*Original scientific paper*
*UDC 338.439.64:004(477)*

# INFORMATION SUBSYSTEM OF AGRI-FOOD ENTERPRISE MANAGEMENT IN THE CONTEXT OF DIGITALIZATION: THE PROBLEM OF DIGITAL MATURITY

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## Abstract

In modern conditions of market economy development, the role of the agri-food sector in ensuring national security is growth. After all, enterprises in the agri-food sector provide a significant share of exports and affect the level of food security of the country. Despite the significant number of competitive advantages, national agri-food enterprises face considerable challenges, especially with increasing competition in both domestic and foreign markets. Therefore, agricultural enterprises are constantly forced to look for ways to ensure a high level of competitiveness and sustainable development. The sustainable development of these enterprises currently depends on the speed of business processes digitalization, as the introduction of digital technologies allows achieving productivity growth and ensuring competitiveness. One of the necessary stages of digitalization is to determine the level of digital maturity of the enterprise, which makes it possible to increase the speed and efficiency of digitalization of business processes of agri-food enterprises. The purpose of the research is to develop tools to determine the level of digital maturity of agri-food enterprises in Ukraine.

In order to assess the digital maturity of the information subsystem of agri-food enterprises management in the context of digitalization, we have proposed model consists of the four components assessment: strategic, technological, analytical, and competence (STAC model). The assessment results of four components allowed to distribute digital maturity at the following levels: zero, initialization, conscious, controlled, and optimization. This model for assessing the digital maturity of the information subsystem of agri-food enterprises management in the context of digitalization is developed using the following methods: sequential approximation (Kohonen Network), observation, mathematical modeling, questionnaires, and statistical generalization. Reporting documents of 77 enterprises of the agricultural sector of Ukraine located in Luhansk, Cherkasy, Donetsk, Kyiv, Poltava, Sumy, Dnipropetrovsk, Mykolaiv, Zaporizhzhia, Kharkiv,

Zhytomyr, Kirovohrad, Zakarpattia oblasts and the city of Kyiv served as an information base.

The results of approbation of the STAC model for assessing the digital maturity of the information subsystem of management of agri-food enterprises in the context of digitalization made it possible to determine the digital maturity of 77 agricultural enterprises. The research shows a disbalance in the development of individual components and some differences in digital maturity among these enterprises. The analysis of the discrete components of digital maturity reveals the reserves of their development. So, gaining the balance between the discrete components can accelerate the process of digitalization. Also, according to digital maturity indicators, the agri-food enterprises were clustered into three clusters. As a result of the analysis, it was determined that 2.6% of the enterprises belong to the cluster with a controlled level of digital maturity, 46.8% of the enterprises belong to the cluster with the initial level of digital maturity. The cluster with a conscious level of digital maturity is the largest in number and includes 50.6% of the agri-food enterprises. Therefore, a significant number of enterprises should pay attention to the formation of digitalization strategy, the development of enterprise information infrastructure, and the creation of staff training system. The influence of individual components of the model on the level of digital maturity may be the subject of further research.

The method tested by the authors made it possible to assess the level of digital maturity and the readiness of 77 agricultural enterprises to implement innovative types of information technologies. The use of the Kohonen network made it possible to distribute these enterprises into clusters and visually show the level of digital maturity of enterprises. The model proposed by the authors is suitable for practical use by agricultural enterprises in order to diagnose digital maturity and on this basis to develop proposals to improve information security in the context of digitalization.

***Key words**: Digitization, Digital transformation, Digital maturity, Business-processes, Smart-farming.*

## 1. Introduction

In modern conditions, the role of the agri-food sector in the national economy is growing. According to World Bank's statistics, the share of the agri-food sector in Ukraine's GDP is 9.268 percent, and the number of enterprises is more than 46 thousand [1]. With many competitive advantages due to geographical and climatic conditions, including: a significant share of soils with high productivity, favorable location relative to markets in Europe, Asia and the Middle East, Ukrainian agri-food enterprises face specific problems, namely: legal insecurity and turbulent legal environment, inefficient state program to support agricultural enterprises, low rates of implementation of innovative technologies, inefficiency of the system of training highly qualified personnel and lack of adequate training system for employees. Businesses are also facing challenges as a result of globalization, such as the need to harmonize product quality standards and complicate competition in both domestic and foreign markets. Under such conditions, digitalization can become a tool that will significantly increase the level of efficiency of agricultural enterprises and ensure their sustainable development.

The modern world is experiencing the fourth industrial revolution, which is reflected in almost all aspects of public life, changing the technological way of life, living environment, labor market, political systems and more. According to Schwab, [2], digitalization is a manifestation of the fourth industrial revolution, and, unlike digitalization, involves a set of processes aimed at increasing the use of digital technologies in various spheres of public life, including economic activity. In the process of economic activity, the manifestation of digitalization is a holistic rethinking of business models, implementation of digital technologies and the introduction of data management to improve the efficiency and competitiveness of the enterprise. Businesses are active agents of digitalization, as it allows businesses to gain a competitive advantage and achieve sustainable development. In turn, for the effective implementation of digitalization an important step is to determine the digital maturity of the enterprise.

