

Article

Wartime Supply Chain Resilience: Crisis Management Capabilities of Ukrainian Agribusinesses

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Abstract

This study explores how Ukrainian agribusinesses manage operations under prolonged geopolitical disruption by examining the wartime resilience strategies and pathway divergence of Kernel and Astarta. Drawing on a qualitative comparative case study approach, the paper combines the 4R (Reliability, Relationships, Responsiveness, and Resilience) framework with dynamic capabilities theory. The 4R framework is used to identify the main dimensions of wartime resilience, while dynamic capabilities theory explains how firms sense emerging threats, seize adaptive opportunities, and transform resources, routines, and stakeholder relationships over time. The findings highlight resilience as a multidimensional and evolving capability shaped by context-specific assets and stakeholder networks. This study provides rare insights into strategic organizational adaptability in active conflict zones and contributes to the resilience and dynamic capabilities literature in the context of extreme, long-term disruptions.

Keywords: resilience; dynamic capabilities; crisis management; war; Ukraine; supply chain; agri-business**JEL:** M10, M11, R11

1. Introduction

The Russian invasion of Ukraine in February 2022 sent shockwaves through global markets, disrupting industries and supply chains. The destruction on Ukrainian territory has caused a significant decline in production, and the loss of workforce has led to significant operational and economic challenges (Polityuk, 2024). Additionally, destroyed infrastructure (Kyiv School of Economics, 2023) and ongoing Russian attacks on power facilities have led to widespread power outages (Coles et al., 2024), increased logistical costs, and threaten business viability (Polityuk, 2024).

These challenges resulted in harsh economic conditions, particularly for the agricultural sector, Ukraine's primary economic driver. The Ukrainian agricultural industry, one of the world's largest grain exporters, faced severe logistical and operational challenges. The blockade of Black Sea export routes forced a shift to alternatives like railways and river ports. However, significant challenges emerged from the differing rail gauges between Ukraine (1520 mm) and European target markets (1435 mm), leading to bottlenecks at the border crossings. Despite these overwhelming hardships, the Ukrainian agricultural sector has demonstrated a remarkable ability to adapt to new conditions, as Petr Krogman, Chairman of the Board of Agromino, emphasized: *"Ukraine has proved that even in the most difficult circumstances, it can remain a reliable partner for the world. We continue to fulfil our commitments and help maintain stability in the global food mar-*

ket" (Ukrainian Agribusiness Club, 2025). From March to June 2022, grain exports through rail, truck, and river barge almost doubled, showcasing the industry's adaptation to the crisis (Ukrainian Agribusiness Club, 2025).

Business resilience has gained considerable attention within management and supply chain literature in light of increasingly frequent and severe global disruptions, ranging from pandemics to geopolitical conflicts such as the war in Ukraine. While supply chain resilience has received increasing scholarly attention in recent years, most research remains grounded in contexts of natural disasters, pandemics, or market-driven disruptions (Ponomarov and Holcomb, 2009; Ivanov and Dolgui, 2020). Studies that address organizational resilience under sustained, large-scale armed conflict remain limited, particularly regarding operational-level strategies deployed by companies in active war zones. Existing models for sustained competitiveness, such as the 4R (Reliability, Relationships, Responsiveness, and Resilience) framework (Christopher and Peck, 2004) and dynamic capabilities theory (Teece et al., 1997), have been applied largely in peacetime scenarios or environments with temporary disruption, leaving a conceptual gap in understanding how these frameworks perform under long-term, high-impact conflict situations like the war in Ukraine. While recent contributions (Altuntas Vural et al., 2025) begin to explore wartime organizational responses, they often lack firm-level granularity and longitudinal insight into how resilience evolves during prolonged crises. Moreover, there is a need for qualitative case stud-



ies that connect tangible operational adjustments to broader strategic frameworks in high-risk environments.

In order to identify how and why companies develop and demonstrate crisis resilience, this paper examines the resilience strategies via case studies of two Ukrainian agricultural companies—Kernel Holding S.A. and Astarta Holding PLC. Kernel operates primarily within the grain and oilseed sector, focusing on large-scale exports. This specialization in bulk commodity exports makes it highly sensitive to global trade and logistics disruptions. Meanwhile, Astarta has a more diversified portfolio that includes sugar production and dairy farming. Their operational diversification offers insights into how agribusinesses adapt to crises and geopolitical challenges.

This study investigates how both companies strategically leverage capabilities across their supply chain to achieve resilience and ensure survival amid the sustained disruption of war. Based on the 4R framework and dynamic capabilities theory, this article empirically analyzes the operational and strategic responses of Kernel and Astarta to the large-scale conflict in Ukraine. By showcasing how these companies leverage their assets to manage risks and ensure competitiveness during wartime, the research addresses a critical gap in the literature on supply chain resilience, particularly the lack of theory-led firm-level, qualitative insights from active war zones. These findings offer valuable lessons for companies navigating high-risk conditions in today's volatile geopolitical environment, where conflicts can unpredictably disrupt global markets. Theoretically, the study advances the application of the 4R framework by integrating it with dynamic capabilities theory, contributing to a deeper understanding of how resilience strategies evolve under conditions of prolonged warfare.

2. Theoretical Framework

“An organizational crisis is a low-probability, high-impact event that threatens the viability of the organization and is characterized by ambiguity of cause, effect, and means of resolution, as well as by a belief that decisions must be made swiftly” (Pearson and Clair, 1998). Thus, crises often arise from external factors, requiring prompt managerial action. Risks include natural disasters, geopolitical events, supplier failures, transportation issues, and demand fluctuations.

Crisis management requires organizations to anticipate, respond to, and recover from major disruptions that threaten operations, reputation, or stakeholders. It involves addressing immediate threats and reshaping the organization's strategies, structures, and relationships to foster long-term resilience. Effective crisis management entails a dynamic communication, decision-making, and adaptation process, highlighting proactive planning, flexibility, and organizational learning (Pearson and Clair, 1998).

2.1 Dynamic Capabilities Theory

The Dynamic Capabilities Theory focuses on how organizations reconfigure their resources and strategies in response to rapidly changing environments and the resulting uncertainty we also find in crises. The theory was developed by Teece, Pisano, and Shuen in 1997. Unlike static capabilities, which provide a company with a competitive advantage under stable conditions, dynamic capabilities enable companies to sense opportunities, seize them through appropriate responses, and transform their operations to maintain long-term success (Teece et al., 1997). The first component of the Dynamic Capabilities Theory is sensing, which refers to an organization's ability to detect potential threats and opportunities in its external environment. Companies with strong sensing capabilities actively monitor industry trends, market shifts, and geopolitical risks to stay ahead of competitors. The second element is seizing, which involves companies acting quickly to allocate resources, invest in new capabilities, or restructure their business models once an opportunity or threat is identified. Effective decision-making in this phase ensures that organizations capitalize on emerging trends and mitigate risks efficiently. The third component is transforming, which refers to reconfiguring business models, operational structures, and leadership strategies to ensure long-term competitiveness (Teece et al., 1997). Consequently, companies with high dynamic capabilities do not simply react to their environment; they innovate and evolve in response to changing conditions.

2.2 4R Framework

While crisis management addresses immediate disruptions, resilience describes the capacity of an organisation to absorb disturbance. It involves anticipating, withstanding, adapting to, and recovering from disruptions through three critical elements: the adaptability and collaboration of its employees (Lengnick-Hall et al., 2011), the robustness and flexibility of its organizational structure (Lawrence and Lorsch, 1967), and the strategic availability and management of resources (McManus et al., 2008). This interplay allows organizations to survive and thrive amid uncertainty.

Ponomarov and Holcomb (2009) framed resilience in supply chains as a multidimensional capability. Similarly, the 4R framework offers a systematic approach to optimizing supply chain management by emphasizing four inter-related dimensions: Resilience, Responsiveness, Reliability, and Relationships. Originally developed to help supply chains remain competitive in dynamic and uncertain environments, the framework has gained particular relevance in the context of geopolitical conflicts such as the war in Ukraine, where disruptions, damaged infrastructures, and political instability continuously threaten supply chain stability. In this model, resilience refers to the capacity to recover from disruptions, for example, by diversifying suppliers or maintaining safety stocks. At the same time, re-

sponsiveness emphasizes the ability to rapidly and flexibly adjust to shifting market or operational conditions. Reliability focuses on ensuring consistent performance and quality even under stress, and relationships highlight the critical role of partnerships, collaboration, and trust in promoting transparency and coordinated responses.

Building on these principles, foundational works by Christopher and Peck (2004), Pettit et al. (2010), and Sheffi and Rice (2005) have introduced a complementary set of “4Rs”: redundancy, robustness, resilience, and reconfiguration. These frameworks extend the discussion by detailing how supply chains can prepare for, absorb, and recover from major disruptions through a strategic balance of flexibility, operational slack, and adaptive capacity. Together, these models provide a holistic and structured foundation for analysing and designing supply chains capable of withstanding layered shocks and extreme conditions, such as those experienced during wartime. Their integration in the literature underscores the importance of combining structural readiness with dynamic adaptability and relational strength as central pillars for achieving long-term supply chain resilience.

3. State of Research

Recent research emphasises that building resilience is not merely about recovery; it also involves proactive adaptation, risk management, and ensuring long-term continuity in highly volatile environments. We provide an overview of the research on strategies to assist companies in preparing for, responding to, and recovering from disruptive events in order to highlight the gap addressed in this paper.

The Dynamic Capabilities Theory has been widely applied in research on corporate strategy, technology management, and crisis adaptation. Teece (2007) emphasized that companies with strong dynamic capabilities outperform competitors in uncertain environments by continuously innovating and adapting their strategies. Eisenhardt and Martin (2000) demonstrated that companies in volatile industries such as technology and finance rely on dynamic capabilities to sustain competitive advantages. This theory has been extensively used to examine how organizations navigate global crises, such as the 2008 financial crisis, the COVID-19 pandemic, and geopolitical conflicts. It provides a valuable framework for analysing how companies adapt to sudden market disruptions and uncertain regulatory environments. Rao, Mackenzie, and Subedi (2024) apply the dynamic capabilities framework to examine how a regional Australian agribusiness adapted to compounding disruptions, including drought, the COVID-19 pandemic, and geopolitical instability. Through a longitudinal case study, they identify the key capabilities of sensing, seizing, and transforming that enabled the company to respond strategically and build resilience. They emphasize the role of leadership, local embeddedness, and institutional support in shaping adaptive capacity.

