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BUILDING RESILIENCE IN EUROPEAN FOOD SUPPLY CHAINS: RESULTS OF A DELPHI STUDY

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ABSTRACT: The COVID-19 pandemic and the war in Ukraine have negatively affected the sustainability of the food market and contributed significantly to the increase in agricultural prices. The goal of this article is to present the results of a European Delphi study on enabling factors and barriers to developing robustness within food distribution networks. The paper also aims to identify ways to ensure food security and build resilience in supply chains for European Union (EU) citizens, as well as strategies to protect the agricultural sector. The Delphi theses, the expected timing of their implementation and their impact on selected stages of supply chains were assessed. The paper employs a literature review, the Delphi method and STEEPED analysis to identify factors for increasing the robustness of European food distribution networks. The research findings highlighted crucial factors in enhancing food supply chain resilience, including financial aid to farmers, the use of advanced technologies (like AI, remote sensing, GIS, VR, or drones), and the encouragement of conscious consumption practices. The study revealed that severe weather, inadequate financial support for farmers and insufficient favourable legislation at the national level are the main barriers to achieving resilience in food supply chains. The main recommendations for building food resilience include encouraging localised food supply chains and, advocating for eco-friendly, sustainable production approaches and small-scale agriculture and reducing unnecessary food losses. The originality of the study is reflected in the presentation of the opinions of international experts on developing robustness within food distribution networks in view of the disruption caused by COVID-19 and the geopolitical situation.

KEYWORDS: Delphi method, disrupted supply chains, supply chain resilience, sustainable food market

Introduction

Building resilience in supply chains in Europe is a very complex issue, mainly due to the multiple and interrelated factors affecting these supply chains. These factors include, among others, extreme weather events, climate change, sanitary and veterinary crises, food scandals, technological and innovative consumer preferences and habits, as well as supply delays.

Climate variability and change pose risks to the food supply chain through diverse channels. One such channel involves the potential to intensify foodborne diseases by impacting the occurrence, endurance, virulence, and toxicity of specific categories of pathogenic microorganisms. Various chemical hazards like pesticides, mycotoxins, and heavy metals also threaten food safety. Alterations in weather patterns, such as reduced rainfall, increased air temperature, and a higher occurrence of extreme weather events, contribute to emerging concerns regarding food safety (Duchenne-Mountien & Neetoo, 2021; Maggiore et al., 2020).

Although it might appear that food products and food production in the European Union and in developed countries are safer than ever before, there are several factors contributing to the rapid spread of new diseases and food safety incidents. Over the past two decades, there have been widespread food scandals (dioxin crisis, melamine case, etc.) and food-related concerns (food additives, residues, etc.) (Bánáti, 2011).

The European Union has recently formulated its Common Agricultural Policy framework to highlight a shift towards a 'quality turn' in the food supply chain (European Commission, 2023). This involves transitioning to food production that adheres to standardised quality standards and promotes localised, eco-friendly products based on trust and tradition. This shift may ultimately result in distinct socio-economic consequences at regional and farm levels, diverse environmental implications, and heightened consumer interest (Mattas et al., 2022).

Not without significance for building the resilience of supply chains are also dietary habits. Examining individuals' sustainable practices and perspectives throughout the stages of purchasing, consumption, and waste management provides a thorough understanding of their decision-making criteria, motivations, and preferred incentives (Strambu-Dima, 2022).

The other factors that significantly impact supply chains in Europe are the digitalisation of the food system and transportation policy. The digitisation of the food system stands as a crucial and timely consideration in the shift toward a food system capable of providing universally accessible, affordable, and nutritious food while maintaining sustainability and resilience (Gebresenbet, 2021), whereas transportation policy aiming at reducing supply delays is a critical part of developing a sustainable agri-food supply chain besides the internal process in the agri-food producer (Kresnanto et al., 2021).

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The main aim of this article is to share the findings from a European Delphi study that explored the factors facilitating or hindering the establishment of resilience in food distribution networks. The secondary objective of this paper is to explore ways that guarantee food security and strengthen the supply chains to support European Union citizens, along with measures to safeguard the farming industry.

The European Parliament that commissioned this study was interested in examining the resilience of supply chains in relation to the pandemic and the war in Ukraine (Ejdys et al., 2023).

Therefore, other factors that may influence disruptions in resilience were not taken into account in the presented study.

Both the COVID-19 pandemic and the conflict in Ukraine adversely impacted the sustainable food market by leading to a notable rise in agricultural prices (Shakini et al., 2022). However, in the subject literature, one can also observe different effects of the interaction of these factors on building resilience.

By and large, pandemics have the potential to significantly impact the food supply chains, affecting producers, retailers, wholesalers, and consumers alike (Cardoso et al., 2021; Wronka, 2023). Covid-19 has significantly affected the entire process, spanning from cultivation to consumer access. Given recent challenges in the food supply chain, there is heightened apprehension regarding aspects such as food production, processing, distribution, and consumer demand. The pandemic led to constraints on the movement of workers, shifts in consumer demand, the closure of food production facilities, constrained food trade policies, and financial strains within the food supply chain (Serpil & Mehmet, 2020).

The war in Ukraine, in turn, led to the destruction of farmland and infrastructure and the displacement of farmers, leading to a decline in agricultural production. It has forced many farmers to leave their land and homes, resulting in a shortage of skilled labour in the agricultural sector. This can impact the cultivation, harvesting, and processing of food, further affecting the supply chain. The ongoing conflict generates an atmosphere of unpredictability, posing challenges for businesses to strategise and allocate investments in the agricultural sector. As a result, there is a reduced inclination to invest in essential aspects such as infrastructure, technology, and farming methods (Hossain et al., 2020). This lack of investment directly impacts the effectiveness and resilience of the food supply chains.

In order to reach the objectives of the study, a Delphi study and STEEPED analysis were carried out, involving experts from Europe representing mainly academia, business, NGOs and interest groups. The Delphi method is a consensus-building method around an agreed research methodology (Kononiuk et al., 2021; Kowalewska & Głuszyński, 2009; Nazarko et al., 2015; Flanagan et al., 2016; Mirata et al., 2020; Gnatzy et al., 2011; Tiwari et al., 2020), while STEEPED analysis allows for the analysis of Social, Technological, Economic, Environmen-

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tal, Political and Legal, Ethical and Demographic factors (Kononiuk, 2010; van Woensel, 2020).

The article consists of four sections. The first section presents a literature review on supply chain disruptions and the role of Russia and Ukraine in this regard. The next section demonstrates the research methodology in relation to the Delphi method and STEEPED analysis. The third part presents the results of the research, which allowed the identification of the most important Delphic theses, enabling factors and barriers to their implementation. An assessment of the importance and uncertainty of factors in building resilience in supply chains is also presented. The following sections demonstrate a confrontation of the main results with the literature and depict both limitations and directions for further research.

