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FROM TRADITIONAL TO DIGITAL SOLUTIONS: MODERN ASPECTS OF THE INFORMATION AND ANALYTICAL APPROACH IN THE FOOD INDUSTRY

The article highlights the key features of implementing an information-analytical approach in the context of the digital transformation of the food industry, which has become relevant given today's demands for transparency, quality, and product competitiveness. The key elements of the information-analytical approach are examined, implemented through tools for collecting, processing, and analyzing big data, as well as integrating Internet of Things (IoT) and Artificial Intelligence (AI) technologies, which optimize management decisions by reducing human impact and increasing production efficiency. The models of «Big Data and Analytics» and «Forecasting and Modeling» are analyzed, providing businesses with the ability to respond more flexibly to market changes and minimize risks through scenario-based forecasting and modeling. Challenges in the digitalization process are explored, including the lack of resources among small and medium enterprises to implement costly information-analytical technologies, a shortage of qualified personnel, and the absence of unified standards for data processing and storage. It is identified that a critical factor for successful digitalization is the creation of comprehensive state infrastructure support that promotes the integration of new technologies into the food industry through financing mechanisms, innovation incentives, and professional training support. Attention is drawn to the need for coordinated efforts among the government, businesses, and educational institutions to create the necessary conditions for the digital transformation of the industry, ensuring cost reduction, increased efficiency, and long-term sustainable development. The understanding of the role of state regulation in supporting digitalization has been expanded, including initiatives to establish a regulatory framework that ensures transparency and meets the requirements of the digital economy. Recommendations are provided on the application of information-analytical tools to improve supply chain management, enhance quality control, and ensure stability in production processes. Conclusions are drawn on the necessity of government-business interaction to create a competitive and resilient food industry capable of addressing global challenges.

Key words: information-analytical approach, digitalization, food industry, digital transformation, smart contracts, blockchain, digital ecosystem

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ВІД ТРАДИЦІЙНИХ ДО ЦИФРОВИХ РІШЕНЬ: СУЧАСНІ АСПЕКТИ ІНФОРМАЦІЙНО-АНАЛІТИЧНОГО ПІДХОДУ У ХАРЧОВІЙ ГАЛУЗІ

У статті було виділено ключові особливості впровадження інформаційно-аналітичного підходу в умовах цифрової трансформації харчової галузі, що стало актуальним з огляду на сучасні вимоги до прозорості, якості та конкурентоспроможності продукції. Розглянуто ключові елементи інформаційно-аналітичного підходу, які реалізуються через застосування інструментів для збору, обробки та аналізу великих даних, інтеграції технологій Інтернету речей (IoT), штучного інтелекту (ШІ) і дозволяють оптимізувати управ-

лінські рішення, знижуючи вплив людського фактору та підвищуючи ефективність виробничих процесів. Проаналізовано моделі «Великі дані та аналітика» і «Прогнозування і моделювання», які надають підприємствам можливості більш гнучкого реагування на ринкові зміни та дозволяють мінімізувати ризики шляхом прогнозування та моделювання сценаріїв розвитку. Досліджено виклики, які виникають у процесі цифровізації, через брак ресурсів у малих та середніх підприємств для впровадження дорогих інформаційно-аналітичних технологій, дефіцит кваліфікованих кадрів та відсутність уніфікованих стандартів для обробки і зберігання даних. Визначено, що важливим аспектом для успішної цифровізації є створення комплексної державної інфраструктурної підтримки, яка б сприяла інтеграції нових технологій у харчову галузь, через механізми фінансування, стимулювання інновацій та підтримку підготовки фахівців. Акцентовано увагу на необхідності узгоджених дій держави, бізнесу та освітніх закладів для створення відповідних умов для цифрової трансформації галузі, яка б забезпечила зниження витрат, підвищення ефективності та забезпечення стабільного розвитку в довгостроковій перспективі. Розширено розуміння ролі державного регулювання у підтримці цифровізації, включно з ініціативами щодо створення нормативної бази, яка б забезпечувала прозорість та відповідала вимогам цифрової економіки. Надано рекомендації щодо застосування інформаційно-аналітичних інструментів для підвищення якості управління ланцюгами постачання, покращення контролю за якістю продукції та забезпечення стабільності у процесах виробництва. Зроблено висновки щодо необхідності взаємодії держави і бізнесу для створення конкурентоспроможної та стійкої харчової галузі, здатної відповідати на глобальні виклики.

Ключові слова: інформаційно-аналітичний підхід, цифровізація, харчова галузь, цифрова трансформація, смарт-контракти, блокчейн, цифрова екосистема.

Formulation of the problem. The digital transformation of the food industry, amid rapid technological advancements, faces serious challenges that complicate the effective implementation of the information-analytical approach. Primarily, the food industry requires fundamental changes in management structures and technological processes, as most enterprises still rely on outdated control systems that cannot handle large volumes of data. This is particularly critical for the food industry, where supply chains are multi-tiered, and the need for quick responses to market shifts, demand changes, and quality control is extremely high. The lack of unified standards for data processing leads to information fragmentation, reducing the effectiveness of management decisions and complicating the overall integration of new technologies. One of the main obstacles to implementing the information-analytical approach is the limited resources of small and medium-sized enterprises. Investments in modern analytical tools, such as IoT, artificial intelligence, and machine learning, are substantial, and not all companies can afford these expenses. At the same time, without these technologies, it is difficult to achieve adequate levels of automation and process optimization, which, in the long term, may lead to smaller enterprises lagging behind larger market players, further exacerbating market inequality. A lack of qualified personnel capable of working with analytical data and new digital tools also presents a serious challenge for the industry. This issue is compounded by insufficient training for specialists who could not only integrate cutting-edge technologies but also further develop them within the food industry. Workforce training becomes a critical factor in successfully implementing information-analytical systems, as qualified personnel are essential for effective use of technology and stable industry growth in the digital economy. Additionally, the absence of adequate government support in the form of funding and the development of necessary infrastructure only complicates this process. Given the rapid changes in the global food industry, there is a growing need for government initiatives aimed at fostering innovation, developing regulatory frameworks for working with big data, and standardizing information exchange processes across all market participants. Without this, creating a unified digital ecosystem that ensures transparency and efficiency across all production stages will be challenging.

