

Russia's full-scale military invasion of Ukraine led to the occupation of a large part of the territory of Ukraine, active warfare in the East and South parts of Ukraine, activation of military logistics, rapid development of humanitarian logistics. At the same time, non-kinetic warfare, destruction of functional society, attack on the logistics infrastructure and supply chain disruptions are observed. Civil Logistics and Supply Chains acquired the specifics of working in wartime conditions – constant danger, brittle, anxious, nonlinear, incomprehensible. The following two research questions were asked in the paper. First – how was it possible to ensure the functioning of the supply chains, overcoming logistics obstacles. Second – how are the events unfolding and what strategic consequences will the war have for Ukraine's logistics landscape. To answer the first research question, the focus group method was used (the representativeness of which was ensured by top managers of logistics companies). The answer to the second research question was obtained by the method of summarizing and systematizing figures and facts about the events that have a direct impact on the logistics industry of Ukraine, supplemented by the method for graphical visualization of research results – Futures-Wheel. As a result, the highlighted strategies that were used in managing supply chains when facing logistics obstacles caused by war can potentially be useful in other crises. Futures-Wheel presents an overall picture of the impact of war on the logistics landscape of Ukraine as well as a vision of the future

Keywords: supply chain resilience, civil logistics, russia-Ukraine war, logistics landscape, Futures-Wheel

UDC 005.87:005.932-021.484

DOI: 10.15587/1729-4061.2023.272877

DEFINING SUPPLY CHAIN RESILIENCE DURING WARTIME

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Received date 01.11.2022

Accepted date 12.01.2023

Published date 28.02.2023

How to Cite: Krykavskyy, Y., Chornopyska, N., Dohun, O., Hayvanovych, N., Leonova, S. (2023). Defining supply chain resilience during wartime. *Eastern-European Journal of Enterprise Technologies*, 1 (13 (121)), 32–46.

doi: <https://doi.org/10.15587/1729-4061.2023.272877>

1. Introduction

The decades-old supply chain (SC) management practices, such as just-in-time, lean, outsourcing, etc., have proven effective and have become a kind of measure of supply chain competitiveness. However, they put enormous pressure on operations and the stability of the environment. And, therefore, increase the vulnerability of supply chains to disruptions. According to research, even before the global Covid-19 pandemic, approximately 81 % of businesses worldwide had at least once a disruption in SC during the year with an average loss of USD 3 million [1]. Therefore, the need to prepare an action plan in case of disruption is of paramount importance in the management of SC.

The ability to survive, adapt, and develop in conditions of turbulent changes that cause disruptions, disturbances is a sign of the stability of SC. The environment will never be the same again. Volatility, uncertainty, unpredictability will increase. Therefore, research on the development of supply chain resilience in the face of unforeseen shocks and rapid changes is relevant.

2. Literature review and problem statement

Analysis of research and publications shows that early publications on the topic of Supply Chain Resilience (SC re-

silience) appeared about 18 years ago. The increase in publication activity in the international scientometric database Scopus was significant in the period of 2020–2022 (65 % of all papers): 92 – in 2020, 184 – 2021, 275 – 2022.

In study [2], about 250 sources were analyzed. In most papers, factors influencing disruptions in SC are grouped into external and internal, depending on different types of risks, on the impact on individual spheres, on the nature of origin. It is indicated that SCs are becoming more global and complex, so the impact of various disruptions is increasing. The study outlines the importance of building resilience by long-term partnerships, public policy, an IT approach, and a culture of emergency preparedness. The authors of [3] analyzed 94 articles over 12 years on the resilience of SC, structured the factors influencing the resilience of SC by year and industry. Scientists filled the gap of their predecessors – they devised an integrated approach to quantifying the resilience of the network covering SC in the context of social and physical networks. Another approach was revealed using a case study [4], in which managers of companies from different countries were interviewed to build basic links between risk and resilience. The authors identified 180 factors formed in 24 concepts and linked by connections into a fuzzy cognitive map. However, the necessary measures and strategies are not sufficiently disclosed and need to be investigated, as well as what results should be expected when implementing them.

Thus, in these works, the problem of SC resilience is closely related to changes in the environment due to the action of certain factors but the tools for managing accompanying risks in SC are not sufficiently developed.

In study [5], the author analyzes sources that describe the risks of SC and the resilience of SC. A survey of 500 companies revealed closely related aspects that contribute to the formation of SC resilience, namely supplier participation in product development, SC design, and risks. The value of the study is in the theoretical model of relationships and in its application in practice in the management of SC risks. The limitation of [5] is that there are no surveys that investigate the participation of the supplier. The researchers in work [6] applied a systematic review of the literature and were among the first to investigate the relationship between stability and resilience, which helps clarify concepts, synergies, and trade-offs. The results from [6] are valuable for formulating the recommendations of this study since resilience is also disrupted under conditions of war. Study [7] focuses on the development and testing of an integrated theoretical framework that examines the relationship between the dynamism of SCs, the focus on disruptions in SCs, the stability of SCs, and financial indicators. The results of a survey of 227 companies in the United States indicate that the capital of the relationship can significantly contribute to the resilience of SC, acting as an intermediary between the innovation process and resilience. However, for more relevant results, it is necessary to interview companies in different countries.

