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Risk management in green logistics within the organic food retail sector using the Ishikawa diagram method

Abstract. Green logistics plays a key role in the sustainable development of the organic food retail sector by reducing the environmental impact of transport and warehousing operations. The study aimed to analyse the principal risks in green logistics and to develop mitigation measures using the Ishikawa diagram method. The article examined the share of organic food products in total retail sales, per capita consumption levels in the global market, the contribution of different countries to organic product sales, and identified the ten leading countries in terms of per capita consumption of organic goods. Between 2018 and 2021, the global share of organic products increased from 1.7% to 2.0%, but declined to 1.9% in 2022-2023. In Ukraine, the share remained at 0.1% before falling to 0.0% in 2022-2023. Particular attention was given to analysing trends in the export of Ukrainian organic products, as well as the dynamics of domestic sales, including breakdowns by product category. In Ukraine's domestic market, sales increased from 21 million USD to 33 million USD, but fell to 17 million USD in 2022. The main risks identified in the field of green logistics include supply instability, high costs associated with environmentally friendly transport, regulatory constraints, and shifting consumer priorities. The most significant challenges relate to a shortage of certified suppliers, low levels of digitalisation in logistics processes, and difficulties in packaging disposal. The proposed measures for optimising green logistics include the implementation of advanced IT solutions, the use of alternative modes of transport, the development of local supply networks, and improved management of reverse logistics. The practical value of the study lies in offering recommendations for retail operators aimed at reducing environmental risks, enhancing the efficiency of logistics processes, and supporting the growth of the organic products market

Keywords: fishbone diagram; environmental logistics; retail sales; risk-based approach; sustainable development

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INTRODUCTION

Contemporary environmental challenges such as global warming, environmental pollution, and the depletion of natural resources necessitate a transformation of business processes towards sustainable development. Within the organic food retail sector, the concept of green logistics plays a pivotal role. It aims to minimise negative environmental impact by optimising the transportation, storage, and packaging of products. At the same time, effective risk management in this area has become critically important for businesses, as it ensures supply chain stability, compliance with environmental standards, and increased consumer trust.

An analysis conducted by O. Nikolaichuk & H. Lavronenko (2023) demonstrated that sustainable trade development is a promising approach to achieving sustainability goals. The advancement of sustainable trade is inextricably linked with the transformation of logistics processes, as these directly influence the efficiency of goods delivery and their environmental impact. Research by M.M. Mamchyn & V.V. Naida (2025) indicated that the retail sector, while playing a key role in providing the population with everyday goods, also exerts a considerable environmental impact. This negative impact is evident across all stages of the product life cycle – beginning with production processes that generate greenhouse gas emissions and consume natural resources, continuing through logistics, packaging, storage, and sales, and concluding with disposal, where a significant proportion of products or packaging ends up in landfills. Thus, retail activity generates a complex environmental footprint, necessitating a reassessment and the adoption of sustainable approaches to the management of goods flows. In this context, researchers R. Hrinchenko & O. Gorlova (2024) emphasised in their study that the integration of environmentally friendly practices into logistics processes enhances operational efficiency, reduces costs, and supports the long-term resilience of businesses amid growing environmental pressures. As noted by V. Skupeiko *et al.* (2022), the more active adoption of green logistics methods in business operations can improve the overall efficiency of logistics processes while significantly reducing their harmful impact on the environment. Specifically, the implementation of environmentally focused solutions in transportation, storage, packaging, and distribution contributes to lower pollutant emissions, more efficient use of energy and material resources, and better environmental performance overall. In addition to the ecological benefits, green logistics aligns more closely with the expectations of modern consumers, who increasingly favour companies that demonstrate transparency and responsibility in their business practices. In the long term, this will also help conserve natural resources and support the development of sustainable supply chains. Y. Salo (2023) argued in her study that green logistics is currently both relevant and in demand in Ukraine and abroad. Considering the potential outcomes of implementing environmentally oriented logistics technologies – including the efficient and rational use of company resources, improved environmental safety, reduced ecological harm, and staff training in environmental matters – it can be concluded that the transition to green logistics is an objective necessity of the present stage. According to the research conducted by N. Hryniv & V. Andrukhiv (2023), many enterprises are offering environmentally friendly market mechanisms, high-tech "green" solutions, and promoting the development of supply chains that do not harm the environment. However, these processes continue to be hindered by the insufficient financial resources available to businesses. As noted by N. Kalycheva & Y. Chuguyev (2024), one of the key drivers of effective green logistics development is the formulation and implementation of targeted policies at national and regional levels. This assertion is supported by a systematic analysis of European Union initiatives, particularly the implementation of the European Green Deal, whose primary aim is to achieve climate neutrality by 2050 through a substantial reduction in greenhouse gas emissions in the transport sector. The study provides a detailed characterisation of public policy instruments, which include both fiscal mechanisms (such as taxes, excise duties, and entry fees for eco-zones) and incentive-based measures (such as financial support for enterprises, the

development of environmental infrastructure, and standardisation and certification initiatives). The importance of international coordination of these measures is also emphasised, as addressing environmental issues at the national level cannot be fully effective without a global revision of logistics supply chains. Therefore, coordinated state policy serves as the foundation for greening logistics processes, implementing innovative technologies, and enhancing the competitiveness of retail enterprises during the transition to sustainable development.

This study aimed to analyse the risks associated with green logistics in the organic food retail sector using the Ishikawa diagram method, and, based on this analysis, to develop recommendations for their mitigation. The research objectives were to examine the dynamics of retail trade of organic food development at both global and Ukrainian levels; to analyse the principles of green logistics within the organic food retail sector; and to justify the methodological and practical approaches to applying the Ishikawa diagram for risk management in this field.

MATERIALS AND METHODS

The study covered the period from 2018 to 2023 and included an analysis of data from the following global regions: Africa, Asia, Europe, Latin America, North America, and Oceania. Statistical data were drawn from open sources, including the national portal OrganicInfo (n.d.) and the annual analytical report The World of Organic Agriculture (FiBL, n.d.), published by the FiBL Institute. At the time of writing, complete or verified data for 2024 had not yet been released by these sources, due to typical delays in official statistical reporting. In light of this, the most recent available data for 2023 were used for the analysis, as they remain representative for assessing the current state of the research subject. The selected sources are leading authorities in monitoring the organic product market and ensuring a high degree of information reliability. The use of these data enabled the formulation of relevant conclusions and reflected the dynamics of key trends while taking into account the specific characteristics of the sector. Additional insights into global organic product consumption (including in Ukraine) were obtained using data from Statista (n.d.). The core of the research is based on sources specialising in the organic product market: Overview of the Ukrainian organic market (2018; 2019; 2020), The world of organic agriculture... (2021; 2022; 2024; 2025), which provide verified and thematically relevant data. Particular attention was given to countries in the European region (Switzerland, Denmark, Austria, Luxembourg, Sweden, Germany, France, Belgium, Norway, and Liechtenstein), due to Ukraine's geographical proximity and the close economic, political, and sociocultural ties that exist between European nations. This focus allowed for a more in-depth examination of the regional context relevant to the national economy and the formulation of practical recommendations. Methods based on absolute and relative values were used to analyse changes in the retail trade of organic food products in Ukraine in comparison with global indicators. The study examined the following indicators: the share of organic food in total retail sales; the monetary value of retail trade in organic food; per capita consumption of organic food products; the share of global sales by country; the export of Ukrainian organic products; and domestic sales volumes by product category. The analysis of these indicators was essential for a comprehensive study of the dynamics of the organic food market, the identification of development trends, and the development of recommendations for managing green logistics risks within the organic food retail sector.

