadoux and McBratney (2019) and Verboven et al. (2019) think that digital transformation can create new employment sectors in agriculture, such as developing, maintaining, and supporting digital agricultural technologies. Nasirahmadi and Hensel (2022) also note that various jobs may appear in agriculture, from drone operators and data analysts to agro-technology engineers and farmers using these technologies.

Digital technologies can also change the nature of work in agriculture. For example, farmers may focus more on data management and analysis and less on physical farming operations. This may open up new opportunities for specialisation and diversification in the industry. In addition, with the development of digital technologies, new rural services may emerge, such as crop advisory, data analytics, farm planning, etc. This could create new jobs for agronomists and consultants (Moghadam et al., 2020).

Digitalisation can create new opportunities for agricultural start-ups and innovative enterprises, which may require additional expertise and labour. Digital technologies can also facilitate the development of e-commerce in agriculture, which can create new jobs in logistics, e-commerce and marketing (Pazur and Bolliger, 2017).

According to Pylianidis et al. (2021), it is essential that young people get interested in working in agriculture if modern technologies and digital tools are used.

Hence, the literature review shows that the impact of digitalisation on employment in agriculture is composed of various factors and can have both positive and negative consequences for the labour force and employment in this sector.

The interaction between digital transformation and agriculture is complex, so further research will help better understand the impact of digital transformation on agriculture and develop strategies that will promote sustainable and innovative development of this critical sector.

2. Materials and Methods

The main stages of studying the impact of digitalisation on agriculture in Ukraine and Slovakia:

Stage 1: Identification of critical indicators that should be considered when analysing the impact of digitalisation on agriculture. These indicators include:

- number of agricultural enterprises;

- total area of agricultural land;

- total number of people working in agriculture;

- number of rural population with education in information technology;

- number of farms using modern agricultural technologies (e.g. GPS navigation);

- amount of investment in the digitalisation of agriculture;

- gross value added;

- average monthly nominal wage of full-time employees.

Stage 2. A comparative analysis of the state of agricultural development and the level of digitalisation in Ukraine and Slovakia was carried out.

Stage 3. Forecasting for the further development of agriculture in Ukraine and Slovakia in the context of digitalisation. Considering the analysis results, we tried to predict possible trends and identify critical areas of development which can be helpful for government agencies, businesses and other stakeholders.

2.1. Research Methods

The following methods were used to obtain the most objective and reliable information:

– *The descriptive analysis method* was used to provide a general overview of the state of agricultural development and digitalisation and to conduct a descriptive analysis of the state of agricultural development and the level of digitalisation in Ukraine and Slovakia.

– *Analysis of statistical data and literature review* related to the digital transformation of agriculture in the EU region. This allowed us to understand current trends, challenges, and opportunities for digital transformation in this sector. Official statistical sources on agriculture, investment, employment, economic indicators and other statistical data in Ukraine and Slovakia were the Ministry of Digital Transformation of Ukraine (2023), the State Statistics Service of Ukraine (2023), the Statistical Office of the Slovak Republic (2023), the Ministry of Agriculture and Rural Development of the Slovak Republic (2023), the Ministry of Investment, Regional Development and Informatics of the Slovak Republic (2023), reports of international organisations such as The World Bank (2023) and the

United Nations Economic Commission for Europe (2023) containing information on agriculture and digital transformation.

– *Correlation analysis.* The data obtained were processed and analysed using statistical and analytical methods, including statistical processing, calculation of performance indicators, and correlation analysis to identify relationships between various factors. Performance indicators were calculated based on the amount of investment in agricultural digitalisation, gross value added, average monthly nominal wages of full-time employees, and the total population working in agriculture, which may be necessary for assessing the impact of digitalisation on agricultural productivity and competitiveness. Calculating efficiency based on the amount of investment in agrarian digitalisation can be essential to determine how much investment in digital technologies affects the development and performance of the agricultural sector; gross value added indicates the value created in agriculture, and average monthly wages can mean the level of remuneration and possible changes in the quality of the labour force.

The impact of digitalisation on employment in agriculture in Ukraine and Slovakia is calculated using the formula 1:

$$k = G / T \tag{1}$$

k is a digital investment indicator,

G – the amount of investment in the digitalisation of agriculture *(Gross fixed capital formation for formation)*

T – total population working in agriculture *(Total number of employees)*

This indicator can help analyse the costs of digital transformation in different areas of activity and compare the effectiveness of these investments among employees.

– *Case study.* Special attention was paid to analysing specific cases of successful integration of digital technologies in agriculture in Ukraine and Slovakia. This approach allowed us to identify particular examples and study their impact on practice.

