

Features of innovative development of food industry enterprises in crisis conditions in Ukraine

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Abstract. The study aimed to identify key trends and characteristics of innovative solutions implementation in Ukrainian food industry enterprises during economic and social instability. The methodology was based on the use of statistical and economic-statistical analysis to assess production volumes, growth indices and financial results, content analysis of scientific publications, as well as a case study of the MHP company. The results showed that in 2020, the volume of food products sold amounted to UAH 480 billion, in 2022 it increased to UAH 708.27 billion, in 2023 it decreased to UAH 633 billion, and in 2024 to UAH 522 billion. The production index fluctuated: in 2022, it fell to 78.4%, but in 2023, it recovered to 106.8% and reached 115.9% in the first half of 2024. Exports of finished food products exceeded USD 3.27 billion in 2023 and more than USD 4 billion in 2024. MHP's financial results fluctuated: after a loss of USD 269 million in 2022, the company posted a net profit of USD 122 million in 2023 and USD 141 million in 2024. Total capital investment in the food industry in 2024 amounted to UAH 33.4 billion, which is 91.1% more than in 2023, of which 70.9% was spent on equipment modernisation. The introduction of biogas complexes (MHP over 12 MW, Astarta about 12 MW) and solar power plants also indicated the spread of renewable energy in production. The practical significance of the study lies in the possibility of using its results to develop strategies for modernisation, digitalisation and energy efficiency that would ensure the sustainability and competitiveness of Ukrainian food industry enterprises in the context of crisis challenges

Keywords: transformation; adaptation; industry; efficiency; digitalisation; competitiveness; production

Introduction

In the context of the crisis that the Ukrainian economy is experiencing, food industry enterprises are forced to operate in an environment of high uncertainty. Military action, inflationary fluctuations and a decline in the purchasing power of the

population directly affect the production activities and financial stability of companies. This necessitates the search for innovative solutions that will maintain profitability and competitive positions in both domestic and foreign markets.

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Food industry enterprises in Ukraine faced numerous risks during the full-scale invasion, including the destruction of production facilities, interruptions in the supply of raw materials, loss of sales markets, staffing constraints, financial instability, and logistical difficulties. O. Hryvkiivska & M. Horinnyi (2024) emphasised that these factors made it difficult to ensure the continuity of production processes, reduced financial stability and created additional barriers to export activity. The study emphasised the importance of maintaining food security as a key task, as it was the functioning of the food industry that ensured employment and stability of the domestic market. Baking enterprises in Ukraine were in a situation where increasing economic and social risks required updating management approaches, modernising production and introducing innovations. Y. Danko *et al.* (2025) studied the strategic foundations of innovative development, defined the essence of this concept, outlined the key risks for the baking industry, and emphasised the need to update the material and technical base, introduce modern technologies, and adapt to changes in consumer preferences. As a result, the study argued that effective and sustainable development is only possible if innovation is boosted, a comprehensive strategy is developed that incorporates the challenges of Industry 4.0, and there is a focus on environmental safety and competitiveness.

Small enterprises in Ukraine face challenges related to economic and political instability, increased global competition, changes in the regulatory environment, and the need to adapt quickly to a dynamic market environment. P. Tishakov (2024) researched innovative adaptive management strategies that ensured stability and competitiveness for enterprises. The study substantiated that the implementation of strategic planning, innovative marketing, and investment mechanisms contributes to increasing business efficiency and flexibility, as well as creating conditions for rapid response to market changes. The development of the innovative potential of food industry enterprises in Ukraine is characterised by a low level of activity in the implementation of innovations, which was due to a lack of funding, the absence of an effective state support strategy, market monopolisation and the focus of business on short-term tasks. G. Mokhonko & K. Klymenko (2020) studied the state of the innovative potential of enterprises, identified its key components (financial, technical and technological, human resources, research and development, and market) and showed that only about 1% of enterprises were engaged in innovative activities.

Innovative activity of enterprises in Ukraine in the context of a full-scale invasion (2022) was accompanied by numerous challenges, including increased financial costs, logistical complications, destruction of production facilities, loss of traditional markets, shortage of skilled personnel, and changes in the legal environment. O. Hryvkiivska & M. Horinnyi (2025) revealed the risks that arose during the introduction of new technologies and products, identified their key types (financial, logistical, production, marketing, personnel, and regulatory) and proposed a methodology

for integrated assessment to quantitatively determine their level. The study emphasised that financial risks remained the most threatening, while innovation risks were less critical but still required proper control. In Ukraine, enterprises operating in the bakery industry faced a range of challenges, including falling consumer demand, rising raw material prices, declining purchasing power of the population, the development of small-scale baking, and low-capacity utilisation. A. Hrishchenko (2024) researched the conceptual foundations of forming an innovative development strategy, developed a mechanism for its implementation, and identified the main stages of implementation, including analysis of the internal and external environment, formation of a goal tree, and monitoring of innovative potential.

In Ukraine, companies operating in the food production sector faced difficulties due to the unstable economic environment, limited investment resources, and the need to quickly adapt to modern challenges. V. Kaidanovych (2024) researched innovative development guidelines, identified key factors influencing their effective implementation, and emphasised the importance of integrating modern technologies into production and management processes. The study showed that digitalisation, the use of artificial intelligence, and the introduction of innovative approaches in production contributed to increased productivity and competitiveness. In the context of military challenges, Ukrainian food production companies faced limited access to resources, logistics disruptions, rising costs, and a decline in the purchasing power of the population. N. Slobodian *et al.* (2024) researched innovative development tools and substantiated their role in improving the efficiency of enterprises, emphasising the introduction of digital technologies, the formation of new management approaches, and the expansion of environmentally-oriented practices.