The results presented in the article are an excerpt from research conducted by the foresight research team from Bialystok University of Technology in 2022/2023 for the European Parliament entitled *A preparedness plan for Europe: Addressing food, energy and technological security* (Ejdys et al., 2023).

An overview of the literature

Supply chain disruptions occur when unforeseen events or situations disrupt the smooth movement of goods, materials, or services within a supply chain network (Shen & Li, 2016). These disruptions can have substantial consequences for businesses, industries, and the global economy. Examples of disruptions include natural disasters (Abe & Ye, 2013), pandemics and health crises (Moosavi et al., 2022), political and trade issues (Blanchard et al., 2016), supplier issues (Parast & Shekarian, 2019) cybersecurity threats (Cheung et al., 2021), economic volatility (Althaf & Babbit, 2021) or labour disruptions (Deconinck et al., 2020). To minimise the effects of these disruptions, companies frequently employ risk management tactics. These may include diversifying their supplier base, keeping sufficient safety stock, formulating backup plans, embracing technology for instantaneous monitoring and visibility, and constructing more resilient and adaptable supply chain networks (Kausar Azam et al., 2023).

The authors' intention was to determine the main factors that promote or hinder the development of open strategic autonomy while also addressing the resilience of supply chains in food security.

Maintaining global food security poses a significant challenge, given the ongoing disparity between production capabilities and actual consumption at the national level. As populations grow and dietary habits change, the pressure on food systems increases. Bridging the gap between production and consumption necessitates innovative and sustainable solutions, including enhanced agricultural productivity, equitable distribution, reduced food waste, and resilient supply chains. Addressing this multifaceted challenge requires global collabora-

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tion among governments, international organisations, the private sector, and local communities to ensure food security for current and future generations (Trucmel & Vintilla, 2023).

Given the challenging geopolitical situation, there is now a pressing need to prioritise the resilience of the food system (Karoliina et al., 2023). This involves ensuring the availability of nutritious and safe food, even in the face of unexpected disruptions in the operational environment. Food systems are increasingly facing disturbances and shocks, and this trend is expected to continue in the future. Concerns about maintaining a consistent food supply have been heightened by recent events like the conflict in Ukraine and the COVID-19 pandemic.

These disruptions have had a significant impact on global supply chains, resulting to a considerable surge in the prices of food and commodities. As a result, the stability of the food market, which has been experiencing notable transformations in recent years, has been threatened, and food safety has been compromised (Din et al., 2022; Rimhanen et al., 2023).

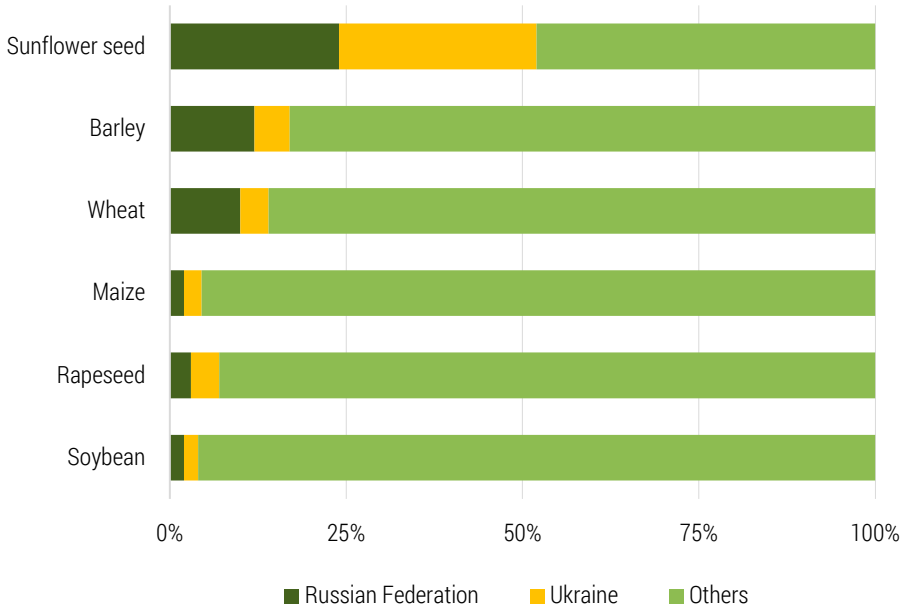

Figure 1. Share in global production of selected crops (2016/17-2020/21 Avg.)
Source: authors' work based on FAO (2022).

Ukraine and Russia hold significant positions as countries that produce and export large quantities of agricultural products like wheat, barley, maise, rapeseed and rapeseed oil, sunflower and sunflower oil (Figure 1). In 2021, they

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ranked among the top 3 worldwide exporters of most of these commodities (FAO, 2022). For example, in the wheat sector between 2013/14 and 2023/24, Ukraine is responsible for 9 % and Russia for 18% of the total global wheat exports (Figure 2) (AMIS, 2023).

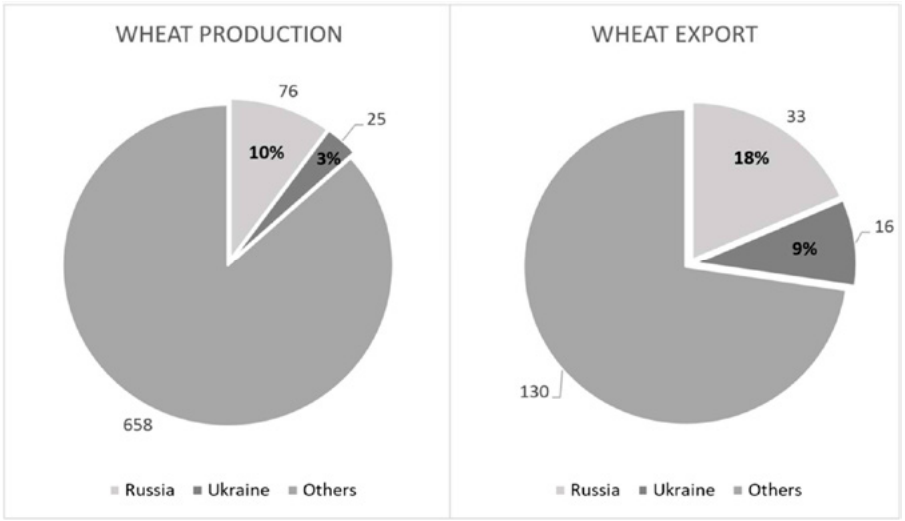

Figure 2. National production and export of wheat in Russia and Ukraine vs world state - (Million tonnes) (2013/14-2023/24 Avg.)

Source: authors' work based on AMIS (2023).