3. Results

The digitalisation measures used in Europe have great potential to promote innovation in the agricultural sector and support farmers in implementing digital technologies and sustainable agriculture. Developing digital skills among farmers and

access to modern digital infrastructure is essential for the successful digitalisation of agriculture.

Slovakia actively supports innovation in the dairy and potato sector through energy efficiency, advisory services, waste management and energy audits, which help farmers use modern production methods and reduce their environmental impact. Close cooperation between farmers, researchers and technologists improves agriculture, allowing the exchange of knowledge and innovative solutions, improving agricultural practices and increasing production efficiency.

Such support promotes sustainable agriculture by ensuring a balanced approach to production and resource management, fostering business development job creation and improving the quality of life of local people. It is important to note that such initiatives contribute to the digital transformation of agriculture and its sustainable development and increase farmers' competitiveness in the global market.

Digitalisation in Ukrainian agriculture is an essential area of agricultural development. This includes the use of modern technologies, software, and information systems to improve the productivity, quality and competitiveness of agriculture, the introduction of electronic accounting and document management systems that allow farmers to reduce bureaucracy and improve reporting, and the use of specialised software products for production planning, fertiliser and crop protection calculations, soil quality control and other aspects of agriculture.

In general, it can be noted that both Ukraine and Slovakia are experiencing some growth in agriculture and digitalisation. Still, both countries have specific features and development paces (Tables 1, 2).

The data shows that Ukraine has more agricultural enterprises and a larger population engaged in agriculture. In addition, the number of farms using modern technology has also increased in Ukraine. However, investment in digitalisation declined between 2016 and 2022, which was also affected by the pandemic (2019-2020) and full-scale war (2022).

Slovakia has fewer agricultural enterprises, but the country has made more progress in increasing the number of farms using modern technology and attracting investment in digitalisation.

Table 1. Dynamics of indicators of agriculture and digital transformation in Ukraine

Indicator	Year						
	2010	2012	2014	2016	2018	2020	2022
Number of agricultural enterprises, thousand	42	46	49	47	45	43	49
Total agricultural land area, mln ha	41.6	41.5	41,5	41.5	41.5	41.3	41.3
Total population working in agriculture: thousand people	2760	2795	2870	2937	3010	2721	2692
Number of rural population with education in information technology, %.	12	14	16	18	20	22	24
Number of farms using modern agricultural technologies (e.g. GPS navigation, automated systems and tools)	3200	3400	3600	3800	4000	4200	4400
Investment in agricultural digitalisation, USD million	462	845	1206	1626	1463	1267	1142
Gross value added, USD million	2183	6311	9499	9383	10344	15277	14812
Average monthly nominal salary of full-time employees, USD	40	87	199	233	256	323	385

Source: The World Bank (2023).

This may indicate that Ukraine has the potential to develop the digital transformation in agriculture further, especially if investments in the sector increase.

To calculate the impact of digitalisation on employment in agriculture in Ukraine and Slovakia, the value of the digital investment indicator (k) is calculated.

For Ukraine:

$$k = \frac{1142}{2692} = 2692 1142 \approx 0.424$$

Table 2. Dynamics of indicators of agriculture and digital transformation in Slovakia

Indicator	Year						
	2010	2012	2014	2016	2018	2020	2022
Number of agricultural enterprises, thousand	16,4	16,8	17,5	18,9	21,4	23	25
Total agricultural land area, mln ha	3.2	3.1	3.3	3.2	3.1	3.0	2.9
Total population working in agriculture: thousand people	50,5	48,9	51,8	52	52.5	52,8	53
Number of rural population with education in information technology, %.	18,4	18,9	19	19,4	20,1	24	28.6
Number of farms using modern agricultural technologies (e.g. GPS navigation, automated systems and tools)	3010	3240	3980	4150	5400	6700	9100
Investment in agricultural digitalisation, USD million	98	121	134	154	2148	2584	4122
Gross value added, USD million	361	456	512	632	658	756	884
Average monthly nominal salary of full-time employees, USD	756	956	1203	1306	1380	1420	1500

Source: The World Bank (2023).

For Slovakia:

$$k= \frac{3353}{52.9} = 52.93353 \approx 63.32$$

The obtained values of the average digital investment indicator show a significant difference in the level of digital investment between Ukraine and Slovakia.

As a member of the EU, Slovakia can benefit from support and funding from European funds for developing agriculture and digital infrastructure. This support can stimulate investment in digital transformation. In addition, the high average value of digital

investment in Slovakia indicates that the country is investing significant resources in the digital transformation of agriculture. This can contribute to developing modern technologies in the agricultural sector, increasing productivity and reducing dependence on manual labour. In addition, high investment activity in the digital transformation of agriculture can stimulate innovation, increase productivity, and reduce dependence on manual labour, contributing to the sector's sustainable development.