Analysis of recent research and publications: The essence, characteristics, advantages, and disadvantages of the information-analytical approach have been studied by the following national and foreign experts: Shannon S., Neumann J., Varenko V.M., Boyko N.V., Karakai M.S., Kolomiets E.V., Kasyanyuk S.V., Semchuk Zh.V., Trush O.O., Vasylenko D.V., Bortnikova M., Chirkova Yu., Kulish D., Balabanov O.S. However, the issue of defining key aspects of the informationanalytical approach, mechanisms, tools, and international experience in the context of state regulation of food industry enterprises has not been previously addressed.

The purpose of the article is to analyze and describe the key aspects of the information-analytical approach in the digital transformation of the food industry, as well as to develop and substantiate models and tools that will facilitate its effective implementation. Additionally, within the scope of the study, it aims to: identify and structure aspects of government regulation that could support and

accelerate the adoption of these technologies in the industry; explore the potential applications of information-analytical technologies.

Results of the research: With rapid technological advancement, digital transformation is increasingly impacting various industries, and the food industry is no exception. The information-analytical approach has become a crucial element of digital strategy, offering tools for analyzing large volumes of data, which helps enhance production processes, monitoring, and quality control. Technologies such as machine learning, artificial intelligence, and IoT open up new opportunities for supply chain management, optimizing production operations, and minimizing risks at all stages of production and distribution. However, implementing the information-analytical approach comes with numerous challenges, including limited resources for digital technology adoption in small and medium enterprises and a high demand for skilled personnel. Information-analytical tools require a high level of data standardization and integration, necessitating unified approaches at both government and business levels. In this context, government initiatives play a crucial role in promoting innovation, funding, and creating conditions for digitalization. Thus, this study primarily focuses on analyzing the information-analytical approach within the digital transformation of the food industry, examining key aspects, models, and

tools that could form the foundation for effective and sustainable digitalization.

So, let's consider the essence of the information-analytic approach in Fig. 1.

According to Figure 1, the information-analytical approach, shaped by the works of Claude Shannon and John von Neumann, laid the foundation for the development of modern information technologies and data analysis. Claude Shannon, by developing the mathematical theory of information, enabled the creation of efficient communication systems (Shannon, 1948). Von Neumann, through his studies of self-replicating automata, established the basis for complex computational systems and process automation, which are critically important for modern management (Neumann, 1996). In the digital age, the information-analytical approach by Claude Shannon and John von Neumann becomes central due to the application of big data for optimizing production processes, demand forecasting, and supply chain management.

This requires the creation of appropriate state infrastructure for data processing and analysis, cybersecurity assurance, and the development of digital skills among employees. The information-analytical approach serves as a key tool for improving the efficiency of management processes in modern enterprises through the application of principles for collecting, processing, and analyzing large data sets. By implementing
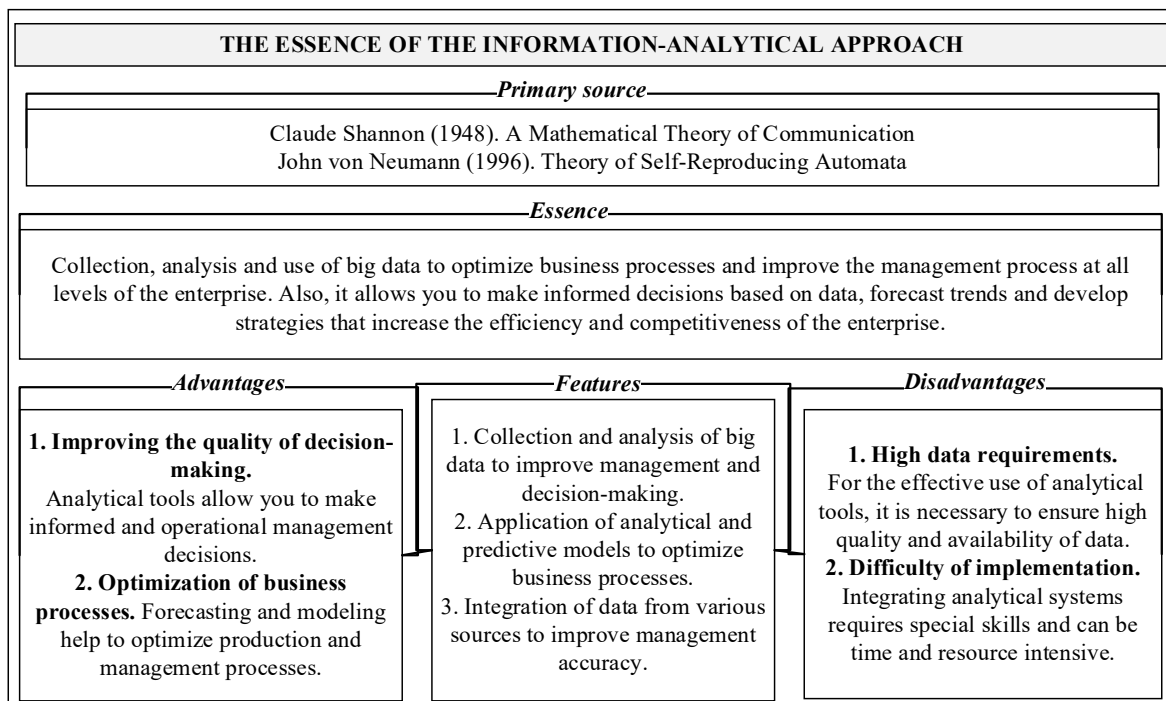

THE ESSENCE OF THE INFORMATION-ANALYTICAL APPROACH

Primary source

Claude Shannon (1948). A Mathematical Theory of Communication
John von Neumann (1996). Theory of Self-Reproducing Automata

Essence

Collection, analysis and use of big data to optimize business processes and improve the management process at all levels of the enterprise. Also, it allows you to make informed decisions based on data, forecast trends and develop strategies that increase the efficiency and competitiveness of the enterprise.