In June 2022, Ukraine found itself grappling with a significant challenge as an estimated 22 to 25 million tonnes of grains remained confined within its borders, emphasising the pivotal role of maritime commercial activity, as pointed out by Abdülkerimov (2022). This predicament underscores the critical interplay between domestic grain storage and the maritime industry, highlighting the broader implications on national and international trade dynamics.

Additionally, Russia leads global nitrogen fertiliser exports, is the 2nd largest potash exporter, and 3rd biggest phosphate exporter (FAO, 2022).

Because global exports of key foodstuffs and fertilisers are concentrated in just a few exporting countries, such as Russia and Ukraine, disruptions in their production and trade are reflected in global markets with shocks and volatility (FAO, 2022). The continuing Russo-Ukrainian conflict has the potential to significantly impact the wheat production and exports of both countries. This is particularly concerning for Ukraine, which during the year 2020 held the distinguished position of being the fifth-largest global exporter of wheat, boasting a total export value of US$4.61 billion for its wheat products (Lin et al., 2023). The country has faced challenges in maintaining its export capacity due to war-re-

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lated restrictions, difficulties in agricultural production caused by military interventions, and the high cost of energy resources and fertilisers. Assuming these war-related disruptions continue, the Food and Agriculture Organization of the United Nations' preliminary forecasts for the 2023/24 season indicate that Ukrainian wheat production could fall by 50% compared to 2021/22 levels to around 10 million tonnes (FAO, 2022).

Furthermore, Russia and Ukraine combined account for over half of the global production of sunflower oil (Ben Hassen & El Bilali, 2022; FAO, 2022). The research findings indicate that the war has also disrupted the supply of organic fertilisers, resulting in reduced agricultural output and contributing to the subsequent increase in the prices of agricultural products. The study suggests that the escalating costs of fertilisers directly impact food production and supply (Shahini et al., 2022). The literature review presented here allowed the development of four Delphic theses, which are the subject of more in-depth analysis presented in the next sections of the article. In this way, the research presented fills a cognitive research gap in terms of enabling factors, barriers to implementation, and the expected timeframe for their realisation in the conditions of the unstable geopolitical situation. The ongoing study also addresses a research gap regarding insufficient knowledge in the area of building resilience in European food supply chains.

Research methods

To reach the research goal, the Delphic studies were employed. The Delphi method involves conducting expert research, where the intuitive opinions of experts are considered valuable inputs for anticipating the future outcomes of the research subject. This technique is employed to predict the evolution of long-term phenomena in situations of uncertainty, especially when (i) traditional forecasting analytical methods are unsuitable for the projected phenomena and (ii) there is a dearth of reliable data concerning the phenomena under study, (iii) external factors exert a significant influence on the projected phenomena (Kononiuk et al., 2021; Kowalewska & Głuszyński, 2009). The main characteristics of this method include a multi-stage procedure, maintaining anonymity, providing feedback, and independence of experts' opinions. The application of the method or its modifications for various research fields is popular in the existing published works (Nazarko et al., 2015; Flanagan et al., 2016; Mirata et al., 2020; Gnatzy et al., 2011; Tiwari et al., 2020) therefore, the authors of the study considered that it would be an appropriate method to evaluating the factors that facilitate and hinder the development of resilience in European food supply chains amid an uncertain and turbulent environment.

The examples of Delphi method for the similar research fields may be found in works by Zickafoose et al. (2022) who applied this method for forecasting food

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innovations or in the paper of Allen et al. (2019) who used the method to develop a new metric system assessing the sustainability of food systems and diets.

The Delphi method requires conducting repeated surveys with the same group of experts. In the traditional approach, the Delphi study begins with formulating the Delphi theses and additional questions. The Delphi thesis refers to describing the relationships between issues in the study's field and a predefined research objective. In simpler terms, it is a research question about the future presented as a thesis (Kononiuk et al., 2021).

The methodology employed for the research comprised five steps (Figure 3).

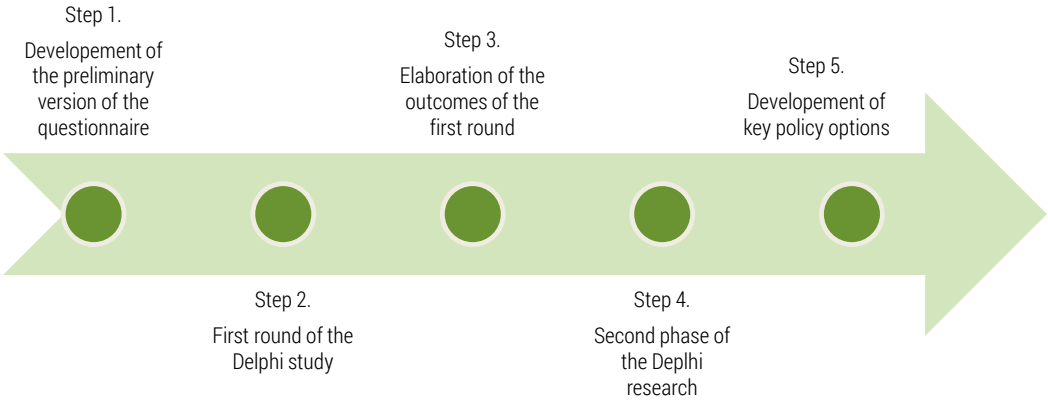

Figure 3. The methodology employed for the research

Source: authors' work based on Ejdys et al. (2023).

The primary phase of the research involved carrying out comprehensive, one-on-one interviews with experts specialising in food security. The aim was to gather expert perspectives on the initial drafts of the Delphi questionnaires, encompassing Delphi theses and factors contributing to or impeding the phenomena within the research domains. Taking into account the results of the literature review and those of individual interviews with three independent experts in the area of food, the preliminary Delphi questionnaires were developed by a research team from the Faculty of Management Engineering at Bialystok University of Technology. The feedback obtained from the individual interviews played a pivotal role in refining the ultimate version of the Delphi questionnaire. For the food domain, four theses were formulated:

- Thesis F_T1: EU countries will achieve self-sufficiency in wheat production without relying on Ukraine and Russia.
- Thesis F_T2: EU countries will emerge as major producers of sunflower oil.

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- Thesis F_T3: In a strategic move to decrease reliance on Russia, European Union countries will channel extra financial investments into NPK fertiliser production.
- Thesis F_T4: There will be a shift in policy, moving away from previous restrictions on agribusiness.

The procedure of choosing the theses entailed analysing statistical data and engaging in expert deliberations concerning the exports of grain and sunflower oil from Russia and Ukraine, as well as the significance of NPK fertilisers in agricultural activities. Furthermore, potential policy changes aimed at reducing food production were also taken into account.