On the other hand, Ukraine has a significantly lower average value for digital investment than EU countries, which may indicate a lower adoption of modern technologies in agriculture and may impact the productivity and competitiveness of the agricultural sector.

The statistical software Excel was used to calculate the correlation coefficient, and a linear trend line was plotted. The relationship between the number of agriculture employees and the investment in agricultural digitalisation in Ukraine has increased over the years. Still, the correlation coefficient (R) is 0.0195, which indicates a fragile linear relationship between these variables (Figure 1).

The relationship between the average monthly nominal wage of full-time employees and the volume of investment in agricultural digitalisation is characterised by a correlation coefficient of R of 0.973, which indicates a solid positive linear relationship between these variables. An R-value close to 1 means a robust linear relationship between the average monthly nominal wage of agriculture full-time employees and the investment in agricultural digitalisation.

Therefore, over time, there is an increasing relationship between the average monthly wage of agricultural workers and the amount of investment in agrarian digitalisation. But the relationship between the number of employees and investment is smaller and less stable.

It is worth noting that digitalisation helps increase productivity and efficiency in agriculture, which in turn leads to an increase in the gross value added to this sector. The calculation was performed using the statistical software Excel. The correlation coefficient (R) value is close to 1, indicating a strong positive linear relationship between the investment amount in agricultural digitalisation and gross value added in agriculture. In other words, investment in agrarian digitalisation is usually accompanied by increased gross value added to the sector (Figure 2).