That is, studies are also reported that rely on a review of scientific sources and surveys. However, they do not characterize the relationships between different SCs and the mutual influence of factors when disruptions occur simultaneously in several different industries.

In scientific work [8], a review of 62 papers was carried out and a holistic structure was presented – the researchers proposed a mutually exclusive categorization of technologies for activating the Industry 4.0, which support the stability of SCs. This eliminates the gap in previous studies. It was found that visibility and speed are precursors to resilience, which are beginning to show better performance with the introduction of Industry 4.0. The value of the study is that scientists can analyze the resilience potential of underexplored technologies. Practitioners who are often looking for ways to mitigate disruptions in SC can use the structure to select the right technologies, and SC partners – to negotiate and collaborate. At the same time, the connections were empirically proved only partially, the strengths of the connections were not tested. Therefore, further research is important for the selection of priorities and the safe choice of technology in order to achieve specific goals of SC resilience under conditions of limited resources [8]. Owing to the theoretical model of OIPT (Organizational Information Processing Theory), study [9] contributed to information systems and operations management. There is also some advice to SC managers. In paper [10], with the help of 120 respondents to logistics companies, it was found that the flexibility of SC, the transparency of SC, and the development of SC suppliers have a significant impact on business efficiency. The authors outlined the role of SC management in Industry 4.0. and reported studies that identify gaps in management at each of the SC links (outdated approaches, inefficient use of resources, etc.). In earlier studies, the impact of these components on business efficiency was considered separately; in [10], the authors

substantiated an integrated approach, taking into account the role of each indicator on the overall result.

The positive interaction between technology and SC is also confirmed in study [11]. Scientists have proposed a model of how blockchain technology affects the transparency of the operational supply chain and ST (swift-trust) in disasters. The data was provided by 256 respondents from international NGOs (Non-governmental organization) involved in disaster relief and with the help of the OCHA (Office for the Coordination of Humanitarian Affairs) coordinator. The practical significance of the study is to outline the direction of action and improve operations for the relevant managers. The limitations of this study are in the use of a single method, so in the future several methods can be combined to obtain additional conclusions. Thus, scientists are investigating the impact of information technology and programs on the resilience of SC, but it has not yet been considered what alternatives should be considered and how to act if access to technology is limited due to a military threat.

In addition to the above-mentioned issues, the growth of publication activity on the issue of SC resilience is due to the conditions of the Covid-19 pandemic, which questioned the established paradigms that did not work against the disruptions of SCs [12]. Pandemics pose a unique threat to SC because they are unpredictable, the consequences are delayed, and the spread can last for months or years [13]. Risk models and recovery of SCs indicate that during the pandemic, the time and sequence of recovery of online facilities at different levels and nodes of SCs have the greatest impact on the effectiveness of SC [3]. The authors of paper [14] predicted the growth rate of the pandemic using several models and a hybrid method of forecasting based on close neighbors and clustering. Operational studies have identified the need for a reliable database for more accurate predictions of the academic community, policymakers, and SC specialists.

There is no consensus on the definitions, indicators, and models of sustainable SC, so a comprehensive system view and advanced resilience analytics are needed to develop SC resilience. Work [15] states that COVID-19 is a “black swan” event that revealed the brittleness of global supply chains. The study surveyed 102 SC participants in the pharmaceutical industry. Scientists have substantiated the existence of a positive relationship between the orientation of SC, the rules of cooperation, and the resilience of SC. Strengthening the orientation of SC in the form of leadership support, improving trust, cooperation between partners, joint regulation in the form of combining processes and simplifying them leads to a reduction in the risk and vulnerability of SC resilience. The concept of joint regulation as a mechanism for managing behavior is relatively new, so the results of study [15] can be used for SC research in other industries.

Paper [16] built a simulation model of the public distribution system network (Public Distribution System) with 3 scenarios to demonstrate disruptions in the SC of food. It should be noted that not only during the pandemic but also in other crisis situations, this area is a critical infrastructure. Therefore, these results can help the development of sustainable and operational SC of food, taking into account the demand and changes in routes in accordance with the restrictions. Work [17] examined strategies that were considered effective for the resilience of SC after COVID-19. Automotive companies believed that this was the development of local sources of supply and the use of advanced technologies of Industry 4.0. The aviation industry noted the importance of im-

mediately preparing for the challenges of business continuity, identifying activities both at airports and on flights. In [18], researchers demonstrated that both proactive and reactive approaches contribute to the resilience of SCs, and innovation is an effective way to avoid or mitigate the devastating effects of a pandemic. It has been found that the size of the firm is a significant factor only for risk management. Therefore, it is still worth investigating other hidden factors that affect the effectiveness of efforts to increase resilience [18]. Instead, study [19] presents the immediate actions of logistics companies, providing an overview of the consequences on their activities and SC. However, the study is limited to companies in one country, which requires testing and expanding research on the safety and vulnerability of SC, taking into account the geography and context of the disruptions.