In the second research stage, the initial round of Delphi thesis evaluation was conducted with experts representing various supply chain links in food security. Recruitment prioritised principles such as using publicly available databases, employing the snowballing technique for expert nominations, ensuring diversity, wide participation across the supply chain, and an open recruitment process. The study carried out focused on the 27 countries of the European Union [EU(27)]. The survey was conducted in the period December 2022-January 2023. A total of 153 experts were successfully recruited, each receiving an invitation with research details, survey instructions, a hyperlink, and a token. The experts participating in the survey demonstrated significant diversity in education, age, gender, sector, and nationality. The survey reached a wide range of researchers, with over 20,000 individuals being selected from the Web of Science database using relevant keywords. The keywords were used to identify experts related to the subject matter of the study commissioned by the European Parliament. Keywords were 'food supply chains' or 'resilience of food supply chains' or 'European food supply chains' or 'satellite communication' or 'semiconductors' or 'energy'. The use of the last three keywords in the study was due to the fact that part of the study was also to demonstrate the relationship between the thematic areas adopted in the study.

In the third research stage, the subsequent step of Delphi research took place. Respondents were provided with comprehensive findings obtained during the initial survey phase.

The first and the second round of the Delphi research utilised the CAWI technique, offering benefits like automated data verification, efficient result storage, and the ability to reach dispersed respondent (Couper, 2000). The group of experts who took part in the initial round of the survey received the follow-up questionnaires for the second round, with an invitation expressing gratitude, research details, objectives, instructions, a survey hyperlink, and a token. Certificates of appreciation were also provided. The final round received 117 responses.

The fourth stage of the research involved examining the outcomes derived from the second phase of the Delphi study. This facilitated the opportunity to evaluate the proposed theses in the investigated area. To simplify data analysis, certain questionnaire variables were presented as indicators summarising

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detailed observations. Indicators of significance (Is) were calculated using a specific formula to determine the strategic importance of the theses.

$$I_S = \frac{100n_{VH}+75n_H+50n_A+25n_L+0n_{VL}+0H_S}{n-n_{HS}}. \quad (1)$$

where:

n – is the number of responses: VH – very high, H – high, A – average, L – low, VL – very low, HS – hard to say.

The analyses were presented using a comparative approach. Each of the four theses received exceptional or exceedingly high ratings, as evidenced by the significance indicators. The indicator ranges from 0 to 100, with higher values indicating greater strategic importance assigned to the theses under study (Kononiuk et al., 2021). Likewise, indicators for enablers (IE) and barriers (IB) to thesis execution were determined, facilitating the identification of the most important enablers and barriers.

The fifth stage of the methodology involved leveraging the findings from the survey to develop comprehensive policy options. The objective was to create an ecosystem within the European Union that could effectively address and mitigate disruptions, ultimately enhancing the resilience of the supply chain. These policy options were carefully crafted to encompass a wide range of strategies and measures aimed at bolstering the EU's ability to navigate challenges and uncertainties in various sectors. By considering the diverse perspectives and insights gathered through the survey, the goal was to devise robust policies that would promote collaboration, innovation, and adaptability across the supply chain. The overarching aim was to establish a resilient ecosystem in the EU, capable of withstanding disruptions and fostering sustainable growth and stability in the face of evolving circumstances.

The Delphi method was complemented by STEEPED analysis, which identified factors that could support the resilience of food supply chains in Europe. This method is treated as a checklist of social, technological, economic, environmental, political, legal, ethical, and demographic factors enables a more complex view of the investigated research field (Kononiuk, 2010). It is a strategic analysis framework widely used in strategic management and scenario planning to assess the external factors that can impact organisations and industries.

Results of the research

In the group of the analyses theses, F_T1 showed the highest significance index indicating a potentially high importance of decoupling wheat production in EU countries from Ukraine and Russia. Conversely, F_T4 had the lowest relevance index, suggesting more uncertainties among experts in assessing this thesis. This

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may indicate that taking action to move away from limiting agricultural production is relatively less important compared to the statements presented in other theses (Figure 4).

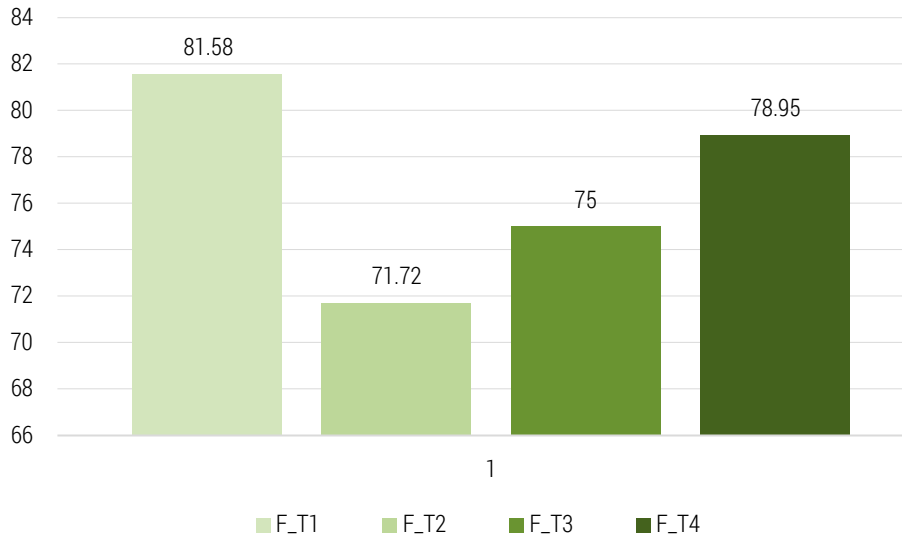

Figure 4. Values for importance indicators in the food area

Source: authors' work based on Ejdys et al. (2023).

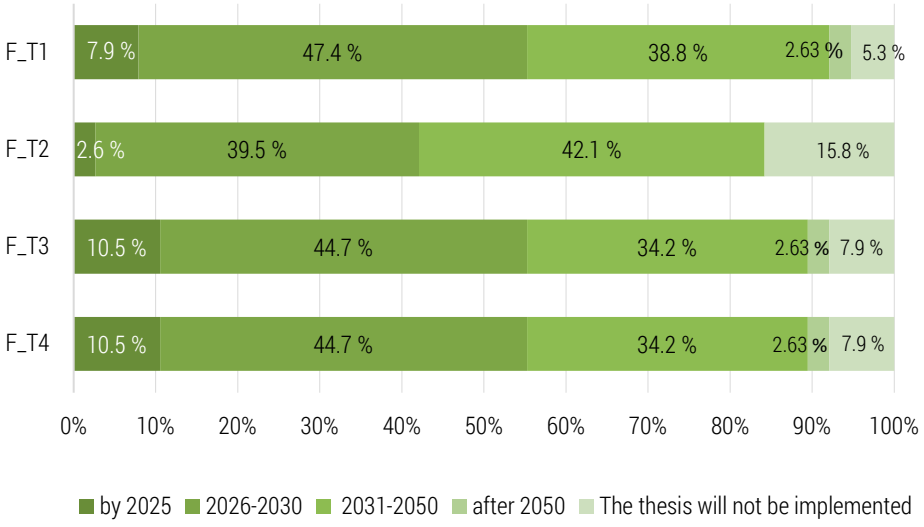

Figure 5. The time framework for the implementation of the theses

Source: authors' work based on Ejdys et al. (2023).