Figure 1. Correlation between the amount of investment in agricultural digitalisation, the total number of people working in agriculture and the average monthly nominal wage of full-time agricultural workers in Ukraine
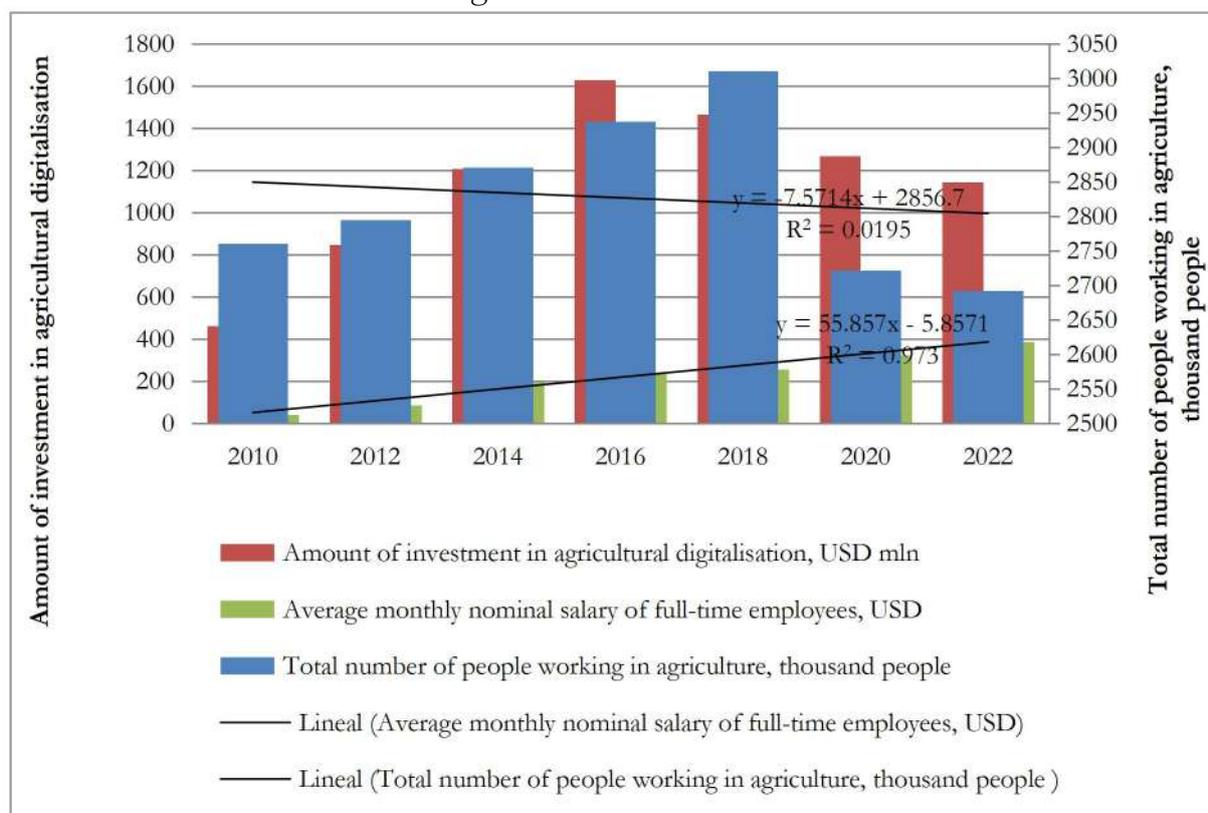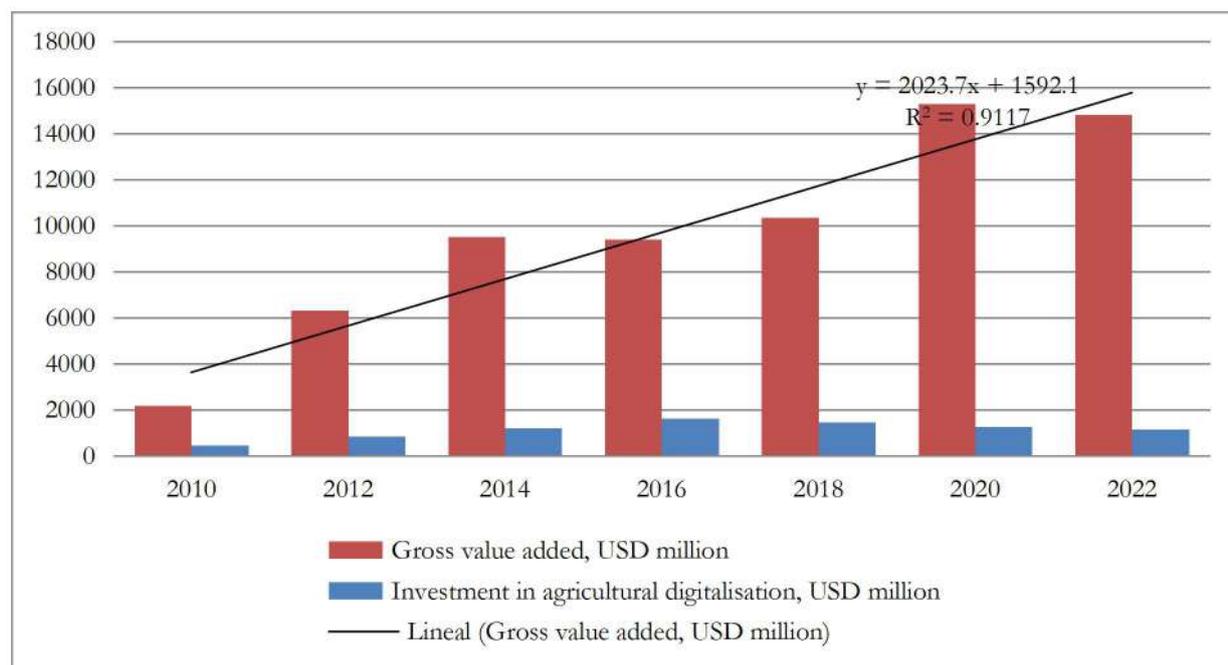

Source: developed by the author.

In Slovakia, the relationship between the number of people working in agriculture and the investment in agricultural digitalisation has increased over time from 2014 to 2022. R is 0.7089, indicating a moderate positive linear relationship between the number of people working in agriculture and the investment in agricultural digitalisation.

The correlation between full-time employees' average monthly nominal wage and investment in agricultural digitalisation is very high. The positive relationship between these two indicators increases over time and becomes even stronger in 2022. The R-value close to 1 confirms a significant linear relationship between these two variables.

This may indicate that investments in the digitalisation of agriculture impact increasing workers' wages in the sector and may contribute to improving their lives and working conditions (Figure 3).