Digital maturity is the ability of an entity to respond to technological innovations that emerge in the market and use them effectively to achieve long-term goals of the enterprise.

Almost all agricultural enterprises face a global trend of digitalization, but each individual enterprise is at a unique point in this transformation. This leads to the existence of various models of digital maturity, which are largely shaped by a unique set of factors, such as: industry, enterprise size, measurement focus, and so on. Determining the level of digital maturity is an extremely important tool, as it allows enterprise management to adapt digital strategy and accelerate the digitalization of business processes.

Such a global trend as digitalization has been the focus of much attention among many scholars. Many works are devoted to the study of various aspects of digitalization, which indicates the complexity of the process, its significance for society and a fairly new genesis. One of the aspects studied by researchers is digital maturity. Westermann *et al.,* [3], in their article

consider digital maturity as a bilateral process of integration of organizational operations, human capital and digital processes. Yılmaz, [4], considers digital maturity as a degree of readiness for constant digital change and analyzes inhibitors and catalysts of digital maturity. In his work, Yılmaz notes that achieving digital maturity is a permanent process, as companies operate in an environment of continuous improvement of technology, implementation of new business models and market fluctuations. The study of digital maturity is taking place in many areas. Beulen, [5], examines digital maturity at the national level and identifies factors that slow down the process of digitalization. In their work, Kupilas and Montequín, [6], explore key elements of the digital maturity model of research organizations and emphasizes the relationship between digital maturity and the fourth industrial revolution, noting the need and benefits of digitalization in the long run, determining the impact of digital maturity on the level of digitalization of the enterprise. Assessing the level of digital maturity is an important issue, as determining the level of digital maturity can help accelerate the digitalization of business processes. Ilin *et al.,* [7], in their work analyze the existing approaches to assessing the level of digital maturity of the enterprise and the possibility of their application in the project management process, noting some advantages and disadvantages. Ochoa-Urrego and Peña-Reyes, [8], conducted a systematic review of existing models of digital maturity and identified more than twenty models that have been implemented by service enterprises. The authors compared the implemented models and levels of enterprise architecture and concluded that the digital maturity model is significantly influenced by the digital strategy and architecture of the business model of the enterprise. In their work, Schwer *et. al.,* [9], analyze the variables of digital maturity depending on the level of enterprise architecture and identify fifteen models that co-opt more than one hundred variables. The authors identified the impact of individual digitization variables on enterprise architecture: strategy, business environment, applications, technologies, implementation and migration, which, according to the authors, allows building an optimal model of digital maturity in accordance with enterprise goals. According to Jovanović *et. al.,* [10], Colli *et. al.*, [11], the selected model allows to determine the level of maturity, and at the next stage to form measures to increase the level of maturity and digitalization.

Many studies have focused on the features of digital maturity of small and medium enterprises. Thus, Schallmo *et. al.*, [12], provide a comparative analysis of existing models of digital maturity used by small and medium-sized enterprises, noting the diversity of models and the lack of consensus on their components. Schallmo *et. al.*, [12], offer to use as components of the model the following: digital strategy, business processes, partner interface, customer interface, products and services, employees and technology. In their article, Borštnar and Pucihar, [13], emphasize the differences between the digital maturity of small and medium-sized enterprises and investigate the features of using the model of maturity assessment with multiple attributes.

Many scholars are researching industry aspects of digital maturity. Thus, Đurek *et al.*, [14], developed a model of digital maturity for higher education. Mettler and Pinto, [15], examine digital maturity in health care and note that investing in hardware and software is more effective in a hospital setting than in staff development and support. Burmann and Meister, [16], in their work analyze the problems of implementation of various models of maturity in the process of digitalization of hospitals. The authors [17-21] have identified innovative models that should be implemented to increase the level of digital maturity of enterprises. Digital maturity in the agri-food sector is studied by Büyük *et. al*., [22], and they propose a model for assessing the level of digital maturity of agri-food enterprises using the Best-Worst method. Zos-Kior *et al*., [23], Rossokha *et al*., [24], explore the need to introduce innovative technologies in the agricultural sector.

Despite the large number of scientific papers devoted to the study of various aspects of digital maturity, the digital maturity of agri-food enterprises remains poorly covered and requires more detailed research.

The purpose of the study is to develop methods for assessing and analyzing the level of digital maturity of national agri-food enterprises.

In order to achieve the purpose of the research, a survey was conducted at 77 agri-food enterprises using the developed questionnaire. Using Kohonen maps, clustering of agricultural enterprises was obtained in accordance with the level of digital maturity. The analysis of the obtained data resulted in recommendations for the introduction of digital technologies.