SCs had just begun to gradually resume pre-pandemic activities when the next challenge arose – the war. All of the above gives grounds to assert that, unlike the global Covid-19 pandemic, the trigger of events is concentrated in Ukraine although it also has a global impact (energy crisis, food crisis, etc.). As in the global Covid-19 pandemic, the epicenter is a threat to human life and health, but, unlike a global pandemic, the threat of destruction of the entire human living space has been added. On this basis, the nature of wartime conditions is more similar to the disasters that are the object of humanitarian logistics. The achievements of researchers [20] can be considered a fundamental review work of 155 articles; it has theoretical value. Paper [21] notes that logistics is a critical activity in crisis situations that determines the success or failure of operational actions during disaster relief. However, these studies lack specific applied aspects; strategies or operational measures that have worked in individual crisis situations and that could potentially be valuable in a war situation are not covered. It should also be noted that disasters are the result of natural factors (tsunamis, floods, earthquakes, etc.) while the war is political.

The war brings specificity to the resilience of SCs, so it was advisable to conduct a study of the response of logistics to the disruptions of SCs caused by the Russian invasion of Ukraine. And the most valuable thing in this situation is the study of unique Ukrainian experience, which is acquired directly in the trigger of events.

3. The aim and objectives of the study

The purpose of this study is to show how sustainable supply chains are against disruptions caused by war. This will make it possible to form a general picture of the impact of the war on the logistics landscape of Ukraine.

To accomplish the aim, the following tasks have been set:

- to highlight the peculiarities of logistics of civilian supply chains under wartime conditions;
- to identify the consequences of direct action – the trigger of the Russian-Ukrainian war – on the logistics landscape of Ukraine, as well as their derivatives – the consequences of the 2nd, 3rd, and 4th levels, and summarize their interrelations.

4. The study materials and methods

The object of our study is civilian supply chains, which suffered disruptions caused by the Russian-Ukrainian war.

The main hypothesis of the study assumes that the resilience of supply chains is measured by the health of logistics. Logistics, as a linking link of SCs, has faced numerous obstacles, and the largest of them is related to security. No one anywhere on the territory of Ukraine is safe (the “air raid warning” signal is turned on throughout the entire territory, and, in the zone of hostilities, it does not turn off). Given that the logistics infrastructure is a purposeful object of destruction for the aggressor, logistics companies must show considerable flexibility, speed, endurance under conditions of limited availability and lack of logistics capacity. Logistics has become a bottleneck and a glitch of SCs. Solving the problem of the “bottleneck” of SCs, the viability of the entire SC is ensured. The resilience of SC is determined by the ability to survive and adapt logistics.

Empirical research methods were chosen to confirm this hypothesis. Depending on the stage of implementation of the study, various methods were used (Fig. 1). The authors watched the course of the war for 200 days covered in the media, including Government portal, Voice of America, the newspaper “Voice of Ukraine” of the Supreme Council of Ukraine, Interfax Ukraine, Ukrainska Pravda, and others.

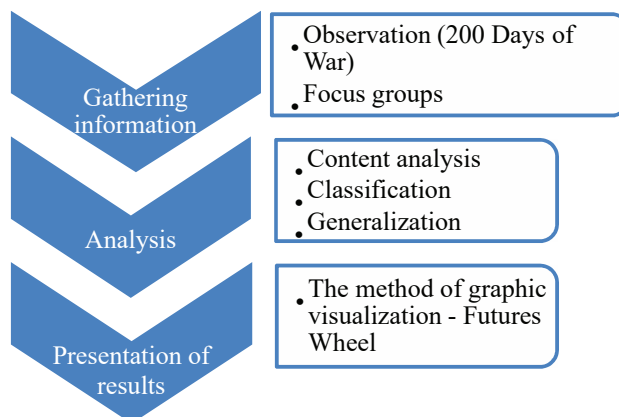


Fig. 1. Research methodology

The object of the content analysis was also the reports of authoritative research centers, namely, the report “Rapid Damage and Needs Assessment”; European Economic Forecast report; reports by Accenture, the Razumkov Centre, the Ukrainian Institute for the Future, and other organizations. The authors recorded those facts that concerned logistics and SCs, purposefully distinguishing them from the entire set of the information array and filtering them into areas – military logistics, humanitarian logistics, civil logistics. Subsequently, only what concerns civil logistics was used. As a result, a general picture of the impact of the war on the logistics landscape of Ukraine on day 200 of the war was obtained. To present the results of the study, the method of graphical visualization, Futures Wheel, was used [22].

On day 56 of the war – April 21, 2022 – within the framework of the European Supply Chain Day 2022 – the authors conducted a survey/discussion using the focus group method “Supply chain logistics in wartime conditions”. Managers of logistics companies took part in the survey (Table 1).

The focus group consisted of 10 people (Table 2).

The research search of a moderator during the discussion itself with respondents looked like a cyclical chain of steps. Namely: a hypothesis was put forward – a hypothetical impulse was formed in the form of a question – a reaction was recorded – a field of facts was formed – the incomprehen-

sible was clarified and focused – a new hypothesis was put forward – a new hypothetical impulse was formed, etc., and so on, until the zone of the incomprehensible disappeared. Key questions:

- 1) How has the activity of your company changed after February 24, 2022?
- 2) What is the biggest challenge for your business in wartime. Was the company ready to accept these challenges?
- 3) What decisions/strategies have ensured resilience?
- 4) What experience gained in wartime conditions should be left for peacetime?
- 5) Vision of the unfolding of events. What are your plans for the near future?