Figure 2. Correlation between investment in agricultural digitalisation and gross value added in Ukraine
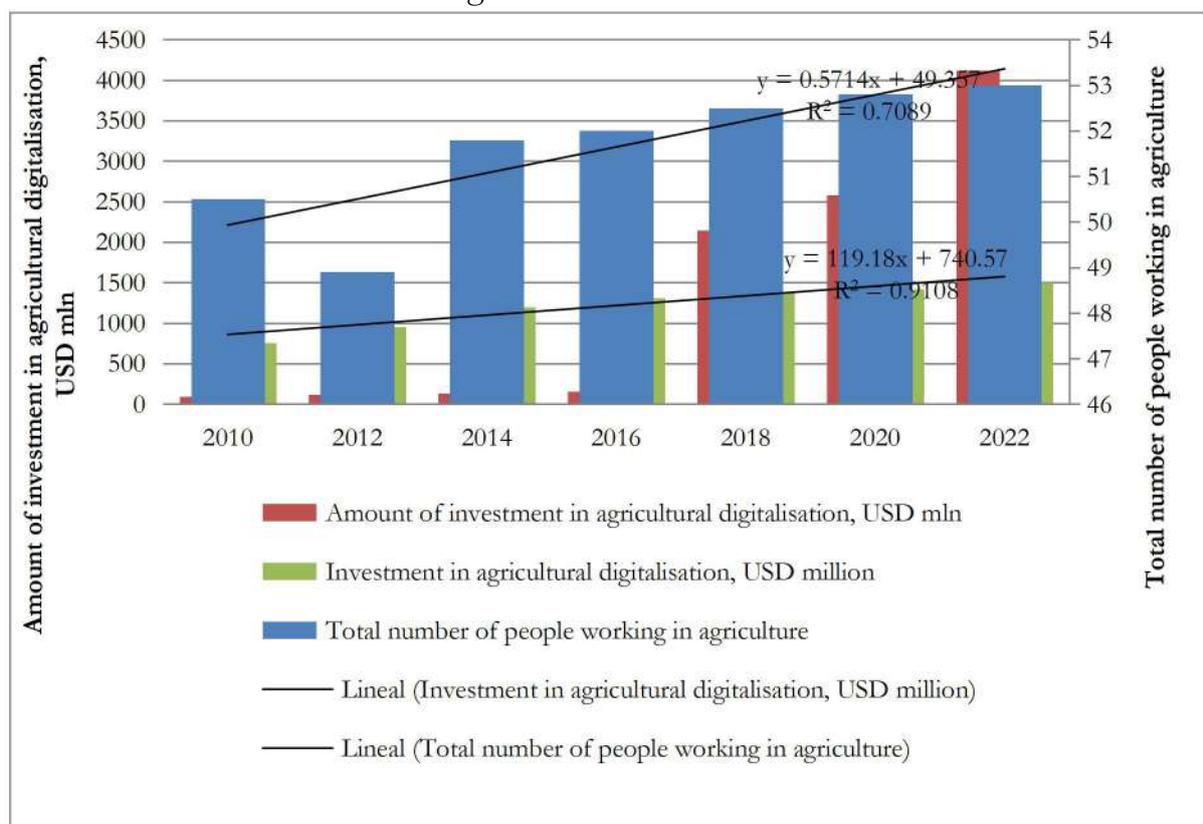

Source: developed by the author.

In addition, this strong correlation may reflect the impact of investment on wages in agriculture or the chosen development strategy for the sector in which investment and wages are highly interdependent.

The correlation coefficient (R) is approximately 0.9841, indicating a relatively strong positive linear relationship between the investment amount in agricultural digitalisation and gross value added in agriculture. This may suggest that digitalisation contributes to increased productivity and profitability of agriculture, which in turn leads to an increase in gross value added (Figure 4).

Both countries have a strong positive correlation between the average monthly nominal wage of full-time employees and the investment in agricultural digitalisation. However, in the case of Ukraine, the relationship between the number of people employed in agriculture and investments in digitalisation is fragile, while in Slovakia, it is moderate. In other words, in Ukraine, investments in agricultural digitalisation may not have as strong an impact on the number of employees in agriculture as in Slovakia.

Figure 3. Correlation between the volume of investments in agricultural digitalisation, the total number of people working in agriculture and the average monthly nominal wage of full-time agricultural workers in Slovakia

Source: developed by the author.

A case study for Ukraine:

A specific example for Ukraine is using drones to monitor fields and crops. Ukraine is already using drones equipped with unique cameras and sensors that collect data on the condition of crops, soil moisture, temperature, and other factors. This data is processed using data analytics and artificial intelligence, which allows farmers to receive accurate information about the condition of their fields.

The results of using drones include:

1.   *Accurate field monitoring:* farmers can detect problems such as pests, diseases or insufficient watering in time and take the necessary measures.

2.   *Optimizing the use of resources:* data collected by drones can help reduce the cost of water, fertiliser and pesticides.

3.   *Increased yields:* with precise crop monitoring and management, you can increase yields and improve product quality.

This example demonstrates how using specific digital technologies, such as drones, can improve agricultural efficiency and become a successful innovation for farmers in Ukraine (Ostapchuk et al., 2021).