## 2. Materials and Methods

Examining the digital maturity of agri-food enterprises, it is expedient to single out the following model of digital maturity, which consists of four components. The components of digital maturity are the following: strategic component, technological component, analytical component, competence component. The structure of the proposed model of digital maturity is shown in Figure 1.

Digitalization is one of the priorities of modern agricultural enterprises, so the strategic component

focuses on the principles of digital strategy, which provides an action plan for digitalization of business processes. A clearly defined digital strategy allows ensuring the effective transition of the enterprise into the digital future through the implementation of digital technologies and automation of processes. Creation of an internal environment that stimulates the introduction of innovative technologies is essential for success.

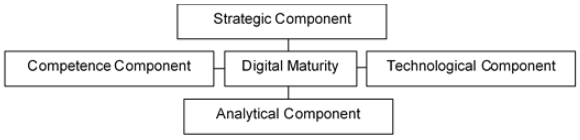


**Figure 1. The structure of the digital maturity model (Source: Author's development)**

The technological component involves the development and implementation of information and communication infrastructure, a set of digital technologies that ensure the functioning of business processes in the enterprise, as well as the latest technologies presented on the market that can be used in the future. Given the high level of digital maturity, the technological component is a set of digital technologies used in business processes efficiently and infrastructure, which fully ensures their support in the agri-food enterprise, and agricultural specialists are informed about the latest technologies and able to make decisions on their implementation in accordance with the needs of the enterprise.

The analytical component is responsible for the collection, circulation, use and security of information, as well as analytical tools to ensure an effective decision-making process at all levels. The information system of an agricultural enterprise with a high level of maturity collects high-quality information that thoroughly characterizes all business processes of the enterprise, provides quick access to information and allows integrated solutions to make decisions involving the necessary data and results.

Competence component reflects the set of knowledge, skills and abilities required to work with technological and analytical components, implementation and use of digital technologies in business processes of the enterprise, which are owned by the staff of the agricultural enterprise. The high level of digital maturity is characterized by the level of knowledge, skills and abilities that allow full use of digital technologies and data analysis.

Based on the above, it is advisable to distinguish several levels of digital maturity, which are characterized by the degree of implementation of various digital technologies in the business processes of agri-food enterprises: zero, initialization, conscious, controlled, optimization.

Zero level is characterized by the lack of implementation of information technology in the business processes of the enterprise. The implementation of business processes is based on "traditional" principles of management, and digitalization is perceived as an unnecessary burden on the resource fund. Management does not have a clear understanding of what information technology should be implemented in the enterprise.

Initialization – the level of digital maturity at which digitalization is not a high priority, there is a situational implementation of information technology in business processes, and the management of the digitalization process is in the absence of a clear strategy. The information infrastructure and its support system are underdeveloped. The data collection system is inefficient and does not allow the collected data to be used for analysis in order to make management decisions. The staff does not have the knowledge and skills needed to use information technology and data management, while the enterprise's management does not raise the issue of training for digitalization.

Conscious - a level characterized by growing awareness of the use of information technology, but there is no strategy for the introduction of information technology in the business processes of agri-food enterprises. The information infrastructure is underdeveloped, but serves the basic needs of information technology, which begins to implement the enterprise. Data management does not allow to adequately characterizing all business processes. Implemented technologies allow accumulating some relevant data, but access to them is difficult due to which it does not have a significant impact on the effectiveness of management decisions. The staff of the enterprise does not have sufficient competencies, which does not allow the use of information technology in full.

Controlled - the level of digital maturity at which management clearly understands the benefits and complexities of digitalization of business processes, developed and implemented a strategy for the introduction of digital technologies. The organizational culture of the agricultural enterprise reflects the perception of digitalization as a factor in increasing competitiveness, and helps to accelerate the implementation of relevant innovations. The information infrastructure of the enterprise provides effective support for the needs of digitalization of business processes and operates in conditions of

adequate technical support. Data management is based on the system principle, which allows you to create a data management system that provides collection and processing of data that relevantly characterize business processes, access to collected data occurs at different levels of management and supports effective management decisions. The staff of the enterprise has the necessary competencies, which allows you to effectively use the implemented digital technologies.

Optimization - the level at which the management of an agricultural enterprise perceives the digital transformation of business as a task with the highest priority, because automation and digitalization of business processes is the way to increase efficiency, ensure competitive advantage and sustainable development in the future. Digitalization is a key element of the overall strategy of the enterprise, and organizational culture supports the introduction and improvement of digital technologies. The information infrastructure fully supports all implemented digital innovations. The agricultural enterprise has a data management system that allows collecting relevant data that comprehensively characterize the enterprise's business processes in real time, provides access to collected data at all levels in accordance with regulations and is an organically integrated element into the decision-making system. The staff of the agricultural enterprise has all the necessary competencies, makes full use of digital technologies and participates in the development of digitalization strategy.

The presented model allows to study the level of digital maturity of agri-food enterprises and to adapt the digital strategy of the enterprise to its unique conditions in order to increase the level of competitiveness and ensure sustainable development of the enterprise.