The data was captured in a zoom video conference recording and then viewed to analyze and present the results of the study.

failure of SC – was logistics. Damage to infrastructure has led to limited logistics capacity, lack of drivers, vehicles. Logistics has acquired specific features caused by wartime conditions (Table 3).

Let us highlight the strategies that worked under such conditions. Responses of focus group participants:

- 1) Diversification strategy.

“At the beginning of the war, almost the entire logistics business reoriented to humanitarian logistics. Everyone wanted to somehow help in meeting the needs of the territorial defense, the military and people affected by the war. Volunteer organizations have established import supply chains for humanitarian aid, organized logistics hubs in neighboring countries, our company has provided appropriate transport and delivery throughout Ukraine. Since traditional SCs have broken apart and are recovering very

Table 1

Characteristics of enterprises represented by focus group participants

Feature of characteristics	Enterprise 1	Enterprise 2	Enterprise 3	Enterprise 4	Enterprise 5	Enterprise 6
Logistics services market segment	Rail transportation	Mail	Courier-Expedition-Post	Contract logistics	FTL (Full Truck Load)	FTL/LTL (Full Truck Load/Less Truck Load)
Country of origin	Ukraine	Ukraine	Canada	The Netherlands	Germany	Ukraine
Experience in Ukraine	1991 onwards	1994 onwards	1992 onwards	2003 onwards	2000 onwards	2004 onwards
Geographical coverage of the market	Europe-Asia	World	Europe-America	Europe	Europe	World
Number of interviewers	3	2	1	2	1	1

Table 2

Characteristics of respondents

Respondents	Position	Experience
Manager 1	Head of the branch	37+ years
Manager 2	Commercial Director	24+ years
Manager 3	Operations manager	33+ years
Manager 4	Business development manager	22+ years
Manager 5	CEO	25+ years
Manager 6	Head of the HR department	10+ years
Manager 7	Head of the sales department	17+ years
Manager 8	Logistics professional	15+ years
Manager 9	Deputy Director	14+ years
Manager 10	Director	27+ years

5. Results of investigating the resilience of supply chains under the conditions of the Russian-Ukrainian war

5.1. Features of the logistics of civilian supply chains in wartime

Since the beginning of the war, all SCs have been disrupted. And even the SCs of global companies, which seemingly have a wide arsenal of contingency plans, preferred security – suspending (or limiting) their activities in the Ukrainian market. Instead, internal SCs, having felt the consequences and extent of the destruction (and their impact on all aspects of life), despite the risks, sought opportunities for recovery. And the most vulnerable link – the

slowly, we will carry out the transportation of humanitarian goods until victory” – Manager 10.

“For us, the highest value is employees. Therefore, our company, first of all, organized the relocation of its employees (backoffice) (and their families) from dangerous regions to the western regions of Ukraine and abroad where there are our branches. We are also organizing humanitarian assistance for the families of our employees who are currently defending the country” – Manager 6.

“Our company has brought to the market a new service – “property moving” to Ukrainians who were forced to go abroad” – Manager 4.

“The relocation of enterprises from dangerous regions can best be provided by the railway. This is another new direction of our activity, which is already being implemented” – Manager 1.

- 2) Cooperation strategy.

“The cooperation of two logistics operators – railway and postal – contributed to the offer of a new service “Iron Mail” – last mile logistics in dangerous regions” – Manager 2.

“The cooperation of logistics operators with IT companies has contributed to the rapid emergence of new, very timely IT solutions. For example, the electronic document management service “Vchasno” has created a special program “Security Chain”; WareTek is a specialized platform for all players in the warehouse logistics market that allows one to quickly find partners and outsource logistics, etc.” – Manager 5.

- 3) Coopetition Strategy.

“The blockade of seaports forced logistics operators to look for alternative ways to deliver export and import goods and reorient to rail transport, which led to an acute shortage of cars and locomotives. Transshipment to the wagons of European railways was a partial solution to the problem of vehicle shortages” – Manager 3.

“The creation of logistics hubs near customs crossings contributed to the breakdown of the route - to the border and after. Foreign partners go to the border, and then Ukrainian carriers. Shorter routes ensured higher truck turnover and driver shortages” – Manager 7.

4) The strategy of “deeper penetration of digitalization”.

“The global Covid pandemic has prepared us in part for the challenges of war. The company has learned to quickly reconfigure business processes, working under conditions of remote access, online. This digital management model has contributed to maintaining activities in the face of danger; reducing bureaucratic procedures, accelerating decision-making; increasing the transparency of the actions of all participants in the supply chain and continuous improvement” – Manager 9.

5) Partnership “business-government-society (public organizations, volunteer movements)”.