Figure 4. Correlation between investment in agricultural digitalisation and gross value added in Ukraine
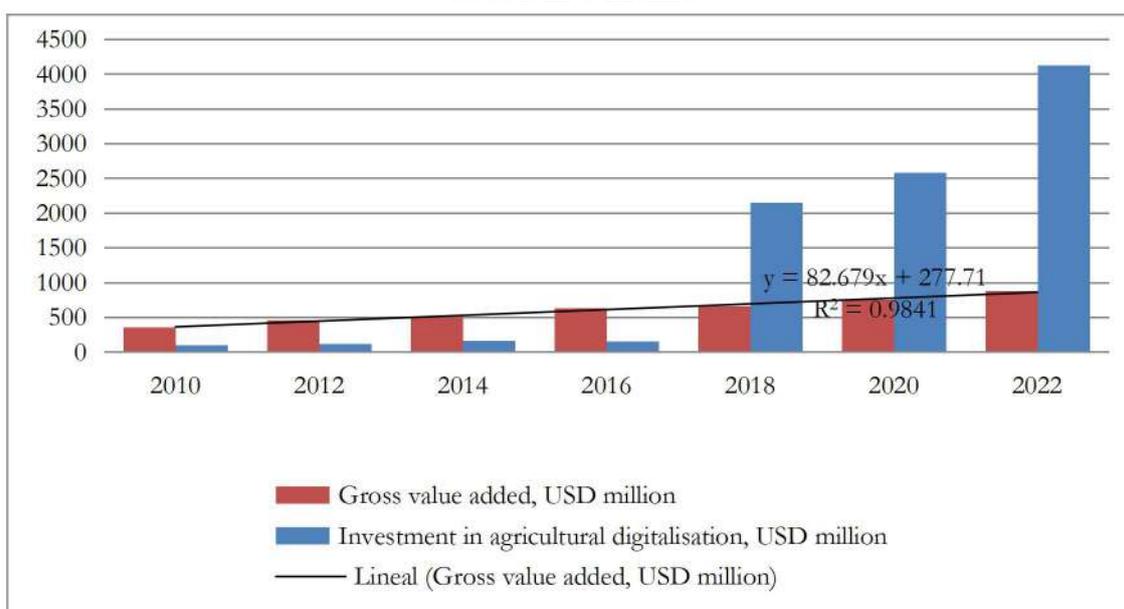
Source: developed by the author.

A case study for Slovakia:

Slovakia has introduced digital technologies in agriculture through the "Smart Agriculture" initiative, aimed at introducing various technologies to improve the efficiency of agricultural production: modern plant and animal monitoring systems using sensors and drones, the use of automated systems for tillage, irrigation and harvesting, and the use of data analytics and artificial intelligence to provide farmers with recommendations on the optimal use of resources and farm management.

Results:

- Thanks to the introduction of digital technologies, agriculture in Slovakia has increased yields and reduced production costs.

- Farmers have access to real-time information about the conditions on their farms and can make more informed decisions.

- The development of digital markets contributed to the expansion of foreign trade and increased farmers' incomes.

- Economic models have shown that investments in digital technologies pay off by increasing productivity and product quality (Dobrovodska et al., 2019).

Both cases demonstrate the successful integration of digital technologies into agriculture in Ukraine and Slovakia. The analysis of such cases is an essential component of the study of the impact of digitalisation on agriculture and provides specific examples of successful innovative solutions.

Ukraine has a large agricultural sector, and its young IT industry could become an essential driver of digital transformation. However, important factors that hinder this process include limited internet access in rural areas, lack of funding, farmers' age and their lack of readiness to use digital technologies. To develop digital agriculture further in Ukraine, it is essential to expand infrastructure, create financial mechanisms, and provide training and support to farmers.

Slovakia has a high level of technical education and access to financial resources but also faces bureaucratic constraints that hinder the adoption of digital technologies in agriculture. Some of these constraints include complex licensing and registration procedures for using agricultural technologies, limited access to finance for farm modernisation, land and property issues, certification and standards requirements, and tax and financial obligations. These bureaucratic difficulties may hinder the digital transformation of agriculture in Slovakia despite the availability of technical expertise and financial resources. To further develop digital agriculture in Slovakia, simplifying bureaucracy, developing training programmes, and investing in research and innovation are essential.

Both countries have the potential to improve their approaches to the digital transformation of agriculture and use digital technologies to increase productivity and efficiency in the agricultural sector.

The findings may indicate differences in the level of investment and approaches to digitalisation in both countries and may serve as a basis for further analysis and strategising for the development of digital agriculture. It is essential to remember that this is a general overview, and other aspects such as policy, regulation and access to resources may also influence agricultural development and digitalisation in both countries.