**Table 1. Classification of questions according to the model of digital maturity and rating scale**

| Component | Variable | Questionnaire questions | Rating scale | |
|---|---|---|---|---|
| | | | Most | Least |
| Strategic component | C1 | The enterprise has a strategy that clearly and understandably explains how to implement and use digital technologies and data in business processes | 5 | 1 |
| | C2 | Digitalization of business processes is a key element of organizational culture and strategy of the enterprise due to which there is an increase in competitiveness and productivity | 5 | 1 |
| | C3 | The enterprise's staff participates in the development of digitalization strategy, in particular selects technologies that will be implemented in business processes | 5 | 1 |
| | C4 | The staff of the enterprise systematically analyzes innovative technologies that can be implemented in business processes to increase the efficiency of the enterprise | 5 | 1 |
| | C5 | The enterprise has a plan of long-term measures for the introduction of digital technologies and attracting staff with the necessary competencies to use innovation and data analysis | 5 | 1 |
| Technological component | T1 | The staff has a good understanding of current and evolving digital technologies that can be applied to business processes | 5 | 1 |
| | T2 | The existing digital infrastructure meets all the needs to support the digitalization of business processes | 5 | 1 |
| | T3 | The enterprise is in a constant process of improving the technological infrastructure | 5 | 1 |
| | T4 | The use of digital technologies used in business processes is convenient and efficient | 5 | 1 |
| | T5 | The level of technical support for business processes is high and meets all business needs | 5 | 1 |
| Analytical component | A1 | All business processes are automated | 5 | 1 |
| | A2 | Business decisions are made on the basis of all data collected and processed at the enterprise, including data from sensors, equipment, satellites | 5 | 1 |
| | A3 | All data is stored in digitized form | 5 | 1 |
| | A4 | The enterprise has data management systems that provide quick access to the necessary information and data security | 5 | 1 |
| | A5 | Data management systems used in the enterprise allow making predictions used in the process of making business decisions | 5 | 1 |
| Competence component | K1 | The staff is able to effectively use digital technologies (digital equipment and devices, software, etc.) used in the enterprise | 5 | 1 |
| | K2 | The staff is able to solve minor problems arising in the process of using digital technologies, and in other conditions receives competent technical support | 5 | 1 |
| | K3 | The enterprise has personnel whose responsibilities include creating conditions for the safe use and storage of data | 5 | 1 |
| | K4 | The enterprise has staff whose responsibilities include communications and other forms of interaction with other companies on the implementation and use of digital technologies | 5 | 1 |
| | K5 | The enterprise always has the opportunity to participate in trainings and refresher courses, which allow more efficient use of digital technologies and increases the efficiency of the decision-making process with the involvement of data management systems | 5 | 1 |

Source: Author's development

In order to survey agri-food enterprises, a questionnaire was developed to assess digital maturity for all components. The questionnaire provides for 20 questions, which are divided into groups C, T, A, K and 5 questions according to the structure of the components of the digital maturity model. To assess the answers, the 5-point Likert scale was chosen, where 1 – absolutely disagree, 2 – disagree, 3 – to a large extent, 4 – agree, 5 – absolutely agree. The classification of issues according to the digital maturity model is shown in Table 1. For the purpose of the research, 308 questionnaires were distributed among agri-food enterprises and 237 questionnaires were received with answers, i.e. the level of answers was approximately 77%.

## 3. Results and Discussion

General information on the survey is shown in Figure 2. The data obtained indicate that the highest score was given to indicators C1, C3, T1, whose average score is 2.6. That is, respondents note the existence of a strategy of digitalization of the enterprise, and believe that the enterprise's staff understands the technologies that can be used in business processes, and can to some extent influence the choice of technologies to be used. However, it is important to note that strategies do not form a clear enough understanding of the algorithm of digitalization and ways to influence the formation of strategy. The lowest score was given to C4, T5 with an average score of 1.6, and the highest score they received was 3. Which indicates a lack of practice in involving staff in the analysis of potentially useful innovative technologies and the level of technical support is assessed as underdeveloped. It is worth noting that none of the indicators received the highest score. That is, according to respondents, none of the components of the model of digital maturity reaches the highest level of development.