The areas of innovative transformation remained insufficiently explored, in particular, the practical integration of digital solutions and innovative strategies into the activities of enterprises of various sizes, considering local conditions and crisis factors, as well as the issues of financing and assessing the long-term effectiveness of such mechanisms, which require further scientific study. Therefore, the study aimed to identify the factors and mechanisms that ensure the effective implementation of innovations in the activities of food industry enterprises in Ukraine in conditions of crisis instability.

Materials and Methods

The study was empirical in nature and covered two time periods and two levels of analysis: for the food industry of Ukraine in 2020-2024 and for the MHP case in 2016-2024. To assess the dynamics of the total volume of food products sold and the production index in 2020-2024, statistical analysis was used to identify changes in indicators in the context of crisis challenges, determine growth and decline trends, and track the recovery of production capacities. The source of the analysis was data from N. Smolinska *et al.* (2025), as this study contains systematised

statistical materials on the functioning of the food industry in Ukraine during the specified period, which ensures the accuracy and representativeness of the results. In addition, a comparative analysis method was used to compare changes in the structure of production, which traced the redistribution between the meat, oil, dairy products and other groups. For this purpose, materials from Agropotal (2025), T. Besarab (2025) and the study by V. Ivchenko *et al.* (2024) were used, as they contain generalised statistical data on the structure of the food industry in Ukraine and make it possible to assess the dynamics of changes in the industry. To identify the factors that influenced innovation activity during the period of instability, content analysis of scientific publications and reports by O. Pyschulina *et al.* (2021) and A. Barbu *et al.* (2022) was used. This method was used to systematise information about the economic, technological, social and political conditions that shaped the need for innovation, as well as international and regulatory influences.

Case studies were used for further analysis of the activities of MHP, which was selected as an example of Ukraine's largest food producer and exporter actively implementing digital and management innovations. The case study method was used to analyse specific technological solutions. To assess the effectiveness of the implementation of digital technologies in production and logistics processes, Marel's I-cut intelligent machines, Clean-in-Place washers and the Smart Maintenance platform were analysed. The study also covered the Data Model Meat Processing system, the Smart Technology Assistant (Smart TA) tool, and the Systems, Applications and Products in Data Processing (SAP) ERP solution used to manage production resources. The Rinkai Transportation Management System, which is used to analyse opportunities for logistics optimisation and cost reduction, was considered separately.

MHP's (2017; 2021; 2023; 2024) financial results were studied for the period 2016-2024. To this end, economic and statistical analysis based on official financial reports was used, which made it possible to track the latest changes in the company's financial indicators. This method determined how innovative investments affected income, gross and operating profit, adjusted Earnings Before Interest, Taxes, Depreciation and Amortisation (EBITDA) and net profit. The year 2016 was chosen as the base year because it marked the end of the pre-innovation stage of the company's development, while 2017 saw the start of the active phase of digital technology implementation, and the period 2020-2024 was considered the peak in terms of testing the effectiveness of innovation strategies.

A descriptive method was used to evaluate MHP's investments in the ERP system Systems, Applications and Products in Data Processing, Suite 4 for High-Performance Analytic Appliance (SAP S/4HANA) and in the logistics business through the acquisition of KTL Ukraine. The method was used to analyse how digital solutions and the development of the company's logistics infrastructure affected its management efficiency and competitive position.

To assess the prospects for innovation in Ukraine's food industry, a method of systematisation and generalisation was applied. The analysis covered state programmes to support innovation, in particular "Support for farms and other agricultural producers" (Order of the..., 2024) and the "5-7-9%" preferential lending programme. Examples of the implementation of renewable energy sources were considered separately the activities of leading biogas enterprises in Ukraine and the use of solar technologies to improve the energy efficiency of production. These areas were analysed based on materials from Agravery (2020), which summarised the practices of using renewable energy in the food industry. In addition, the dynamics of the expansion of food exports were analysed. This analysis was based on materials from the Association of Milk Producers (2025), which tracked changes in the structure of foreign supplies. The use of this method ensured the combination of statistical data with practical examples and highlighted the priority areas for the development of the food industry.

Results

Dynamics of innovative activity of food industry enterprises in Ukraine during the crisis

In 2020-2024, Ukraine's food production showed mixed dynamics, reflecting the impact of the COVID-19 pandemic and military operations. The total volume of products sold increased from UAH 480 billion in 2020 to a peak of 708.27 billion UAH in 2022, demonstrating the ability of enterprises to adapt to crisis conditions. At the same time, in 2024, the volume decreased to UAH 522 billion due to the exacerbation of economic and social instability. The production index in 2020 was 99.2% and exceeded the average industrial indicator (95.5%), in 2022 it decreased to 78.4%, but in 2023 it increased to 106.8%, confirming the recovery of production capacities. In the first half of 2024, the index maintained positive dynamics at 115.9% compared to the same period in 2023. Figure 1 shows the dynamics of food sales in Ukraine in 2020-2024, reflecting changes in the production capabilities of enterprises under the influence of crisis factors.