Advantages	*Features*	*Disadvantages*
1. Improving the quality of decision-making. Analytical tools allow you to make informed and operational management decisions. **2. Optimization of business processes.** Forecasting and modeling help to optimize production and management processes.	1. Collection and analysis of big data to improve management and decision-making. 2. Application of analytical and predictive models to optimize business processes. 3. Integration of data from various sources to improve management accuracy.	**1. High data requirements.** For the effective use of analytical tools, it is necessary to ensure high quality and availability of data. **2. Difficulty of implementation.** Integrating analytical systems requires special skills and can be time and resource intensive.

Fig. 1. The essence of the information and analytical approach

developed by the author based on source (Shannon, 1948; Neumann, 1996; Varenko, 2014; Boiko, 2020)

the information-analytical approach, enterprises make more informed decisions, minimize the influence of human error, and employ more intuitive methods in their operations. The use of analytical tools allows for the optimization of current business processes and forecasting of future trends, which greatly enhances the adaptability and resilience of enterprises in a constantly changing market environment. However, a crucial aspect of the information-analytical approach is the integration of data from various sources, which enables comprehensive, cross-sectional analytics of enterprise activities and efficient operation across all levels of management. This allows for faster and more accurate decision-making. Despite the obvious advantages, several challenges in the information-analytical approach remain, including high requirements for data quality and accessibility, the complex and lengthy process of implementing analytical tools, and the need to create a corporate culture that supports analytical thinking within the enterprise and prepares for future changes.

Consider the key elements of the information-analytical approach and their interaction in Fig. 2.

As shown in Figure 2, the elements of the information-analytical approach include data collection, analytics, forecasting, integration into business processes, and ensuring a high level of managerial accuracy. At the micro level, implementing the information-analytical approach leads to increased precision in management decisions, positively impacting the internal efficiency of the enterprise through resource optimization and improved control over business processes. At the macro level, these processes contribute to better strategic planning, enhance the resilience of enterprises to challenges in the food industry, and improve adaptability to the external environment by enabling a quick response to market changes. The global impact of the information-analytical approach in the context of digital transformation increases the level of innovative activity among food enterprises and encourages them to adopt new technologies. The wide-
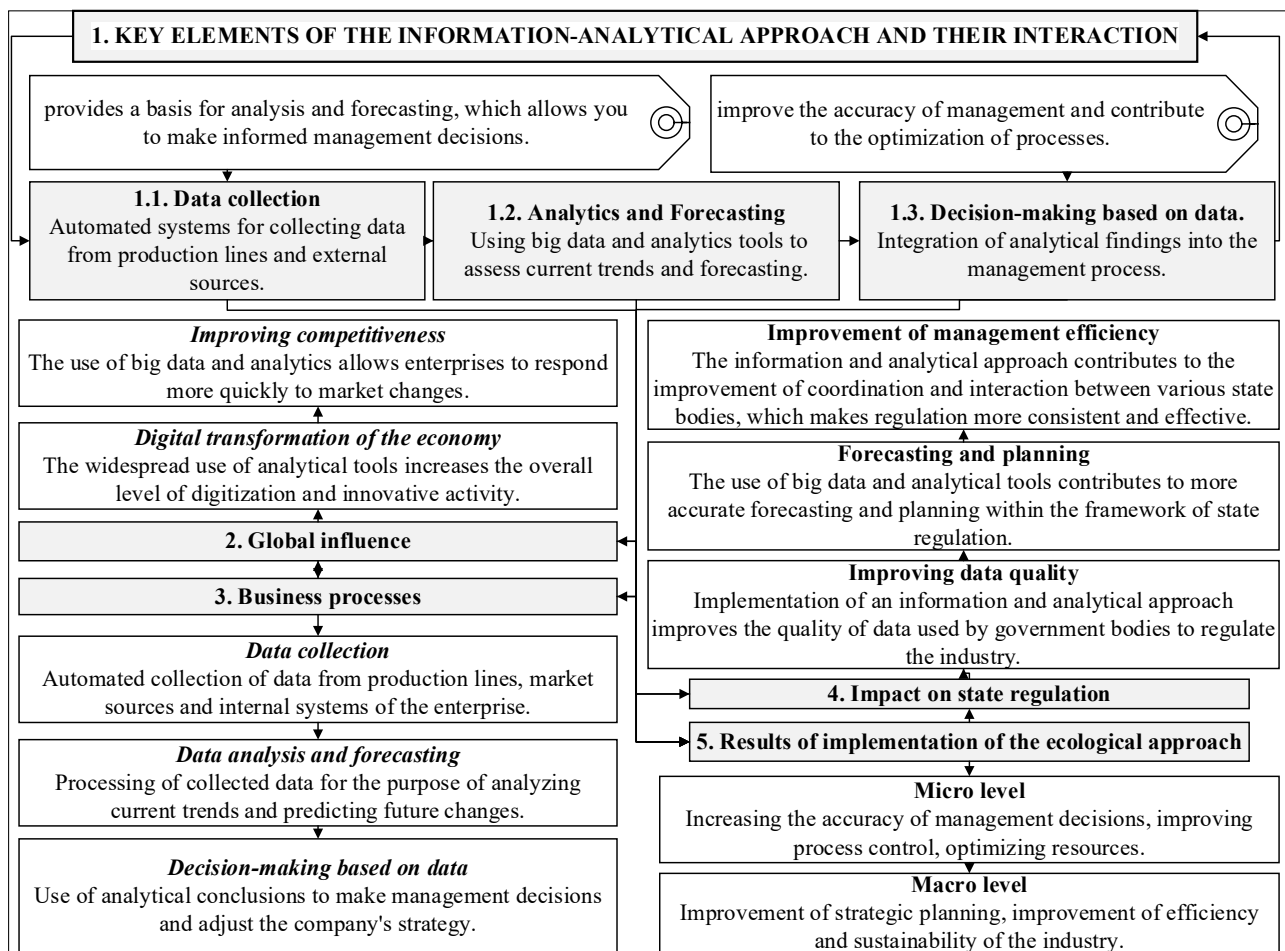

Fig. 2. Key elements of the information-analytical approach and their interaction

developed by the author based on source (Shannon, 1948; Neumann, 1996; Varenko, 2014; Boiko, 2020)

spread use of big data analytics tools enhances the competitiveness of food enterprises by optimizing their development strategies to achieve better outcomes. From the perspective of government regulation, the implementation of the information-analytical approach improves the quality of data used by government agencies for regulatory decisions, enabling the development of more effective measures to support the economy and increase stability amid market changes. Additionally, the use of analytical tools by regulatory bodies allows for more accurate forecasting of future market changes, contributing to more effective planning and faster adaptation to new conditions.