Extensive research analysed supply chain management in the light of disruptions that shape their external environment (see Altuntas Vural et al., 2025), with resilience emerging as a key term within crisis management. Hillmann and Guenther (2021) highlight the conceptual ambiguity surrounding resilience, which is variously defined as a process, a capability, or a capacity, in a comprehensive systematic review. Across 126 reviewed studies, they identify 22 attributes associated with resilience and group these into six conceptual domains: awareness, stability, change, behaviour, growth, and performance.

The concept of resilience has evolved into a multi-dimensional, systemic, and dynamic capability central to companies navigating disruption. Koronis and Ponis (2018) define organizational resilience as a process built on preparedness, adaptability, responsiveness, and learning, supported by social capital elements like trust and communication. This framing emphasizes resilience as both a structural and cultural asset. Complementing this, Teece et al. (2016) argue that companies facing deep uncertainty must cultivate dynamic capabilities to remain strategically agile and innovative, balancing the costs of agility with environmental turbulence. Efforts to measure resilience have advanced through the work of Ambulkar et al. (2015), who developed a scale defining resilience as a firm’s ability to stay alert, adapt, and respond rapidly to supply chain disruptions. They identify key antecedents such as disruption orientation, resource reconfiguration, and risk management infrastructure, emphasizing that the severity of a disruption determines the prioritization of strategies. Ivanov (2021) contributes by outlining four key adaptation strategies: intertwining, scalability, substitution, and repurposing, providing a comprehensive framework for supply chain viability during crises like the COVID-19 pandemic.

Recent research extends the 4Rs by incorporating innovative and adaptive strategies. Li et al. (2025) demonstrate how multinational enterprises employ business model innovation to build resilience under deep uncertainty. Short and Pfarrer (2025) highlight the importance of blending anticipatory and reactive impression management to mitigate stakeholder backlash during information-asymmetric crises. Powley (2009) introduces a socially activated view of resilience, identifying mechanisms such as compassionate witnessing and relational redundancy that help organizations restore normalcy following high-impact disruptions.

Focusing specifically on geopolitical disruption, Ivanov and Dolgui (2020) extend supply chain resilience research by applying panarchy theory, showing how intertwined supply networks can build survivability by combining circularity, resource reconfiguration, and innovation. Scholten et al. (2014) emphasize relational processes, particularly trust and collaboration, as critical antecedents for building resilience, while Kamalahmadi and Parast (2016) provide a comprehensive review of enterprise and supply chain resilience principles, including redundancy, flexibil-

ity, and proactive risk management. Together, these studies underscore the importance of both structural capabilities and relational mechanisms in sustaining operations amid layered and cross-level shocks.

Addressing Ukrainian agribusiness, Kantaruk Pierre et al. (2025) find that exporting small and medium-sized enterprises (SMEs), despite lacking proactive crisis plans, sustain operations through relational capital, particularly trust, commitment, and cooperation with foreign partners, paired with strategic shifts such as operational reconfiguration and market diversification. This dual role of relational capital underscores both its enabling and limiting aspects, calling for integrated risk and relational management.

The state of research shows that both the dynamic capabilities theory and the 4R framework have been employed separately to explain how companies manage to withstand prolonged, severe disruptions. As demonstrated, previous research on supply chain resilience has focused on natural disasters, pandemics, or short-term crises, leaving wartime contexts like those faced by Ukrainian agribusiness underexplored, even though the war in Ukraine has spurred increased interest in the topic (see Kantaruk Pierre et al., 2025). Additionally, integrating the theoretical perspectives of Dynamic Capabilities and the 4Rs may close the gap concerning the holistic identification of wartime resilience strategies in companies.

4. Methodology

We address this gap through qualitative methodology by assessing the social reality of crisis management in armed conflict as it unfolds. To empirically examine wartime crisis response strategies, we opt to analyse corporate action during the Russian Aggression against Ukraine and the intensified warfare on Ukraine's territory since 2022 as the research context. According to Yin (2014), case studies aim to understand complex social phenomena and real-life events such as organizational and managerial processes, as well as crisis management strategies and resilience practices in volatile geopolitical contexts. The main strength is reconciling theory and context (Welch et al., 2022). Therefore, the case study approach helps examine the applicability of theories on resilience to novel contexts and crisis situations. Our methodological approach is consequently based on Yin (2014) and Mayring (2014), with content analysis integrated into case analysis. That generates a comprehensive understanding of the social reality across the investigated agribusinesses. Based on our research questions, we have conducted an extensive literature review on corporate crisis resilience and the corresponding theoretical foundations of the 4R Framework and Dynamic Capabilities Theory to develop a deductive framework for content analyses.

4.1 Case Selection

We adopt a multi-case study approach (Yin, 2014) within the agribusiness sector due to the strategic impor-

tance of agriculture in Ukraine's economy, its crucial relevance for the country's civic health, as well as its strong connections to global supply chains (ParkerRussell, 2025). The examined agribusinesses resulted from a theoretical sampling process that followed two selection criteria: industry affiliation and headquarters location within Ukraine as a war-torn country. This ensures the contextual relevance of the cases and vertical integration, which offers valuable insights into internal resilience mechanisms (Porter, 1985). Additionally, the selected companies are characterized by their substantial size and market presence, providing a rich context for exploring strategic and operational responses to disruptions (Eisenhardt and Graebner, 2007). The availability of detailed public disclosures, such as annual reports and sustainability statements, further supports data triangulation and transparency (Yin, 2018). Lastly, their comparability, which is rooted in shared sectoral challenges but differing strategies, enhances the analytical depth of the cross-case comparison (Seawright and Gerring, 2008). This sampling strategy aligns with the principles of purposeful case selection for theory-building (Eisenhardt, 1989; Patton, 2002).

We examine how Kernel and Astarta manage supply chain disruptions from the ongoing conflict in Ukraine. Kernel Holding and Astarta Holding, two of Ukraine's largest agribusinesses, operate large, vertically integrated agricultural supply chains and have faced significant impacts from the Russian invasion, disrupting operations and logistics. Kernel is export-oriented, relying heavily on international commodity trade, particularly grains and oilseeds, making it vulnerable to geopolitical shocks (Kernel, 2020). In contrast, Astarta has a more diversified, domestically oriented portfolio, including sugar, dairy, and crops (Astarta, 2025a). This contrast enables a comparative analysis of different organizational strategies in response to similar external threats (see Table 1).

Founded in 1995 by Andrii Verevskyi, Kernel Holding S.A. is one of Ukraine's largest agribusinesses, integrating the agricultural value chain. Current operations include farming, production, storage, processing, and export, solidifying its position as a key player and major grain exporter in the Black Sea. By investing in silos, processing plants, and port infrastructure, Kernel achieved substantial growth, including a record grain export of 7.9 million tons in 2020 (Kernel, 2020). Strategic investments enhanced operational efficiency. The construction of the largest oilseed processing plant in Starokostiantyniv in 2021 further strengthened its market presence, while co-generation units reduced operational costs and supported renewable energy (Kernel, 2021a). Kernel's infrastructure consists of interconnected business units linking Ukrainian farmers to global markets. In 2020, it managed 514,000 hectares of farmland, making it Ukraine's largest crop producer, with a procurement team purchasing grain and sunflower seeds nationwide. A network of 31 silos across key grain-producing

Table 1. Case company overview.

	Astarta	Kernel
Company Size	Medium-sized agri-business (approx. €620 m revenue in 2023)	Largest agri-exporter in Ukraine (approx. €3.24 bn revenue in 2023)
Business Model	Vertically integrated: crop farming, sugar, soy, dairy, bioenergy	Focused on sunflower oil production and grain exports
Export Structure	• Approx. 50% of revenue from exports • Strong Ukrainian market integration	• Strong reliance on Black Sea exports and own terminals • Global trade focus
Earnings	EBITDA 2021: €201 m	EBITDA 2021: €681 m
	EBITDA 2022: €155 m	EBITDA 2022: €209 m
	EBITDA 2023: €145 m	EBITDA 2023: €503 m
	EBITDA 2024: €159 m	EBITDA 2024: €352 m

EBITDA, Earnings Before Interest, Taxes, Depreciation, and Amortization.

regions enables local procurement within a 100-kilometre radius. Services like grain intake, drying, storage, and off-loading support the company's farming segment and third-party farmers. Eight oil processing plants are positioned within the sunflower seed belt, ensuring short transport routes and enhancing profitability. Kernel's fleet of 3400 railcars connects silos and processing plants to export points, delivering cost efficiencies. Grain exports primarily move through two terminals in Chornomorsk or third-party facilities in Pivdennyi, providing access to international markets. Sunflower seed processing yields oil and meal, exported through third-party terminals (Kernel, 2021a). This infrastructure highlights Kernel's operational scale and supply chain depth.

Astarta Holding PLC, established in 1993, is a pre-eminent, vertically integrated agro-industrial enterprise in Ukraine. The company manages approximately 212,000 hectares of arable land dedicated to cultivating grains and oilseeds, ensuring a stable supply of raw materials for its processing operations. As the nation's largest sugar producer, Astarta operates multiple sugar plants with a combined annual production capacity ranging between 250,000 and 500,000 tonnes. Additionally, the company processes soybeans to produce soybean meal and oil and is a significant dairy producer, with an annual milk output of approximately 115,000 tonnes. Astarta's strategic investments in bioenergy projects further demonstrate its commitment to sustainability by reducing environmental impacts and enhancing energy efficiency. Moreover, the company's integrated business model, encompassing comprehensive grain and oilseed storage and logistics services, facilitates robust control over the entire value chain, from production to processing and distribution. This holistic approach ensures consistent product quality and operational efficiency, consolidating Astarta's status as a leader in Ukraine's agricultural sector (Astarta, 2025a).