The dynamics were wave-type: after a period of growth from 2020 to 2022, there was a decline in 2023-2024. This indicates the impact of crisis factors on the activities of enterprises. In general, the trend shows a loss of stability in production and sales. The structure of production has changed. The most stable positions were held by sunflower oil (24.4%) and animal fats (24.9%), whose share remained almost unchanged in 2015-2023. At the same time, the share of meat and meat products increased from 11.3% in 2015 to 20.5% in 2023, which was explained by higher prices. During the period 2015-2023, sugar production increased 8-fold, fish products 5.4-fold, and meat products 4.3-fold. At the same time, in 2021-2023, the value of oil production decreased by 9.6%, and that of flour and cereal products by 10.2%. The quality of dairy products improved significantly: in 2022, 69.5% of the assortment consisted of extra and premium milk (Ivchenko *et al.*, 2024;

Agropotal, 2025). In 2024, meat production increased by 4-5% and amounted to about 2.35-2.54 million tonnes, with meat and meat products accounting for about 20.6% of the total volume. Sunflower oil production amounted to 6.3-6.4 million tonnes (with 14.4 million tonnes of seeds processed), which, together with animal fats, accounted

for 25.1% of food production. Milk production reached 7.25 million tonnes (2.5% less than in 2023), accounting for 13-15% of the total structure, while sugar held a share of about 5% (1.8 million tonnes). Fish production showed slight growth, with freshwater fish production in the Lviv region increasing by 30% (Besarab, 2025).

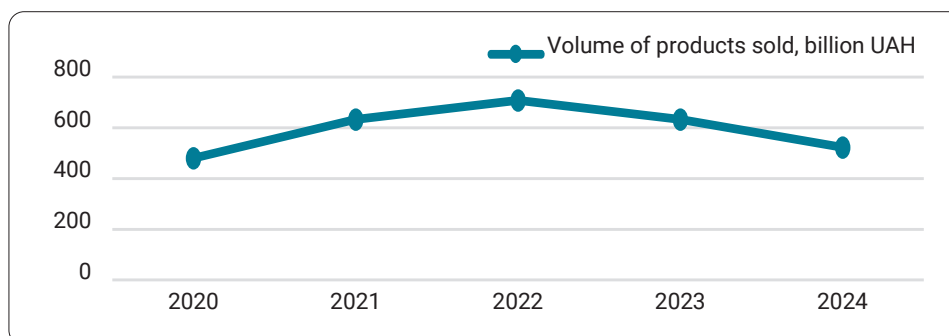


Figure 1. Dynamics of sales volume for 2020-2024 (billion UAH)

Source: compiled by the author based on N. Smolinska *et al.* (2025)

The distribution by market segments remained relatively stable: bakery products accounted for 20.8-26.5% of total output, while domestic consumption focused on pasta, confectionery and margarine. The export component retained its leading position in sunflower oil, meat, sugar, and confectionery, with large companies, in particular MHP, being central. In 2023, exports of finished products exceeded USD 3.27 billion, and in 2024, they grew to over USD 4 billion (In 2023, exports..., 2023).

The cost component of enterprises became more complicated in the context of a full-scale invasion. In 2022, 76% of manufacturers reported disruptions in the supply of raw materials and supplies, and nearly 21% reported problems with electricity, forcing them to switch to expensive alternative energy sources. Logistics became more complicated due to the destruction of infrastructure and rising transportation and storage costs. At the same time, there was an increase in the prices of energy resources and raw materials, which led to higher production costs and lower profitability, even though output volumes remained unchanged. In 2023-2024, there was a gradual recovery in production and stabilisation of financial activities. Companies were more active in introducing innovative technologies, modernising equipment, and seeking new markets and suppliers. These measures helped to reduce costs, improve product quality, and ensure competitiveness even in crisis conditions (Agropotal, 2025).

Thus, in 2020-2024, the Ukrainian food industry was characterised by a combination of deep crisis declines and rapid recovery, the preservation of stable segments (oil, fats, meat), increased exports and improved product quality. Rising costs and logistical constraints were key factors that hampered financial results, but innovative approaches and the adaptability of enterprises made it possible to maintain growth momentum even during a

period of prolonged instability. In 2020-2024, the innovative activity of food industry enterprises was determined by several interrelated factors that either strengthened or restrained the dynamics of development. Economic conditions had the greatest impact. The COVID-19 pandemic and military actions caused a drop in household incomes, inflationary pressure, and an increase in the cost of energy resources and raw materials. This forced enterprises to seek ways to reduce costs, which increased the importance of innovations capable of reducing production costs and ensuring more efficient use of resources. Technological factors were significant. The active development of digital platforms, geographic information systems, automation and analytics systems created conditions for increasing productivity and optimising production processes. The use of modern technologies reduced the impact of the human factor, reduced the number of errors and adapted production more quickly to changes in demand (Pyschulina *et al.*, 2021).

The social factor was linked to changing consumer preferences. Growing demand for high-value-added, environmentally friendly and high-quality products stimulated innovative approaches. In addition, in the context of a full-scale invasion, there was increased attention to job preservation and employee training, which also required the introduction of new methods of work organisation and staff training. Political and regulatory factors remained relevant. As part of its European integration course, Ukraine undertook to adapt its production standards to EU requirements, which stimulated the modernisation of equipment and the introduction of quality control and certification systems. At the same time, the state and international institutions provided financial support, which created additional opportunities for innovative activities of enterprises during a period of instability (Barbu *et al.*, 2022).

The international factor also reinforced the importance of innovation. The emphasis on exporting sunflower oil, meat, sugar and confectionery products required compliance with international standards, while competition on global markets encouraged the introduction of technologies that improved the quality and efficiency of production. The export component became a stimulus for innovation, as it was new approaches that maintained and expanded sales markets for enterprises. Thus, in the period 2020-2024, innovation activity in the food industry of Ukraine was determined by a combination of economic, technological, social, political and international factors. These factors created ambiguous conditions: on the one hand, they complicated operations due to rising costs, risks and logistical constraints, but on the other hand, they stimulated enterprises to modernise, digitise and become more environmentally friendly, which ensured their competitiveness even in crisis conditions.