Let's consider the features of the implementation of the «Information-analytical approach» models in Fig. 3.

According to the data of fig. 3., the implementation of an information-analytical approach is carried out by applying two key models «Big Data and Analytics» and «Forecasting and Modeling».

The «Big Data and Analytics» model focuses on the automated collection and processing of large data volumes to identify patterns and current trends that help business owners make more balanced and precise strategic decisions. Key elements of the «Big Data» model enable more efficient data management with visualization capabilities, allowing enterprises to quickly navigate complex information flows and respond promptly to market changes. Decision-making based on data analysis reduces multifactorial risks, which positively impacts the future competitiveness of the business. The «Forecasting and Modeling» model is aimed at identifying key business indicators and developing future growth scenarios based on historical data from past activities. This approach enables the creation of predictive data models through the application of statistical methods and machine learning algorithms, allowing for action planning in a dynamic market environment (fig. 3).
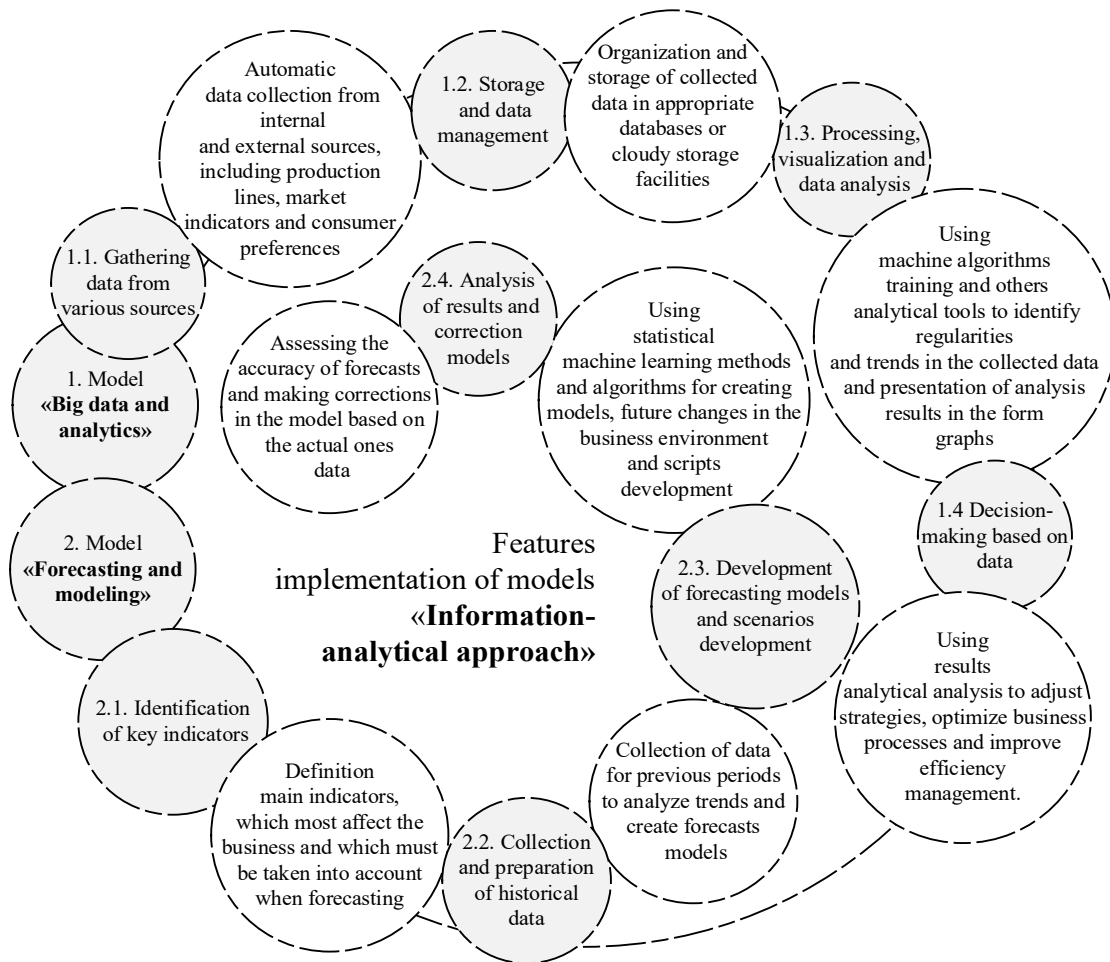

Fig. 3. Features of model implementation «Information-analytical approach»

developed by the author based on source (Shannon, 1948; Neumann, 1996; Varenko, 2014; Boiko, 2020; Karakai, Kolomiiets, Kasianiuk, 2020)

Additionally, a critical stage of this model is scenario modeling, which helps develop diversification strategies for various future scenarios, increasing the flexibility and adaptability of food enterprises. When comparing the «Big Data and Analytics» and «Forecasting and Modeling» models, it becomes clear that the «Big Data and Analytics» model emphasizes real-time data processing to uncover future insights, while the «Forecasting and Modeling» model focuses on long-term analysis and forecasting of future trends based on past experience. Thus, both models aim to optimize decision-making processes, though they differ in their temporal perspectives for addressing current tasks and planning future strategic activities.