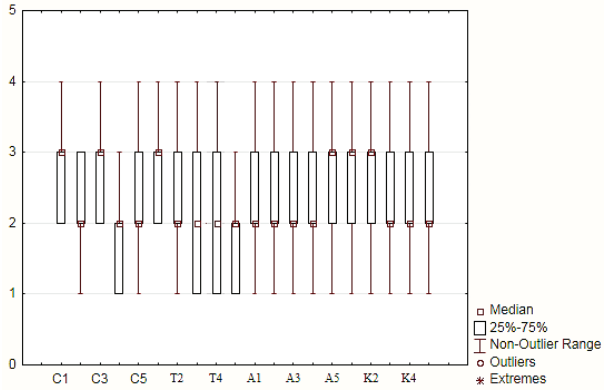


**Figure 2. Screenshot of the scale diagram (box graph) with data on the results of the survey of respondents (Source: Calculated by the authors using the Statistica 10 tools)**

The obtained data make it possible to determine the level of development of individual components of the model of digital maturity of agri-food enterprises. For the purpose of analysis, the integrated indicator of the level of development of the component of the digital maturity model according to formula 1 was calculated.

$$D_i = \sum_{j=1}^{n} P_j \cdot n^{-1} \quad (1)$$

Where: $D_i$ is an indicator of the level of development of the i-th component of the model of digital maturity,
n - the number of indicators that characterize the i-th component of the model of digital maturity,
$P_j$ – $j$-th indicator, which characterizes the i-th component of the model of digital maturity.

Based on the obtained data, petal-type diagrams were constructed for each agricultural enterprise. The variables presented on the four axes reflect the components of digital maturity, namely: strategic (denoted as C), technological (T), analytical (A) and competence (K). The analysis of the obtained data showed the differentiation of enterprises according to the level of development of the components of the digital maturity model. The result of this analysis is shown in Figure 3. Visualization of the result allows analyzing the area of the obtained figures and finding that among the surveyed agri-food enterprises E6 has the lowest level of digital maturity, and E45 and E8 have the highest level of digital maturity. The level of differentiation of digital maturity of enterprises E6 and E45 is shown in Figure 4. However, the analysis also reflects the uneven nature of the development of individual components of the model in agri-food enterprises. Many companies are characterized by unbalanced development of individual components. Enterprises E25, E42, E76 are characterized by the most balanced development, and enterprises E37, E40, E62 are characterized by the most unbalanced development.

The highest level of development of the strategic component is characterized by the enterprise E45, which indicates a fairly clear strategy for digitalization of the enterprise and the availability of opportunities for staff to influence its formation. The lowest level of the strategic component characterizes the enterprises E10, E13, E17, E19, E23, E32, E33, E37, E56, E61, E62, E63, E64, E68, E70, E72. For these enterprises it is expedient to develop a clear and understandable strategy of digitalization of the enterprise, to create a mechanism for involving staff in the development of the strategy.

The technological component received the highest rating at the enterprise E8, i.e. the technological infrastructure of the enterprise meets the needs of digitalization of the enterprise, and the enterprise has a

technical support system that makes the use of digital technologies quite efficient and convenient for staff. The lowest level of development of this component is characterized by enterprises E6, E12, E14, E24, E33, E35, E37, E41, E58, E62, and E64. Increasing the level of digital maturity requires these companies to improve their technological infrastructure, implement an effective system of technical support for business processes, and synchronize the needs of business processes and implemented digital technologies.

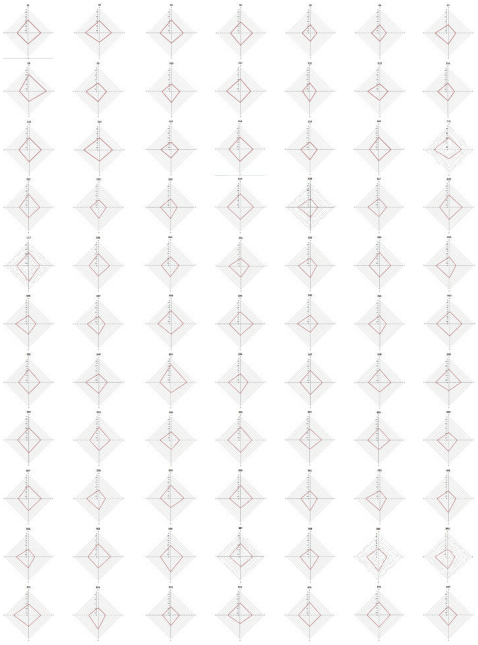

**Figure 3. Differentiation of enterprises according to the level of development of the components of the digital maturity model**
**(Source: Calculated by the authors using MS Excel tools)**

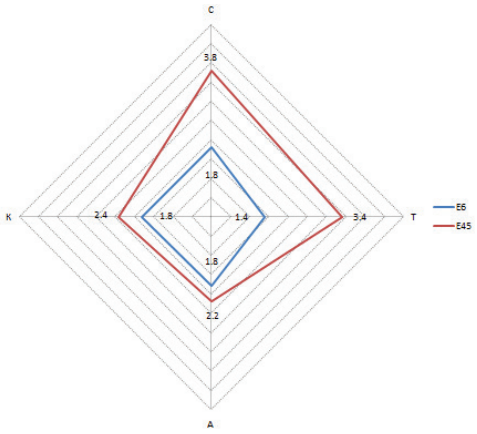


**Figure 4. Level of differentiation of digital maturity of enterprises E6 and E45**
**(Source: Calculated by the authors using MS Excel tools)**

At the enterprise E29, the highest score was given to the analytical component, which indicates a significant number of automated business processes and a fairly efficient data management system that provides fast, convenient, secure access to information that allows it to be used effectively in decision-making. The lowest level of development of the analytical component is characterized by enterprises E6, E17, E40, E49, and E74. In order to increase the level of digital maturity, these companies should pay attention to the automation of business processes, including the use of project management systems, financial management systems, CRM-systems, time and personnel management systems, etc. It is important to implement a data management system that will allow efficient and secure collection, storage and use of information to analytically support the decision-making process.

