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Human Capital in the Digital Economy: The Impact of Technology on the Labor Market in Agriculture and Logistics

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Abstract - **The digital economy affects the success of the agricultural and logistics industry, however, the adoption of computer technology differs in these sectors, although they are interconnected. Another aspect is the impact of information technology on personal potential and the influence of employees' qualifications on the success of innovation. The aim of our study was to determine the mutual influence of digitalization and human capital by survey analysis of workers of agricultural and logistics companies. The methods of analysis, synthesis, survey, statistical, graphical, and abstract and logical comparison were used in the research. An online survey was conducted of 1460 employees of the agricultural sector and logistics companies, who were divided into groups depending on their professional qualifications. The survey results were compared using the t-test. A higher level of awareness of information technologies and their practical use was identified among employees of logistics companies. Moreover, medium-level managers and company executives had a high level of knowledge and skills in working with digital technologies, while drivers, loaders, and lower-level workers had a lower than average level of skills. Among agricultural workers, there was a low level of awareness of information technology, and among the types of innovations, respondents mostly mentioned simple sensors for irrigation, soil temperature and moisture control. In contrast, the level of information technology skills among medium-level managers was above average and the highest among all agricultural workers. However, the information technologies of this group were used for logistics, financial, analytical operations, marketing, and communications. Managers of agricultural enterprises rated their digitalization skills below average, which was the main reason for the low implementation of innovations in agricultural processes in the agricultural sector.**

Keywords: **Digital Economy, Digital Technologies, Human Capital, Agriculture, Logistics, Sustainable Development**

I. INTRODUCTION

The modern economy is closely linked to digital technologies, which is changing the approach to doing business and is being distinguished as Industrialization 4.0. As a result, a separate industry has emerged - the digital economy, combining the economic production of digital goods and the digital segment that provides digital services and goods (Williams, 2021). Digitalization spreads quickly along with the development of digital infrastructure, while the digital industry is developing slowly, which indicates a short stay of the industry in the market, which limits the ability to create information technology corporations (Zhang et al., 2021). Another aspect is the role of personal potential in creating successful digital corporations since employees must be knowledgeable in information technology to work effectively and efficiently. It is the presence of a developed digital infrastructure combined with professional human resources that determines the success of the digitization of the economy (Grigorescu et al., 2021; Williams, 2021).

On the one hand, human capital is a lever for the implementation of innovations and the establishment of cooperation in the digital economy, due to its intellectual potential. On the other hand, rapid digitalization causes a mismatch between staff qualifications and technological innovations, resulting in human resource dysfunction, which negatively affects business activities and reduces the efficiency of information technology (Aliyev et al., 2023). Thus, understanding the impact of digital tools on the labor market and the impact of human capital on the adoption of digitalization. Innovations are slowly being introduced into the agricultural sector, as most cases of digitalization are at the prototype stage (Abbasi et al., 2022). The activities of

agriculture enterprises is closely linked to logistics ones, and the issue of the mutual influence of digitalization and human resources in these sectors is of considerable interest and insufficiently studied (Kryshtal, 2023). Thus, researching the degree of implementation of digitalization and assessing the skills and attitudes of employees towards digital tools in the agricultural sector and logistics will allow us to assess and compare the state of development of digitalization in these areas, identify problems in the development of new technologies and ways to solve them.

The aim of the research was to determine the mutual influence of digitalization and human capital by analysing the survey of agricultural and logistics workers.

II. Literature Review

Digitalization is an integral part of the economy since it has a positive impact on economic activity in all areas, expanding its capabilities and providing access to the global market (Shevchenko et al., 2023). The impact of innovations on agriculture is positively identified in both regional and international studies. There is a correlation between the index of information technology adoption and labor and land productivity. The authors note that this impact is more related to labor efficiency by providing access to information and optimizing task performance. On the other hand, the efficiency of land use is less dependent on information influence, as it is significantly affected by soil quality, climatic features of the region, crop use, breeding, access to pesticides and fertilizers, irrigation systemem features and availability of agricultural machinery (Rajkhowa & Baumüller, 2024). There is a limited amount of research on the effective use of information technology in optimizing agricultural operations, which requires identifying the challenges of implementing digital tools in the industry.