“In the entire 30-year history of logistics in Ukraine, this is the first time when the state has actively intervened and promptly solved urgent problems of logistics in the regulatory sphere. Prior to that, the development of Ukrainian logistics was the work of business exclusively, without active assistance from the state, which hindered the development of the country’s logistics potential. In the worst times (military), customs barriers fall, visa-free travel is introduced, the digital transformation of society (electronic documents, electronic payments, etc.) is gaining momentum” – Manager 8.

- 2) destruction of logistics infrastructure;
- 3) supply chains disruption;
- 4) non-kinetic warfare;
- 5) destruction of functional society.

The accumulation of figures and facts in 5 directions contributed to the identification of 2, 3, and 4 levels of consequences of indirect action (derivatives, ripple effects). As a result, a general picture of the impact of the war on the logistics landscape of Ukraine as of the 200th day of the war was drawn (Fig. 2).

The first main group – the consequences of the direct action of the trigger of the russian-Ukrainian war on the logistics landscape of Ukraine – is the occupation of a significant part of the territory of Ukraine, active warfare in the East and South parts of Ukraine (Fig. 3). Derivative effects (ripple effects):

- 1. 1. The rapid decline of the economy and corresponding economic factors.
- 1. 2. Purposeful destruction of Energy Sector.
- 1. 3. Activation of international relationships, creation and acceleration of new policies.
- 1. 3. 1. EU candidacy.

1. 3. 2. Transport visa-free, Customs visa-free with the EU.

1. 3. 3. Lend lease.

1. 3. 4. Anti-putin coalition, sanctions against russia.

1. 4. Activation of military logistics.

1. 5. Rapid development of humanitarian logistics.

1. 6. Worldwide recognition of Ukraine.

1. 7. Danger of nuclear disaster.

A few numbers:

– russian troops entered 3620 settlements of Ukraine – this is almost 125 thousand square km (300 thousand square kilometers are filled with mines and projectiles that have not exploded) [23];

– the most affected are Donetsk, Luhansk, and

Kharkiv oblasts, followed by Kyiv, Chernihiv, and Zaporizhzhia oblasts. The total damage is almost USD 252 billion [24];

– losses to Ukraine are estimated at USD 97 billion;

– economic losses: a drop in GDP by more than 30 % in 2022, and the unemployment rate – 35 % [25]. According to a preliminary estimate, Ukraine’s economy will shrink by about 45 % due to the war [26];

– the war in Europe has reduced the forecast of world GDP by a trillion dollars. In 2023, global growth will slow down even more, and few countries will be able to avoid the economic consequences of the war [26].

Along with this, there are significant agreements between Ukraine and other states on the settlement of the energy crisis, the economic crisis, and the consequences of the war in general, in particular:

– 05/09/22 US President Joe Biden signed a law on the provision of a lend-lease program for Ukraine [27];

Table 3

Features of wartime logistics

Characteristic/ property of wartime conditions	Dimension	Challenges for logistics
Brittleness	Hazard level for: – territories; – people; – material objects; – material flows; – information flows; – financial flows	Provision of defense (military) SCs. Humanitarian assistance. Migration (exponential passenger traffic). Relocation, moving. Redesign of SC configuration. Cyber risk. Digital documents and payments. Financial risk
Anxiety (anxious)	Increasing the number of potential points of failure (destruction)	Damaged infrastructure. Restriction of types of transportation. Lack of rolling stock. Lack of drivers. Traffic jams at customs
Nonlinearity (nonlinear)	Development and implementation of creative, innovative, breakthrough, bold solutions in the “just-in-time” mode (chaos level)	Flexibility
Incomprehensibility (incomprehensible)	Level of transparency, riskiness	Logistic competencies. Talent management

Partnership and unity, which originated in difficult times, provided a synergy effect, manifested in the general acceleration of qualitative changes of a geopolitical nature. The war “exposed” the strategic importance of logistics – both military, humanitarian and civil – and finally moved the regulatory factors that have long hampered the development of logistics in Ukraine.

5. 2. The impact of the russia-Ukraine war on the logistics landscape of Ukraine

In the process of analysis and generalization, 5 main groups were identified – the consequences of the direct action of the trigger of the russian-Ukrainian war on the logistics landscape of Ukraine, namely:

1) occupation of a significant part of the territory of Ukraine, active warfare in the East and South parts of Ukraine;

- within the framework of the project “Support to Public Spending to Ensure Sustainable Public Administration in Ukraine”, Ukraine attracts a loan on preferential terms under guarantees from the UK and Denmark (from June 2022) [28];
- the leaders of the European Union approved the decision to grant Ukraine the status of a candidate for accession (recommendation of the European Commission of 17.06.22) [29];
- 29.06.22 Ukraine and the European Union signed an Agreement on freight transportation by road [30];
- launch from 01.08.22 of electronic consignment notes (e-consignment note). Ukraine has joined the international customs information exchange system (NCTS), which makes it possible to use transit declarations in the NCTS

without the need to draw up additional transit documents within 36 countries of the world [30].

At the same time, we observe the rapid development of humanitarian logistics. The scale of the humanitarian catastrophe in Ukraine is the largest since the Second World War. Deprived of the opportunity to live and earn at home, Ukrainians need more than 10 thousand tons of ready-made food in the form of humanitarian aid every day. Hundreds of thousands of people are involved in the defense of the state. Thousands of civilians and military need dressings, blood products, medicines, and equipment for resuscitation or military medicine every day. Ukraine meets most of these needs thanks to humanitarian assistance collected by our citizens, NGOs, and international organizations, donor countries, and corporately responsible businesses around the world [23, 31].