Time series analysis was used as the methodological approach, enabling the identification of market development trends based on data collected between 2018 and 2023. This method involved analysing changes in the volume of organic food sales, per capita consumption of organic food, the share of global sales by country, the export of Ukrainian organic products, and domestic sales volumes by product category. This approach made it possible to identify both cyclical and trend components. The Ishikawa diagram (also known as the fishbone diagram) was used for a systematic analysis of green logistics risks in the organic food retail sector. This method enabled the identification of key factors affecting the efficiency of logistics processes and

establishes cause-and-effect relationships between them. The study identified six main risk categories: human factors, methods, materials, equipment, environment, and financial factors. The use of the Ishikawa diagram allowed not only for the systematisation of risks but also for the development of strategies to mitigate them, thereby enhancing logistics efficiency and reducing environmental impact.

The development of an economic-mathematical model for managing green logistics risks in the organic food retail sector enabled the quantitative assessment of logistics efficiency and the optimisation of costs in accordance with environmental requirements. The proposed model takes into account key parameters, including costs related to eco-friendly transport, storage, and packaging; CO_2 emissions levels; the probability of product spoilage; demand; transport distance; and storage time. The formalisation of the optimisation problem was based on minimising total costs while adhering to environmental constraints, allowing for the identification of effective risk management strategies. The bibliographic method used in this study on green logistics risk management in the organic food retail sector involved the systematisation and analysis of academic sources, along with an examination of statistical data and market trends. Through logical generalisation, specific facts and observations served as a basis for formulating broader theoretical and practical conclusions that can be applied to other contexts and wider categories.

RESULTS AND DISCUSSION

The use of green logistics in the organic food retail sector represents a key direction in sustainable development, integrating environmental, economic, and social dimensions. Route optimisation, the reduction of greenhouse gas emissions, the use of eco-friendly packaging, and the adoption of energyefficient technologies all contribute to reducing negative environmental impact. At the same time, the quality and safety of organic products are supported through environmentally sound methods of storage and transportation. Implementing green logistics strengthens a company's reputation, increases consumer trust, and creates competitive advantages in the market. Moreover, adherence to environmental standards and regulatory requirements helps businesses adapt to legislative changes and facilitates entry into international markets (Andrusenko & Prutska, 2025). Although the introduction of green initiatives may require substantial initial investment, in the long term, they contribute to cost optimisation and improved logistics efficiency. Therefore, green logistics is an essential component of business operations for companies engaged in the sale of organic food products, as it ensures a balance between economic efficiency, environmental responsibility, and consumer expectations.

Retail trade in food products is an important indicator of a society's socio-economic condition. Its dynamics reflect the population's standard of living, influence the formation of tax revenues, and demonstrate broader economic development trends. One segment of this market that is gaining increasing significance is the retail trade of organic food products. Growing interest in healthy eating, rising levels of environmental awareness among consumers, and support for sustainable agriculture are all contributing to the growing demand for organic produce. Moreover, the development of this segment reflects shifts in consumer preferences, indicating a societal move towards higher quality and safer food, while also encouraging the emergence of new business models in the agri-food industry.

The organic products market experienced unprecedented growth between 2018 and 2023. Consumers' reasons for choosing organic products include health benefits, taste, environmental friendliness, safety, and support for local farming (Ashaolu & Ashaolu, 2020). In a study by K.R. Shenoy *et al.* (2024) on the drivers of organic consumption, it was noted that the impact of the pandemic on mental health, emotional stability, and overall mood may have influenced dietary choices and consumption habits. Thus, the rise in the popularity of organic products during 2018-2023 is attributed to increased consumer concern about health, the environment, and food safety. Figure 1 illustrates the share of organic food products in retail sales over the period 2018-2023

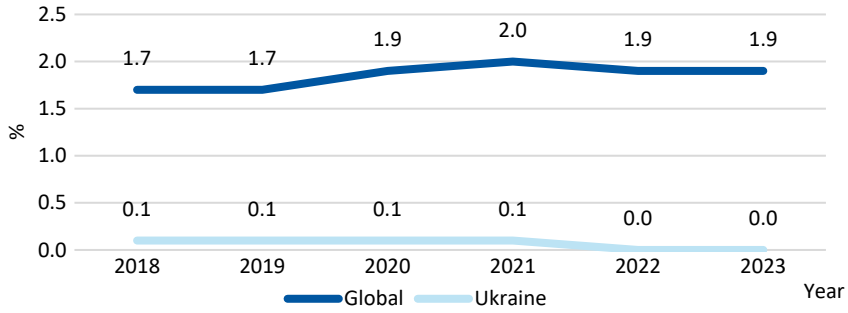

Figure 1. Share of organic food products in retail sales, %
Source: developed by the authors based on data from Food – Worldwide (consumer) (n.d.) and Food – Ukraine (consumer) (n.d.)

Global trends indicate a gradual expansion of the organic food market. In particular, the share of organic products remained stable at 1.7% during 2018-2019, before rising to 1.9% in 2020 and 2.0% in 2021. A slight decline followed, with the figure settling at 1.9% in both 2022 and 2023. This may suggest a stabilisation of demand or reflect the influence of external factors, such as economic fluctuations and shifts in consumer preferences. In contrast, the situation in Ukraine reveals significantly lower figures compared to global trends. Between 2018 and 2021, the share of organic products in retail sales remained at 0.1%, but dropped to 0.0% in 2022 and remained at that level in 2023. The most significant factor behind this decline was the ongoing Russian-Ukrainian war, which led to the disruption of supply chains, reduced production of organic goods, and a reallocation of household spending towards essential items. Other contributing factors included economic hardship, decreased purchasing power, and challenges with organic product certification under martial law. The analysed data highlight clear differences in the development of the organic food market at global and national levels. While the global organic segment continues to show a tendency for gradual growth, Ukraine's market has declined, primarily as a result of the war's impact.

A reliability and sensitivity analysis conducted by R. Daraboina *et al.* (2024) revealed the existence of a multi-segment organic food market. Consumer segmentation based on pairwise comparison results and subsequent cluster validation enabled the identification of three distinct segments: health-oriented, quality-oriented, and value-oriented consumers. The authors concluded that the highest likelihood of switching from organic to conventional products was observed among value-oriented consumers. Table 1 presents the dynamics of organic food retail sales across different global regions between 2019 and 2023, along with changes in per capita consumption.