4. Discussion

Digitalisation is one of the most important transformational forces in the modern world, affecting various sectors of the economy and society. Countries with high investment in digital infrastructure and technology can enjoy the benefits of digitalisation to a greater extent, including increased efficiency and job creation. One sector experiencing digitalisation's impact is agriculture (Ostapchuk et al., 2021; Arıcıoglu et al., 2020). However, the availability of workers capable of using digital technologies in agriculture can affect the success of introducing these technologies and their impact on employment (Kova et al., 2019).

The specifics of agriculture and market conditions may vary between countries. The existence of developed agricultural markets and demand for digital services may alter the employment impact of digitalisation. Changes in countries' political, economic and trade policies can also affect the level of employment in agriculture and the effectiveness of digital transformation (Lopez-Morales et al., 2020).

In addition, the study is similar to the findings of various scholars that digital technologies can increase productivity in agriculture, which may boost demand for specialised labour (Nasirahmadi and Hensel, 2022).

Researchers note that the digital transformation of agriculture can significantly impact employment and job creation. In particular:

1. *Creation of new jobs* in areas such as software development for agricultural technologies, technical support for farmers using digital solutions, data analysis for production improvement, and many other related areas.

2. *Improving working conditions* for rural workers through automation and using robots. Routine and heavy physical work can be done with the help of autonomous technologies, allowing agricultural workers to avoid overwork and reduce the risk of injury.

3. *Improving safe working conditions.* For example, monitoring systems and sensors can warn of potentially dangerous situations and control the operation of machinery and equipment, reducing risks.

4. *Improving production efficiency.* Digital solutions allow farmers to optimise production processes, increasing yields and production. This, in turn, may create demand for additional labour to maintain and monitor these new technologies.

5.   *Development of related industries.* The digital transformation of agriculture contributes to developing associated industries, such as agricultural technology production, agro-technology consulting, engineering, and programming of farming needs.

Therefore, the digital transformation of agriculture provides new opportunities for efficiency and sustainability of the sector and contributes to the creation of employment and improved working conditions (Werkheiser, 2020).

Introducing digital technologies may require training and upskilling workers, but it opens up new professional growth and development opportunities. In addition, digital transformation contributes to the development of rural areas, reduces the gap between cities and rural areas, and promotes job creation in rural areas.

Through training and skills development, rural residents can acquire new skills needed to work with digital technologies, which opens up opportunities for professional growth and improved quality of life. Digital transformation also has the potential to reduce the economic and infrastructural gap between localities, as it allows rural regions to access modern technologies and resources. This, in turn, can stimulate the development of farms and businesses in rural areas. Rural job creation is also an essential component of digital transformation. New technologies and innovations can contribute to developing agriculture and rural industries, which require additional workers and create more jobs in rural communities.

Digital transformation can improve productivity and quality of life in rural areas and create new professional growth and development opportunities in rural communities (Dueñas et al., 2021).

The level of investment in agricultural digitalisation correlates with the gross value added in this sector, which confirms that investments in digital technologies help increase agriculture's productivity and profitability, leading to an increase in gross value added (Jorge-Vázquez et al., 2021; Némethová and Rybanský, 2021).

The development of digital agriculture impacts the wages of workers in the sector. Digital tools and process automation can increase agricultural enterprises' efficiency, leading to higher revenues and, consequently, higher wages for workers. These findings highlight the importance of investing in the digital transformation of agriculture to increase efficiency, profitability, and competitiveness (Dobrovodska et al., 2019).

However, various authors, similar to the study presented here, note that the success of digital transformation may depend on multiple factors, such as the availability of infrastructure, financing, education and training of farmers, as well as the effectiveness of managing this process at the state and regional levels (Bernal-Jurado et al., 2021).

In addition, this study differs from the findings of some studies on the impact of various factors on employment. After all, a country's economic context and level of development can significantly impact how digital transformation affects employment. In developed countries, there may be more opportunities to use digital technologies to create new jobs. In contrast, preserving and stabilising existing jobs in less developed countries may be more critical. Therefore, it is essential to conduct analyses in a country-specific context and consider all aspects that may affect the relationship between digital transformation and employment in agriculture (Reis et al., 2021).

Digitalisation in agriculture in Ukraine and Slovakia has excellent potential to improve the rural population's production efficiency and quality of life. However, adopting digital technologies requires investment, training and a regulatory approach to ensure equal access and beneficial use of these opportunities (Berawi et al., 2020; Jan Drahokoupil and Fabo, 2019).