Use of the latest tools in production and management processes

The introduction of digital technologies became a key area of transformation for MHP in 2017-2024. Thanks to geographic information systems, the company was able to accurately map and account for land plots, which eliminated paper document flow and increased the efficiency of management decisions. The use of precision farming with Global Positioning System navigation and automated systems for applying fertilisers and plant protection products has optimised resource use and increased crop uniformity. The integration of data into a single ERP system minimised the human factor, and the use of artificial intelligence ensured operational monitoring of field conditions and real-time adjustment of agrotechnical measures. A substantial effect was the return of about 30% of low-productive areas to production at 12 of the company's enterprises, which directly contributed to an increase in gross yield (MHP shared the..., 2018).

Investments in digitalisation grew gradually. While in 2017-2018 the company focused on its first projects, in 2022-2024 it launched a large-scale digital transformation, becoming a leader in agricultural digitalisation in Eastern Europe. One of the first steps was the automation of processes in the meat processing division. To this end, a hydrocutter for 3D meat cutting was introduced, which made it possible to cut raw materials with high precision according to specified parameters, minimising losses and increasing the yield of finished products. A substantial advantage was the ability to configure different cutting modes to meet customer needs, which made it possible to create products with higher added value. At the same time, Japanese automated systems for separating meat from bones were integrated, which increased the speed and safety of operations and made it possible to reduce costs by saving working time and using raw materials more efficiently. Mare's I-cut intelligent machines were substantial, optimising cutting based on computer

vision, which ensured consistent product quality regardless of production volumes. A significant addition was the Clean-in-Place washing system, which was used for automated cleaning of equipment without dismantling it. This reduced water, detergent and time consumption and ensured compliance with international food safety standards (Shawarma robots, AI..., 2025).

The Smart Maintenance digital platform was instrumental in the technical maintenance of equipment, enabling repairs to be managed based on real data, predicting failures and reducing production downtime. In addition, production efficiency was enhanced by the Data Model Meat Processing system, which is based on big data analysis and provides real-time control of process parameters and optimisation. Among the most advanced solutions is Smart TA, which uses artificial intelligence algorithms to manage incubators and poultry houses. It controls the microclimate, lighting and feeding, adapting conditions to the needs of poultry at each stage of development. In the field of management and logistics, the integration of SAP ERP has become a key tool, combining financial, production and logistics processes into a single digital platform. This has ensured transparency of decisions, increased planning accuracy and reduced operational risks. The Rinkai Transportation Management System was implemented, which reduced transport mileage and fleet costs, resulting in a threefold reduction in excess mileage and a more than 10% reduction in fleet costs. The final element was the integration of Customer Relationship Management solutions, which made it possible to consolidate customer and supplier data into a single system, increase the transparency of interactions and the speed of request processing, which had a positive impact on sales efficiency and customer trust (Approach to digital..., 2023).

In 2024, MHP's innovative activities contributed to the launch of new products and brands: the premium chicken brand Super Filo (AgroElita, 2024) and MHP Food Service, dedicated to catering for corporate clients. This transitioned the company from raw material production to a culinary direction with high added value. A substantial result was the strengthening of export potential. In 2024, MHP's export revenue amounted to USD 1.7 billion, which accounted for a significant share of Ukraine's total food exports (over USD 4 billion). A notable case study is Perutnina Ptuj (2025) in Slovenia, which increased its production from 88 to 146 thousand tonnes in five years (2020-2024) and almost doubled its revenue. Innovations ensured the expansion of markets in the EU, the UK and Asia, and had a multiplier effect on MHP exports, with each euro bringing EUR 3.8 to production. At the same time, the expansion of innovative activity and entry into new markets was accompanied by a gradual recovery in the company's financial results. As shown in Table 1, the dynamics of key indicators were characterised by significant fluctuations due to the impact of crisis factors, but a recovery was observed in subsequent years.

Table 1. Financial indicators of MHP for 2016-2024

Year	Income (million USD)	Gross profit (million USD)	Operating profit (million USD)	Adjusted EBITDA (million USD)	Net profit (million USD)
2016	822	299	278	343	102
2017	970	331	318	371	257
2020	1414	322	194	332	-109
2021	1647	573	416	552	377
2022	1876	398	176	304	-269
2023	2294	463	247	367	122
2024	2262	627	346	478	141

Source: compiled by the author based on MHP (2017; 2021; 2023; 2024)

In 2016-2017, MHP demonstrated stable growth in financial results. Revenue increased from USD 822 million in 2016 to USD 970 million in 2017 (+18%), while net profit more than doubled from USD 102 million to USD 257 million. Gross and operating profits also showed positive dynamics, creating a financial basis for investments in modernisation and further digital transformation. In 2020-2024, MHP's financial results fluctuated, reflecting a combination of crisis challenges and gradual recovery. In 2020, the company generated revenue of USD 1.414 billion and gross profit of USD 322 million for the first nine months, resulting in an operating profit of USD 194 million. However, the year ended with a loss of USD 109 million, which was due to both currency losses and unstable market conditions. In 2021, the situation improved: revenue grew by 16% to USD 1.647 billion, gross profit increased to 573 million USD (+78%), and operating profit more than doubled to USD 416 million. Adjusted EBITDA increased by 66% to USD 552 million, and net profit amounted to 377 million USD, contrasting with the negative results of the previous year. This indicates a recovery in profitability due to increased production, improved margins, and stabilisation of exchange rate fluctuations. However, in 2022, the full-scale war in Ukraine became a decisive negative factor. Despite revenue growth to USD 1.876 billion, gross profit declined by 31%, operating profit fell by half, and adjusted EBITDA declined by almost half. The net financial result was negative: a loss of USD 269 million. This was due to war-related expenses, logistics problems and rising energy costs. In 2023, a gradual recovery began: revenue grew to USD 2.294 billion, gross profit rose to USD 463 million, operating profit increased by 40% to USD 247 million, and adjusted EBITDA amounted to USD 367 million (+21% compared to 2022). Net profit reached USD 122 million after losses in the previous year. In 2024, the positive trend continued: gross profit grew by 35% to USD 627 million, operating profit rose to USD 346 million (+40%), and adjusted EBITDA to USD 478 million (+30%). Net profit increased to USD 141 million.