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The majority of experts (over 70%) predict that the theses will be implemented between 2026 and 2030 or 2031 and 2050 (Figure 5). Nonetheless, the outlook for the implementation of F_T3 and F_T4 by the end of 2025 is not very promising, with only 10% of the experts expressing confidence in their actualisation. A smaller proportion of experts (7.9% and 2.6%, respectively) hold the belief that the events outlined in the first and second theses will take place by the year 2025's end. Figure 5 shows that a low percentage of experts (5.3% and 7.9%, respectively) believe that the relationships described in F_T1, F_T3, and F_T4 will never happen, while 15.8% expressed such belief for F_T2.

Figure 6 illustrates the calculation of indicators for each thesis regarding actions that support the implementation of the theses.

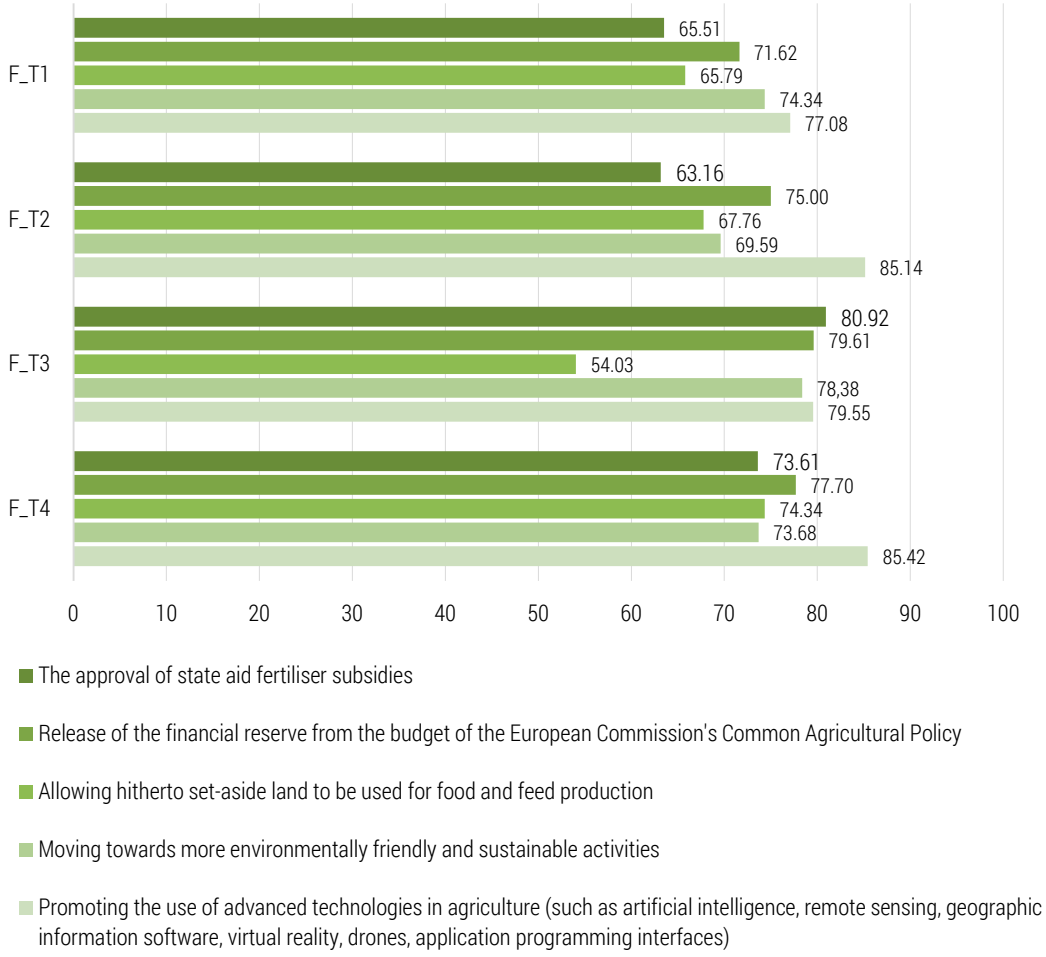

Figure 6. Indicators reflecting the factors supporting the implementation of the theses

Source: authors' work based on Ejdys et al. (2023).

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Across all theses, except F_T3, the promotion of advanced agricultural technologies emerges as the most influential factor facilitating theses implementation. On the other hand, except for F_T3, the importance of approving state aid fertiliser subsidies is relatively low in facilitating the achievement of the theses.

Notably, F_T3 deviates from this trend as the described event assigns high importance to this specific enabling factor. The least significant factor for this thesis pertains to the utilisation of previously unused land for food and feed production, which suggests its limited relevance to the overall theme of the research.

Figure 7 showcases the indicators reflecting obstacles to the execution of the theses.