Let's consider the «Aspect of the development of digital transformation» of the state regulation of food industry enterprises according to the structure of «Digital platforms» in Fig. 4.

According to Figure 4, the element «Online Platforms for Management and Control» is implemented through the combined efforts of digital solution developers, government institutions, and enterprises, creating new opportunities for automating management processes, reducing administrative costs, and increasing the transparency of regulatory procedures, which facilitates faster decision-making and better access to up-to-date data. However, digital transformation faces several systemic challenges, including significant costs
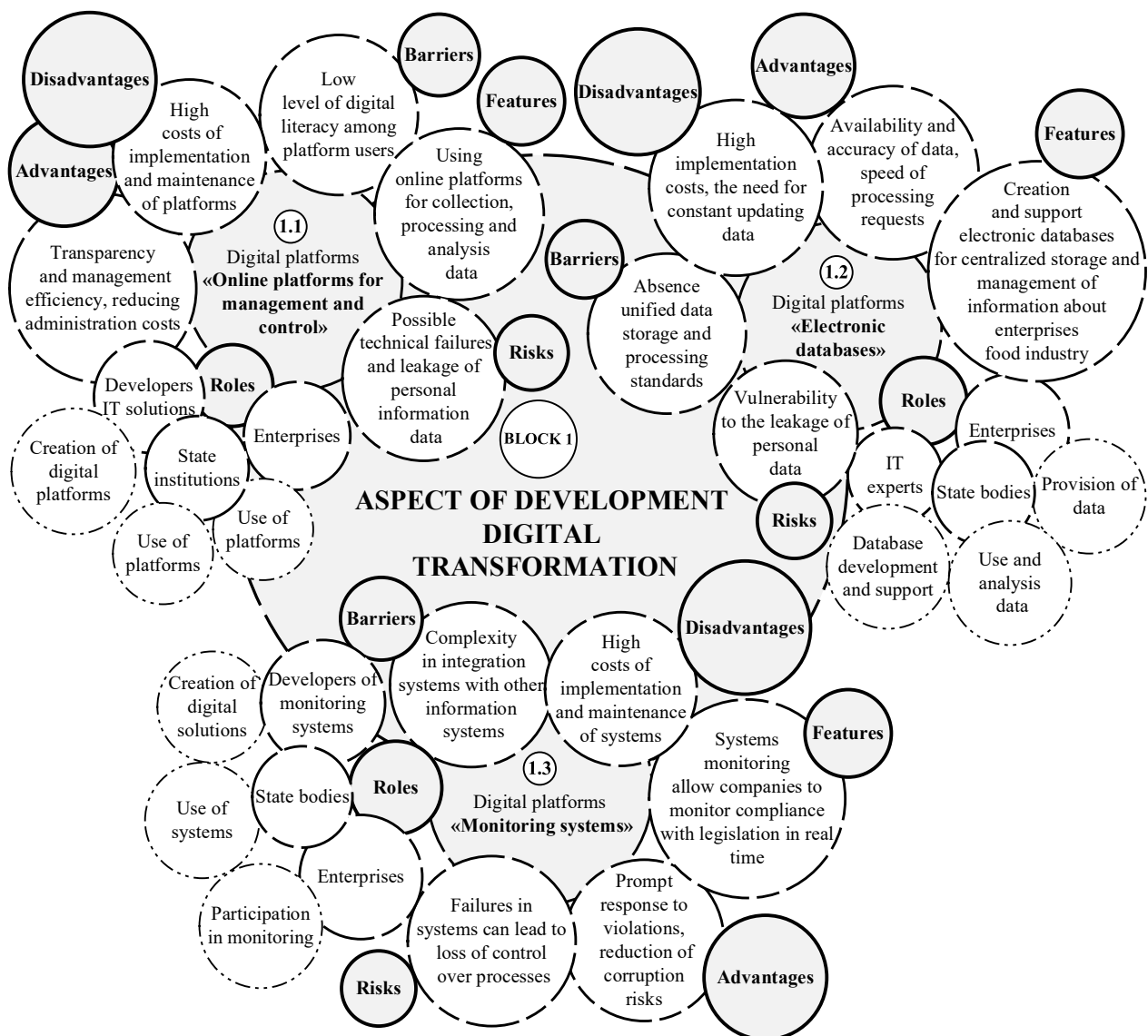

Fig. 4. «Aspect of the development of digital transformation» of state regulation of food industry enterprises according to the structure of «Digital platforms»

developed by the author based on source (Shannon, 1948; Neumann, 1996; Varenko, 2014; Boiko, 2020; Karakai, Kolomiiets, Kasianiuk, 2020; Semchuk, 2022; Trush, 2023; Bortnikova, Chyrkova, 2022;, Kulish, 2024; Balabanov, 2019)