4.2 Data Collection

We gathered data from corporate communication, press reports, and an in-depth interview to provide a com-

prehensive view. Organizational documents have long been a cornerstone in qualitative research, and analyzing their content is an effective method for understanding crisis management practices (Bowen, 2009). Our data focused on the companies' electronically available public communication documents listed in the tables (Bowen, 2009). Both cases provided rich and transparent empirical material through publicly available corporate documents, including annual reports, investor presentations, and Environmental, Social, and Governance (ESG) disclosures. We first skimmed the documents to locate pertinent paragraphs, followed by an in-depth reading of the identified paragraphs and then interpreting relevant phrases through content analysis (Bowen, 2009) to elicit meaning, gain understanding, and develop empirical knowledge (Corbin and Strauss, 2008). Data on the sample companies has been collected and studied in English, if available, and Ukrainian, and then translated.

According to Bowen (2009), document analysis is a suitable qualitative method for understanding organizational phenomena, particularly when documents are produced routinely and for external accountability. Annual and financial reports were selected for their credibility, regularity, and strategic relevance, reflecting how companies communicate crises and strategic responses to investors and the public (see Table 2). ESG disclosures, in turn, provide insight into how companies frame their social and environmental responsibilities, which is particularly relevant when evaluating organizational resilience, transparency, and adaptability during times of disruption.

Yin (2014) recommends case study research that uses multiple sources of evidence to enable triangulation. He suggests that researchers use different evidentiary sources, such as documentation, archives, interviews, direct observation, participant observation, and physical artefacts, each with its specific advantages and disadvantages. Based on this, we triangulated data from a semi-structured interview and a document analysis, validating document information through a semi-structured expert interview. The interviewee was chosen for insight into the research question and context. Taras Gagalyuk, a leading researcher at

Table 2. Analysed documents.

Company	Document title	Document type	Publication date
Kernel	Kernel Secures Partnership with FMO	Investor Relations Report	2024
Kernel	Annual Reports	Annual Report	2019–2024
Kernel	Quarterly Operations Updates	Financial Report	2022–2025
Astarta	Code of Conduct of Astarta N.V.	Code of Conduct	2021
Astarta	Annual Reports	Annual Report	2020–2023
Astarta	Viktor Ivanchyk - “Businessmen are natural optimists — they believe in their companies and their future success. It is an axiom.”	Interview with KPMG	2022
Astarta	Viktor Ivanchyk - “We strive to create an ecosystem of responsible partnerships to help increase the self-reliance and resilience of Ukrainians”	Interview with Forbes Ukraine	2024
Astarta	“Astarta Exports its Agricultural Products to 44 Countries”	Announcement	2024
Astarta	“Appointment in the Astarta Management”	Announcement	2022
Astarta	“WFP Re-confirms Astarta’s Accreditation”	Announcement	2024
Astarta	“History”, “Partners”, “News”	Website	2025
Astarta N.V., Astarta Holding N.V.; FMO, Dutch Entrepreneurial Development Bank; KPMG, Klynveld Peat Marwick Goerdeler; WFP, United Nations World Food Programme.			

the Leibniz Institute of Agricultural Development in Transition Economies (IAMO), was interviewed to contextualize findings from corporate documents, validate interpretations, and enhance our understanding of structural challenges in the Ukrainian agricultural sector. Expert input assessed the credibility of reported strategies and revealed dynamics beyond official disclosures, bolstering triangulation and study reliability. The questions focused on four areas: the structural and economic background of Ukrainian agriculture; resilience strategies of vertically integrated companies, such as Kernel and Astarta; the role of international partnerships and technologies in enhancing resilience; and future perspectives for strengthening supply chains amid geopolitical uncertainty.

4.3 Data Analysis

We employed directed content analysis to structure the content, offering both supporting and non-supporting evidence, as per Mayring (2014). This process filters documents via defined classification criteria, categorizing content deductively based on the 4R Framework’s Resilience, Responsiveness, Reliability, and Relationships. It systematically captures the dimensions of supply chain and organizational performance under crisis conditions to assess how each company manages internal and external linkages, adapts to disruptions, maintains operational continuity, and recovers from shocks. Responsiveness involves rapid adaptation to evolving market conditions, crucial for sustaining operations in unpredictable environments. Relationships emphasise the strategic management of interactions and partnerships in the supply chain to enhance performance, focusing on trust, collaboration, and long-term partnerships. Reliability ensures consistent performance and quality in the supply chain, even in difficult circumstances.

Resilience indicates an organization’s ability to adapt to disruptions, securing long-term sustainability.

Using an established concept as the backbone of the deductive coding supports the credibility and confirmability of our study (Hsieh and Shannon, 2005; Sinkovics et al., 2008) and increases the transferability of our method to other cases and contexts (Tracy, 2010). Both concepts offer explanatory power for the strategic commonalities and differences observed between Kernel and Astarta.

5. Findings

5.1 Kernel

Even with proactive risk management, none of the reports prior to the war predicted a possible geopolitical conflict (Kernel, 2019; 2020; 2021a). The escalation of military actions in northern and eastern Ukraine disrupted operations and supply chains, creating a volatile environment characterized by occupied territories and unpredictable attacks (Kernel, 2022a). Kernel identified possible logistics blockades and energy shortages as critical threats early in the conflict and responded by adapting its strategies and supply chain processes to navigate the uncertainty, reflecting the 4Rs.

5.1.1 Responsiveness

This section examines Kernel’s strategic adjustments to maintain operational continuity and demonstrate responsiveness amid the war in Ukraine. The blockade of Ukrainian Black Sea ports severely disrupted the company’s export activities. At the same time, the temporary relief offered by the Black Sea Grain Initiative and its subsequent collapse highlighted the rapidly shifting export landscape (Kernel, 2022a) (see Fig. 1).

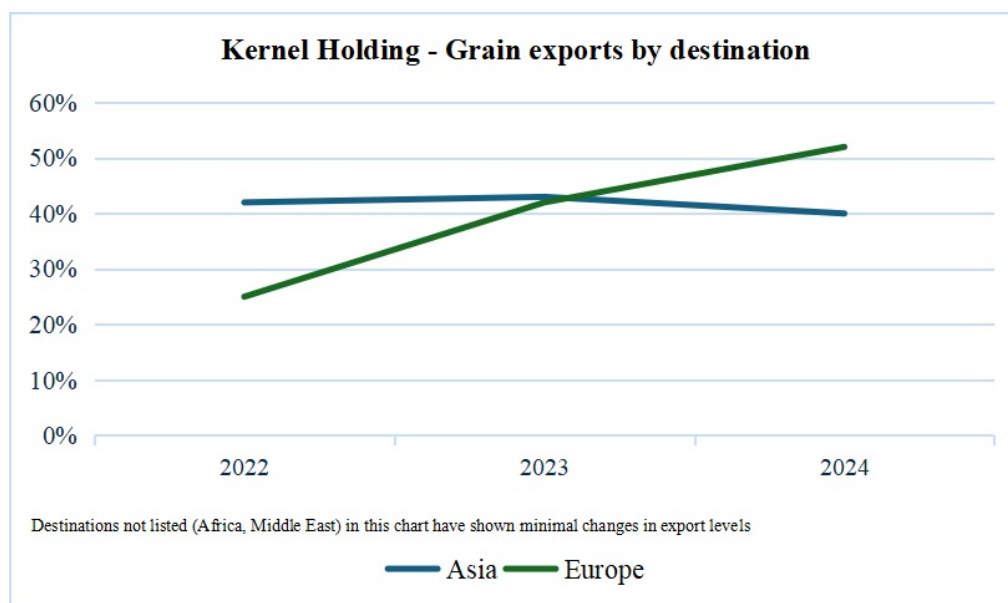


Fig. 1. Kernel's shift in Grain Export Destinations due to conflict (Kernel, 2021a; 2022a; 2023a; 2024b).

At the onset of the war, Kernel swiftly transitioned to crisis management, instituting daily anti-crisis meetings. This illustrates fast internal coordination and decisive financial and operational action (Kernel, 2022a). This facilitated rapid decision-making, clear internal communication, and real-time updates. A notable example is the prompt initiation of creditor negotiations, underscoring the company's coordinated approach to managing financial risks and securing liquidity under pressure (Kernel, 2022a).

Despite severe challenges, Kernel was able to proceed with spring planting in 2022 by strategically excluding 28,000 hectares in the heavily affected northern regions and increasing sunflower acreage. Prioritizing oilseeds, which offer higher added value and are less shipping-intensive, allowed the company to offset planting constraints and logistical costs through its substantial crushing capacity and favourable margins (Kernel, 2021a, p. 15; Gagalyuk, 2025). This reflects the firm's agility in restructuring operations and optimizing resources to maintain continuity.

Although initially limited due to the bulk nature of Kernel's products, the company quickly secured alternative transshipment capacities at Ukraine's Danube River port of Reni and along the western border. It signed multiple take-or-pay agreements with terminals in Romania, Germany, and Lithuania, as well as inland railway transshipment facilities, providing fallback options in case of further Black Sea export disruptions (Kernel, 2022a).

Kernel addressed storage and logistics issues, with one silo under Russian control and two damaged, reducing capacity. It invested in 0.3 million tons of flexi bags for on-site storage, mitigating trucking and electricity shortages that hampered silo operations (Kernel, 2022a, pp. 24, 31; Gagalyuk, 2025). This flexible strategy helped maintain operations despite infrastructure limits.

In sum, Kernel's rapid and multifaceted response to wartime disruptions demonstrates exceptional organizational adaptability. Effective crisis management, proactive financial measures, strategic crop adjustments, and the development of alternative export and storage solutions collectively illustrate the company's capacity to navigate fast-evolving challenges and sustain operations in a conflict environment.

5.1.2 Relationships

Kernel's reliance on Black Sea ports for efficient and cost-effective exports was abruptly disrupted, with no immediate alternative routes to handle export volumes (Kernel, 2022a). External interventions, notably the Black Sea Grain Initiative and Ukrainian Navy corridors, played a crucial role in stabilizing grain and sunflower oil exports, preventing storage and logistics collapse (Gagalyuk, 2025; Kernel, 2022a). Importantly, these were indirect relationships: Kernel benefited from the actions of governments and international bodies without direct partnerships or negotiations.