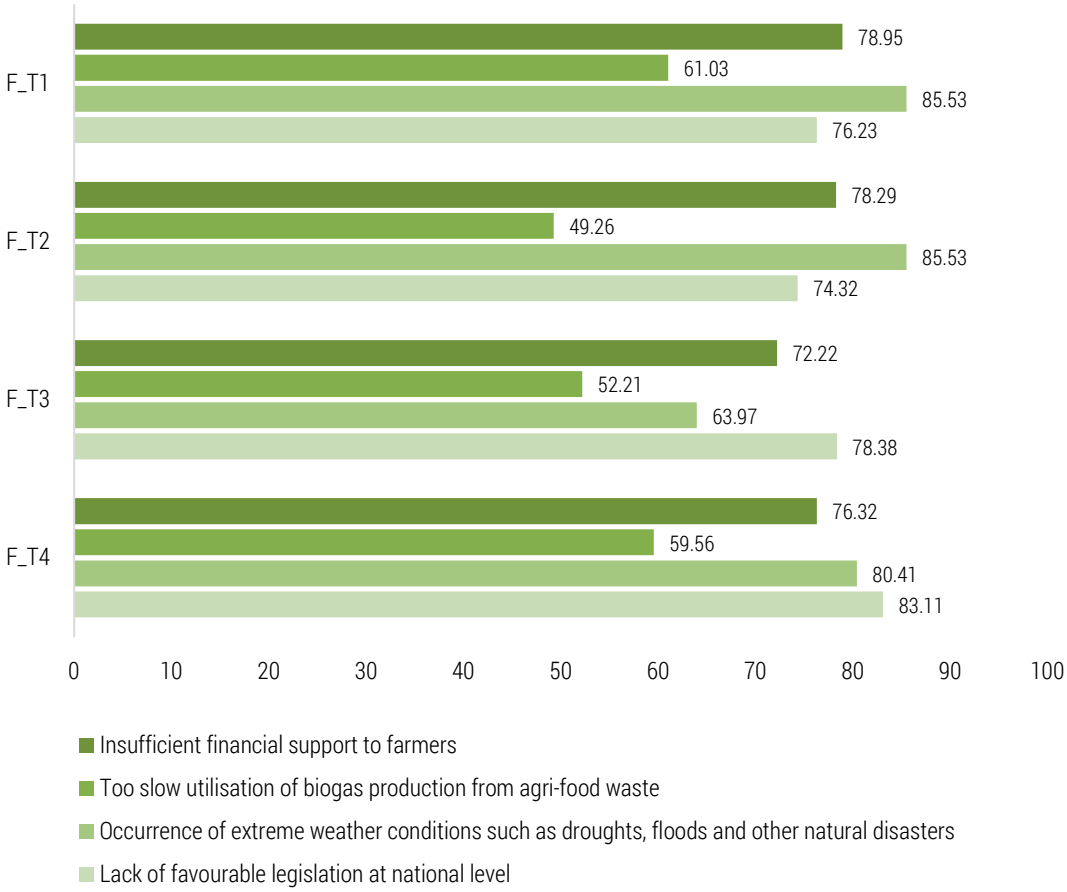

Figure 7. The indicators reflecting the challenges and impediments to the execution of the theses

Source: authors' work based on Ejdys et al. (2023).

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The primary hindrance to the realisation of F_T1 and F_T2 is the occurrence of severe weather conditions, such as droughts, floods, and other natural disasters. This barrier can be categorised as a wild card event (Kononiuk & Nazarko, 2014), with a substantial impact but low likelihood, and its impact on the European Union's political factors is relatively insignificant. Insufficient financial support for farmers is another significant barrier across the individual theses, with a significance index ranging from 72.22 to 78.95. As for F_T3 and F_T4 theses, the lack of favourable legislation at the national level is identified as the major barrier. Regarding the food sector, experts perceived the slow utilisation of biogas production from agri-food as the least significant barrier.

In the further step of the research, the analysis of the assessment of the effects of the theses' statements on the operations of supply chains was conducted. The results are presented in Table 1.

Table 1. Values of indicators of the theses' impact on the functions of supply chains

Theses	Functions of supply chains	Value of the indicators
F_T1	A	69.08
	B	65.13
	C	73.68
	D	**80.26**
F_T2	A	67.76
	B	61.18
	C	70.39
	D	**73.68**
F_T3	A	68.92
	B	61.81
	C	65.13
	D	**70.27**
F_T4	A	71.05
	B	65.54
	C	73.03
	D	73.03

A – Reducing expenses related to product and data transmission while ensuring the customer's preferred service standard upheld; B – Guaranteering rapid order fulfillment; C – Enhancing the dependability, regularity, and adaptability of the supply; D – Strategically managing inventory levels across the entire supply chain to optimize efficiency while customizing it to suit the specific preferences and demands of individual market segments

Source: authors' work based on Ejdys et al. (2023).

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The theses' statements have the highest impact on strategic managing inventory levels across the entire supply chain to optimise efficiency while customising it to suit the specific preferences and demands of individual market segments. Conversely, the statements have the lowest impact on guaranteeing rapid order fulfilment. Enhancing the dependability, regularity, and adaptability of the supply, as well as reducing expenses related to product and data transmission while ensuring the customer's preferred service standard is upheld, reside within the limited scope of influence.

The research also revealed sixteen factors (identified through STEEPED technique) that, according to the researchers, could contribute to building the robustness of European food distribution networks. Specifically, in the food domain, the study identified the following determinants:

- F_01 Dominant dietary patterns and habits,
- F_02 Level of trust in modern technologies within society,
- F_03 Application of advanced technologies in agriculture (e.g., AI, remote sensing, GIS, VR, drones, APIs),
- F_04 Utilization of biogas production from agri-food waste,
- F_05 Approval of government subsidies for fertilisers,
- F_06 Allocation of financial reserve from the budget of the EU's Common Agricultural Policy,
- F_07 Level of financial support provided to farmers,
- F_08 Utilization of set-aside land for food and feed production,
- F_09 Transition towards environmentally friendly and sustainable practices,
- F_10 Occurrence of extreme weather conditions like droughts, floods, and natural catastrophes,
- F_11 Extent of country-specific laws,
- F_12 Quality of legislation pertaining to digital data use in agriculture,
- F_13 Openness to adopting new dietary patterns and habits,
- F_14 Embracing conscious consumerism,
- F_15 Effects of an ageing society,
- F_16 Level of international migration.

The factors presented in the study were subsequently assessed following the methodology posited by (Kononiuk & Nazarko, 2014). The assessment involved rating each factor on a seven-point scale to determine its level of importance (ranging from very low importance at 1 to very high importance at 7) and uncertainty (ranging from very low uncertainty at 1 to very high uncertainty at 7). The ratings for each factor can be seen in Figure 8.

In general, all factors received high importance ratings. Factors with the highest importance scores included F_10, F_7, F_3 and F_14. Factors with the lowest impact on resilience were F_5, F_4, F_16. However, the differences in average ratings were not significant, indicating that all factors identified in the study may positively impact the ability of the supply chain to withstand and recover

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from disruptions. Factors with the highest uncertainty included international migration, biogas production, extreme weather conditions, and social trust in technologies. Among these, extreme weather conditions were a wild card, with high impact but low probability, making it challenging to control through EU policies for supply chain resilience.