Although the digital economy is inextricably linked to agriculture, there are barriers that include significant investments in digital technologies, technological risks, high demands on staff skills, distrust of algorithms, and maintenance costs (Nakamura & Lindholm 2025). Economically developed countries, realizing the benefits of using digital tools in agriculture, promote the development of the digital economy. National governments are increasing farmers' confidence in technology mainly by creating secure and representative databases, promoting and facilitating innovation, and training qualified personnel (McFadden et al., 2022). However, the application level of digital technologies in agriculture is insufficient even in economically developed countries (Gabriel & Gandorfer, 2023). While in economically less successful countries, in most of which agriculture makes the significant contribution to GDP, the application level of digitalisation is unsatisfactory in the agricultural industry (Srimuang, 2023).

The agricultural sector is closely related to logistics, so it is advisable to compare the implementation of the latest technologies in these industries. Digitalization is also actively used in logistics, as it optimizes routes by adjusting logistics schedules, which reduces the duration and cost of transportation. The most commonly used IT tools in logistics are the Internet of Things, blockchain, big data, and artificial intelligence (Toha, 2025). The Internet of Things and blockchain allow logistics operations to be more flexible and monitor trips in real time, fight fraud, and reduce delivery times and routes (Al-ma'aitah. 2024). Optimization of routes, in turn, contributes not only to improved service and economic benefits but also to environmental ones by reducing the number of trips and greenhouse gas emissions (Desyatnyuk et al., 2025a). Blockchain technology also ensures the transparency of financial transactions and reduces the risks of fraud and error. Thus, the digitization of financial transactions increases the competitiveness of the enterprise, enhances trust by reliably protecting financial transactions and provides access to transactions for people with disabilities (Desyatnyuk et al., 2025b). Moreover, the implementation of digitalization ensures the achievement of the principles of sustainable development by facilitating the implementation of eco-enterprise projects, including through the digitalization and inclusiveness of the financial sector (Feng et al., 2022). Thus, the digital economy is closely linked to both environmental sustainability and the development of an inclusive economy, which aims to create a fair, accessible, socially oriented economic environment (Krysovatyy et al., 2024a).

In addition to new opportunities digital economy has increased competition between companies, as it has expanded market access to a large number of businesses, requiring them to constantly improve to retain their customers and attract new ones. This has made it difficult for businesses in less developed countries to offer competitive services in the absence of digital infrastructure (Wang, 2021). Another challenge is the security of personal data leakage and fraud. This is precisely why the digital economy is constantly being enhanced by new technologies to combat cybercrime (Sreeja et al., 2018). For example, blockchain technology and artificial intelligence are the basis for maintaining financial and national security, due to transparency, accountability, and availability of information that allows detecting suspicious financial transactions, such as money laundering and misuse of funds (Desyatnyuk et al., 2024). The creation of an effective regulatory framework that controls the risks associated with digitalization and automation of processes is equally important (Krysovatyy et al., 2024b).

Although information technology allows optimizing business processes, increasing companies' revenues, and facilitating communication with consumers and partners, it is human capital that determines the success of digitalization in practice (Bielialov et al., 2023; Ivanová et al., 2021). Thus, a new term – digital human capital – is emerging, which includes the high qualification of employees in the field of information technology. Employees with digitalization skills and knowledge determine the competitiveness of companies, especially at the international level. Economically developed countries that invest in digitalization and training of skilled personnel do not experience a shortage of human resources.

Along with this, countries that do not invest in the development of information technology experience a shortage of qualified personnel, which in turn becomes an obstacle to their implementation in practice (Grimpe et al., 2023).

There is a shortage of digital human capital in agriculture, especially in developing countries, which leads to a low level of farmers' trust in new information technologies and their preference for traditional approaches to farming (Ashoka et al., 2023). As well the authors emphasize the role of skilled personnel in the implementation of digitalization in the agricultural sector, which allows farmers to obtain useful information, manage risks, and respond to market fluctuations (Gong et al., 2024). Thus, the assessment of the mutual influence of human capital and digitalization in agriculture is relevant. Since agricultural development depends on logistics, and considering that the level of implementation of digital tools in the logistics sector is higher, the impact of human capital and digitalization has been studied in the field of logistics, given the higher level of information technology adoption in this area (Kryshtal, 2023).