The war exposed vulnerabilities in downstream relationships. Black Sea exports halts forced the cancellation of sales contracts (Kernel, 2022a, p. 19), shifting the market focus toward European and domestic sales (Kernel, 2022a; 2023a; 2024b). Longstanding practices, such as selling crops via forward contracts, were disrupted, resulting in large carry-over stocks (Kernel, 2022a, pp. 19, 31; 2023a, p. 20). Export restrictions created buyer hesitation and weakened trust, underlining how external shocks can undermine downstream reliability and amplify the importance of international support as an alternative risk buffer.

Kernel's upstream relationships, particularly with farmers, deepened during the crisis. Long-term part-

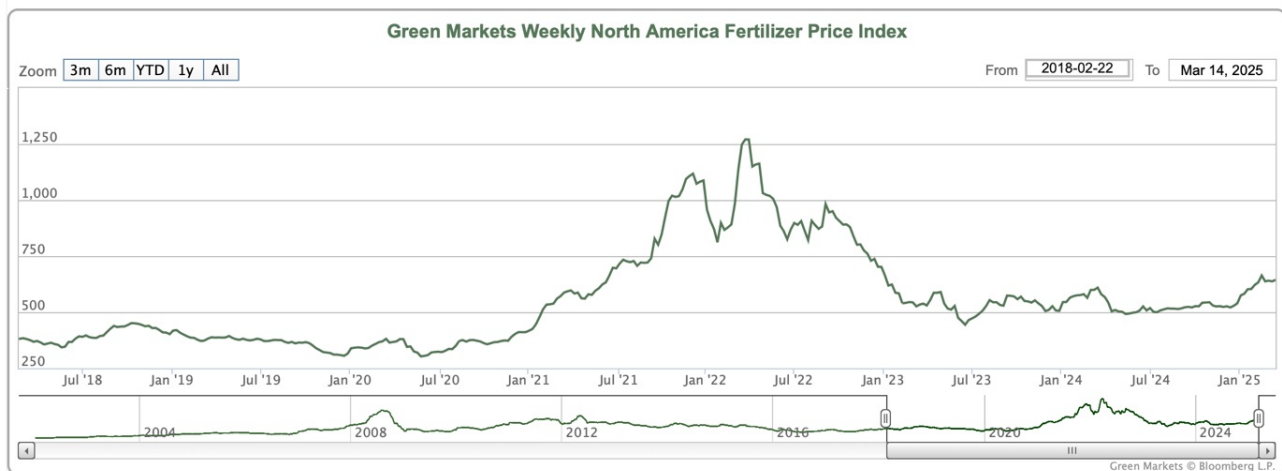


Fig. 2. Green Markets Weekly North America Fertilizer Price Index (Green Markets, 2024).

nerships built through its centralized customer relationship management (CRM) system, iBuyMore and the Open Agribusiness program evolved, shifting from primarily financing support to providing agricultural consulting and flexible payment terms (Gagalyuk, 2025; Kernel, 2021a, p. 21; 2022a, p. 64). These measures signal solidarity and strengthen mutual trust, helping secure continuity in the production base.

At the midstream level, Kernel's rapid negotiations with creditors preserved liquidity and bolstered resilience, leading to postponed repayments, waivers, and ultimately the successful repayment of US\$300 million in Eurobonds in 2024 (Kernel, 2022a; 2024b). The company also actively diversified its financing sources, securing a US\$57 million loan from the European Bank for Reconstruction and Development (Rosca, 2021) and a US\$150 million package with Dutch Entrepreneurial Development Bank (FMO) (Kernel, 2024b).

The delisting from the Warsaw Stock Exchange in 2023 further signals a strategic realignment of investor relations, consolidating ownership under Namsen Limited and enhancing decision-making efficiency during a period of intense external pressure (Kernel, 2023a; Gagalyuk, 2025).

5.1.3 Reliability

Kernel prioritized employee safety and retention by providing protective equipment, evacuation support, and compensation for mobilized staff and their families (Kernel, 2022a, p. 57). Training, skill development, and transfer investments helped mitigate operational disruptions from labour shortages (Kernel, 2022a; 2023a; 2024b Gagalyuk, 2025). This proactive human capital strategy preserved internal expertise and enhanced adaptability, reflecting a commitment to long-term resilience.

Kernel's integrated business units form a robust supply chain supporting its reputation as a reliable supplier, even in wartime volatility. Geopolitical shocks, farmland

occupation, and resource shortages (Gagalyuk, 2025) were countered through tools like the Open Agribusiness program, the iBuyMore system, and advanced digital farming techniques (Kernel, 2021a, p. 25), maximizing output on reduced land.

To safeguard export reliability, the company invested in alternative logistics: securing Danube River capacity, acquiring terminals at Chornomorsk, and signing take-or-pay shipping contracts to maintain export flows despite potential Black Sea disruptions (Kernel, 2022a, p. 26). While these measures sometimes involved financial trade-offs, they underscored a long-term commitment to customer service and supply stability.

5.1.4 Resilience

This is achieved through three essential components: collaboration among employees, a robust yet flexible organizational structure, and the strategic management and accessibility of resources. Before the war, Kernel built essential assets and infrastructure through solid relationships and a company-owned export system. When the conflict started, the company faced severe challenges in its grain sector, relying heavily on bulk shipments via Black Sea ports. Attacks on facilities caused setbacks and loss of vital resources, necessitating further investments to restore these assets (Kernel, 2022a; 2023a; 2024b). In the following, we explore resilience resources, identifying the key factors that helped Kernel adapt and stay operational amid the conflict.

Transitioning from grain and corn to sunflower seeds marks a strategic shift for Kernel. The higher added value offsets logistical costs and smaller farmland acreage, addressing the rising fertilizer and natural gas costs (Kernel, 2022a Gagalyuk, 2025). These details can be reviewed in Figs. 2,3.

Corn uses more fertilizer and natural gas for silo drying, making it less favourable than sunflower seeds (Kernel, 2022a). Wheat is shipped in bulk for cost effi-

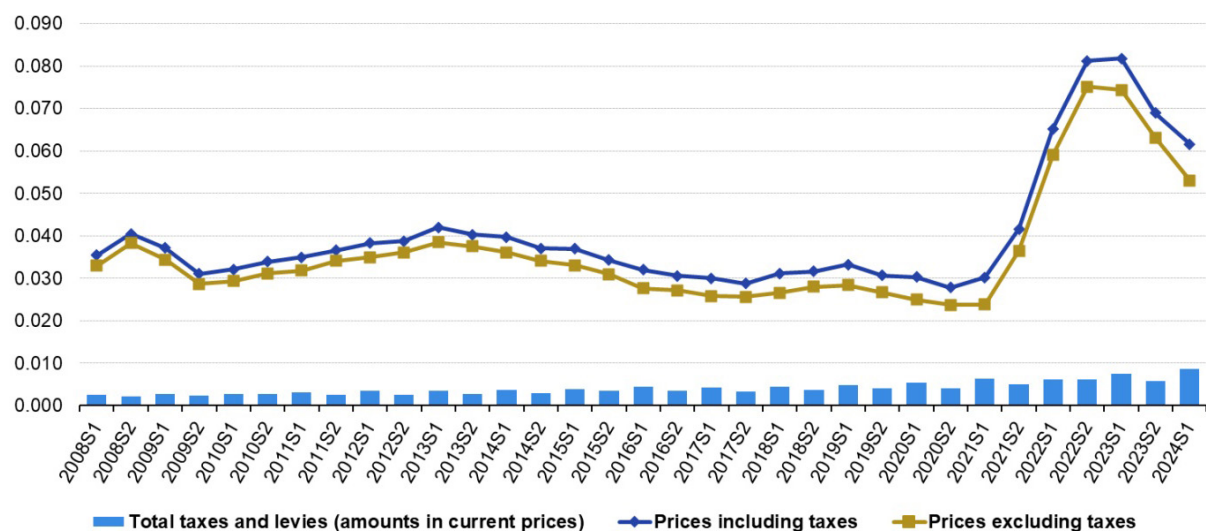


Fig. 3. Development of natural gas prices for non-household consumers (European Commission, 2024).

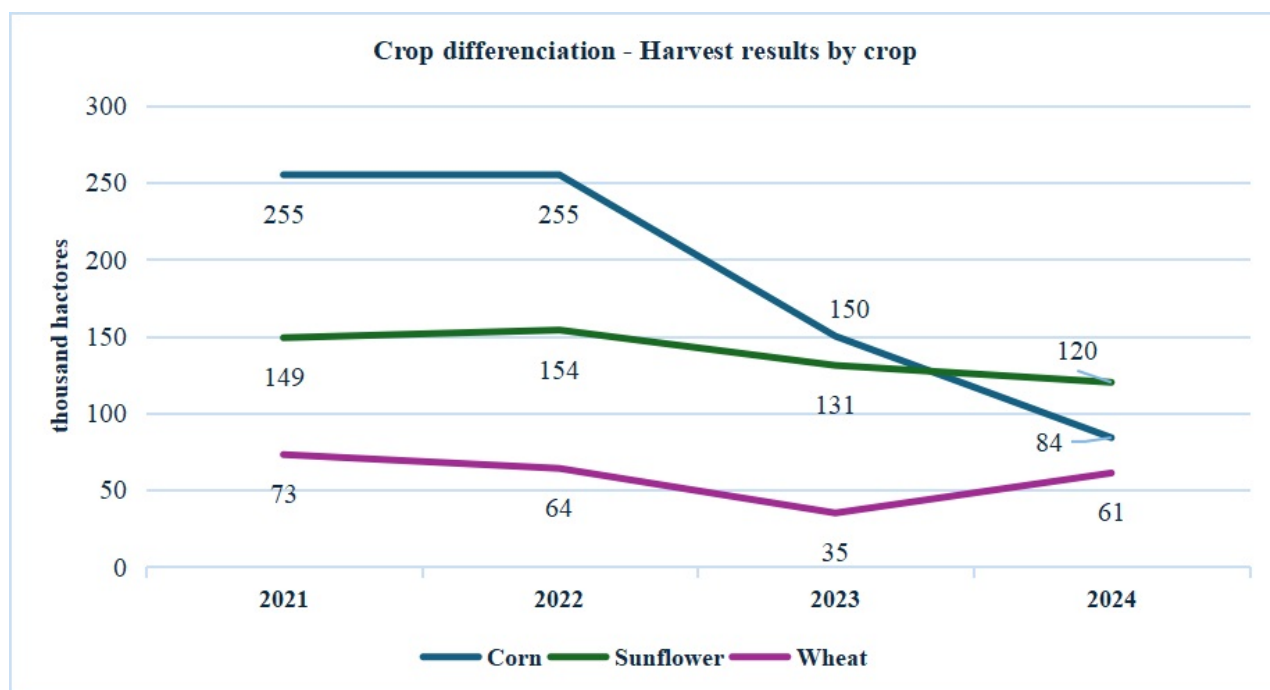


Fig. 4. Kernel's adjusted crop strategy (Kernel, 2021a; 2022a; 2023a; 2024b).

ciency, depending on specialized infrastructure and large-scale seaborne transport. This complexity complicates alternative export routes, with no viable options for bulk shipments. Fig. 4 shows that sunflower seeds emerged as the favoured crop compared to corn and grain in the following years.