for the development, implementation, and maintenance of online platforms, low levels of digital literacy among many user groups, and considerable risks in ensuring a secure environment for user personal data and databases, which poses a major barrier to the global integration of digital solutions. The element «Use of Electronic Databases» aims to improve the accessibility and accuracy of processed information; however, without clearly established standards for data storage and processing, there is a risk of system fragmentation and data loss, which hinders effective interaction between government bodies and enterprises. The vulnerability of these tools to frequent data leaks and threats from hackers also requires special attention to establishing a reliable data protection infrastructure. The element «Implementation of Monitoring Systems» is critically important for real-time control over the compliance of food industry enterprises with legal requirements. These systems enable the detection of violations in real time, allowing for prompt responses and reducing corruption risks while ensuring regulatory compliance. However, the high costs of implementing and maintaining such systems, along with challenges in integrating them with existing information platforms at food enterprises, slow down the pace of expansion of these systems. Thus, the successful implementation of digital transformation technologies and tools depends on coor-
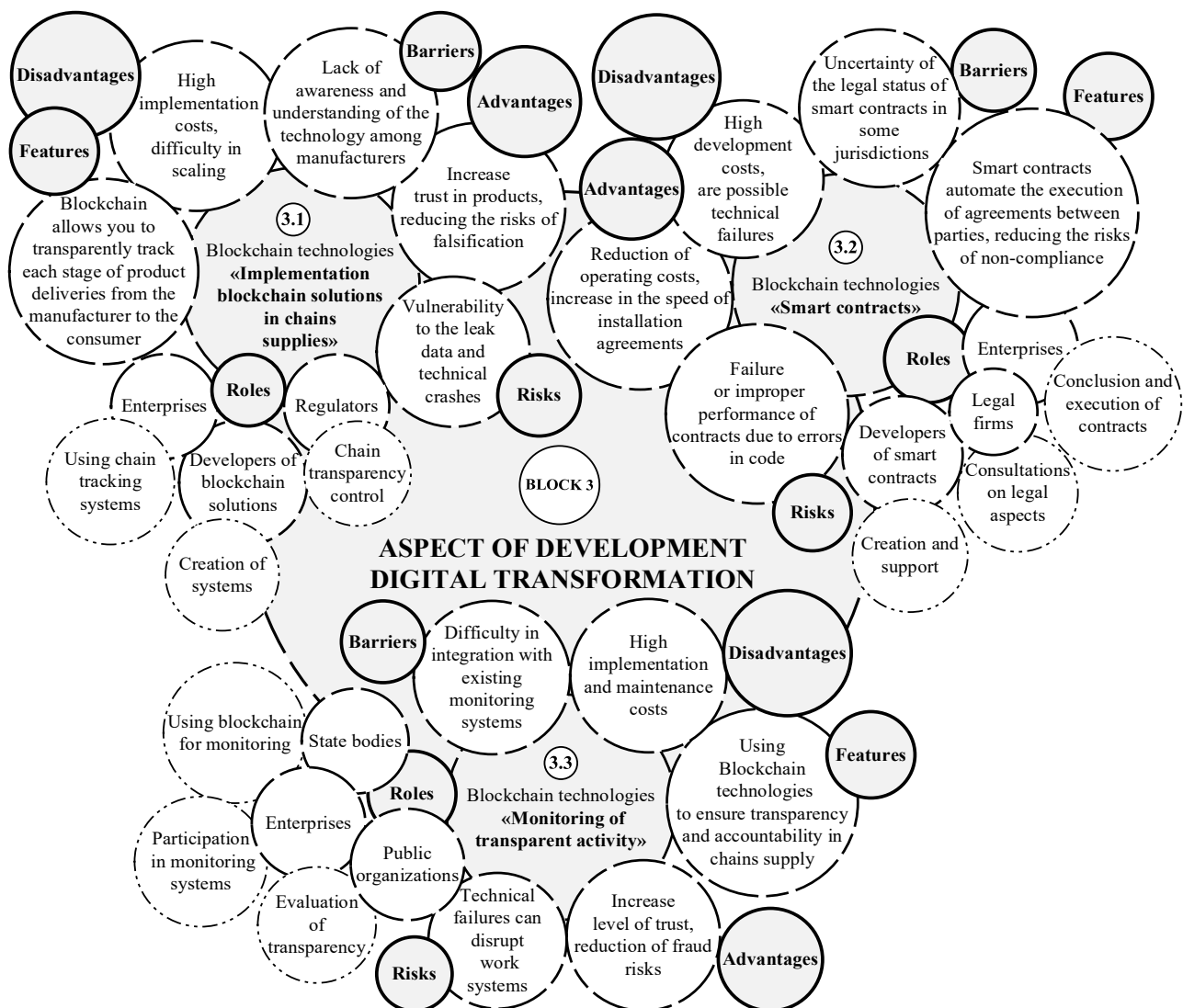

Fig. 5. «Aspect of the development of digital transformation» of state regulation of food industry enterprises according to the «Digital Economy» structure

*developed by the author based on source *developed by the author based on source (Shannon, 1948; Neumann, 1996; Varenko, 2014; Boiko, 2020; Karakai, Kolomiiets, Kasianiuk, 2020; Semchuk, 2022; Trush, 2023; Bortnikova, Chyrkova, 2022; Kulish, 2024; Balabanov, 2019)*

dinated efforts between the government, businesses, and the IT sector, as well as the ability to adapt existing processes to the new conditions of the digital economy. Ultimately, large-scale digitalization of the food industry could act as a catalyst for its innovative development if an adequate level of digital platform development, simplified integration tools with existing food enterprise and regulatory systems, and systematic preparation for future changes are ensured. Let's consider the «Aspect of the development of digital transformation» of state regulation of food industry enterprises according to the «Digital Economy» structure in Fig. 5.