Table 1. Retail sales and per capita consumption in the global organic market

Region	Year					Absolute change 2023 vs 2019	Relative change 2023 vs 2019, %
	2019	2020	2021	2022	2023		
Retail sales, million EUR							
Africa**	17.0	16.0	n/a	n/a	n/a	–	–
Asia	10,949	12,540	13,747	15,032	15,471	4,522	41
Europe	45,049	52,000	54,539	53,070	54,749	9,700	22
Latin America*	810	778	778	778	778	–32	–4
North America	48,201	53,717	53,901	64,366	63,920	15,719	33
Oceania	1,378	1,594	1,866	1,510	1,510	132	10
Total	106,404	120,647	124,845	134,760	136,430	30,026	28

Table 1, Continued

Region	Year					Absolute change 2023 vs 2019	Relative change 2023 vs 2019, %
	2019	2020	2021	2022	2023		
Per capita consumption, EUR							
Africa**	0.01	0.01	n/a	n/a	n/a	–	–
Asia	2.4	2.7	3.0	3.3	3.3	1	38
Europe	55.8	63.2	65.7	64.0	66.0	10	18
Latin America*	1.5	1.2	1.2	n/a	n/a	–	–
North America	132.3	147.5	143.7	171.5	167.0	35	26
Oceania	33.5	38.4	41.9	33.9	33.9	0	1
Total	14.0	15.8	15.7	n/a	17.0	3	21

Note: *Data for Latin America include only Belize, Brazil, Chile, Jamaica, Mexico, and Peru, **Data for Africa include only Ethiopia and Kenya, n/a - not applicable, "-" - no data available
Source: developed by the authors based on The world of organic agriculture… (2021; 2022; 2024; 2025)

The analysis of retail sales confirms the data presented in Figure 1 regarding the overall growth of the global organic food market. In 2019, the total volume of retail sales stood at 106.4 billion EUR, rising to 136.4 billion EUR in 2023 – an absolute increase of 30.0 billion EUR and a relative growth of 28%. The largest contributions to this overall increase came from North America (15.7 billion EUR, +33%) and Europe (9.7 billion EUR, +22%). Asia also experienced notable growth of 4.5 billion EUR (+41%), indicating the rapid development of this market segment. In contrast, Latin America recorded a decline in sales by 32 million EUR (–4%), possibly due to economic difficulties and shifting consumer priorities. The market in Oceania (Australia and New Zealand) remained relatively stable, showing a moderate increase of 10%. Data for Africa for the period 2021-2023 are unavailable, which limits the ability to analyse regional trends in that market. Per capita consumption of organic products also showed a general upward trend. The global average rose from 14.0 EUR in 2019 to 17.0 EUR in 2023, reflecting an increase of 21%. The highest levels of consumption were traditionally recorded in North America, where per capita spending increased from 132.3 EUR in 2019 to 167.0 EUR in 2023 – a 26% rise. In Europe, per capita consumption increased by 18%, reaching 66.0 EUR in 2023. The Asian market also showed dynamic growth – from 2.4 EUR in 2019 to 3.3 EUR in 2023 (+38%). In Oceania, consumption levels remained nearly unchanged, fluctuating between 33.5 EUR and 33.9 EUR. Data for Latin America and Africa are incomplete, making it difficult to conduct a comprehensive analysis of developments in those regions. The results indicate a gradual expansion of the organic food market, with the most notable growth seen in North America, Europe, and Asia. At the same time, certain regions show negative trends or suffer from a lack of reliable data.

Europe holds the second-largest share of organic agricultural land globally, surpassed only by Oceania. Despite the rapid growth in sales, organic production has yet to keep pace with demand: in most European countries, organic farmland accounts for less than 15% of total agricultural land. Liechtenstein has the highest share of organic land in Europe – over 43%. The total area of organic agriculture continues to grow and has already reached 18.5 million hectares (Organic food market in Europe…, 2024).

Figure 2 illustrates changes in the share of individual countries in global organic food sales over the period 2019-2023. The USA remains the market leader, with its share fluctuating between 39% and 43%. After a dip to 39% in 2021, the US share rose to 43% in 2022-2023, indicating a recovery of the country's position in the organic market. Germany has maintained a stable presence, with its share increasing from 11% in 2019 to 13% in 2021. However, it declined to 11% in 2022, before recovering slightly to 12% in 2023. A similar trend is observed in France, where the share gradually declined from 11% in 2019 to 9% in 2022-2023, remaining unchanged in the final two years. Thus, the highest

retail sales of organic food products in Europe are recorded in Germany (15.4 billion EUR) and France (12 billion EUR). In terms of the highest share of organic products in total retail food sales, Denmark, Austria, and Switzerland lead the way. Since 2013, the United Kingdom has seen significant growth in the retail organic food market, which is projected to reach 1.3 billion GBP in 2024 (Organic Food Market in Europe..., 2024). China maintained a market share of 8%-9% throughout the study period, indicating steady development of its organic sector. Canada also showed stable performance, with a slight increase from 3% in 2019 to 4% in 2020, after which the share remained unchanged. The combined share of all other countries gradually declined from 25% in 2019 to 23% in 2022-2023, suggesting a growing concentration of the organic market within the world's leading economies. Overall, the analysis indicates that the key players in the global organic food market continue to be the USA, Germany, China, France, and Canada, while other countries are gradually losing ground in global sales.

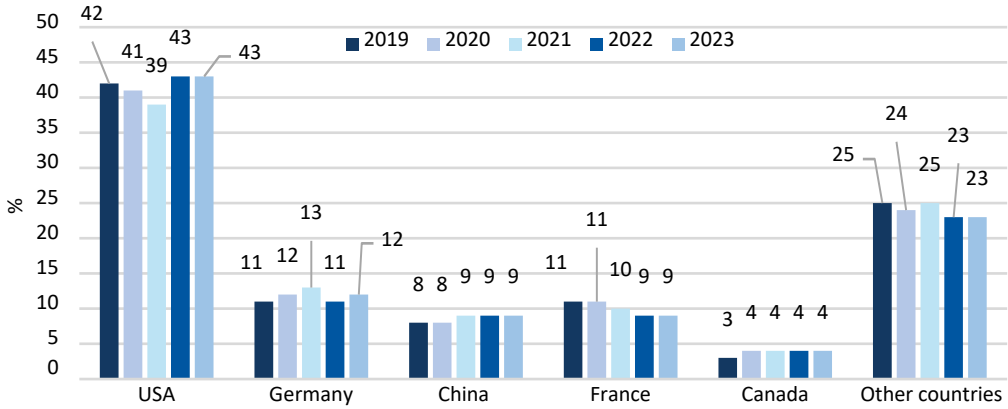

Figure 2. Global market share of organic food sales by country, %
Source: developed by the authors based on The world of organic agriculture... (2021; 2022; 2024; 2025)

Despite Germany having the largest organic food market, the data in Table 2 show that the highest levels of per capita consumption are observed in Switzerland and Denmark. The average organic food expenditure across the EU is approximately 102 EUR per person (Organic Food Market in Europe..., 2024). Switzerland remains the clear leader, recording an absolute increase of 130 EUR or 38% in 2023 compared to 2019. Denmark, which had the highest per capita spending in 2019 (344 EUR), experienced slight fluctuations, with consumption reaching 362 EUR in 2023 – an increase of just 18 EUR or 5%. Austria demonstrates steady growth, with an increase of 76 EUR (35%), indicating a strengthening trend toward organic food consumption. Germany also showed notable growth – 47 EUR or 33% – while France's figures remained almost unchanged (+2 EUR, +1%), suggesting a stable organic food market. The USA and Canada show relatively high growth rates – 26% and 32% respectively – reflecting increasing interest in organic products across North America. In contrast, Luxembourg experienced a decline in per capita consumption by 37 EUR (–14%), while Sweden saw only a marginal increase of 5 EUR (2%). The data for Belgium, Norway, and Liechtenstein are incomplete, as these countries have alternately appeared in and dropped out of the top ten rankings over the years, making it difficult to assess their market dynamics. Overall, countries with traditionally high levels of organic food consumption – such as Switzerland, Denmark, and Austria – continue to lead the market, while some others show inconsistent trends. These fluctuations may be attributed to economic factors, changes in policy support for the organic sector, and the general purchasing power of the population.