The highest level of development of the competence component is typical for the enterprise E16, and the lowest level – for E12. For an enterprise with a low level of development of this component, it is advisable to develop and implement a system of training and retraining of personnel, which will increase the level of knowledge, skills and abilities to use digital technologies implemented in the enterprise. It is also important to have or support outsourced staffing of digital technologies implemented in the enterprise.

In order to achieve the purpose of the study it is necessary to cluster the studied enterprises by the level of digital maturity. Based on the large number of different characteristics, to build a clustering of agricultural enterprises by digital maturity, it is advisable to use a neural network, namely the self-organizing Kohonen map. The Automated Neural Networks toolkit of Statistica 10 software was used to build the Kohonen map. Clustering objects using Kohonen maps involves using a neural network learning algorithm that transitions input vectors that exist in multidimensional space into output two-dimensional space. A feature of the Kohonen network is the use of the method of uncontrolled learning, i.e. only a set of input variables is used to teach the network. The neural network architecture includes only two layers, namely input and output. The Kohonen network identifies clusters based on input data, and the next step is to distribute the data to the appropriate clusters.

In the study, 20 indicators of digital maturity were selected, i.e. we have 20 neurons at the input layer. Topological map (source layer), which is a rectangular two-dimensional lattice, built with the following parameters: height is 2, width is 2. That is, the source layer has 4 neurons.

As a result of neural network training, a topological map with clustered agri-food enterprises was obtained, which is presented in Figure 5.

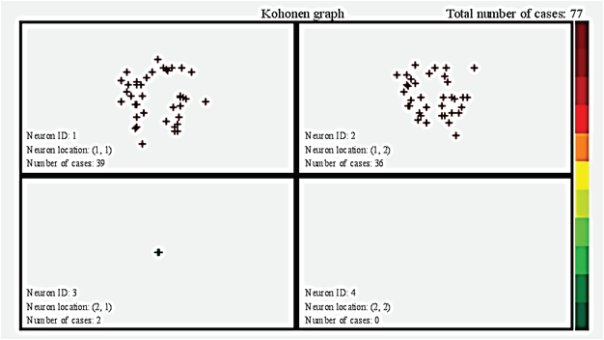


**Figure 5. Screenshot of Kohonen map with agri-food enterprises divided into clusters**
**Source: Calculated by the authors using the tools of Automated Neural Networks, Statistica 10**

As a result of the training, the neural network divided 77 surveyed enterprises into 3 clusters, namely: cluster 1 with coordinates (1, 1), which includes 39 enterprises, cluster 2 with coordinates (1, 2), which includes 36 enterprises, cluster 3 with coordinates (2, 1), which includes 2 agri-food enterprises. It is worth noting that cluster 4 did not receive objects.

The location of objects on the Kohonen map reflects the differentiation of agricultural enterprises according to the level of digital maturity – the closer the objects are to each other, the closer they are to the level of digital maturity. Thus, cluster 2 with coordinates (1, 2) and cluster 3 with coordinates (2, 1) are the most distant from each other, due to a significant difference in the level of digital maturity. At the same time, the objects within the same cluster are quite close to each other, which emphasizes the slight difference in the level of maturity. For example, cluster 3 objects visually look like a single object, reflecting almost the same level of digital maturity of these enterprises.

The analysis of the obtained results indicates that the first cluster, which includes 39 agri-food enterprises E1, E2, E3, E4, E5, E11, E15, E16, E18, E20, E21, E22, E25, E28, E29, E30, E34 , E38, E39, E42, E43, E47, E48, E49, E50, E51, E53, E54, E55, E57, E59, E60, E65, E66, E67, E71, E74, E75, E76, unites enterprises with level of digital maturity – conscious. The second cluster, which unites 36 agricultural enterprises: E6, E7, E9, E10, E12, E13, E14, E17, E19, E23, E24, E26, E27, E31, E32, E33, E35, E36, E37, E40, E41, E44, E46, E52, E56, E58, E61, E62, E63, E64, E68, E69, E70, E72, E73, E77, is characterized by an initialization level of digital maturity. The third cluster includes 2 agri-food enterprises E45, E8 and is characterized by a controlled level of digital maturity. The distribution of agri-food enterprises by clusters is shown in Figure 6.