During the period 2020-2024, MHP's investment policy was shaped by the need for large-scale modernisation and adaptation to crisis conditions, and external financing

became substantial in this process. The involvement of strategic partners, such as the Saudi Agricultural and Livestock Investment Company (2025), which invested approximately USD 54 million in the company's shares in September 2024, strengthened MHP's position in the Middle East and was used for the implementation of joint projects in the agricultural sector. At the same time, over USD 53 million was allocated to the construction of an incubator, a feed mill and poultry farms, which underscores the company's desire to ensure vertical integration of the production process (Information about MHP, 2025). Investments in digitalisation, which have become a key element of the business model transformation, should be highlighted separately. In 2024, the IT budget reached USD 27 million, of which more than USD 20 million was invested in 2022-2023 in the implementation of the ERP system, Systems, Applications and Products in Data Processing, Suite 4 for High-Performance Analytic Appliance (SAP S/4HANA). This made it possible to create a single integrated platform for managing all business areas, from production and logistics to finance and sales. At the same time, the company actively invested in the digitalisation of agricultural production processes, the application of big data analytics and risk management systems.

Logistics became another area of development: MHP made its first investment in the logistics business by acquiring KTL Ukraine to scale up maritime transport and expand its presence in international markets. This increased the efficiency of supply chains and reduced transportation costs (Rodak, 2025). Equally relevant was the focus on green energy: the company doubled its investments in this area and announced plans to build a 60 MW wind farm by the end of 2025. This correlates with both the strategic goals of improving energy efficiency and the requirements of environmental sustainability, which is a determining factor for competitiveness in European markets (How MHP develops..., 2024). Thus, MHP's investment strategy for 2020-2024 combined financing for production modernisation, digital transformation, logistics development and environmental projects. It became the basis for strengthening financial results, expanding export potential and increasing the company's long-term profitability even in crisis conditions.

Prospects for the introduction of innovative technologies in the food industry of Ukraine

In 2020-2024, the food industry of Ukraine operated in conditions of profound economic and social instability caused by the COVID-19 pandemic, military actions and heightened geopolitical risks. Despite this, the industry demonstrated a relatively high level of innovation activity, which manifested itself in a significant increase in capital investment, the introduction of new technologies, and the expansion of international presence in key export markets. One of the key factors confirming the stability and innovation of the industry is the dynamics of capital investments. In 2024, the total volume of capital investments in the food industry of Ukraine amounted to approximately UAH 33.4 billion, which is 91.1% more than in the crisis year of 2023. Most investments, namely about 70.9%, were directed towards the renewal of machinery and equipment. This indicates the strategic focus of enterprises on modernising production capacities, introducing digital technologies and ensuring energy efficiency. In the future, this direction is expected to remain a priority, as equipment modernisation and production digitalisation are key prerequisites for increasing productivity and reducing production costs (Ivchenko *et al.*, 2024).

Despite objective difficulties, the food industry remained attractive to foreign investors. Foreign direct investment in food production in 2023 amounted to approximately USD 67.3 million. Although this figure is lower than in 2021-2022, the trend indicates that international companies remain interested in the Ukrainian market even during the period of military action and devaluation of the national currency. This is attributed to both the high export potential of the industry and the prospects for further modernisation of production, focused on compliance with European food quality and safety standards. In the coming years, a substantial driver will be the emphasis on the production of organic and functional products, which are in high demand on world markets (Ivchenko *et al.*, 2024).

A separate area of focus was the introduction of innovations in energy efficiency and renewable energy sources. In 2020-2024, several projects were implemented in Ukraine to utilise biogas plants for the environmentally friendly disposal of organic waste from the food industry. Biogas complexes have become a significant element of the circular economy: they have reduced the burden on the environment and greenhouse gas emissions, while providing enterprises with independent sources of electricity and heat. Biogas plants are widely used for the environmentally friendly disposal of organic waste from the food industry, sugar factories, and fruit and vegetable processing. For example, the MHP agricultural holding operates several biogas complexes (Biogas Ladyzhyn with a total capacity of over 12 MW and Orel-Leader with 5.5 MW), which produce electricity from organic waste. Other large producers in the food industry, such as Astarta, also have biogas plants based on sugar factories with a total capacity of about 12 MW (Bioenergy Complex in Hlobyn, Hlobyn

Sugar Factory, Hlobyn Processing Plant). Further development is expected in the construction of biogas and wind complexes, which will significantly strengthen the energy independence of the industry by 2030 (Agravery, 2020).