Table 2. Countries with the highest per capita consumption of organic products (Top 10), EUR

Country	Year					Absolute change 2023 vs 2019	Relative change 2023 vs 2019, %
	2019	2020	2021	2022	2023		
Switzerland	338	418	425	437	468	130	38
Denmark	344	384	384	365	362	18	5
Austria	216	254	268	274	292	76	35
Luxembourg	265	265	313	259	228	–37	–14
Sweden	215	212	266	248	220	5	2
Germany	144	180	191	181	191	47	33
France	174	188	187	176	176	2	1
USA	136	148	146	176	172	36	26
Canada	93	112	130	147	123	30	32
Belgium	–	–	–	–	101	–	–
Norway	83	83	–	85	–	–	–
Liechtenstein	–	–	230	–	–	–	–

Note: "-" - no data available
Source: developed by the authors based on The world of organic agriculture... (2021; 2022; 2024; 2025)

The main reasons why European consumers choose organic products include concerns for health and a desire to avoid pesticides and chemical sprays. At the same time, many are unwilling to accept high prices. In 2023, most respondents in the EU reported that food prices had become more important to them over the previous 12 months. This may explain why consumers in many European countries plan to reduce their purchases of organic products. If prices are not adjusted, this trend may persist (Organic Food Market in Europe..., 2024). Ukraine is an important supplier of organic products to the global market, with 99% of its exports in 2023 directed to Europe, demonstrating significant potential in this sector. However, in recent years, there has been a dynamic fluctuation in export volumes, which may be attributed to both internal and external factors (Organic Sales 2016-2023..., n.d.). Figure 3 illustrates the trends in the export of Ukrainian organic products over the period 2018-2023.

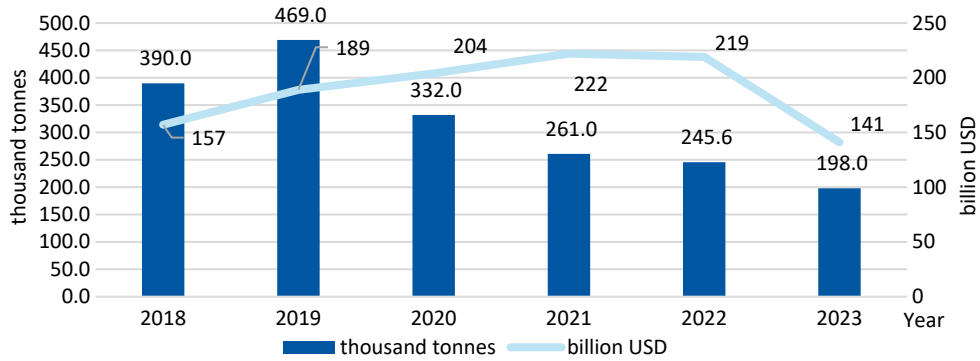

Figure 3. Trends in Ukrainian organic exports
Source: developed by the authors based on Organic sales 2016-2023...(n.d.)

Throughout the analysed period, fluctuations in export volumes are evident in both monetary and physical terms. In 2018, the volume of organic exports stood at 390 thousand tonnes, generating 157 billion USD in revenue. The following year saw an increase in exports to 469 thousand tonnes (+20.3% compared to 2018) and a corresponding rise in revenue to 189 billion USD (+20.4%). The peak in export revenue occurred in 2021, reaching 222 billion USD,

despite a continued decline in the physical volume of exports, which fell to 261 thousand tonnes. This suggests a rise in the average export price or a shift in the export structure towards products with higher added value. From 2022 onwards, export indicators began to show a downward trend. In 2022, the volume of exports amounted to 245.6 thousand tonnes (–5.9% compared to 2021), while revenue fell to 219 billion USD. The most notable decline occurred in 2023, with export volumes dropping to 198 thousand tonnes and revenue falling to 141 billion USD – the lowest figures recorded during the analysed period.

A number of factors contributed to the decline in exports in 2022-2023. Military operations and the blockade of logistical routes significantly hindered the export of food products in general, and organic goods in particular. There may also have been reduced interest in purchasing Ukrainian organic products due to increased competition from other countries or shifts in importers' trade priorities. Currency fluctuations, inflation, and the general economic downturn may have affected the competitiveness of Ukrainian products on global markets. Additionally, reductions in sown areas, shortages of fertilisers and other resources also played a role (Overview of the Ukrainian Organic Market, 2018).

Research conducted by O.P. Karpii & N.R. Struk (2021) indicated that the main consumers of organic products in Ukraine are individuals with medium to high incomes who are informed about the benefits of organic produce. These include young people under the age of 30 and adults aged 45-60 who are concerned about their health and aim to lead a healthy lifestyle. Demand for organic products in Ukraine depends largely on consumer purchasing power, public awareness of the advantages of organic production, and the broader macroeconomic context. Between 2018 and 2023, the domestic organic market showed uneven dynamics (Fig. 4).

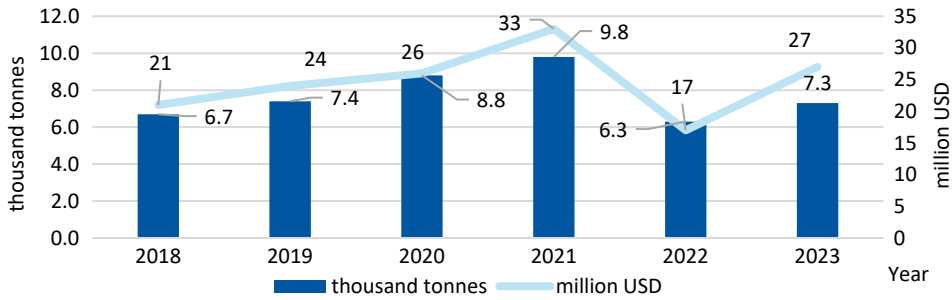

Figure 4. Sales dynamics of organic products on the domestic market
Source: developed by the authors based on Organic sales 2018-2023...(n.d.)