For agricultural enterprises in the second cluster, in order to increase the level of digital maturity, it is advisable to first develop a strategy for digitalization of

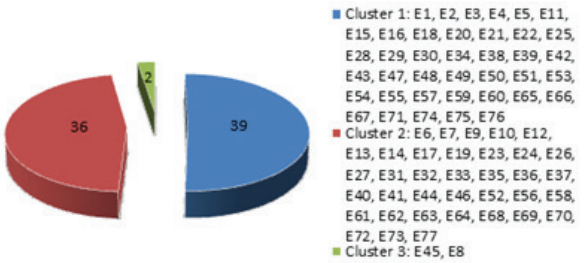


**Figure 6. Distribution of agri-food enterprises by clusters**
**Source: Author's development using MS Excel tools**

the enterprise, which can form a clear understanding of the algorithm for achieving the planned level of digital maturity. At the same time, it is important to create conditions for training and digital literacy of staff. It is also important to develop the digital infrastructure in accordance with the developed strategy.

Enterprises that are grouped into the first cluster and are characterized by a conscious level of maturity should pay attention to improving the strategy of digitalization of the enterprise, which will accelerate the process of automation of business processes. It is important to further develop the information infrastructure, which will allow accumulating better data and using them more efficiently in the decision-making process. Also, in order to increase the efficiency of the use of implemented technologies, it is advisable to provide various measures for staff training.

Reserves for increasing the level of digital maturity for third cluster enterprises can be improving the mechanism of staff participation in the formation of digitalization strategy, development of data management system by improving the use of cloud technologies, raising staff awareness of technologies that have just appeared on the market and may be implemented at the enterprise in the future.

## 4. Conclusions

- In the context of globalization and constant turbulence of markets, agri-food enterprises face many challenges, including accelerating the pace of digitalization. The digitalization of the agri-food sector allows companies to increase efficiency and ensure their sustainable development, but requires companies to radically transform business processes, which involves a thorough transformation of technologies, algorithms, infrastructure and the formation of new staff competencies. An important stage of digitalization is to determine the level of digital maturity of the enterprise, which characterizes the ability of agricultural enterprises to respond to innovations that emerge in the market, and effectively implement them to achieve the goals of the enterprise.

- Digital maturity can be considered as a combination of four components: strategic, technological, analytical, and competence. Using this model of digital maturity, a questionnaire was developed, which allowed conducting a survey, the results of which were used to assess both individual components and digital maturity of agricultural enterprises in general. The level of digital maturity is characterized by the degree of implementation of various digital technologies in the business processes of the enterprise: zero, initialization, conscious, controlled, optimization.
- As a result of the research, it was found that agricultural enterprises are largely differentiated by the level of digital maturity and the level of balanced development of individual components of the model.
- Clustering of agri-food enterprises according to digital maturity indicators was also carried out. As a result of the analysis, it was determined that 2.6% of agricultural enterprises belong to the cluster with a controlled level of digital maturity, 46.8% of enterprises belong to the cluster with the initial level of digital maturity. The largest in number is the cluster with a conscious level of digital maturity, which includes 50.6% of enterprises. Therefore, a significant number of enterprises should pay attention to the formation of digitalization strategy, the creation of a system of staff training and development of information infrastructure of the enterprise.

## 5. References


[1] World Bank. Agriculture, forestry, and fishing, value added (% of GDP) - Ukraine. <URL:https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=UA&view=chart. Accessed 8 January 2021.

[2] Schwab K. (2021). *The Fourth Industrial Revolution*. Encyclopedia Britannica. <URL:https://www.britannica.com/topic/The-Fourth-Industrial-Revolution-2119734. Accessed 8 January 2021.

[3] Westerman G., Bonnet D., McAfee A. (2014). *The Nine Elements of Digital Transformation*. MIT Sloan Management Review. <URL:https://sloanreview.mit.edu/article/the-nine-elements-of-digital-transformation/. Accessed 8 January 2021.

[4] Yilmaz K. Ö. (2021). *Mind the Gap*: *It's About Digital Maturity, Not Technology*. In book: Esakki T. (Ed.), Managerial Issues in Digital Transformation of Global Modern Corporations, IGI Global, Hershey, USA, pp. 222-243.

[5] Beulen E. (2020). *Digital Maturity: A Survey in the Netherlands*. In: Oshri I., Kotlarsky J., Willcocks L. P. (Eds.), International Workshop on Global Sourcing of Information Technology and Business Processes, 410, Springer, Cham, Switzerland, pp. 69-81.

[6] Kupilas K., Montequín V. (2020). *The list of Digital Maturity Models as a result from initial Research*. Conference: IX International Doctorate Conference. <URL:https://doi.org/10.13140/RG.2.2.31398.96322. Accessed 8 January 2021.

[7] Ilin I., Levaniuk D., Dubgorn A. (2021). *Assessment of Digital Maturity of Enterprises*. In: Murgul V., Pukhkal V. (Eds.), International Scientific Conference Energy Management of Municipal Facilities and Sustainable Energy Technologies EMMFT 2019. Proceedings, Springer, Cham, Switzerland, pp. 167-177.