Kernel's strong crushing margins highlight its strategic preference for sunflower seeds, which are less resource-intensive and better suited to wartime constraints. This reflects the company's ability to optimize resources in a volatile environment, demonstrating the resilience and adaptability of its business model. Aligning operations with

limited fertilizer and farmland acreage highlights flexibility under pressure.

Continuous attacks on Ukraine's energy infrastructure have caused blackouts that severely disrupt operations, particularly oil processing, which uses 70% of the company's electricity. These outages also affect silos, export terminals, and rail logistics, causing delays and export halts (Kernel, 2021a, pp. 5–6). To counter these challenges, Kernel expanded its pre-war investments in co-generation units and, in 2022, added diesel generators at key crushing sites to strengthen energy resilience. A direct power bridge between port facilities and the Chornomorsk co-generation

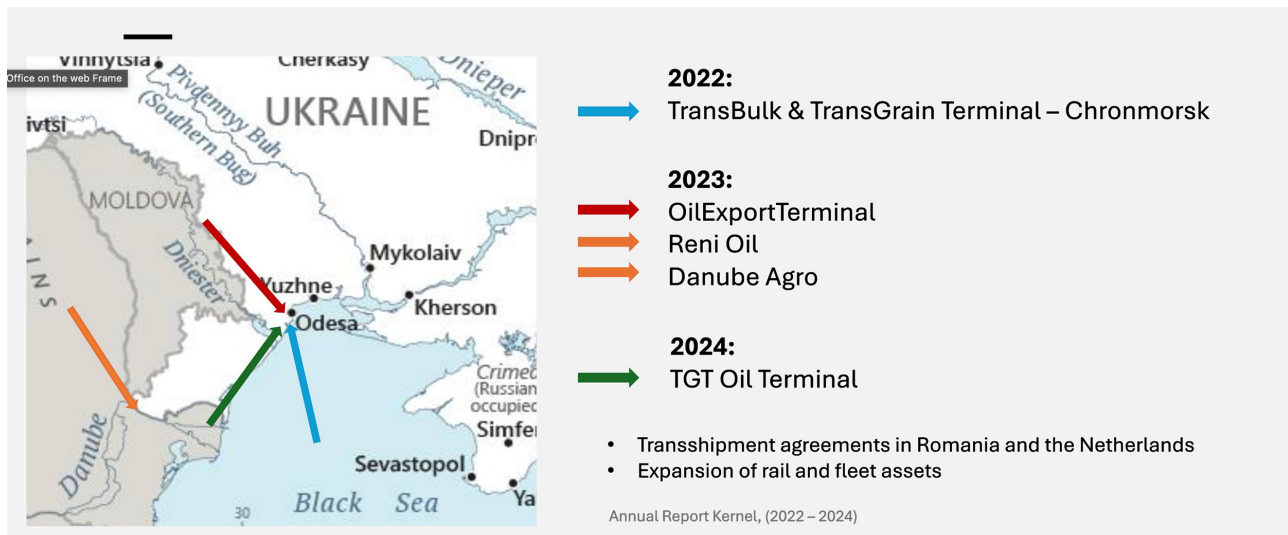


Fig. 5. Kernel's diversification of export routes (Kernel, 2022a; 2023a; 2024b).

heat and power plant stabilized operations (Kernel, 2022a, pp. 27, 210). By 2024, six crushing plants were equipped with co-generation units, underscoring the company's commitment to resilience and continuity as a reliable supplier (Kernel, 2023a, p. 7).

Taras Gagalyuk describes Kernel's pre-war organizational structure as inherently flexible, needing minor wartime adjustments. Decision-making was decentralized, allowing local managers to spend within limits, while procurement of essential inputs and finances remained centralized. This balance gave access to essential resources, maintained local agility, helped navigate market disruptions, and ensured supply chain stability. The hybrid structure, reflected in Kernel's annual reports, enhances efficiency and engagement through a Key Performance Indicator (KPI) system that aligns employee and team objectives with company goals (Kernel, 2020; 2021a; 2022a; 2023a; 2024b). Combining decentralized decisions with centralized control, Kernel boosts adaptability and responsiveness, strengthening its resilience under crises.

Since 2022, Kernel has proactively diversified export routes, employing rail and truck transport across the Ukraine-EU border and transshipping via Danube River ports. Fig. 5 illustrates the diversification of these export points. Given the smaller oil export volumes, rail logistics has proven efficient. Investments in standardized tank containers and multimodal logistics have enhanced flexibility, while new transshipment facilities address rail gauge differences, reducing bottlenecks (Kernel, 2022a, p. 20; Gagalyuk, 2025). Control over the value chain, including railcar ownership, enables long-term logistics planning and facilitates coordination with Ukraine's state railway monopoly, underscoring Kernel's ability to ensure operational resilience and risk mitigation.

However, finding alternative routes for bulk commodities, like grain and sunflower meal, has been more

challenging. Although Kernel explored options, the volume and need for cost-efficiency limit feasible choices. The Danube River remains the primary export route, but its use is constrained by low port productivity and a shortage of vessels. To address this, Kernel has invested in barges, coasters, and handy-size carriers to improve Danube export efficiency (Kernel, 2022a). By 2023, the focus expanded to include Danube ports and rail deliveries to Romania's Constanta port. Kernel acquired terminals at the Reni port for the transshipment of vegetable oil and grain/sunflower meal and secured partnerships with operators at Izmail and Constanta to ease transport to Europe (see Figs. 6,7). To mitigate the risks of relying on single ports, Kernel further diversified by acquiring terminals in Pivdennyi and Chornomorsk (Kernel, 2023a; Gagalyuk, 2025).

In 2024, the company continued prioritizing these routes, expanding capacity, and investing in its fleet. Kernel secured vessels for river logistics and barges to maintain operations despite disruptions to Black Sea ports. This strengthens logistics infrastructure, providing access to multiple transshipment points, mitigating the blockade's effects, and positioning the company for growth and resilience (Kernel, 2024b).

In conclusion, the theory of three essential components applies to Kernel's resilience. The company has demonstrated resilience through strategic decisions and investments. Adaptability is shown in its shift in agricultural production focus, diversifying export routes, and investing in energy resilience. Balancing decentralized flexibility with centralized control ensures smooth operations despite disruptions. Proactive measures to address supply chain issues and strong relationships have positioned Kernel as a reliable player in the global agricultural market, evidenced by the repayment of US\$300 million in Eurobonds upon maturity in 2024.

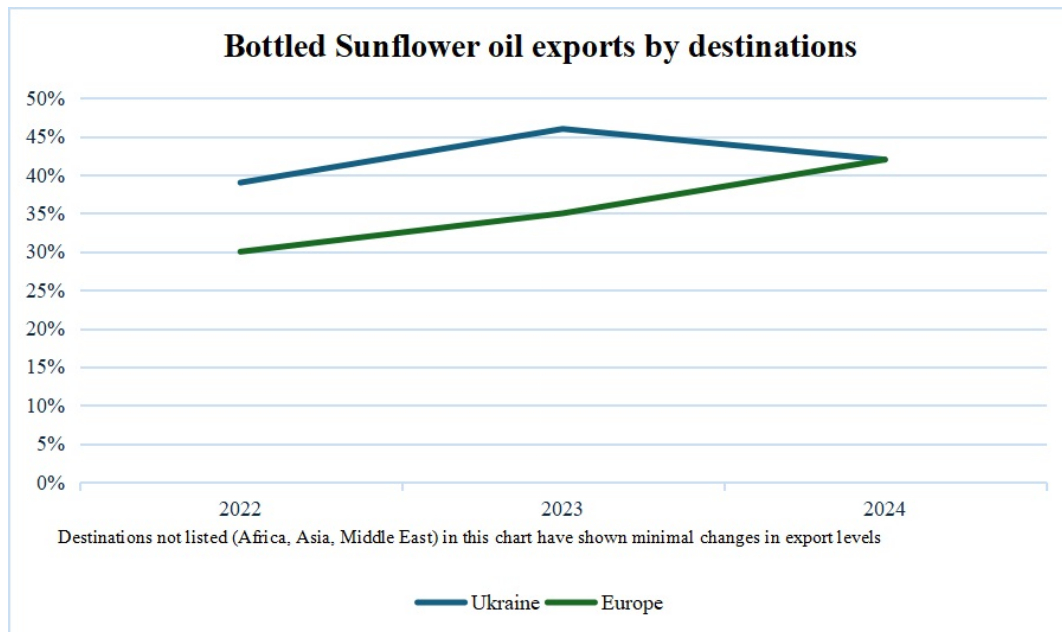


Fig. 6. Kernel's shift in bottled Sunflower oil export destinations due to conflict (Kernel, 2022a; 2023a; 2024b).