In addition to biogas solutions, the food industry has also seen a widespread transition to solar energy. Several companies, including MHP and Agro-Region, have installed solar power plants, which have reduced their dependence on traditional energy sources and partially offset the rise in electricity prices during the crisis years. The available examples demonstrate the real movement of the industry towards decarbonisation and increased energy independence. In the future, solar power stations will be integrated into the production complexes of medium and large enterprises, which will meet the European requirements for a "green transition" (Solar Max, 2025). State support for innovation became a relevant area of development. In 2020-2025, programmes were implemented to stimulate investment in the food industry, among which the programme "Support for farms and other agricultural producers" (Order of the..., 2024) is worth highlighting. In 2025, more than UAH 4.7 billion was allocated for its implementation. The programme provided not only budget subsidies but also grants and loans at preferential rates of "5-7-9%" (BDO, 2025). Such instruments contributed to the preservation of small and medium-sized businesses, which are the basis for the development of the food industry, and supported the renewal of the material and technical base and the introduction of modern technologies. In the future, state support will increasingly target the financing of innovative projects, especially in the field of energy efficiency and digitalisation, which correlates with the European Green Deal policy.

The development of innovation in Ukraine's food industry is also closely linked to the expansion of export geography. In 2020-2024, China, Egypt and India remained the main importers of Ukrainian food products, traditionally forming the basis of foreign supplies. In addition, the Netherlands, Spain, Turkey, Poland and Italy were substantial for consumers. During this period, there was an increase in supplies to Iraq, as a result of which the country entered the top 10 importers of Ukrainian products, ahead of Germany. This indicated the diversification of markets and the strengthening of Ukraine's presence in the markets of Asia and Africa. Further development of foreign trade is focused on expanding exports of high-value-added finished food products, which will encourage producers to more actively implement international quality standards and traceability technologies (Association of Milk Producers, 2025). In 2020-2024, Ukraine's food industry also actively integrated into the European sustainable development space. In the context of adapting to European standards, companies implemented measures to increase material efficiency, reduce energy and water consumption, and minimise waste. During the period of military operations, the issue of resource conservation was

of strategic importance. In the coming years, the industry is expected to intensify its implementation of digital resource management technologies, CO₂ emission monitoring systems, and circular economy solutions, which can be used to reach EU requirements for environmental reporting and market access (Green energy in..., 2024).

Notably, in times of crisis, innovation has become the main tool for food industry enterprises to adapt. The use of biogas and solar power plants has reduced energy costs and increased production autonomy. The modernisation of equipment through capital investments has ensured an increase in labour productivity and a reduction in costs per unit of output. The attraction of foreign investment has contributed to the introduction of international management practices and production technologies. In turn, state support programmes have provided the financial basis for expanding innovation even in times of high risk. Therefore, an analysis of trends combined with the outlined prospects indicates that Ukraine's food industry has the potential to maintain and strengthen its competitive position. Further growth in investment in production modernisation, the development of renewable energy sources, the export of finished products and integration into the European market create the conditions for the formation of a new model of sustainable development capable of ensuring the economic and technological independence of the industry in the long term.

Discussion

In 2020-2024, Ukraine's food industry operated in conditions of profound economic and social instability caused by the pandemic, military actions and increased geopolitical risks. The sector became one of the key areas ensuring food security and supporting employment, but at the same time suffered significant losses due to the destruction of production facilities, supply disruptions and a decline in purchasing power. In such conditions, innovation, digitalisation and modernisation of production became the defining mechanisms of adaptation. M. Alkhafaji (2024) addressed the global context. The study analysed the leading trends in the global food industry, including production automation, the use of artificial intelligence, the development of alternative protein sources, as well as food safety and supply chain management issues. In this respect, it echoes the present study in recognising innovation and environmental practices as key means of ensuring sustainability. However, while M. Alkhafaji offered a strategic vision of global challenges; the present study was more applied, addressing survival in the context of a pandemic, full-scale invasion, and economic instability. Similar differences were observed in comparison with the study by K. Lamm *et al.* (2024). The study outlined the global critical issues of the industry: product safety, staff training, quality management and the introduction of new technologies, especially artificial intelligence-based systems. The current study, on the other hand, emphasised innovative mechanisms for overcoming the crisis conditions of inflation, war damage and logistical difficulties. Both approaches agreed that innovation determined the future of the industry

but differed in scale: the global conceptual level was contrasted with local practical adaptation. Similar logic was evident in the comparison with B. Li *et al.* (2021). Both studies recognised the importance of digital technologies and environmental solutions for the modernisation of the food industry. However, in this case, the emphasis was on the crisis realities of military and economic instability, while B. Li *et al.* addressed long-term strategies: biotechnology, optimisation of global supply chains, and digital systems on a global economic scale. What they had in common was the recognition of the leading role of innovation, but the difference lay in the strategic perspective versus crisis practice.