III. Materials And Methods

The study was conducted within the framework of the project of fundamental scientific studies, applied scientific studies and scientific and technical (experimental) developments of young scientists PT-07-2025 "B" on the topic "Information and communication technologies for increasing productivity and involvement of human capital in the agro-sphere" (in accordance with the Order of the Ministry of Education and Science of Ukraine of December 27, 2024 No. 1801) (state registration number 0125U000008). We analyzed the literature and identified the main problematic issues that need to be studied by applying methods of analysis and synthesis. We conducted an online survey among workers of agricultural and logistics enterprises in Eastern Europe to determine the impact of human resource on digitalization and the influence of digitalization on human resources. The survey was conducted using Google Forms, after obtaining informed consent of respondents to participate in the survey. The questions contained open-ended questions that were analyzed independently by 4 authors to avoid bias error. A total of 1460 employees were interviewed, of whom 564 were employees of the agricultural sector and 896 were employees of logistics companies. There were 1024 men (70.1%), 436 women (29.9%), and the average age was 43 + 12.7 years. In order to analyze the state of implementation of digital technologies in the agriculture (a) and logistics (b), and the attitude of the staff towards information technology, the respondents were divided into groups according to their qualifications: Group Ia and Ib (workers and drivers), Group IIa and IIb (medium-level managers), and Group IIIa and IIIb (directors and owners of enterprises). The respondents assessed their level of knowledge and skills in working with information technology and described the types of information technology used in their companies. The questionnaire is presented in the Appendix A. The results were compared in STATA12.1 by applying t-test and presented in the form of diagrams, which were made in Microsoft Excel. Based on the survey data, we conducted an abstract and logical comparison of the answers, which we compared with statistical calculations.

IV. Results And Discussion

Among the 564 agricultural workers, 126 (22.3%) were farm workers, loaders, and agricultural transport drivers, who were classified as Group Ia. 267 (47.4%) were medium-level employees (Group IIa) who deal with finance, communication, establishing relationships with partners, organizing logistics, maintaining documentation, and creating reports. Group IIIa comprised 171 (30.3%) directors and owners of agricultural enterprises. The assessment of skills and knowledge of agricultural workers is presented in Fig 1.

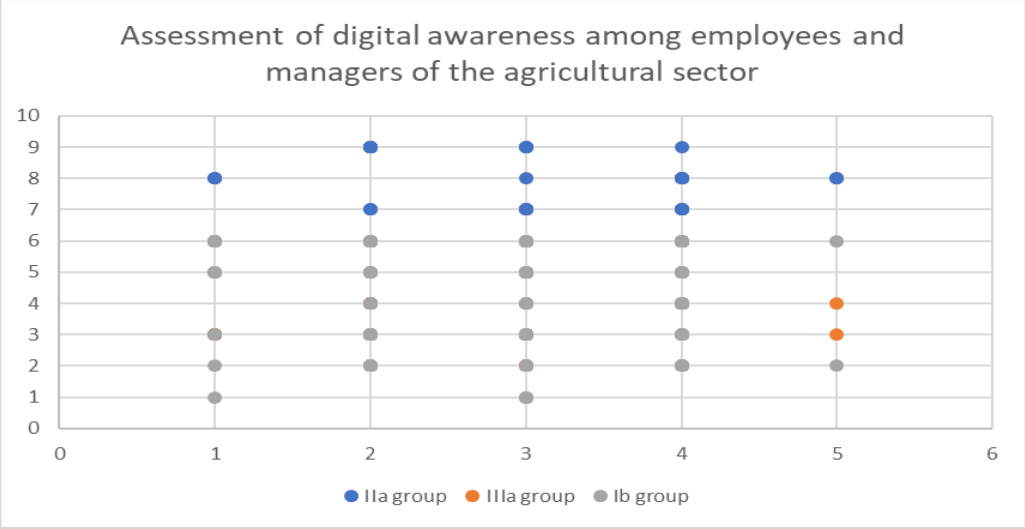

Fig. 1 Assessment of Digital Awareness among Employees and Managers of the Agricultural Sector.

Source: compiled by the author based on a survey

As can be seen from the figure, lower-level employees (Group Ia) had the lowest awareness and skills in information technology, with an average score of 2.9 ± 0.9. While medium-level managers (Group IIa) showed the highest results, with an average score of 5.9 ± 1.9. Among the managers and owners of agricultural companies and farms (Group IIIa), the level of awareness of the peculiarities of digital technologies was below average and amounted to 4.1 ± 1.4. In order to identify the reasons for these results, we analyzed the responses about the types of digital tools used in their enterprises and the ways they are used. The results are shown in Fig 2.