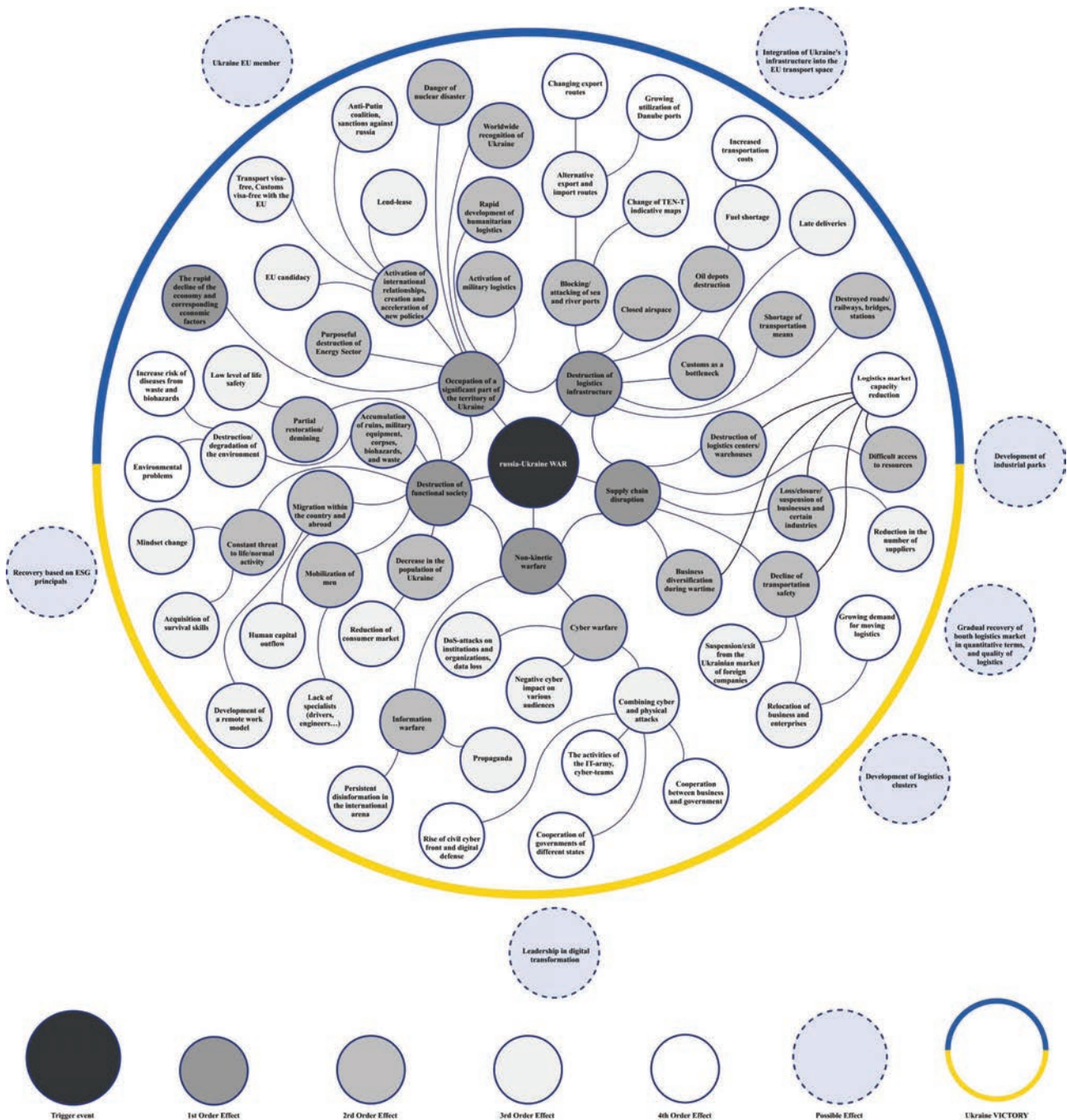


Fig. 2. Futures-Wheel of the russia-Ukraine War: Logistics Landscape 2022+

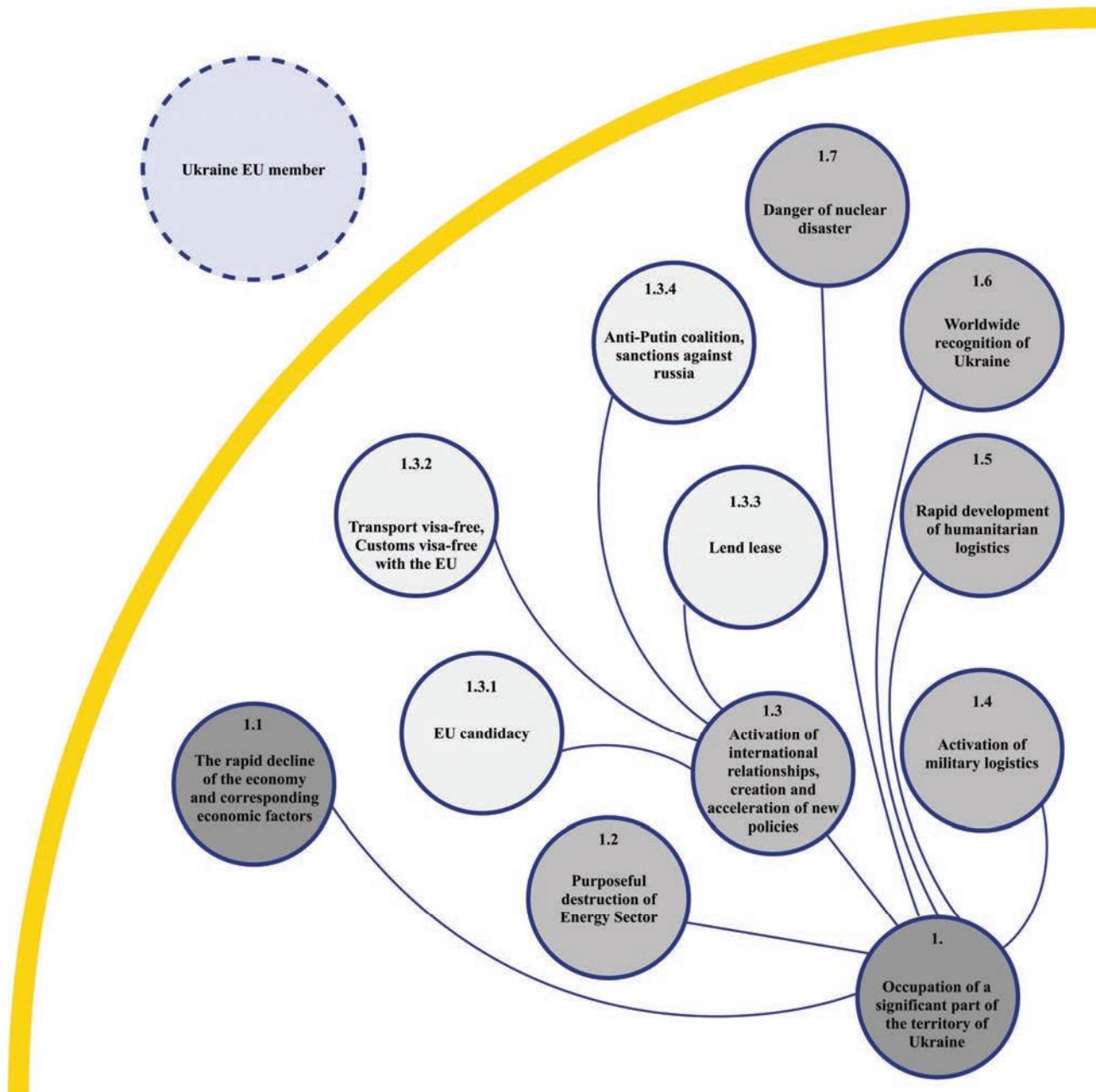


Fig. 3. Impact of russia-Ukraine war on logistics landscape: occupation of a large part of the territory of Ukraine, active warfare in the East and South parts of Ukraine

The second main group – the consequences of the direct action of the trigger of the russian-Ukrainian war on the logistics landscape of Ukraine – is a destruction of logistics infrastructure (Fig. 4). Derivative effects (ripple effects):

- 2. 1. Blocking/attacking of sea and river ports.
 - 2. 1. 1. Alternative export and import routes.
 - 2. 1. 1. 1. Changing export routes.
 - 2. 1. 1. 2. Growing utilization of Danube ports.
 - 2. 1. 2. Change of TEN-T indicative maps.
- 2. 2. Closed airspace.
- 2. 3. Oil depots destruction.
 - 2. 3. 1. Fuel shortage.
 - 2. 3. 1. 1. Increased transportation costs.
- 2. 4. Shortage of transportation means.
- 2. 5. Customs as a bottleneck.
 - 2.5.1. Late deliveries.

- 2. 6. Destroyed roads/railways, bridges, stations.

The damage caused (USD 29.9 billion), losses (USD 26.1 billion), and recovery needs (USD 73.8 billion) in the transport sector of Ukraine are significant and indicate strategic importance [32, 33]. The damage caused by 06/01/22 includes 8,699 km of highways, roadways, and other national highways; 7,619 km of regional and rural roads; 3 million square meters of bridges on national highways; 428,470 sq. m. of bridges on local roads. And also 1,119 km of railways; 93 railway stations; 63,072 sq. m. of railway bridges; 392,843 private cars; 9,473 communal roads; 16 airports and 850 units of rolling stock of urban public transport. According to [34–36], 6.3 thousand km of main tracks were destroyed, with damaged or destroyed 311 bridges and bridge crossings, 24.8 thousand km of roads.