[8] Ochoa-Urrego R. L., Peña-Reyes J. I. (2021). *Digital Maturity Models: A Systematic Literature Review*. In: Schallmo D. R. A., Tidd J. (Eds.), Digitalization. Management for Professionals, Springer, Cham, Switzerland, pp. 71-85.

[9] Schwer K., Hitz C., Wyss R., Wirz D., Minonne C. (2018). *Digital Maturity Variables and their impact on the Enterprise Architecture Layers*. Problems and Perspectives in Management, 16, (4), pp. 141-154.

[10] Jovanović M., Dlačić J., Okanović M. (2018). *Digitalization and society's sustainable development - Measures and implications*. Journal of Economics and Business, 36, (2), pp. 905-928.

[11] Colli M., Berger U., Bockholt M., Madsen O., Møller C., Vejrum Wæhrens B. (2019). *A maturity assessment approach for conceiving context-specific roadmaps in the Industry 4.0 era*. Annual Reviews in Control, 48, pp. 165-177.

[12] Schallmo D. R. A., Lang K., Hasler D., Ehmig-Klassen K., Williams C. A. (2021). *An Approach for a Digital Maturity Model for SMEs Based on Their Requirements*. In: Schallmo D. R. A., Tidd J. (Eds.), Digitalization. Management for Professionals, Springer, Cham, Switzerland, pp. 87-101.

[13] Borštnar M. K., Pucihar A. (2021). *Multi-Attribute Assessment of Digital Maturity of SMEs*. Electronics, 10, (8). <URL:https://doi.org/10.3390/electronics10080885. Accessed 8 January 2021.

[14] Đurek V., Begičević Ređep N., Kadoić N. (2019). *Methodology for Developing Digital Maturity Model of Higher Education Institutions.* Journal of Computers, 14, (4), pp. 247-256.

[15] Mettler T., Pinto R. (2018). *Evolutionary paths and influencing factors towards digital maturity: An analysis of the status quo in Swiss hospitals*. Technological Forecasting and Social Change, 133, pp. 104-117.

[16] Burmann A., Meister S. (2021). *Practical Application of Maturity Models in Healthcare: Findings from Multiple Digitalization Case Studies*. 14th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2021) Proceedings, 5, pp. 100-110.

[17] Khodakivska O., Kobets S., Bachkir I., Martynova L., Klochan V., Klochan I., Hnatenko I. (2022). *Sustainable development of regions: Modeling the management of economic security of innovative entrepreneurship.* International Journal of Advanced and Applied Sciences, 9, (3), pp. 31-38.

[18] Semenov A., Kuksa I., Hnatenko I., Sazonova T., Babiy L., Rubezhanska V. (2021*). Management of Energy and Resource - Saving Innovation Projects at Agri-Food Enterprises*. TEM Journal, 10, (2), pp. 751-756.

[19] Mazur N., Khrystenko L., Pásztorová J., Zos-Kior M., Hnatenko I., Puzyrova P., Rubezhanska V. (2021). *Improvement of Controlling in the Financial Management of Enterprises.* TEM Journal, 10, (4), pp. 1605-1609.

[20] Mayovets Y., Vdovenko N., Shevchuk H., Zos-Kior M.,

Hnatenko I. (2021). *Simulation modeling of the financial risk of bankruptcy of agricultural enterprises in the context of COVID-19*. Journal of Hygienic Engineering and Design, 36, pp. 192-198.

[21] Hnatenko I., Shtuler I., Romashko O., Rubezhanska V., Bulkot G., Bugay N. (2021). *The innovative potential of agro-processing enterprises in the context of resource conservation and crisis management*. Journal of Hygienic Engineering and Design, 35, pp. 61-66.

[22] Büyük A. M., Ateş G., Burghli S., YIlmaz D., Temur G. T., Sivri Ç. (2021). *Digital Maturity Assessment Model for Smart Agriculture*. In: Durakbasa N. M., Gençyılmaz M. G. (Eds.), Digital Conversion on the Way to Industry 4.0. ISPR 2020. Lecture Notes in Mechanical Engineering, Springer, Cham, Switzerland, pp. 289-301.

[23] Zos-Kior M., Shkurupii O., Hnatenko I., Fedirets O., Shulzhenko I., Rubezhanska V. (2021). *Modeling of the Investment Program Formation Process of Ecological Management of the Agrarian Cluster*. European Journal of Sustainable Development, 10, (1). <URL:https://doi.org/10.14207/ejsd.2021.v10n1p571. Accessed 8 January 2021.

[24] Rossokha V., Mykhaylov S., Bolshaia O., Diukariev D., Galtsova O., Trokhymets O., Ilin V., Zos-Kior M., Hnatenko I., Rubezhanska V. (2021). *Management of simultaneous strategizing of innovative projects of agricultural enterprises responsive to risks, outsourcing and competition*. Journal of Hygienic Engineering and Design, 36, pp. 199-205.