As shown in Figure 5, the element «Creating Digital Ecosystems» is aimed at uniting govern-ment bodies, IT companies, and businesses on a single platform to optimize interactions, automate processes, and reduce costs associated with standardization. However, the high costs of implementing digital ecosystems, the ongoing need for process standardization, and the low readiness of some market participants for digitalization are significant barriers. The element «Digital Tools for Business» is implemented through CRM and ERP software solutions and is designed to automate operational business processes in food enterprises, improving the accuracy and flexibility of their management. Proper training and support for the functioning of these systems are critically important, as without them, serious issues may arise in business pro-
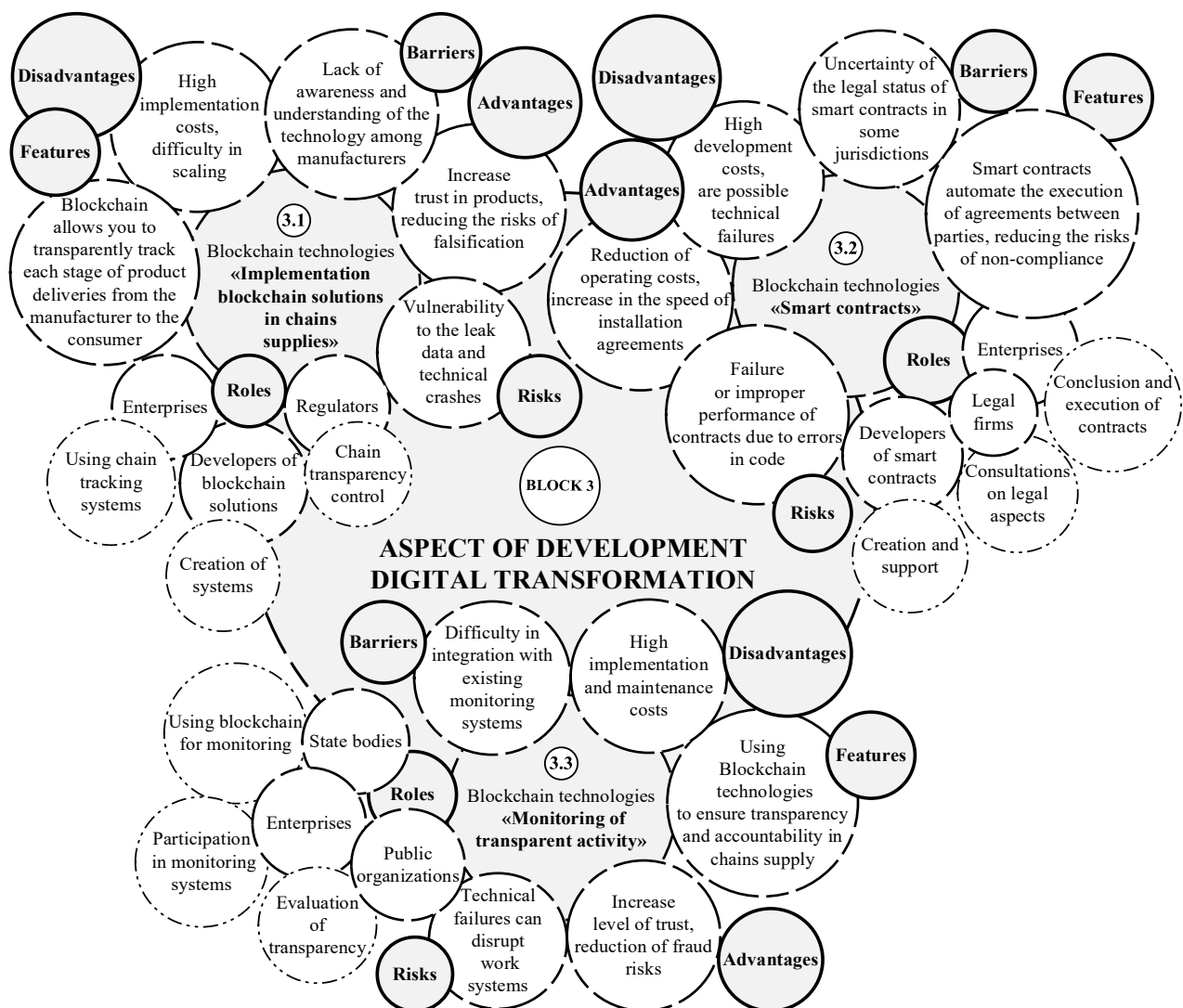

Fig. 6. «Aspect of the development of digital transformation» of state regulation of food industry enterprises according to the structure of «Blockchain technology»

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cess execution due to human error. The element «Training and Workforce Development» is also an essential aspect of digital transformation, where government agencies, food enterprises, and educational institutions should collaborate to prepare highly specialized workers capable of functioning effectively in the future digital environment. This not only helps reduce the overall unemployment rate but also increases the competitiveness of these workers in the labor market. However, high training costs, a lack of qualified instructors, and potential resistance to change among personnel could significantly slow down this process.

Let's consider the «Aspect of the development of digital transformation» of state regulation of food industry enterprises according to the structure of «Blockchain technology» in Fig. 6.

According to the data in Fig. 6, the element «Implementation of blockchain solutions in supply chains» along with the element «Monitoring transparent activities» opens up new opportunities to enhance transparency, trust, and security at every stage of interaction among suppliers, manufacturers, consumers, and government authorities. One of the key advantages of blockchain is its ability to provide reliable, immutable information about each transaction, reducing the risk of fraud and increasing the overall level of trust in products. Businesses that utilize blockchain technology in their processes gain the ability to track each stage of product delivery, thereby ensuring greater accountability and transparency in completed operations. However, the implementation of blockchain technologies has drawbacks, including high
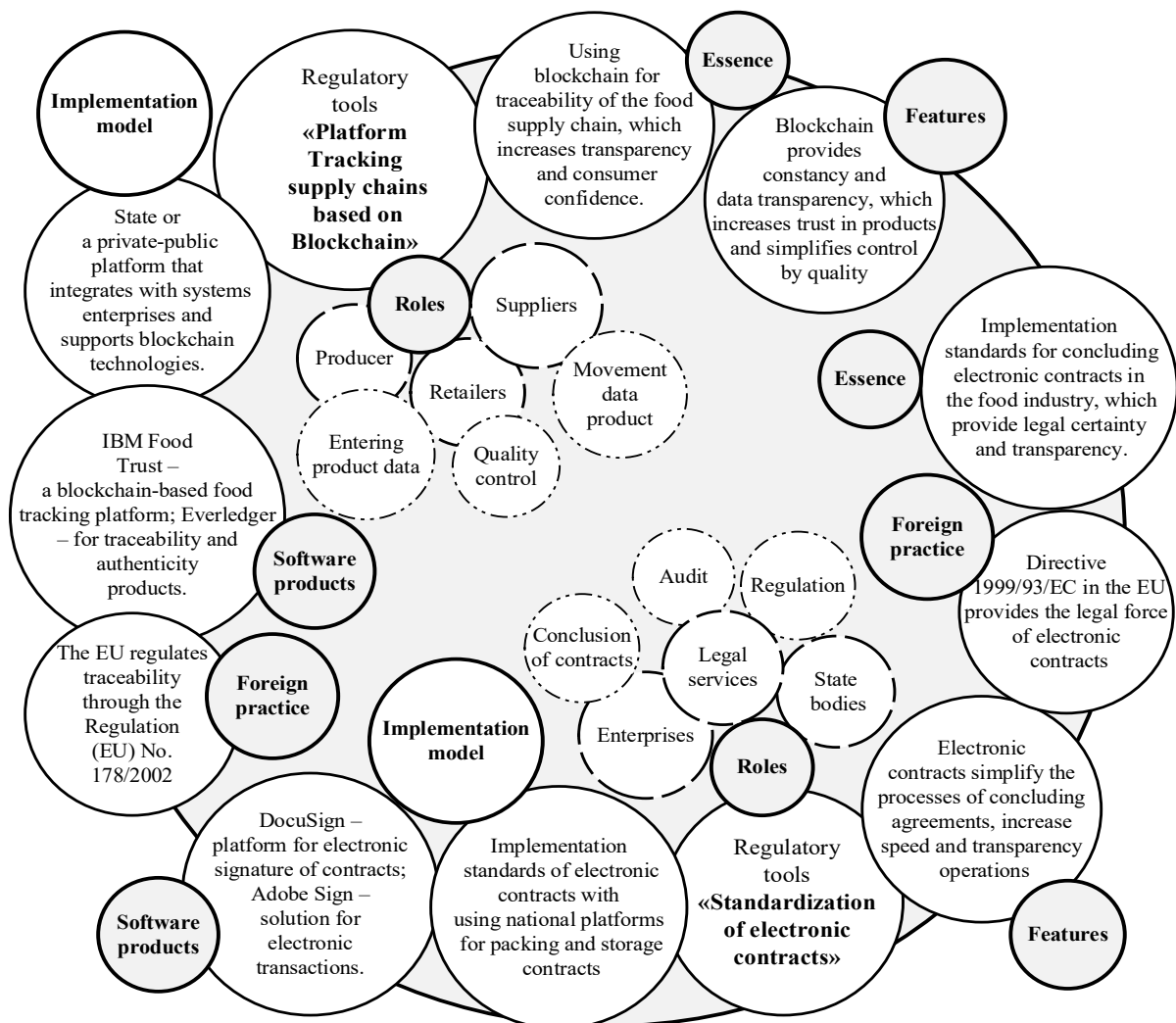