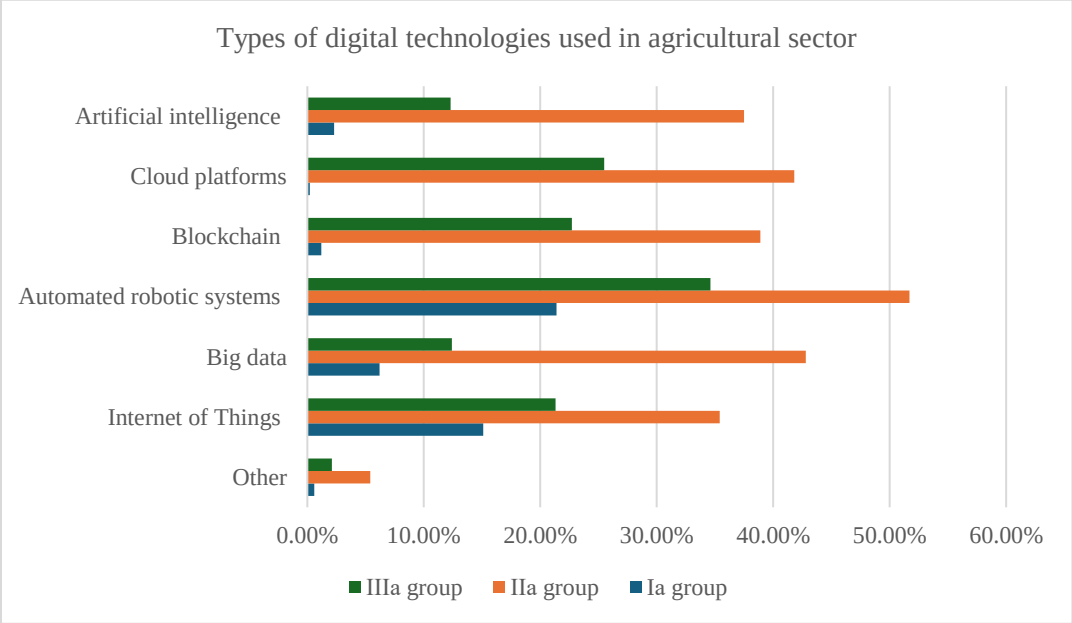

Fig. 2 Types of Digital Tools used in Agriculture.

Source: compiled by the author based on a survey

Respondents in Group Ia most often mentioned automated robotic systems and the Internet of Things, although the results amounted to less than 22%. Moreover, farm workers mostly had knowledge of simple sensors for irrigation, temperature, humidity, etc. Automated robotic systems also had the highest score among managers and executives in the agricultural sector. This is due to the use of automated irrigation, fertilization, disease and weed control. Among employees of large enterprises, drones were used to monitor large fields, which greatly expands the possibilities of yield control. The Internet of Things was identified as one of the priority types of information technologies in agricultural industry, however, through the use of simple sensors rather than expensive navigation systems to monitor soil and environmental parameters. A higher level of IoT use was noted among managers in Group IIa, using it mainly to control logistics and analytical processes that were not directly related to yield optimization.

Big data, cloud technologies, artificial intelligence, and blockchain were most often mentioned by respondents of Group IIa with almost equal distribution, which was related to the purpose of their use and the scope of managers' activities, namely forecasting consumer demand, risk management, market features, marketing, financial transactions, etc. Thus, in general, the insufficient level of implementation of digitalization in agriculture was identified, especially those that directly affect yields and farming in accordance with the requirements of sustainable development. This was also due to the low awareness of managers and owners of agricultural enterprises about the benefits of digital technologies, which did not encourage them to invest in the development of digitization of agricultural processes. In contrast, financial operations, logistics, analytics, and marketing in the agricultural sector are actively using information technology, as managers are highly aware of its use and benefits for process optimization.

Among the employees of logistics companies, 289 (32.2%) were drivers and loaders (Group Ib), 395 (44.1%) were medium-level managers involved in planning and analyzing logistics routes, communication with customers, marketing, and financial operations (Group IIb). Group IIIb consisted of 212 managers and owners of logistics companies (23.7%). The assessment of digital awareness is demonstrated in Fig 3.