Another vector is observed in the study by M. Du *et al.* (2025), which examined global trends in sustainable development, changing consumer preferences, and the role of digital platforms in the transformation of business models. This study remained in the crisis realm, focusing on digitalisation and modernisation as tools for maintaining competitiveness in the context of a full-scale invasion. Similarly, Y. Yang *et al.* (2025) emphasised the importance of international cooperation, the green economy, and food security. Similar parallels can be drawn with the study by T. Zhao *et al.* (2024), which analysed the impact of the COVID-19 pandemic on Chinese companies. The main focus was on flexible business models and digital solutions, while this study demonstrated how innovation supported the food industry in the realities of full-scale invasion and economic destabilisation. Both examples emphasised that innovation was the determining factor in the ability of businesses to remain resilient. G. Jingzu *et al.* (2024) addressed the consumer aspect: the quality of information, the convenience of online platforms, and the impact of digitalisation on user satisfaction. In contrast, the Ukrainian study highlighted production and management aspects: ERP, CRM, and TMS systems and artificial intelligence as tools for maintaining business sustainability. Thus, both works recognised the driving force of innovation but viewed it from different consumer and production perspectives. The study by A. García-Sánchez & R. Rama (2025) shifted the focus to the environmental dimension: eco-innovations in the Spanish food and beverage industry and the regulatory factors of their long-term impact. The current study, on the other hand, emphasised digitalisation and entry into new markets as means of survival in wartime. The common factor was the recognition of innovation as a driver of adaptation, but the difference lay in the focus: strategic environmental decisions versus practical crisis response mechanisms. This study and the work of M. Soler-Porta & B. Rodríguez Díaz (2024) aligned in conclusion that innovation was key to business resilience during the crisis. M. Soler-Porta & B. Rodríguez Díaz analysed family-owned companies in the Spanish jewellery sector during the COVID-19 pandemic, showing that even conservative businesses overcame the effects of the crisis thanks to innovation. In contrast, this study analysed the food industry in Ukraine during wartime, where innovation

ensured not only financial stability but also food security, logistics adaptation and entry into new markets.

A comparison with the study by L. Collado *et al.* (2024) showed a shared vision of innovation as the basis for sustainability in the food industry. However, the emphases were different: L. Collado *et al.* addressed innovation through the lens of local agri-food systems, their dual transformation and social value for communities, while this study analysed enterprises in wartime, focusing on digitalisation, modernisation and bioenergy as means of ensuring food security. This difference in context was even more evident in comparison with the study by K. Łukiewska (2024). Both studies viewed crises as catalysts for innovation, but the sources of these crises differed: the pandemic and regulatory changes in the EU in the case of K. Łukiewska were contrasted with war-related destruction and economic instability in Ukraine. Therefore, while the European study emphasised long-term sustainability, the Ukrainian study showed mechanisms for short-term survival.

A similar dialogue between strategic and crisis approaches was also evident in the study by T. Menichini *et al.* (2024). Both works recognised the importance of digitalisation, environmental orientation and business model adaptation as a way to counter challenges. However, T. Menichini *et al.* highlighted organisational flexibility and risk management in a global context, while this study demonstrated how the same principles were applied in much harsher military conditions, with the destruction of production facilities and disruptions in logistics. A similar division was observed when comparing this study with I. Benedetti *et al.* (2024). Innovation and digitalisation were seen as prerequisites for maintaining competitiveness, but the context was different. I. Benedetti *et al.* emphasised strategic environmental innovations and regulatory requirements in Europe, while this study showed how companies adapted to resource shortages and infrastructure destruction. Similarly, in the study by F. Orazi & F. Sofritti (2024), innovation was interpreted as the basis for sustainability, but again on different scales. European authors focused on strategic innovation management and digital transformation in long-term business models, while the Ukrainian study revealed their role in overcoming the consequences of a full-scale invasion daily: logistical barriers, lack of funding, and destroyed production facilities.

M. Ambrosini (2024) proposed a different view of the situation. While this study focused on financial and technological aspects and the modernisation of production, M. Ambrosini analysed the social mechanisms of the Italian agri-food sector, in particular its dependence on migrant labour and forms of "subordinate integration". What remained common was that in both cases, the adaptation was heterogeneous: Ukrainian enterprises implemented innovations in different ways, while Italian regions demonstrated different models of migrant integration. However, while in Ukraine the adaptation was expressed through innovative solutions, in Italy it was expressed through social forms of labour organisation. The present study and the work of

P. Aerni (2025) shared a similar assessment of innovation as a key factor in the sustainability of agricultural and food systems but differed in context. Both emphasised that the crisis stimulated modernisation and digital transformation. This study addressed military risks, rising costs, logistical difficulties, and the adaptation of Ukrainian enterprises through digitalisation and new management approaches. P. Aerni analysed the global perspective, emphasising the role of institutions and international cooperation in overcoming inequality and ensuring food security. There was a common recognition of the multifactorial nature of innovation processes and their importance for competitiveness, but this study was applied in nature and showed the local experience of Ukraine, while P. Aerni offered a global vision of the transformation of food systems.

The present study and the work of M. Fazle Rabbi & M. Bin Amin (2024) converged in their assessment of innovation as a key factor in the resilience of agricultural and food systems. Both emphasised that crises stimulated new technologies and management decisions. This study highlighted the risks of war, the destruction of capacity, and the need for digitalisation of Ukrainian enterprises, while M. Fazle Rabbi & M. Bin Amin focused on climate threats, resource scarcity, and the social vulnerability of farmers in developing countries. The common feature was the recognition of the multifactorial nature of innovation, but this study was applied in nature, while M. Fazle Rabbi & M. Bin Amin proposed a conceptual model of inclusive innovation. A similar difference in scale was observed in the study by Y. Yuan *et al.* (2025). This study analysed innovation as a global mechanism for ensuring efficiency and food security, using systemic models to predict long-term effects. In contrast, the current study demonstrated how the same technologies became a means of survival in specific crisis conditions of full-scale invasion, infrastructure destruction and logistical barriers. Thus, global systemic approaches were contrasted with practical solutions at the local level.