Fig. 7. Regulatory tools by categories «Standardization of electronic contracts» and «Blockchain-based supply chain tracking platform»

*developed by the author based on source *developed by the author based on source (Semchuk, 2022; Trush, 2023; Bortnikova, Chyrkova, 2022; Kulish, 2024; Balabanov, 2019)*

development and integration costs, challenges with scaling business processes, and insufficient awareness among market participants regarding this technology's application (Fig. 6).

The role of software developers in integrating blockchain technologies into the operations of food enterprises is also crucial, as they must actively adapt to new market and technological conditions to maximize benefits. Meanwhile, regulatory authorities should ensure oversight of blockchain technology use to enable lawful and transparent operations and support ongoing technical assistance. The element «Smart Contracts» is an important component of blockchain technology, automating contract creation and execution without intermediaries, which significantly reduces operational costs and accelerates the deal process. However, risks remain, such as technical errors in the code and the uncertain legal status of smart contracts in some jurisdictions, posing significant obstacles to their widespread adoption. Legal firms and software solution developers must collaborate to ensure the legal accuracy of contracts, and businesses should carefully assess the opportunities and challenges of implementing these tools before using them.

Let's consider regulatory tools in the category «Standardization of electronic contracts» and «Blockchain-based supply chain tracking platforms» in Fig. 7.

As shown in Fig. 7, the category «Standardization of Electronic Contracts» aims to promote legal certainty and transparency in relationships between market participants, as outlined in the European Union's «Directive 1999/93», allowing electronic agreements to have the same legal force as traditional contracts. The use of electronic contracts speeds up the processes associated with agreement execution, making them transparent for all market participants and facilitating easier monitoring of obligations fulfillment. To implement electronic contract technology, digital platforms such as DocuSign and Adobe Sign are recommended, as they allow for automated contract signing, document storage, and subsequent compliance verification. In this category, businesses are responsible for entering into electronic contracts, legal departments ensure compliance with established standards, and government bodies oversee adherence to these standards. The category «Blockchain-Based Supply Chain Tracking Platform» represents the next important step in the evolution of regulatory tools. The application of blockchain technologies creates an immutable and transparent record of each stage in product supply, enabling better quality control. The relevance of blockchain is primarily driven by the growing number of intermediaries between the manufacturer and the end consumer (Fig. 7).

To address this challenge, it is useful to refer to the European Union's practice regulating product traceability through «Regulation No. 178/2002», which highlights the importance of this approach for ensuring product safety. Using platforms such as IBM Food Trust ensures full transparency and accountability for each participant in the supply chain. This, in turn, will help strengthen relationships between consumers, suppliers, and regulators, building a stronger system of trust in products.

Conclusions. Several benefits have been identified from the implementation of information-analytical tools, including increased transparency, cost reduction, and reduced human error, which contribute to operational stability and the long-term competitiveness of enterprises. However, realizing this approach requires significant investment in digital technologies, which can be a serious challenge, particularly for small and medium-sized enterprises that often face limited resources. The disparity in innovation adoption between large and small enterprises may lead to market inequality, reinforcing the advantages of major players. Another important aspect highlighted in the study is the need for standard unification and the creation of appropriate government support to facilitate the integration of diverse information systems and ensure access to modern technologies at all levels. Government involvement should encompass not only funding for digital projects but also support for specialist training and the establishment of a regulatory framework that meets the challenges of the digital age. Developing professional competencies is key for the effective implementation of digital technologies, as a skilled workforce is an essential factor for the sector's sustainable development. Therefore, creating favorable conditions for the digitalization of the food industry, active participation in the development of information infrastructure, and support for innovation should be priorities of government policy. A synergy of efforts between the government, business, and educational institutions will help create a modern, technologically advanced food industry capable of meeting the growing demands of consumers and strengthening the national economy in a globally competitive environment.

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