Figure 4 shows that in 2018, total sales amounted to 21 million USD, with 6.7 thousand tonnes of organic products sold. In subsequent years, growing demand led to increased sales volumes: in 2019, 7.4 thousand tonnes were sold (+10.4% compared to 2018), and in 2020 – 8.8 thousand tonnes (+18.9%). The peak was reached in 2021, with sales totalling 33 million USD and 9.8 thousand tonnes. After steady growth from 2018 to 2021, a significant decline was observed in 2022. Sales volume fell to 6.3 thousand tonnes (–35.7% compared to 2021), and total revenue decreased by 48.5%, dropping to 17 million USD. The main reasons for this sharp decline were: disruptions in supply chains due to the Russian-Ukrainian war; a reduction in consumers' purchasing power owing to macroeconomic challenges and inflation; and a decrease in supply caused by the contraction of organic production as a result of the ongoing war (Overview of the Ukrainian Organic Market, 2018). In 2023, partial recovery of the market was observed – sales increased to 27 million USD (+58.8% compared to 2022), while physical volumes rose to 7.3 thousand tonnes (+15.9%). This recovery can be attributed to the market's adaptation to new economic conditions and rising prices for organic products, which explains the considerable

increase in monetary sales despite only a modest rise in physical volumes.

The conducted study provides grounds to assert that the analysis of the dynamics of Ukraine's domestic organic market between 2018 and 2023 reveals a cyclical development pattern: a period of growth (2018-2021) was followed by a sharp decline in 2022, with partial market recovery beginning in 2023. An examination of the dynamics of both exports and domestic consumption of organic products in Ukraine indicates a predominant orientation towards external markets. Export volumes significantly exceed domestic consumption, which can be attributed both to high international demand for Ukrainian organic products and to the limited purchasing power of the domestic population. Despite fluctuations in export deliveries, there is a noticeable trend of increasing foreign currency revenue during periods of reduced physical export volumes. This may suggest a shift in export structure in favour of higher value-added products. Meanwhile, the domestic market shows uneven performance, largely influenced by the macroeconomic situation, consumer awareness, and the availability of organic products (Organic Sales 2018-2023..., n.d.). Overall, given the scale of exports, it can be concluded that Ukraine plays a significant role in the global organic market. Further development of this segment requires not only continued support from external markets but also stimulation of domestic demand. Table 3 presents the dynamics of domestic sales of organic products by product category.

Table 3. Dynamics of organic product sales in the domestic market by product category, million UAH

Product	Year						Absolute change 2023 vs 2018	Relative change 2023 vs 2018, %
	2018	2019	2020	2021	2022	2023		
Dairy products	345	320	420	550	370	438	93	27
Ice cream****	85	15	9	n/a	n/a	n/a	–	–
Vegetables, fruit, mushrooms**	20	35	25	53	83	259	239	1,195
Groats, cereals, flour, seeds, snacks	80	115	125	122	71	99	19	24
Eggs	n/a	n/a	25	35	24	36	–	–
Juices, beverages, pastes, canned products***	6	15	10	61	27	42	36	600
Assorted oils	n/a	n/a	15	9	4	22	–	–
Meat products	30	30	40	45	35	42	12	40
Other products*	17	35	20	15	9	43	26	153
Spices, sugar	7	10	20	10	4	1	–6	–86
Total	590	575	709	900	623	982	392	66

Note: *Other products include bakery items, dumplings/meat dumplings, sweets (chocolate, candies, fruit leather), honey, tea, and coffee,**Mushrooms were not included in 2018, ***Canned products were not included in 2018, ****Ice cream was listed as a separate category from 2018 to 2020, n/a - not applicable, "-" - no data available
Source: developed by the authors based on the Overview of the Ukrainian organic market (2018; 2019; 2020), Domestic organic market in Ukraine (2021; 2022; 2023)

An assessment of individual product categories (Table 3) reveals several important trends: the most significant growth in sales was observed in the Vegetables, Fruit, Mushrooms category, which in 2023 showed a 1,195% increase compared to 2018. This surge may be attributed to heightened demand for fresh organic produce, an expanded product range on the domestic market, and the development of local farming. Juices, beverages, pastes, and canned products also demonstrated substantial growth (+600% from 2018), indicating increased consumer interest in longer-shelf-life goods. This trend may reflect shifting consumption habits linked to the effects of the RussianUkrainian war. Dairy products have remained a stable segment, with a 27% increase in 2023 compared to 2018. This points to sustained

demand and the ongoing development of domestic production. Meat products showed relatively moderate growth (+40%), which may be due to steady demand combined with limited supply caused by high production costs. Groats, cereals, flour, seeds, and snacks also saw growth of 24% compared to 2018, indicating continued consumer interest in these products. A marked decline was recorded in the Spices, Sugar category, with an 86% drop in 2023 compared to 2018. This may be linked to reduced supply or falling demand for organic spices, possibly due to their relatively high price. The Ice Cream and Assorted Oils categories lack sufficient data for a full analysis.

The development of the domestic organic food market in Ukraine between 2018 and 2023 was shaped by a range of economic, social and environmental factors. These included: increasing public awareness of organic products and their health benefits; macroeconomic instability and changes in purchasing power caused by the Russian-Ukrainian war, which led to a decline in sales; localisation of production and a shift in consumer preferences towards local organic products; and the development of sales channels, including online platforms and farmers' cooperatives. It is important to emphasise that e-commerce plays a crucial role in the retail trade of organic food, as it provides new channels for the sale and distribution of products, thereby enhancing their accessibility to consumers (Ilchuk *et al.*, 2023).

Despite the challenges, the positive trends observed in 2022-2023 highlight the potential for further development of the organic food trade in Ukraine. However, realising this potential will require a focus on improving the efficiency of logistics processes, particularly in the context of green logistics. Given that organic products require specific conditions for transportation, storage and distribution, it is essential to develop mechanisms for minimising risks related to supply instability, logistics costs and environmental requirements. Green logistics, as a concept, aims to reduce environmental impact and ensure efficient resource management within supply chains. However, implementing these principles in the retail trade of organic food products involves a range of risks that demand detailed analysis and effective management. Figure 5 presents a block diagram illustrating the main stages of risk management using the Ishikawa diagram method.

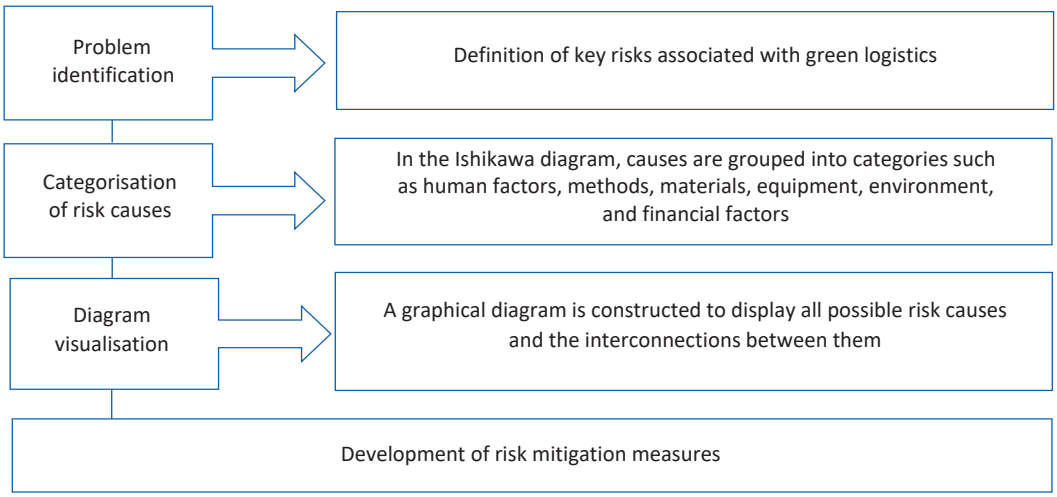

Figure 5. Key stages of risk management using the Ishikawa diagram method
Source: developed by the authors based on their own research

Figure 5 presents a step-by-step process for managing risks in the trade of organic products through green logistics. This includes: defining the problem, identifying key

risks, categorising these risks by type (e.g. human factors, methods, materials, finances, etc.), visualising their interrelationships using the Ishikawa diagram, and developing mitigation measures. At the first stage shown in Figure 5, the key risks associated with green logistics in the organic food trade were identified and are presented in Table 4.