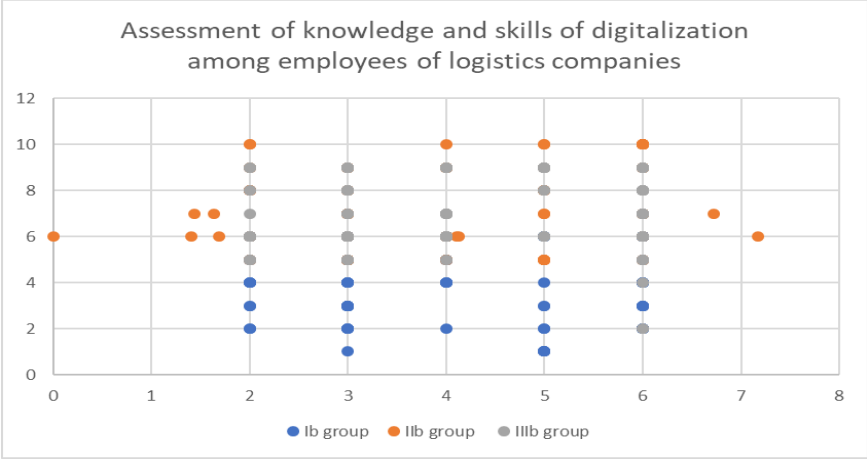

Fig. 3 Assessment of Knowledge and Skills of Digitalization among Employees of Logistics Companies.

Source: compiled by the author based on a survey

As can be seen from the graph, the lowest level of knowledge was found among Group Ib workers compared to Groups IIb and IIIb. The average score was 4.1 ± 1.6. However, when comparing the results of Groups Ia and Ib using a t-test, we found a significant difference between them ($p < 0.01$), indicating a higher level of digitalization awareness among logistics company employees. Medium-level managers had a high level of knowledge and skills in working with information technology, which averaged 7.2 ± 1.7. Among the managers of logistics companies, there was also a high level of awareness of digitalization, which averaged 6.7 ± 1.4. Comparing the results with those of agricultural workers, we found a significant difference, indicating that logistics workers are more aware of digital technologies. The survey on the types and methods of using digital technologies in logistics companies is presented in Fig 4.

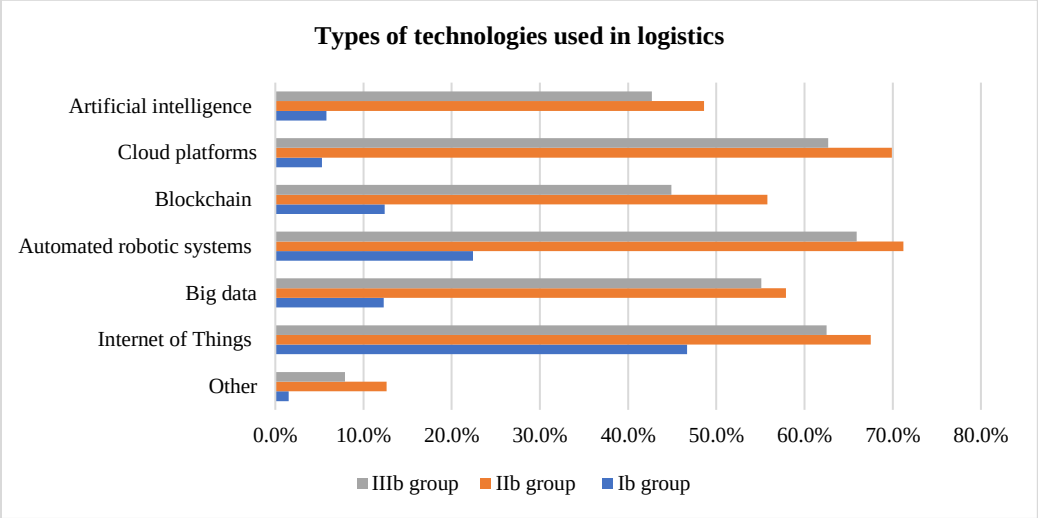

Fig. 4 Types of Digital Technologies used in Logistics.

Source: compiled by the author based on a survey

As can be seen from Fig 4, among executives and managers of logistics, there was a high level of use of artificial intelligence, cloud platforms, blockchain, automated robotic systems, big data and the Internet of Things, which indicates a high degree of implementation of these technologies in logistics processes. Moreover, by assessing the ways in which they are used, we found that digital technologies are applied for optimization, route tracking and other logistics operations, as well as for marketing, customer communication, financial transactions, analytics and data storage. Among drivers, loaders, and other workers in the IB group, the Internet of Things and automated robotic systems for navigation, control of transportation schedules and routes, and blockchain for financial transactions were most often mentioned. Thus, by comparing the assessment of awareness of digital skills and knowledge and the state of their use in practice, we have determined that a high level of awareness among executives and managers contributes to the active implementation of digitalization in enterprises. And the widespread adoption of technology increases the digital literacy of employees, which has been proven by the higher awareness results among employees of logistics companies compared to employees of the agricultural sector. At the same time, educating agricultural managers about the benefits of

digitalizing agricultural processes will help increase the adoption of information technology in practice. After all, by understanding the benefits of optimizing agricultural processes, managers of agricultural enterprises will assess the financial feasibility of investing in the development of innovations.