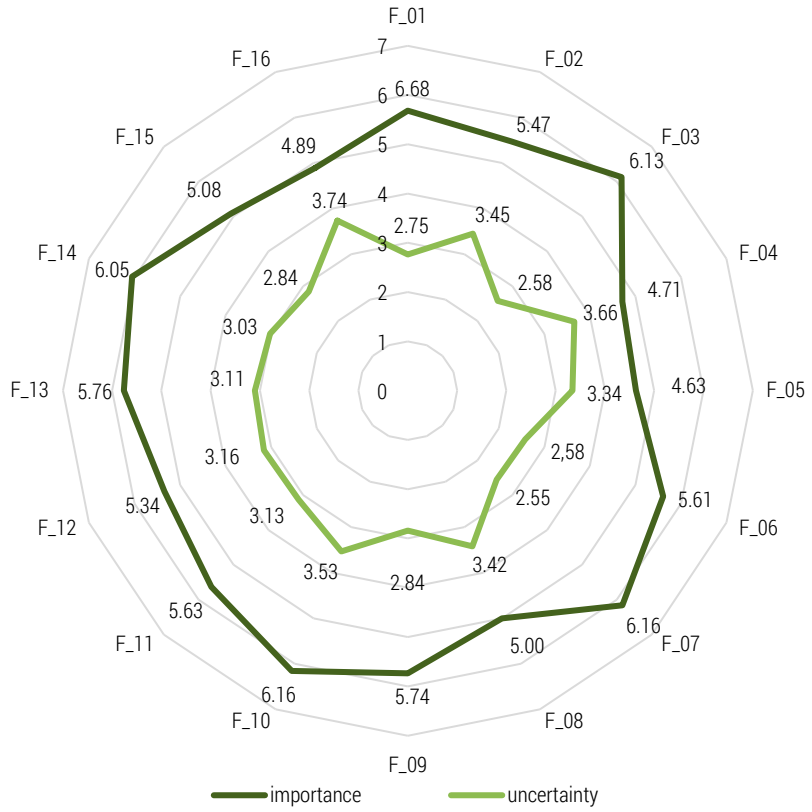

Figure 8. Results of factors' ranking by importance and uncertainty

Source: authors' work based on Ejdys et al. (2023).

The conducted research has resulted in the formulation of policy options aimed at fostering self-reliance and independence while remaining open to international cooperation and trade at the EU level and enhancing the robustness of food distribution networks. The policy options related to the food sector primarily focus on four key areas: promoting local production (for instance, promoting the localisation of food supply chains, endorsing environmentally sustainable production methods, fostering small-scale farming, and enacting efficient approaches to minimise food wastage), educating end-users (e.g. the promotion of responsible food consumption, promoting food donations), emphasizing Sci-

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ence, Technology, Engineering, and Mathematics (STEM) and Research and Development initiatives (R&D) (e.g. encouraging the growth of research and cooperative endeavours between the scientific community and farmers to attain sustainable food supply chains, and advocating for the advancement of STEM and R&D initiatives to bolster the food sector's resilience, advocating for precision agriculture, and establishing regulations to support the robustness building of food distribution networks. Detailed recommendations, as well as their costs and benefits analysis, may be found in work by Ejdys et al. (2023).

Discussion/Limitation and Future Research

The highest significance index in the presented research was assigned to the following thesis (F_T1): *EU countries will achieve self-sufficiency in wheat production without relying on Ukraine and Russia*. Separating wheat production in EU countries from Ukraine and Russia is important for several reasons, such as enhancing food security, reducing trade dependencies, promoting domestic agriculture and sustainability and environmental concerns (Cramon-Taubadel, 2022; Ducros, 2022). By diversifying sources and reducing dependencies, the EU can better manage risks and ensure a more stable and sustainable wheat supply for its member states.

The promotion of advanced agricultural technologies emerges as the most influential determinant facilitating the application of the proposed ideas or statements in the investigated theses. This conclusion is confirmed in the existing published works (Hossain et al., 2020). The authors mentioned above contributed to the literature on modern technologies in agriculture, discussing topics such as precision agriculture, Internet of Things, adoption of technology and their impacts on food security and sustainability. The agricultural industry is getting more and more data-driven and therefore requires more sophisticated technologies and advanced data than before (Khan et al., 2021). The application of modern technologies in agriculture enables farmers to access valuable information and insights for making informed decisions. By utilising sensors, data analysis, and connectivity, farmers can gather real-time data on crop conditions, weather patterns, and market trends (Khan et al., 2021). This data-driven approach facilitates improved planning, risk management, and decision-making, leading to enhanced profitability and competitiveness. Moreover, the adoption of modern technologies in agriculture plays a vital role in addressing global food security challenges. With a growing global population and limited arable land, it is crucial to increase agricultural productivity to meet the rising demand for food. Advanced technologies offer the potential for higher crop yields, mitigation of climate change impacts, and improvement of food production and distribution systems. These advancements contribute to enhancing food security at both local and global levels. According to the authors of the article, it is worth considering

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adopting labour-saving technology, including crops and livestock. The future of labour-saving technologies in agriculture and their potential implications for meeting both societal and economic challenges have been discussed by Gallardo and Sauer (2018).

It should be noted that in addition to extreme weather conditions, which can be treated as a wild card in agriculture, the study experts pointed out that an important barrier to building resilience in supply chains is insufficient financial support for farmers.

The financial needs of farmers that remain unfulfilled by banks have reached €62 billion in 2022, as indicated by two surveys showcased during the 9th annual EU conference on financial instruments funded by the European Agricultural Fund for Rural Development (EAFRD). The impact is particularly pronounced for small farms and young farmers who face challenges in obtaining loans and financial support. Additionally, for small and medium-sized enterprises (SMEs) involved in processing agri-food products, there is a financial shortfall of €5.5 billion, with notable disparities observed among different Member States (Directorate General for Agriculture and Rural Development, 2023).

Utilisation of previously unused land for food and feed production occurred to be the least important factor enabling resilience building of food supply chains, especially in the context of T3: *In a strategic move to decrease reliance on Russia, European Union countries will channel extra financial investments into NPK fertiliser production*. The results obtained seem to be a little bit controversial, as according to Csikós and Tóth (2023), the untapped potential of unused land holds the promise of bolstering food security, facilitating bioenergy production, and enhancing the delivery of crucial ecosystem services. Utilising previously unused land for food and feed production involves transforming and utilising land that was previously not used for agricultural purposes. This can include various types of land, such as abandoned or fallow land, degraded land, or land that was previously designated for other purposes. It can help expand agricultural production capacity, especially in regions where arable land is limited. It also provides opportunities for economic development and employment in rural areas. Additionally, it can contribute to enhancing food security by increasing the availability of food and feed resources. In the body of literature there could be identified several benefits of utilising previously unused land for food and feed production (Lambin et al., 2018; Stürck et al., 2018), which were, surprisingly, not so evident in the study carried out by the authors of the article. According to the authors, the lower rating of importance for this factor in relation to Thesis 3 may have been due to the fact that this factor has little thematic link to extra financial investments into NPK fertiliser production. Hence, experts may have given it less importance.