A. Silva *et al.* (2024) emphasised the circular economy and environmental standards in Southern Europe. There, innovation was viewed as an element of sustainability that ensured environmentally balanced production. In contrast, this study interpreted innovation as a means of overcoming military challenges and financial instability. As a result, the environmentally-oriented conceptual approach in A. Silva *et al.* was contrasted with the crisis-driven practical Ukrainian context, but in both cases, the role of innovation as a driving factor in increasing competitiveness was confirmed. C. Richartz *et al.* (2025) studied the impact of the pandemic on consumer preferences in Germany. The study noted an increase in demand for local and sustainable products, while this study showed how war risks and inflation stimulated the modernisation of production and the digitalisation of enterprises. Thus, the crisis changed both consumer behaviour and producer strategies, although the focus was different: consumer practices versus production and financial decisions. Another aspect of

the global dimension of the food crisis was highlighted by T. Nakamura *et al.* (2024). The study discussed the response of German society and state institutions to the pandemic, full-scale war in Ukraine, and extreme weather conditions. The significance of socio-economic support measures, including tax breaks and food banks, was emphasised. The same study recorded the production and technological mechanisms of adaptation of enterprises: modernisation, digitalisation and innovation. In both cases, a common logic was observed: global crises forced the search for new adaptation mechanisms, but the focus shifted from social support to technological solutions.

A comparison of different approaches showed that innovation was recognised as a universal factor in increasing competitiveness and ensuring food security, but how it was applied was determined by context. Global studies emphasised long-term models of sustainable development, environmental standards and international cooperation. In applied research, digitalisation, modernisation of production, adaptation of logistics and overcoming resource shortages in crisis conditions was substantial. Thus, innovation was not only a means of strategic development but also a tool for survival, ensuring the sustainability of the food industry at various levels, from local to global.

Conclusions

The study established that Ukraine's food industry developed amid profound crisis challenges in 2020-2024 but was able to demonstrate adaptability and innovation. Statistical data showed uneven dynamics: the volume of products sold increased from UAH 480 billion in 2020 to a peak of UAH 708.27 billion in 2022, after which it decreased to UAH 633 billion in 2023 and UAH 522 billion in 2024. Despite these fluctuations, the production index rose to 106.8% in 2023 and to 115.9% in the first half of 2024, demonstrating the ability of enterprises to quickly restore production capacity. The structure of production also changed: the share of meat and meat products increased to 20.5% in 2023, and sugar production increased eightfold

in 2015-2023, confirming the transformation of the market under the influence of price and consumer factors.

Exports remained a key component: in 2023, the value of exports of finished food products exceeded USD 3.27 billion, and in 2024, it exceeded USD 4 billion. At the same time, 76% of producers faced interruptions in the supply of raw materials in 2022, and 21% faced energy supply problems, which increased production costs. Despite this, a gradual recovery took place in 2023-2024 thanks to modernisation, digitalisation and the search for new markets. An example of this was the activity of MHP: export revenue in 2024 amounted to USD 1.7 billion, investments in digitalisation amounted to USD 27 million, and financial results changed from a loss of USD 269 million in 2022 to a profit of USD 122 million in 2023 and USD 141 million in 2024. Total capital investment in the food industry in 2024 reached UAH 33.4 billion (91.1% more than in 2023), of which 70.9% was directed towards equipment upgrades.

In addition, the development of the Biogas Ladyzhyn (over 12 MW) and Oril-Leader (5.5 MW) biogas complexes within the MHP structure and the complex in Hlobino (Astarta) with a capacity of about 12 MW confirmed the integration of renewable energy. Overall, innovation has become the main mechanism for adapting the industry, reducing costs, improving quality, export potential, and ensuring competitiveness even in times of instability. The prospect for future research is to extend the analysis to a longer period, including an assessment of the impact of green technologies and digitalisation on the sustainability of Ukraine's food industry.

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Conflict of Interest

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Особливості інноваційного розвитку підприємств харчової галузі в кризових умовах в Україні

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Анотація. Метою даного дослідження було виявлення ключових тенденцій та особливостей впровадження інноваційних рішень у підприємствах харчової промисловості України під час економічної та соціальної нестабільності. Методологія ґрунтувалася на використанні статистичного та економіко-статистичного аналізу для оцінки обсягів виробництва, індексу динаміки й фінансових результатів, контент-аналізу наукових публікацій, а також кейс-стаді компанії МХП. Результати засвідчили, що у 2020 році обсяг реалізованої харчової продукції становив 480 млрд грн, у 2022 році зріс до 708,27 млрд грн, у 2023 році знизився до 633 млрд грн, а у 2024 році – до 522 млрд грн. Індекс виробництва коливався: у 2022 році він знизився до 78,4 %, однак у 2023 році відновився до 106,8 % і у першій половині 2024 року досяг 115,9 %. Експорт готових харчових продуктів у 2023 році перевищив 3,27 млрд доларів США, а у 2024 році – понад 4 млрд доларів США. Фінансові результати МХП відображали коливання: після збитку у 269 млн доларів США у 2022 році компанія отримала чистий прибуток 122 млн доларів США у 2023 році та 141 млн доларів США у 2024 році. Загальні капітальні інвестиції у харчову промисловість у 2024 році склали 33,4 млрд грн, що на 91,1 % більше, ніж у 2023 році, з яких 70,9% припадало на модернізацію обладнання. Також впровадження біогазових комплексів (МХП – понад 12 МВт, «Астарта» – близько 12 МВт) і сонячних електростанцій свідчило про поширення відновлюваної енергетики у виробництві. Практичне значення дослідження полягає у можливості використання його результатів для розробки стратегій модернізації, цифровізації та енергоефективності, що забезпечували стійкість і конкурентоспроможність підприємств харчової промисловості України в умовах кризових викликів

Ключові слова: трансформації; адаптація; промисловість; ефективність; цифровізація; конкурентоспроможність; виробництво