The results of our research revealed low awareness of information technologies among workers and managers in agriculture. These results were due to the low level of innovation directly in agricultural activities. According to Bhakta et al. (2019), low awareness is one of the determining factors for the slow adoption of digitalization in agriculture. The predominant types of technologies identified by respondents were knowledge and skills in working with irrigation, fertilizer, pesticide, humidity, and temperature sensors. Instead, such complex systems as the Internet of Things, wireless sensor networks, and automated machines were not popular among agricultural workers, although they are the most likely to optimize resource use in a sustainable manner. Similar results were found in the literature – in particular, the literature review concluded that these systems are expensive, not universal, and have a low degree of applicability in the agricultural sector (Sinha & Dhanalakshmi, 2022; Abbasi et al., 2022). In contrast, there was a sufficient degree of knowledge and skills in digitalisation among medium-level agricultural workers, which was related to their activities, including financial operations, analytics, logistics, marketing, and communication, where digitalization is widely used. Digital innovation has led to the transformation of the economy and made it an integral part of many economic processes, including finance, analytics, marketing, etc. (Yuan et al., 2021).

Among logistics companies, a higher level of digitalization knowledge and skills was found among all employees compared to those in the agricultural sector. In addition, a higher level of implementation of information technology in practice in logistics was found. Among managers and executives of logistics companies, we found a high level of knowledge about innovation. This is due to the high level of innovation in logistics processes, which helps to optimize processes and allows companies to compete in the global market (Desyatnyuk et al., 2025a).

Our survey demonstrates a higher level of awareness among employees of large companies compared to small ones, confirming the fact that investing in digitalization contributes to the digitization of human capital. Our research has revealed the importance of training managers and owners of agricultural enterprises and logistics companies on the benefits of digitalization to understand the financial feasibility of investing in innovation. The skills of medium-level managers also have a positive impact on digitalization adoption since they increase confidence in the success of digital projects in the company (Peng & Jia, 2025). At the same time, low awareness of employees is not an obstacle, as with widespread implementation of innovations, employees learn to work with technology faster under the guidance of middle managers, as demonstrated by the results of employees of Ib groups of logistics companies. A limitation of the study was the data obtained in Eastern Europe, given the development of agricultural industry in this region. Thus the prospect of further research is to determine the state of digitalization in the agricultural sector and logistics at the global level. Further study will be dedicated to the comparison of the implementation of information technologies in the agricultural sector in various countries with public policies that promote the development of digitalization of agriculture and logistics.

V. CONCLUSIONS

The results of our research revealed low awareness and skills in working with digital technologies among agricultural workers, which was due to the low level of their use directly in agricultural processes. Agribusiness managers also showed insufficient knowledge of the digital transformation of agriculture which led to a low level of digital tools use in agricultural companies. On the other hand, medium-level managers had a sufficient level of knowledge and skills in working with digital resources, which was related, in particular, to their analytical, communication, and marketing activities. Among the types of digitalization mentioned by them, those used for financial operations, logistics, marketing, and analytics prevailed. Employees in the logistics sector generally showed a higher level of awareness among all groups of employees compared to those in agriculture. This was mainly due to the high level of information technology adoption in logistics processes, due to the financial feasibility of investing in digital technologies that optimize the industry's performance. Among workers in the logistics sector, the level of awareness among managers was high, which led to the active "digitization" of logistics activities. Thus, by comparing the two interrelated industries, it was determined that the agricultural sector lags behind in the implementation of digitalization in the agricultural industry, while other processes in the agricultural sector use information technology at a sufficient level. Taking into account the positive impact of logistics company managers' awareness on the implementation of computer innovations in the company, it is expedient to train agricultural managers on the benefits of information technologies in agriculture to facilitate their implementation in practice.

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Appendix A

Questionnaire

1. Indicate your gender, age and place of employment.

2. Indicate your position and the size of the company you work for
3. Rate your knowledge of digitalization from 1 to 10.
4. Name the types of information technology used in your company.
5. Describe the processes in which the types of information technologies you mentioned above are used.

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