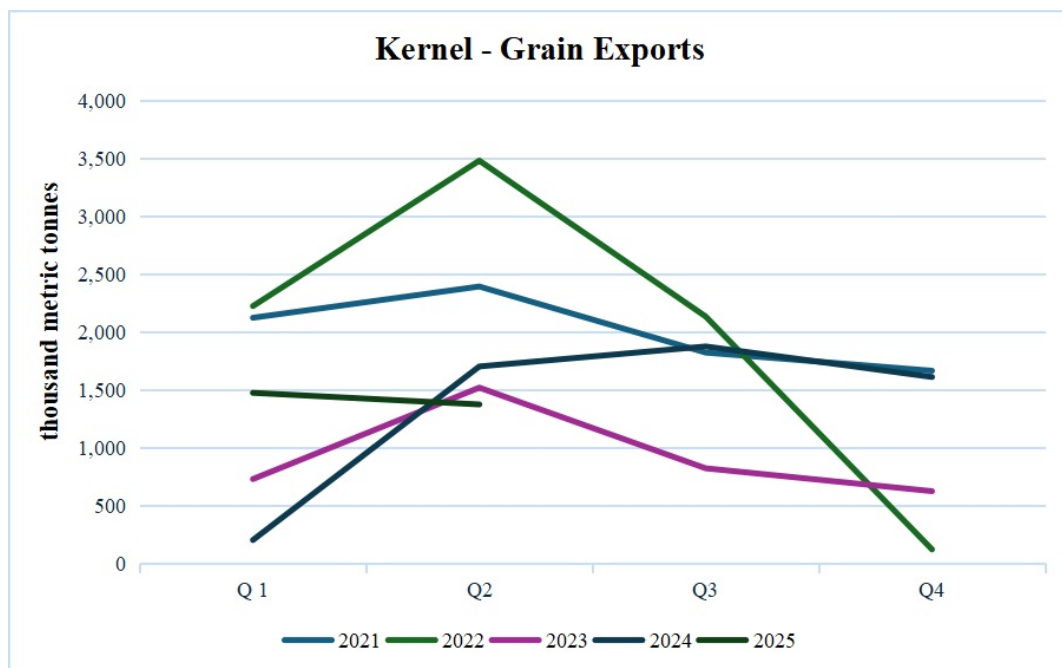


Fig. 7. Conflict influence on Kernel's grain export volumes (Kernel, 2021b; 2022b; 2023b; 2024c).

5.2 Astarta

The following section examines how Astarta achieved high responsiveness, built strong relationships, and ensured reliability through targeted adaptations and optimal use of existing resources, which are key dimensions that underpin its overall resilience.

5.2.1 Responsiveness

A comparison of frontline and operational maps shows that Astarta's key locations, including Poltava, Cherkasy,

and Zhytomyr, were particularly affected, as these regions were near the frontline, especially in the early stages of the war (see Figs. 8,9).

While Astarta reported minimal physical damage to its own assets (roughly 4000 hectares were temporarily disrupted in Chernihiv (Astarta, 2022c; 2023)) widespread destruction of infrastructure heavily strained its supply chain, especially its transport routes and input sourcing. Building on lessons from the 2014 annexation crisis, Astarta strengthened its risk management, recognizing that only di-

Map of Operations



Fig. 8. Astarta's Map of Operations 2022 (Astarta, 2023).

versification and leveraging internal strengths could secure sustainable operations (Astarta, 2022a). This approach included appointing a Director of Security and establishing a risk monitoring department in 2022 (Gagalyuk, 2025; As-

tarta, 2022b), embedding crisis management directly into strategic and operational processes.

Astarta rapidly advanced its energy resilience. Since 2013, its biogas plant has converted sugar waste into bio-

Map of Operations



Fig. 9. Astarta’s Map of Operations 2023 (Astarta, 2024b).

gas, supplemented by emergency generators and upgraded energy-efficient equipment. During the war, securing stable fuel supplies through long-term contracts became critical (Astarta, 2024b).

In upstream activities, Astarta swiftly adapted acreage to changing market and transport conditions. High export costs undermined grain profitability, prompting the company to expand oilseed and sugar beet production while re-

ducing maize and wheat (Astarta, 2024b). Long-term contracts with landowners and suppliers secured raw material flows despite geopolitical uncertainties.

In midstream logistics, the company took the initiative and invested in road infrastructure, building nearly 90 km of gravel roads and repairing 25 km of public roads with local authorities. To boost raw material transport efficiency, Astarta acquired 22 self-propelled loaders (Astarta, 2023).

Exports of agricultural products by transportation type, mln t

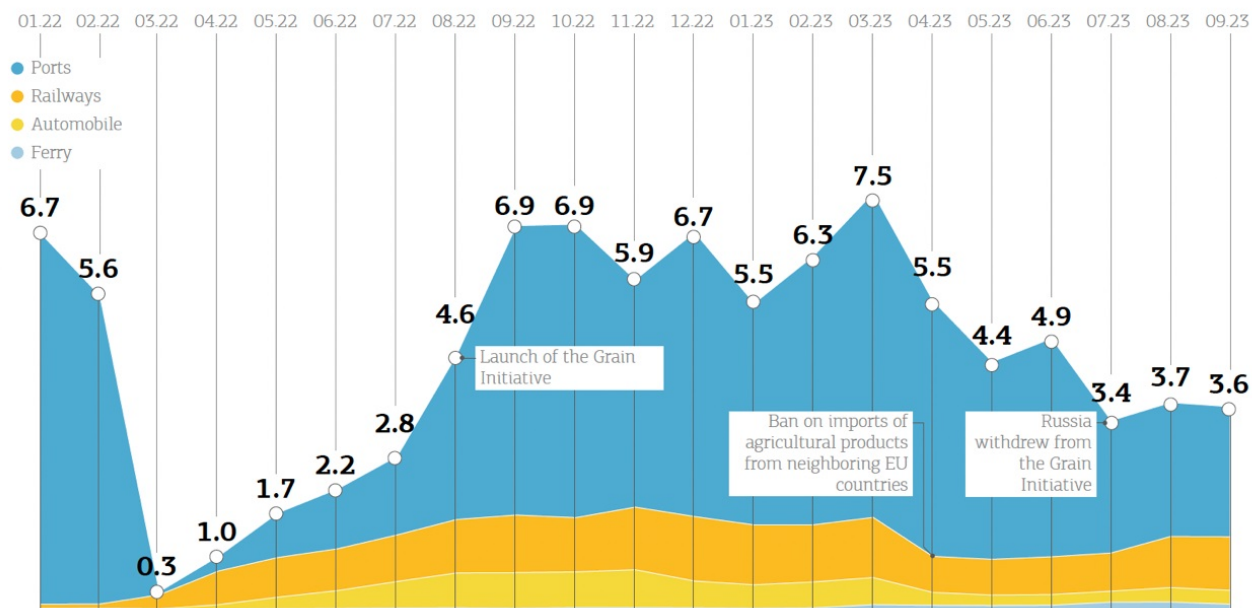


Fig. 10. Astarta's Export Routes (Astarta, 2023; 2024b).

The downstream segment saw the most drastic and rapid response. When sea exports collapsed in early 2022 due to port closures, EU border restrictions, and infrastructure attacks, Astarta quickly diversified its logistics. EU-backed initiatives, such as the Grain Initiative and Solidarity Lanes, helped but came with logistical challenges and raised costs by 60–70% (World Bank, 2023). Astarta expanded Danube transport via Izmail and Reni, deploying 200 wagons for rail exports to neighbouring countries, and operating its fleet of 15 grain wagons and an oil tanker covering a fifth of total transport to Lithuania and Poland. By 2023, the company refocused on large cargo ships and distant markets like Spain, Indonesia, and China, gradually restoring 85% of its transport to sea and exporting to 44 countries (see Fig. 10) (Astarta, 2024c). This flexibility underscored Astarta's capability for rapid downstream adaptation.

5.2.2 Relationships

Before the war, Astarta maintained diverse, stable relationships across its value chain—from upstream suppliers to midstream production partners and downstream customers. Guided by its “moral obligation” to embed social responsibility throughout operations (Astarta, 2025c), the company introduced a Supplier Code of Social Responsibility in 2021 to strengthen responsible and resilient partnerships (Astarta, 2022c).

Upstream, Astarta sourced agricultural inputs from local and international suppliers, partnering with independent farmers via its Centre for Partnerships (Astarta, 2022c), and relied on strategic stockpiling and self-managed farmland

for input security. The 2022 war damaged one-third of Ukraine's farmland, disrupting this network (FAO, 2023). Despite higher costs and delays, Astarta shifted to domestic suppliers, favouring European and local sources over Belarus and Russia. It also expanded partnerships with Ukrainian seed producers and machinery manufacturers, diversifying its supplier base to sustain operations (World Bank, 2023; EBRD, 2023).

Midstream, Astarta's processing and transport activities relied on strong employee and partner relationships, which faced pressure from operational disruptions and workforce displacement. The company countered shortages with financial support, job security measures, retraining, and empowering women in traditionally male roles (Astarta, 2023). Humanitarian initiatives, such as “Common Help UA” (March 2022), further strengthened internal and external trust, supporting over 716,000 Ukrainians and bolstering workforce and community resilience (Astarta, 2023). Collaborating with international organizations like the World Food Programme enhanced Astarta's reputation and strategic positioning for post-war recovery (Astarta, 2024d).

Downstream, the war forced Astarta to reorient export strategies to European markets due to proximity and favourable trade agreements (Astarta, 2022c). Collaborations with transport partners secured alternative routes, stabilizing customer relationships despite cost pressures (OECD, 2023). Access to international financing, including a US\$30 million package from the EBRD (European Bank for Reconstruction and Development) and Clean Technology Fund (2023), provided vital capital for oper-

ations. Institutional stakeholders, such as the Ukrainian government and international organizations, played critical roles, especially when the Black Sea Grain Initiative collapsed, prompting alternative export and storage solutions like grain bags supplied by the Food and Agriculture Organization of the United Nations (Gagalyuk, 2025).

Overall, Astarta's resilience is deeply rooted in its robust stakeholder network. By rapidly adjusting upstream, midstream, and downstream relationships, the company has maintained operational continuity and positioned itself for long-term adaptability in the face of severe disruption.

5.2.3 Reliability

Astarta has demonstrated reliability in its supply chain through quick logistical adjustments and technology integration, particularly AgriChain (Gagalyuk, 2025). Founded in 2017, AgriChain aims to improve operational efficiency and transparency. Before the war, these digital solutions improved planning and resource allocation, increasing efficiency across the value chain. During the war, they were crucial for maintaining performance and quality. Strong stakeholder relationships and digital farm management systems also enhanced Astarta's stability.