The main limitation of the study is that the authors examined supply chain disruptions in the food area in relation to the COVID-19 pandemic and the war in Ukraine. The study did not consider the impact of other disruptions, such as

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extreme weather events, climate change, sanitary and veterinary crises, food scandals, technological and innovative consumer preferences and habits or supply delays. The impact of these disruptions on the resilience of supply chains could be a stand-alone research *per se.*

The other limitations of this research are closely tied to the inherent limitations of the Delphi method itself (Okoli & Pawlowski, 2004; de Loe et al., 2016; Skulmowski et al., 2007). One potential limitation is the possibility of expert selection bias, as the effectiveness of the Delphi method relies heavily on the knowledge and expertise of the participants. However, the authors of the study made significant efforts to recruit highly qualified experts for their research. Another limitation could be the unsatisfactory feedback received. The iterative nature of the Delphi research depends on the feedback provided by participants between rounds. However, the feedback received may not have been detailed enough to effectively stimulate revisions in the experts' answers. Subjective interpretation of the phenomena under investigation is another potential bias, as it can lead to varying conclusions and recommendations. Different experts may have different interpretations, which can affect the overall findings.

Additionally, the use of written communication in the Delphi method limits real-time interaction among participants. This lack of real-time interaction can hinder the ability to clarify points and engage in dynamic discussions.

Therefore, future research on building supply chain resilience may benefit from utilising real-time Delphi tools to address this limitation (Gnatzy et al., 2011). Real-time communication platforms enable quicker feedback, interactive discussions, and improved collaboration among experts. Researchers and practitioners have extensively explored and implemented real-time Delphi variations, which have collectively contributed to the advancement of the methodology. These efforts have enhanced the efficiency and effectiveness of the Delphi process by leveraging the benefits of instantaneous communication and fostering dynamic exchanges among participants.

Another area of further work is the construction of scenarios based on the ranking presented in terms of importance and uncertainty according to the intuitive school of scenario construction (Kononiuk & Nazarko, 2014). The scenarios developed can form the basis for strategic action within the resilience building of supply chains.

Conclusions

The study embraces the possible ways of food supply chain resiliency building in Europe. From the theoretical point of view, in the context of the literature review and the research carried out, the results of the presented research provided insights into the key factors for building resilience in food supply chains, among which are the extent of financial assistance provided to farmers, the adop-

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tion of cutting-edge technologies (such as AI, remote sensing, GIS, VR or drones), and the promotion of mindful consumption practices.

The research, employing the STEEPED technique, not only uncovered the critical factors perceived by researchers as instrumental in enhancing the resilience of European food distribution networks but also shed light on the multifaceted determinants within the food domain. These factors play pivotal roles in shaping the robustness of the distribution networks. They encompass various aspects, including dominant dietary patterns and habits, the level of trust in modern and the utilisation of biogas production from agri-food waste.

Furthermore, the approval of government subsidies for fertilisers, allocation of financial reserves from the budget of the EU's Common Agricultural Policy, and the level of financial support provided to farmers emerge as key influencers. The study also recognises the significance of utilising set-aside land for food and feed production, transitioning towards environmentally friendly and sustainable practices, and coping with the challenges posed by extreme weather conditions like droughts, floods, and natural catastrophes.

The research underscores the importance of country-specific laws and the quality of legislation pertaining to digital data use in agriculture. Additionally, it highlights the role of societal factors, including openness to adopting new dietary patterns and habits, addressing the effects of an ageing society and the level of international migration. STEEPED factors identified in the study collectively contribute to a nuanced understanding of the intricate dynamics influencing the robustness of European food distribution networks, providing valuable insights for policymakers, stakeholders, and researchers alike.

From the practical point of view, the study identified key recommendations for building supply chain resilience, which encompasses a range of initiatives such as the localisation of food supply chains, advocacy for sustainable and eco-friendly production techniques, supporting small-scale agriculture, and reduction of curtailing food wastage and reducing unnecessary food losses.

The survey also revealed significant obstacles to supply chain resilience, including the absence of favourable regulations on a national scale. The study also provided insights into the expert assessment of factors for building supply chain resilience in terms of their importance and uncertainty in the 2030 horizon, which can be the basis for more elaborate scenario analysis following the intuitive school of scenario construction. The use of the scenario method will provide a multi-variant view of building resilience in food supply chains. It will also allow the framework of a desirable scenario to be outlined, which can become a contribution to building strategic action in this area.

The contribution of this study is mainly to fill the research gap in the literature on enabling factors, barriers to implementation, and the expected timeframe for Delphi theses in the field of food resiliency building in conditions of unstable geopolitical situations.

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The contribution of the authors

Conceptualisation, A.K. and A.M.; literature review, A.K. and A.M.; methodology, A.K. and A.M.; formal analysis, A.K. and A.M.; data collection, A.K. and A.M.; writing, A.K. and A.M., conclusions and discussion, A.K. and A.M.

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BUDOWANIE ODPORNOŚCI EUROPEJSKICH ŁAŃCUCHÓW DOSTAW W OBSZARZE ŻYWNOŚCI: WYNIKI BADANIA DELFICKIEGO

STRESZCZENIE: Pandemia Covid-19 oraz wojna na Ukrainie negatywnie wpłynęły na zrównoważony rynek żywności oraz w znaczącym stopniu przyczyniły się do wzrostu cen produktów rolnych. Celem artykułu jest prezentacja wyników europejskiego badania delfickiego na temat czynników i barier budowania odporności łańcuchów dostaw w obszarze żywności a także przedstawienie rekomendacji w tym zakresie. Ocenie poddano tezy delfickie, przewidywany czas ich realizacji oraz ich wpływ na wybrane etapy funkcjonowania łańcuchów dostaw. W pracy wykorzystano przegląd literatury, metodę delficką oraz analizę STEEPED, która posłużyła do identyfikacji czynników zwiększenia odporności europejskich łańcuchów dostaw. Do kluczowych czynników budowania odporności łańcuchów dostaw należy zaliczyć: pomoc finansową dla rolników, wykorzystanie zaawansowanych technologii (takich jak sztuczna inteligencja, teledetekcja, GIS, VR lub drony) oraz zachęcanie do świadomych praktyk konsumpcyjnych. Badanie wykazało, że trudne warunki pogodowe, niewystarczające wsparcie finansowe dla rolników i niewystarczająco korzystne przepisy na szczeblu krajowym są głównymi barierami w osiąganiu odporności łańcuchów dostaw żywności. Do głównych rekomendacji w obszarze budowania odporności można natomiast zaliczyć: regionalizację łańcuchów dostaw żywności, promowanie zrównoważonych, przyjaznych dla środowiska metod produkcji i rolnictwa na małą skalę, a także wydajne i skuteczne promowanie ograniczania strat i marnotrawstwa żywności. Oryginalność badania przejawia się w zaprezentowaniu opinii międzynarodowych ekspertów w zakresie budowania odporności łańcuchów dostaw w obszarze żywności w warunkach pandemii oraz niestabilnej sytuacji geopolitycznej.

SŁOWA KLUCZOWE: metoda delficka, zrównoważony rynek żywności, zerwane łańcuchy dostaw, odporność łańcuchów dostaw

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