Table 4. Key risks of green logistics in the retail trade of organic food products in Ukraine

Risk category	Type of risk	Risk description
Economic risk	High production costs	The introduction of eco-friendly transport, energy-efficient warehouses and waste reduction technologies requires substantial financial investment
	Exchange rate fluctuations	Most green solutions (e.g. electric vehicles, refrigeration equipment for organic goods) are imported, making their costs susceptible to currency volatility
	Lack of financial incentives	There are no government subsidies or tax benefits for businesses implementing green logistics principles
Logistical risk	Lack of environmentally friendly transport	The limited availability of electric lorries and low-emission vehicles complicates the transportation of organic products in line with green logistics principles
	Underdeveloped infrastructure	There is a lack of specialised green warehouses equipped with energyefficient systems and waste-sorting facilities
	Challenges in maintaining product quality	Organic products have a short shelf life and require specific transport conditions (e.g. temperature and humidity control), creating additional risks of product loss
	Supply chain disruptions	Ongoing military operations, market instability in the transport sector, and rising fuel costs are making logistics processes increasingly unpredictable
Environmental risks	Environmental pollution	Inefficient logistics lead to the spoilage of organic products, resulting in higher volumes of food waste
	High CO_2 emissions	The majority of suppliers rely on conventional transport, which does not meet environmental standards
	Shortage of certified eco-friendly packaging	Sustainable packaging (e.g. biodegradable bags, reusable containers) remains more expensive and less widely available on the market
Technological risks	Lack of digitalisation	Supply chain management systems are underutilised, despite their potential to optimise transport routes and reduce fuel consumption
	Limited access to green technologies	The high cost of energy-efficient equipment, solar panels for warehouses, and other innovative solutions hinders their widespread adoption
Social and regulatory risks	Low consumer awareness	A lack of clear understanding about the benefits of green logistics and its impact on the quality of organic goods reduces consumer demand for such products
	Insufficient government support	There is an absence of targeted programmes for the development of green logistics and a lack of direct incentives for businesses to adopt environmentally friendly solutions
	Shortage of qualified personnel	There is a lack of professionals in the field of green logistics with expertise in sustainable supply chain management

Source: developed by the authors

The next stage in conducting a systematic risk analysis of green logistics involves the use of the Ishikawa diagram method (also known as a "fishbone diagram"). This approach enables the structured identification of key factors affecting the efficiency of logistics processes in the retail trade of organic food products, facilitates assessment of their impact, and supports the development of mitigation strategies. The primary areas selected for analysis include: human factors, methods, materials, equipment, environment, and financial factors (Fig. 6).

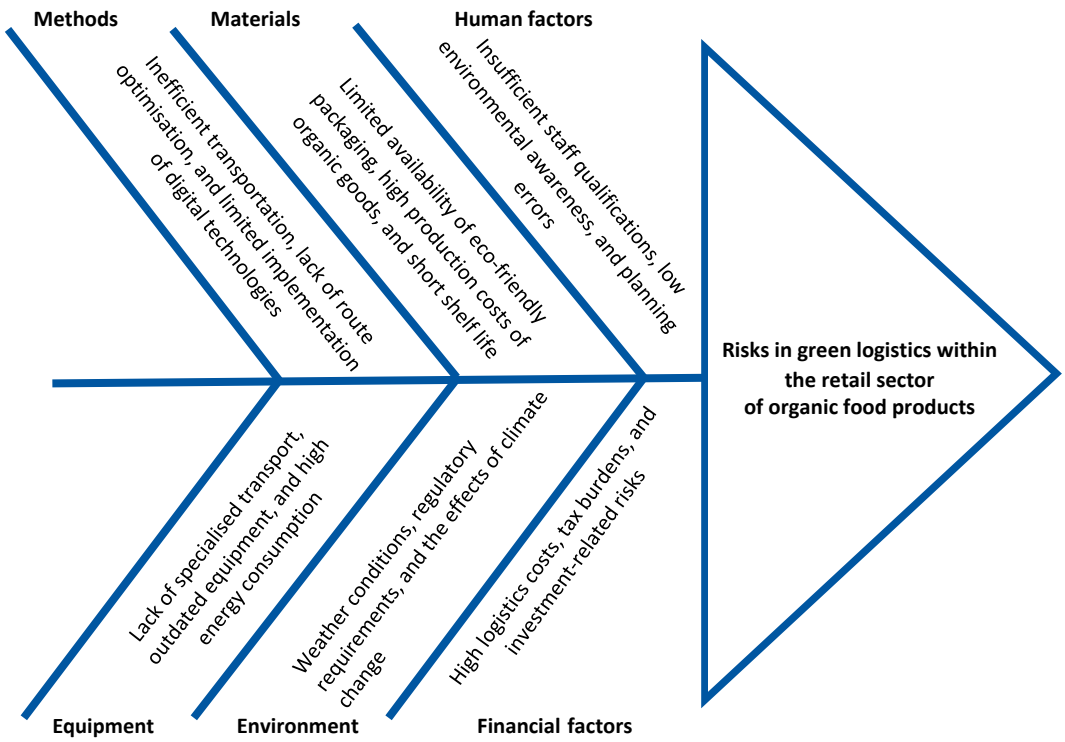

Figure 6. Categorisation of risk factors in green logistics for the retail trade of organic food products using the Ishikawa diagram method

Source: developed by the authors based on their own research

The results of the green logistics risk analysis, conducted using the Ishikawa diagram, enable a systematic identification of the key factors affecting the efficiency of logistics processes. For further research and informed managerial decision-making, it is necessary to develop an economicmathematical model that will allow for a quantitative assessment of logistics efficiency and cost optimisation in line with environmental requirements. Green logistics in the retail trade of organic food products involves the implementation of environmentally sound solutions aimed at reducing environmental impact. One of the core aspects of management is the minimisation of costs while simultaneously reducing environmental risks. Based on the conducted research, an economicmathematical model has been proposed, which takes into account the risks associated with transportation, storage, packaging, and environmental impact.