Within Astarta's upstream and midstream activities, digital farm management was central to maintaining operational resilience. AgriChain Land, an online land management system, facilitated efficient coordination of land use rights, acreage, and ownership, ensuring continuity, particularly in times of crisis. In addition, AgriChain Farm optimized agricultural operations through remote access, enabling flexible adaptation to shifting environmental and market conditions. AgriChain Scout further strengthened risk management by continuously monitoring field conditions, allowing for the early detection of threats such as pest infestations or weather-related crop failures (Agri Chain, 2025; Astarta, 2025b).

Besides establishing novel logistics routes and forming key partnerships, the digitalization of logistics and warehouse processes in downstream activities is crucial for enhancing the efficiency and stability of Astarta's value chain. AgriChain Logistics improved transport coordination, minimizing supply disruptions by optimizing delivery routes, vehicle capacities, and scheduling. AgriChain Barn further streamlined warehouse operations, ensuring efficient stock control and resource utilization while reducing losses (Agri Chain, 2025).

Developed before the war, the AgriChain digital tool bolstered Astarta's operational stability and resilience. Its integration optimized data-driven decision-making, resource efficiency, and supply chain transparency, enabling rapid adaptation to volatile conditions. By commercializing and customizing AgriChain, which was modified by 50% to meet customer needs, Astarta transformed it into a strategic, revenue-generating asset, making its sale a critical resource of resilience (Gagalyuk, 2025). This customization

and fostering sustainable working conditions strengthened Astarta's operational stability and that of other Ukrainian agribusinesses.

In summary, Astarta's ability to maintain supply chain reliability during crises underscores the vital role of digitalization, agile logistics, and strong stakeholder collaboration. Moreover, the successful deployment and commercialization of the AgriChain platform during the war further exemplify how rapid adaptation and effective asset utilization reinforce the company's overall resilience.

5.2.4 Resilience

Astarta's wartime resilience was not a mere reaction to external shocks but a product of long-term strategic planning and expanding pre-existing resources. Maintaining stability and competitiveness amid unprecedented disruptions was rooted in two primary pillars: strong partnerships across its supply chain and the advanced digitalization of its agricultural operations through AgriChain. Its flexible decision-making and diversification strategies reinforced resilience, ensuring sustainable operations amid volatility.

Strong relationships with key stakeholders such as financial institutions, business partners, and international organizations have significantly bolstered resilience. These partnerships have ensured liquidity and provided alternative supply chain solutions, enabling continued production and distribution despite logistical disruptions. Securing funding during crises has supported investments in essential infrastructure, workforce stability, and operational adaptations, mitigating financial distress. Collaborations with global entities like the World Food Programme further reinforce a company's role in food security and solidify its market position and strategic importance.

The second cornerstone of the resilience strategy was an early investment in digital technologies. Digital solutions like AgriChain became essential during the war for maintaining operational continuity and supply chain stability by enabling real-time monitoring, remote decision-making, and optimized logistics. Beyond internal benefits, the commercialization proved crucial; offering the platform to external market participants bolstered the resilience of Ukraine's agricultural sector and generated additional revenue streams, reinforcing financial stability and sustained competitiveness in an uncertain environment.

This resilience is further reflected in key financial and operational performance indicators. 2022 Astarta reported revenues exceeding €500 million, marking the highest level in its public history despite the ongoing war (Astarta, 2023). Additionally, the company ensured workforce stability through initiatives such as "Resilience Stations", which provided essential resources for employees and their families. Beyond immediate crisis response, Astarta remained committed to its long-term sustainability goals, maintaining its decarbonization target of reducing greenhouse gas emissions by 44% by 2030 (Astarta, 2024a).

Astarta showed resilience beyond financial stability and digital infrastructure by strategically shifting in response to market shifts. Its diversification, especially during wartime trade restrictions and logistical challenges, exemplifies this adaptability. The company shifted from traditional grain exports to oilseed cultivation, leveraging existing infrastructure. This transition was an expansion of capabilities, not an improvised crisis response, reducing reliance on vulnerable markets and creating new revenue streams. The ability to implement diversification strategies under such challenging conditions underscores Astarta's long-term resilience, proving its capacity to anticipate and mitigate risks through proactive adaptation.

Astarta's ability to navigate wartime complexities highlights the practical application of resilience within the 4R framework—responsiveness, reliability, relationships, and resilience. These key resources—technological innovation, strategic partnerships, adaptive capabilities, and diversification strategies—are critical pillars of resilience, ensuring Astarta's sustained competitiveness in an increasingly uncertain environment. The company's case underscores the importance of proactive planning and resource integration in securing long-term supply chain sustainability, offering valuable insights for academia and industry in crisis management and supply chain resilience.

5.3 Comparison

Astarta and Kernel adopted fundamentally different strategic approaches both prior to and during the war, which shaped their respective resilience to extreme shocks such as port blockades, infrastructure damage, and logistical bottlenecks. These differences stem from their distinct business models, organizational scales, market orientations, and resource configurations. Any direct comparison must acknowledge these foundational differences, from asset intensity and market roles to the types of resources each company could mobilize.

As a large-scale, export-oriented agribusiness, Kernel was highly exposed to disruptions in international logistics, particularly maritime transport. Its resilience was initially constrained by its reliance on physical assets like silos, terminals, and logistics hubs, which became liabilities under blockade conditions but were later repurposed through alternative export corridors via the European Union. Astarta, in contrast, operated a diversified, vertically integrated, and more domestically oriented model. Its resilience depended on maintaining coherence across a fragmented national supply chain, leveraging organizational flexibility, digital infrastructure, and financial stability to reallocate focus across business segments.

Kernel's wartime response showcased strategic agility and rapid organizational transformation. It transitioned to crisis management, mitigated financial risks, and restructured logistics and product strategies, including shifting export routes through the Danube and adjusting crop portfolio.

Astarta focused on internal stabilization, reallocating production toward oilseeds and sugar beets, investing in energy self-sufficiency (biogas, emergency power), and upgrading midstream infrastructure. These measures reflected a resource optimization strategy to sustain domestic operations despite rising costs and supply risks.

The companies also diverged in their approaches to stakeholders. Kernel pursued financial and operational alignment, maintaining resilient upstream partnerships, engaging creditors, and attracting international financial partners. Internally, it emphasized employee-centred practices and capability development; externally, it leveraged indirect networks and voluntary support mechanisms. Astarta institutionalized its stakeholder engagement through formal governance, such as its Code of Social Responsibility for Suppliers and its Centre for Partnerships with Independent Farmers, while strengthening trust through humanitarian initiatives like collaborations with the World Food Programme. These contrasts highlight Kernel's emphasis on financial leverage and strategic integration versus Astarta's focus on social embeddedness and stakeholder trust.

Kernel's reliability benefited from vertical integration, pre-war digital preparedness, and coordination mechanisms like Open Agribusiness, ensuring continuity despite disruptions. Astarta leveraged early investment in the AgriChain platform for real-time monitoring, remote decision-making, and enhanced supply chain visibility. Kernel relied on organizational depth and structural integration; Astarta's was driven by digital transformation and technological foresight.

Both companies ultimately demonstrated resilience through different pathways. Kernel's strategy revolved around organizational agility, energy resilience, and multimodal logistics optimization, allowing it to recover from infrastructure damage and maintain financial stability. Astarta's resilience stemmed from pre-crisis strategic planning, innovation-led transformation, and strategic diversification, enabling it to achieve strong revenue streams despite extreme conditions.

Agricultural sector leaders, experienced in managing weather, pest, and market uncertainties, applied similar risk management frameworks, of which many were developed after the 2014 geopolitical crisis, to navigate wartime volatility. Financial support, particularly from international partners, was critical for both companies to maintain liquidity, restructure logistics, and adapt supply chains.

Existing assets played a dual role: providing operational stability and serving as a basis for securing external support. Kernel's expertise in sunflower processing and crushing capacity guaranteed profitability even after territorial losses, while Astarta's diversification into biogas and energy efficiency helped counteract rising costs. Both companies adapted logistics to overcome disrupted export routes: Kernel focused on expanding Danube port access and optimizing land-based exports, while Astarta

Table 3. Core strategic actions across the cases.

Dynamic capabilities	Strategic actions in the cases
Sensing	• Identification of emerging threats (e.g., logistics blockades, energy shortages) • Awareness of new opportunities (e.g., alternative routes, digital tools)
Seizing	• Rapid decision-making and asset mobilization • Financial restructuring and strategic diversification
Transforming	• Reconfiguring supply chains, logistics, stakeholder relationships • Institutionalizing adaptive processes and structures

strengthened domestic logistics to reduce reliance on maritime routes, despite higher costs.

Digitalization was another common resilience factor. Kernel's investments in crop production technologies and digital solutions improved productivity on reduced farmland. Astarta's AgriChain platform enhanced supply chain management, increasing adaptability and efficiency under pressure. Strong external relationships were crucial in stabilizing operations, especially with suppliers and financial partners. Astarta's partnerships with independent farmers and Kernel's established supplier networks exemplified how relationship management reduced exposure to geopolitical disruptions. Internally, both companies prioritized employee support, recognizing that labour shortages due to war-related factors posed long-term operational risks.

6. Discussion

Adaptive management choices and structural strengths like strong leadership, financial stability, relationships, and operational flexibility drove Astarta and Kernel's resilience during the war. Although both companies depend on the same fundamental resources, their unique business models influence the management of resources during disruption (see Table 3). In sensing, both companies leveraged digital tools and prior crisis experience to anticipate disruptions. However, Kernel focused more on global logistics and financial risks, while Astarta concentrated on domestic supply chain vulnerabilities and energy dependencies. Both companies mobilized resources toward energy resilience and digitalization. Astarta showed sensing abilities, using early observations and past lessons, for example from the 2014 crisis, to inform decisions. By securing international financing, identifying new routes, international markets, and the opportunity to commercialize in-house digital infrastructure (AgriChain), Astarta showcased remarkable seizing abilities under wartime constraints. Kernel prioritized alternative export routes and financial restructuring, whereas Astarta invested in local supply chains, biogas, and stakeholder trust.