In summary, Ukraine and Slovakia, like many other countries, face challenges and opportunities in the digital transformation of agriculture. The introduction of modern technologies in agriculture can improve production efficiency, increase product quality, and create new jobs. However, this process requires investment, training, and infrastructure development.

Ukraine has the potential to develop digital technologies in agriculture but faces challenges such as limited internet access and financial constraints. The pandemic and full-scale war have also affected investment.

Slovakia has a high technical education and financial infrastructure level and is actively integrating digital solutions into agriculture. However, bureaucratic constraints can be an obstacle to the rapid adoption of technology.

The relationship between investment in digitalisation and employment in agriculture in Ukraine appears weak, indicating that investment may not automatically lead to an increase in the labour force. However, an increase in average monthly wages is

significantly correlated with investment, indicating a positive impact of digital transformation on working conditions (Liu et al., 2021; Rega et al., 2020).

In the context of the European Union, Ukraine and Slovakia can draw on European countries' experience and best practices to improve the situation in their respective agriculture sectors. Focusing on agricultural support policies, agro-technology, efficient use of resources, and attracting young people to agriculture can make agriculture more sustainable and competitive.

Overall, the digital transformation of agriculture has great potential to improve the quality of life of rural residents and the development of rural areas in Ukraine and Slovakia, and its development should be promoted and supported.

Hence, the study meets its objective, and its results highlight the importance of digital transformation of agriculture as a strategic direction to increase the productivity, efficiency, and competitiveness of the sector in Ukraine and Slovakia. The study shows that investments in digital technologies contribute to increased gross value added, higher wages and overall agricultural development in both countries. The findings directly affect governments, businesses, and educational institutions in agriculture and digital technologies.

Conclusions

Improving agriculture through the use of digital technologies can contribute to the development of employment in rural regions of Ukraine and Slovakia. The introduction of modern agricultural technologies and digital solutions can create new opportunities for jobs in the agricultural sector, including jobs in the maintenance and technical support of digital equipment.

Involvement of youth in agriculture by giving them access to modern technologies and training in this direction can be a step in ensuring sustainable employment in the agricultural sector. In addition, the development of digital skills among the rural population can contribute to their adaptation to new requirements in the labor market and increase their competitiveness both as specialists in agriculture and in other fields.

Ukraine and Slovakia have demonstrated the successful integration of digital technologies in agriculture, showing the positive effects of this process on production and

competitiveness of the agricultural sector. Both countries use digital platforms to collect, process and analyse data, contributing to efficient resource management and making agriculture more accurate and productive.

For the further development of digital agriculture in both countries, it is essential to consider the specifics of infrastructure, financing and farmers' readiness to implement digital solutions. Attention should also be paid to simplifying bureaucratic procedures and supporting research and innovation, which will help increase the benefits of the digitalisation of agriculture and further improve the productivity and competitiveness of the sector.

The study's findings are of practical importance as they can be used to develop strategies and policies for the digital transformation of agriculture in Ukraine and Slovakia. They also indicate the potential and prospects for further improving agricultural productivity and efficiency through digital technologies. Thus, the results of this study can serve as a basis for elaborating specific measures and strategies for developing digital agriculture in both countries.

Prospects for further research lie in an in-depth study of the factors influencing the digital transformation of agriculture in Ukraine and Slovakia. Possible research areas include analysing the impact of policy and regulation on this process, examining the role of rural communities and cooperative societies in digital transformation, and exploring the relationship between digital transformation and the sustainability of agricultural production.

Limitations of the study

Various economic, political, and social factors may influence the digital transformation of agriculture, and these factors may be difficult to control or account for in a study.

Recommendations

Efforts must be made in several areas to achieve a successful digital transformation of agriculture in Ukraine and Slovakia. First, both countries should actively work to expand internet access in rural areas. This could include investing in mobile and

broadband networks to ensure reliable access to digital technologies for rural residents and farmers.

Second, creating financial mechanisms to support investment in digital technologies is essential to successful digital transformation. Ukraine and Slovakia should develop subsidies, loans, and grant programmes to support farmers in implementing digital solutions. This could engage more farmers in digital transformation and foster innovation in agriculture.

Third, training and consultations are essential in preparing farmers and rural populations to use digital tools. Training programmes and advisory services can help increase knowledge and skills in using digital technologies, which will positively impact the speed of adoption of these solutions.

The overall success of the digital transformation of agriculture also depends on active cooperation between the countries and the exchange of experience. Both countries can use best practices and experience from the European Union to improve their agricultural sectors. At the same time, developing long-term strategies is critical to creating sustainable and competitive agricultural sectors.

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