The green logistics risk management system in the retail sector of organic food products is considered in terms of the following key model parameters: C_{tr} – cost of eco-friendly transport (UAH/km), which includes expenses related to the use of energy-efficient or electric vehicles that comply with modern environmental standards; C_{st} – storage costs for organic products (UAH/day), referring to expenses for maintaining required conditions (temperature, humidity) in warehouse facilities to preserve product quality; C_{pack} – cost of eco-friendly packaging (UAH/unit), covering the use of biodegradable or recyclable materials for packaging organic goods; E_{CO_2} – level of CO_2 emissions per kilometre of transportation (kg/km). It accounts for the environmental burden of transporting goods; P_{damage} – probability of product spoilage. This estimates potential product losses resulting from breaches of storage or transport conditions; D – demand (units of product). This defines the volume of goods that must be delivered to retail outlets; L – transport distance (km). The total distance that must be covered to supply the

products; S – average storage time (days). The duration for which products remain in storage prior to sale. The optimisation problem involves minimising total logistics costs while accounting for risks, and is formalised through the following objective function:

$$F(C_{tr}, C_{st}, C_{pack}) = C_{tr}L + C_{st}S + \\ + C_{pack}D + E_{CO_2}L10 + P_{damage}C_{pack}D, \quad (1)$$

where $C_{tr}L$ is the total eco-friendly transport costs, including expenditure on fuel or electricity and vehicle depreciation. These are determined by the cost of transportation per unit distance and the total distance covered; $C_{st}S$ is the storage costs, ensuring proper conditions are maintained. These are calculated based on the cost per unit of time or volume and the overall storage period or quantity; $C_{pack}D$ is the cost of eco-friendly packaging for all units of product, based on the packaging cost per unit and the total quantity of goods; $E_{CO_2}L10$ environmental costs, which include penalties for CO_2 emissions during transportation. Here, E_{CO_2} is the CO_2 emission per unit of distance, and the multiplier 10 converts emissions into financial or environmental costs; $P_{damage}C_{pack}D$ is the losses due to product spoilage, determined by the probability of damage and the packaging cost per unit of product. The model incorporates minimum environmental standards (model constraints):

$$C_{tr} \geq 400, C_{st} \geq 150, C_{pack} \geq 100. \quad (2)$$

These constraints specify the following: $C_{tr} \geq 400$ UAH/km – minimum expenditure on eco-friendly transport, ensuring compliance with energy efficiency standards. These transport costs are derived from the average cost of transportation using electric or energy-efficient vehicles, including the cost of electricity or biofuel, maintenance, and depreciation. $C_{st} \geq 150$ UAH/day – minimum storage costs required to maintain suitable conditions for organic products. These costs account for maintaining the appropriate microclimate (cooling, humidity control), based on rental tariffs for environmentally certified warehouses. $C_{pack} \geq 100$ UAH/unit – minimum expenditure on eco-friendly packaging, ensuring product safety and compliance with environmental requirements. These costs are based on the prices of biodegradable or recyclable materials commonly used in the industry (e.g. kraft paper bags, cardboard packaging, bioplastics).

Model optimisation makes it possible to determine the optimal cost values that minimise total expenditure while meeting environmental standards. The developed model demonstrates that the implementation of energy-efficient transport, digitalisation of logistics processes, use of sustainable packaging, and route optimisation contribute to cost reduction and mitigation of negative environmental impacts. Applying this model enables evidence-based decision-making in the development of green logistics in the retail trade of organic food products. The proposed economic and mathematical model for managing green logistics risks allows for: determining optimal logistics costs; assessing the influence of environmental factors; and making informed decisions to mitigate risks. The modelling results indicate that effective risk management in green logistics requires a comprehensive approach, encompassing not only cost optimisation but also infrastructural, technological and regulatory reforms. In light of the identified risks, the development of green logistics in the retail trade of organic food products in Ukraine must take into account the author's proposed approaches presented in Table 5.

Table 5. Directions for improving green logistics in the retail trade of organic products in Ukraine

No.	Direction	Brief description / specific measures
1	Expansion of government support	Effective implementation of green logistics requires a supportive regulatory environment. Government assistance through tax incentives, subsidies, and grants would enhance the investment appeal of eco-friendly transport solutions, energyefficient warehouses, and innovative packaging. In addition, mechanisms should be developed to compensate enterprises for the costs of implementing CO_2 emission reduction technologies and recycling eco-friendly packaging

Table 5, Continued

No.	Direction	Brief description / specific measures
2	Development of modern logistics infrastructure	The advancement of green logistics requires the creation of specialised infrastructure, in particular, environmentally oriented logistics centres that comply with energy efficiency principles and sustainable development goals. This involves the construction of warehouses with climate-controlled systems for organic products, the adoption of renewable energy sources such as solar panels and energy recovery systems, as well as increasing the number of low-emission transport vehicles
3	Optimisation of transport routes	The use of digital technologies for supply chain management enhances the efficiency of logistics processes and reduces the environmental footprint. The implementation of transport management systems, geoanalytics, and artificial intelligence makes it possible to minimise fuel consumption by reducing transport distances, limiting vehicle idle time, and optimising cargo space utilisation
4	Attracting investment in environmental technologies	Investment in technological innovation is a key factor in improving the efficiency of green logistics. This includes the introduction of energy-efficient refrigeration units, automated waste-sorting systems, biodegradable packaging, and hydrogen-or electric-powered vehicles. To support this, favourable conditions must be created for both private and international investment in environmental logistics through public-private partnerships and international financial programmes
5	Development of professional education and workforce training	The effective operation of green logistics is not possible without the training of qualified specialists in the field. It is essential to expand educational programmes in logistics to include courses covering the principles of green logistics, emissions management, digitalisation of transport processes, and environmental product certification. A key area of focus is the organisation of practical training and internships for business representatives in the field of sustainable logistics development

Source: developed by the authors based on their own research

Risk management in green logistics is a key factor in ensuring the sustainable development of the organic food market in Ukraine. The proposed measures aim to reduce logistics costs, improve the efficiency of supply chain management, and minimise the negative environmental impact. Implementing these strategic initiatives will contribute to the creation of an environmentally responsible and economically efficient logistics system that meets modern sustainability standards.

According to recent research, despite the challenges posed by the Russian-Ukrainian war, there has been a positive trend in the growth of organic food sales in Ukraine since 2023. This is supported by studies conducted by O. Yatsenko *et al.* (2024) and O. Shpykuliak *et al.* (2024), who stated that the organic market in Ukraine is an actively developing segment of the agricultural sector, reflecting global trends towards healthy lifestyles and sustainable development. In recent years, there has been a steady increase in the production and export of organic products. However, given the current situation in the country, the impact of military conflict and security threats continues to pose serious challenges to the further development of the organic market.

E. Pakhucha & K. Sukhomlynova (2023) argued that Ukraine's organic sector is predominantly export-oriented, with 80%-90% of organic products sold abroad. This is consistent with the findings of this study, which confirm that export volumes significantly exceed domestic consumption. This imbalance is driven both by strong international demand for Ukrainian organic products and by the limited purchasing power of the domestic population. The findings of the study by S. Petrovskyi & I. Horodniak (2025) indicate that the purchasing power of a significant proportion of consumers remains limited, and their willingness to pay a considerably higher price for organic products is low. Most respondents considered it acceptable for the price of organic goods to exceed that of conventional products by no more than 10%. Interest in organic food is most commonly expressed by those who follow a healthy lifestyle; however, financial circumstances remain the decisive factor in purchasing decisions. Effective communication with the target audience should

focus on messages that emphasise care for children and family, alongside clear information about the nature, benefits, and health-enhancing effects of organic products.