In transforming, Kernel restructured around agile, export-oriented logistics and reduced asset intensity, while Astarta deepened its vertical integration and social embeddedness, enhancing domestic resilience. Despite their differences, both companies converged on resilience as a goal through rapid adaptation, digital foresight, and stakeholder-

centred strategies. Kernel demonstrated operational responsiveness and strategic agility through proactive crisis management, rapid infrastructure reconfiguration, financial risk mitigation, and logistics adaptation. Its resilience strategy was anchored in sensing emerging risks, seizing financial, logistical, and strategic opportunities such as crop shifts, and transforming structures to maintain continuity in uncertain environments, which also enabled stakeholder trust amid disruptions. These efforts highlight Kernel's ability to cultivate new partnerships under duress, demonstrating strong capabilities in seizing and transforming relational assets. Kernel prioritized export flexibility and oilseed processing, while Astarta emphasized domestic supply chain stability and diversification.

Both required financial support and strong relationships, including nurturing new connections and reinforcing existing ones. This highlights that resilience is a continuous journey shaped by strategic decisions, available resources, and external circumstances, stressing the importance of adaptability during crises. Each company drew on its existing assets, modified logistics, and employed technology to overcome challenges. Comparative findings with Astarta further reinforce this perspective: while Kernel focused on infrastructure and financial adaptation, Astarta pursued diversification, digital innovation, and stakeholder realignment. Both companies exemplify active, dynamic adaptation that goes beyond passive resilience, leveraging disruption as an opportunity to strengthen competitive advantage in a volatile wartime environment. Their actions align with the dynamic capabilities framework (Teece et al., 1997; 2016), which emphasizes a firm's capacity to adapt by sensing, seizing, and transforming in response to environmental volatility. Kernel and Astarta demonstrated strong dynamic capabilities in sensing, seizing, and transforming under extreme wartime conditions, each using a distinct approach shaped by their business models.

This aligns with Koronis and Ponis (2018), who frame resilience as structural preparedness and a cultural and social process, relying on trust, communication, and learning. Kernel and Astarta leveraged social capital through strong supplier networks, stakeholder trust, and employee engagement as critical enablers for their adaptive strategies, echoing Scholten et al. (2014) on the importance of relational antecedents. Both companies illustrate Ivanov's (2021) adaptation strategies: Kernel demonstrates substi-

Table 4. Integrated conceptual mapping of 4Rs and dynamic capabilities.

4R	Dynamic capabilities	Explanation
Responsiveness	Sensing and Seizing	The ability to detect disruptions and opportunities early (Sensing), and act quickly through decision-making and resource mobilization (Seizing), enables fast and flexible responses.
Reliability	Seizing and Transforming	Strategic actions like financial restructuring and process optimization (Seizing), along with long-term system reconfiguration (Transforming), ensure consistent performance and delivery.
Relationships	Transforming and Sensing	Reconfiguring stakeholder networks and maintaining trust (Transforming), supported by awareness of stakeholder needs and external shifts (Sensing), strengthens relational capital.
Resilience	Sensing, Seizing, Transforming	Resilience is the cumulative result of detecting risks, acting decisively, and adapting structurally to absorb and recover from shocks.

tution and repurposing by shifting export corridors, while Astarta leverages scalability and intertwining through domestic supply chain strengthening.

We advance the state of research by addressing a major underexplored area: resilience under prolonged, active geopolitical disruption. While prior studies (e.g., Ivanov and Dolgui, 2020; Kamalahmadi and Parast, 2016) focus on resilience in the context of natural disasters, pandemics, or short-term crises, few have qualitatively examined how companies operate under the sustained, layered shocks of active warzones—a context where physical, financial, digital, and human resources are simultaneously under threat. Most frameworks (like the 4R or Ambulkar et al.'s resilience scale) assume disruptions are discrete events rather than chronic conditions, making the Ukrainian wartime context particularly valuable for advancing theory. Labour loss in particular takes a qualitatively different form in wartime than in pandemic or disaster contexts, where workforce disruption is largely temporary and reversible. Active conflict combines indefinite military mobilization, with attendant legal obligations for employers, and large-scale emigration, producing irreversible demographic shifts that fundamentally alter the available labour pool. Both Kernel and Astarta hint at adaptive responses including reskilling and the recomposition of workforces along gender lines, yet the dynamic capabilities literature has yet to theorize labour transformation of this kind as a distinct resilience capability rather than a retention problem.

Furthermore, the dual focus on structural adaptation (physical assets, logistics, energy systems) and relational or social mechanisms (trust networks, humanitarian engagement, stakeholder governance) adds depth to the evolving understanding of resilience as a multidimensional, systemic, and dynamic capability, as highlighted by Hillmann and Guenther's (2021) synthesis of resilience attributes. This case study complements and extends recent work by Kantaruk Pierre et al. (2025), who emphasize relational capital in Ukrainian exporting SMEs, by showing how much larger agribusinesses integrate relational capital and large-scale resource reconfiguration.

In short, the cases of Astarta and Kernel reinforce the argument that resilience in high-turbulence environments is not merely about recovery but about continuous sensing, adaptation, and transformation, which are the capabilities emphasized in dynamic capabilities theory (Teece et al., 1997). However, they also highlight an important theoretical gap: how resilience strategies play out under prolonged warfare conditions, where companies must sustain operations, morale, supply chains, and stakeholder relationships over years, not weeks or months. By addressing this, the chapter helps bridge the gap between abstract resilience frameworks and the lived realities of companies navigating active conflict.

The case studies show how Kernel and Astarta exemplify sensing by rapidly identifying new risks (logistical blockades, energy shortages, labour disruptions) and opportunities (alternative export routes, energy self-sufficiency, digital tools), aligning with the responsiveness element of the 4R model. They display seizing through decisive action—securing financial backing, reallocating production, diversifying supply chains—thus strengthening both robustness and redundancy to absorb and buffer against shocks. Critically, they transform over time by reconfiguring their asset base, organizational structures, and stakeholder relationships, deepening their systemic resilience (see Table 4).

Hypothesis 1: Organizational resilience, as a stabilizing feature that ensures survival in times of war, results from the combined deployment of the dynamic capabilities sensing, seizing, and transforming.

Hypothesis 2: The 4Rs can be interpreted as outcomes and performance dimensions that are enabled by organizational dynamic capabilities.

We thus advance the integration of the 4R framework with dynamic capabilities theory by demonstrating how the dynamic processes of sensing, seizing, and transforming map onto the operational strategies companies deploy across Resilience, Responsiveness, Reliability, and Relationships dimensions as survival strategies under conditions like war.

7. Conclusions

Our paper contributes to the resilience and dynamic capabilities literature by addressing a key gap: the lack of qualitative insights into how companies sustain operations under prolonged, severe geopolitical disruptions, such as active warfare. While prior research has advanced frameworks around resilience in the context of short-term shocks, including natural disasters, pandemics, and supply chain disruptions, it has largely overlooked the compounded, chronic pressures that companies operating in active conflict zones face. By examining the wartime strategies of Astarta and Kernel, this study extends dynamic capabilities theory, illustrating how resilience is built not only through sensing, seizing, and transforming, but also through the integration of physical, digital, financial, and relational resources over an extended crisis horizon. It highlights that resilience is a multidimensional, systemic capability, shaped by context-specific configurations of assets, stakeholder relationships, and adaptive strategies. In doing so, we advance the understanding of resilience as an actively cultivated, evolving capability, underscoring the importance of both organizational agility and social embeddedness in navigating extreme, long-duration disruptions.

Our paper adds a rare, empirically grounded look at how these capabilities function not in isolated or short-lived crises but under sustained, war-induced disruption to dynamic capability research. Existing research broadly examines dynamic capabilities in market turbulence, technological change, or acute disruptions. However, few studies explore how companies maintain adaptive capacity, strategic flexibility, and long-term viability when operating under protracted geopolitical violence. By bridging dynamic capabilities theory with the granular, operational mechanisms of the 4R framework, this paper highlights how resilience is not just a conceptual outcome but an active, ongoing process of cross-level resource reconfiguration and relational management—a contribution that enriches both resilience theory and the dynamic capabilities literature, especially in contexts of extreme geopolitical disruption. These hypotheses warrant further empirical testing.

The findings carry concrete implications for managers operating in volatile geopolitical environments beyond Ukraine. The cases suggest that the critical managerial investment is in the organizational conditions that enable rapid reconfiguration when disruption arrives. These include decision-making structures that combine centralized resource authority with local operational autonomy, allowing fast responses without strategic incoherence; stakeholder relationships with suppliers, creditors, and international partners that are maintained continuously rather than activated transactionally in emergencies; and digital infrastructure that enhances visibility and flexibility across the value chain under pressure. Prior experience of smaller-scale disruption, in this instance the 2014 crisis, materially shaped adaptive capacity in 2022. This suggests that orga-

nizations should treat past crises not merely as events to recover from but as organizational learning opportunities that build the sensing and seizing capabilities on which future resilience depends.

Nevertheless, our research also has limitations. The absence of personnel interviews restricts insights into internal decision-making, as the analysis relies on publicly available information. Furthermore, the ongoing war creates a constantly shifting landscape, making definitive conclusions difficult. Geopolitical and economic uncertainties continue to shape supply chains, logistics, and financial strategies. Lastly, resilience is context-dependent; strategies effective for Astarta and Kernel may not apply to companies in other industries, emphasizing the need for case-specific analysis. Despite these limitations, this study highlights the value of structured resilience frameworks, such as the 4R framework, in evaluating corporate adaptability. Further research is needed to examine the long-term impact of digitalization and management on resilience. Understanding how companies navigate labour shortages, external market dependencies, and evolving geopolitical risks could provide deeper insights into crisis management strategies.

Availability of Data and Materials

Data is available from the authors upon request.

Author Contributions

JM and AS performed the qualitative data collection and analysis. AMH introduced the theoretical frameworks for interpretation. All authors jointly crafted the article. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

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Conflicts of Interest

The authors declare no conflicts of interest. AMH serves as a member of the Editorial Board of this journal. We declare that AMH had no involvement in the peer review process of this article and has had no access to information related to its peer review. Full responsibility for the editorial process of this article was delegated to the Piotr Trapczynski.

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