Ukraine is a key supplier of organic products to the global market and continues to demonstrate considerable potential in this sector. This is supported by the research of O. Khaietska & D. Udalov (2024), which highlighted that, despite the decline in production and export volumes due to the war, Ukrainian producers are continuing to find ways to supply both domestic and international markets with high-quality organic goods. Ukraine maintains its position among the leading exporters of organic produce to Europe, underlining the significant potential and competitiveness of the Ukrainian agricultural sector on the international stage.

As organic products require specific conditions for transportation, storage and distribution, it is essential to establish effective mechanisms to mitigate risks associated with supply chain instability, logistical costs and compliance with environmental standards. M. Liu *et al.* (2023) confirm that nearly all aspects of food supply – namely, production, storage, processing, distribution, retail and consumption – are susceptible to environmental fluctuations and shock events. These can cause disruptions that cascade through the food supply chain, ultimately affecting geographically distant regions and populations. A common theme in the research is the need to implement digital solutions for the early detection and localisation of risks. F.K. Tetteh *et al.* (2024) asserted that green logistics had become a key strategy in achieving net-zero emissions within supply chains, particularly through the use of alternative fuels, route optimisation, and the reduction of empty mileage. The present study also highlights the potential of green logistics to reduce both carbon footprints and overall costs. P. Trivellas *et al.* (2020) highlighted the need to implement a green supply chain management strategy, which is closely linked to transparent information exchange between partners at all stages – from farm to fork – an integrated logistics network, route optimisation, standardised transport, more environmentally friendly intermodal freight systems, and the adoption of information technologies. This, in turn, enhances operational efficiency and ensures business resilience in a turbulent environment. This view is supported by G. Tian *et al.* (2023), who argued that in light of escalating environmental concerns, low-carbon development has become an inevitable choice. The development of low-carbon sustainability is influenced by a range of factors, including social, environmental, technological, and economic development levels, making the process complex and presenting challenges for decision-making. Both the referenced and present studies acknowledge the multifactorial nature of the low-carbon transition and emphasise the importance of technological investment. The present research contributes to the existing body of knowledge on risk management in green logistics within the retail trade of organic food products. It integrates cost optimisation with the implementation of infrastructural, technological, and regulatory changes.

CONCLUSIONS

The conducted study indicates a growing global demand for organic products, particularly in North America, Europe, and Asia. This trend is driven by increasing consumer interest in health, environmental sustainability, and food safety. At the same time, national markets – especially in Ukraine – are experiencing negative impacts from the war, which has led to a reduced share of organic products in retail sales. Between 2018 and 2021, the global share of organic products in retail increased from 1.7% to 2.0%, but declined to 1.9% in 2022-2023. In Ukraine, the share remained at 0.1% before falling to 0.0% in 2022-2023. Globally, retail sales of organic goods rose from 106.4 billion EUR in 2019 to 136.4 billion EUR in 2023 (+28%), while per capita consumption grew from 14 EUR to 17 EUR (+21%). However, market development dynamics vary across regions. The highest demand remains in developed countries such as the USA, Germany, Switzerland, and Denmark. Conversely, certain nations – including some in Latin America and Africa – are experiencing a decline in sales volumes, largely due to economic challenges and shifting consumer priorities. Taking these factors into account, it can be concluded that the

global organic products market continues to expand, although this growth is uneven and dependent on regional conditions.

Ukrainian exports of organic goods experienced a decline in physical volume, falling from 469 thousand tonnes in 2019 to 261 thousand tonnes in 2021. However, revenue in foreign currency increased, reaching 222 million USD. In the domestic Ukrainian market, sales rose from 6.7 thousand tonnes in 2018 to 9.8 thousand tonnes in 2021, with turnover increasing from 21 million USD to 33 million USD. Nevertheless, in 2022, these figures dropped to 6.3 thousand tonnes and 17 million USD, respectively. Overall, market trends indicate a cyclical pattern, with a peak in 2021, a downturn in 2022, and partial recovery in 2023. In particular, 2023 saw a rebound in domestic sales, made possible by adaptation to new economic realities and shifts in consumer behaviour. However, for the continued development of the organic products market in Ukraine, it is essential to support both the growth of external demand and domestic consumption by improving product accessibility and raising public awareness.

The analysis of green logistics risks in the retail trade of organic food products in Ukraine has made it possible to identify key factors affecting the efficiency of logistics processes and provides a basis for formulating strategies to minimise these risks. The use of the Ishikawa diagram method facilitated a systematic examination of the underlying causes of risks, including economic, logistical, environmental, technological, and social factors. The developed risk categories help assess the interrelations between these factors and identify the most critical areas requiring managerial intervention. In particular, attention should be focused on the development of infrastructure to support green technologies, the implementation of environmentally friendly transport and energy-efficient warehouses, as well as the enhancement of workforce qualifications and the promotion of green logistics among consumers. Future scientific research should explore the actual health benefits of organic products for consumers, along with their environmental and social advantages compared to conventional goods.

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CONFLICT OF INTEREST

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Управління ризиками зеленої логістики у сфері роздрібної торгівлі органічними харчовими товарами з використанням методу діаграми Ісікави

Анотація. Зелена логістика відіграє ключову роль у сталому розвитку роздрібної торгівлі органічними харчовими товарами, сприяючи мінімізації екологічного впливу транспортних і складських операцій. Метою дослідження був аналіз основних ризиків у сфері зеленої логістики та розробка заходів з їх мінімізації за допомогою методу діаграми Ісікави. У статті досліджено частку органічних харчових товарів у загальному обсязі роздрібних продажів, рівень споживання на душу населення на глобальному ринку, частку різних держав у продажах органічних продуктів, а також визначено десять країн-лідерів за споживанням органічних товарів на душу населення. У 2018-2021 рр. світова частка органічних продуктів зросла з 1,7 % до 2,0 %, а потім у 2022-2023 рр. знизилася до 1,9 %, в Україні ж вона залишалась на рівні 0,1 %, але у 2022-2023 рр. впала до 0,0 %. Особливу увагу приділено аналізу тенденцій експорту української органічної продукції, а також динаміці її продажів на внутрішньому ринку, включаючи розподіл за категоріями товарів. На внутрішньому ринку України продажі зросли з 21 до 33 млн дол., однак у 2022 р. впали до 17 млн дол. Визначено, що основними ризиками у сфері зеленої логістики є нестабільність постачань, високі витрати на екологічний транспорт, нормативні обмеження та зміни споживчих пріоритетів. Найбільші виклики пов'язані з дефіцитом сертифікованих постачальників, низьким рівнем цифровізації логістичних процесів та труднощами в утилізації упаковки. Запропоновані заходи щодо оптимізації зеленої логістики включають впровадження сучасних ІТ-рішень, використання альтернативних видів транспорту, розвиток локальних мереж постачання та покращення управління зворотними потоками товарів. Практична цінність дослідження полягає у формуванні рекомендацій для роздрібних операторів щодо зниження екологічних ризиків, підвищення ефективності логістичних процесів і стимулювання зростання ринку органічної продукції

Ключові слова: діаграма "риб'ячої кістки"; екологічна логістика; роздрібні продажі; ризик-орієнтований підхід; сталий розвиток