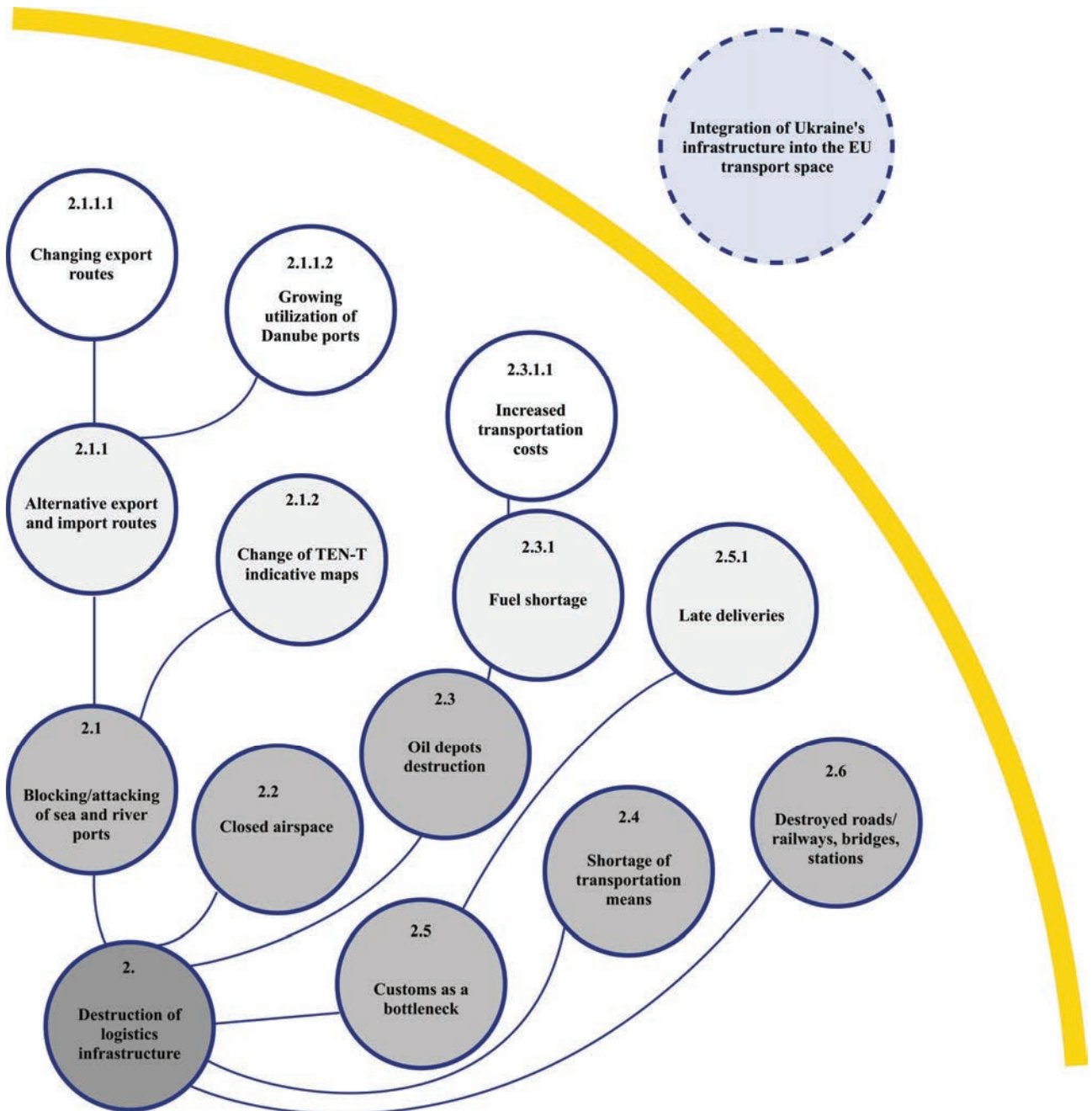


Fig. 4. Impact of Russia-Ukraine war on logistics landscape: destruction of logistics infrastructure

Among the positive consequences – alternative export and import routes have developed, new prospects for Danube ports have opened up. And also the European Commission has amended the indicative maps of the Trans-European Transport Network (TEN-T), including Ukrainian logistics routes – and at the same time removing routes from Russia and Belarus [37].

The third main group – the consequences of the direct action of the trigger of the Russian-Ukrainian war on the logistics landscape of Ukraine – is the supply chains disruption (Fig. 5). Derivative effects (ripple effects):

- 3. 1. Destruction of logistics centers/warehouses.
- 3. 2. Difficult access to resources.
- 3. 3. Loss/closure/suspension of businesses and certain industries.

- 3. 3. 1. Reduction in the number of suppliers.
- 3. 4. Decline of transportation safety.
- 3. 4. 1. Suspension/exit from the Ukrainian market of foreign companies.
- 3. 4. 2. Relocation of business and enterprises.
- 3. 4. 2. 1. Growing demand for moving logistics.
- 3. 5. Business diversification during wartime.
- 3*. Logistics market capacity reduction.

According to [33], supply chain problems due to Russia's war in Ukraine could lead to a loss of Eurozone GDP of up to 920 billion euros (or 7.7 %) by 2023. The report notes that up to 30 % of gross profit in the Eurozone depends on the operation of the cross-border supply chain, illustrating how much of the economy is vulnerable to supply chain shocks.

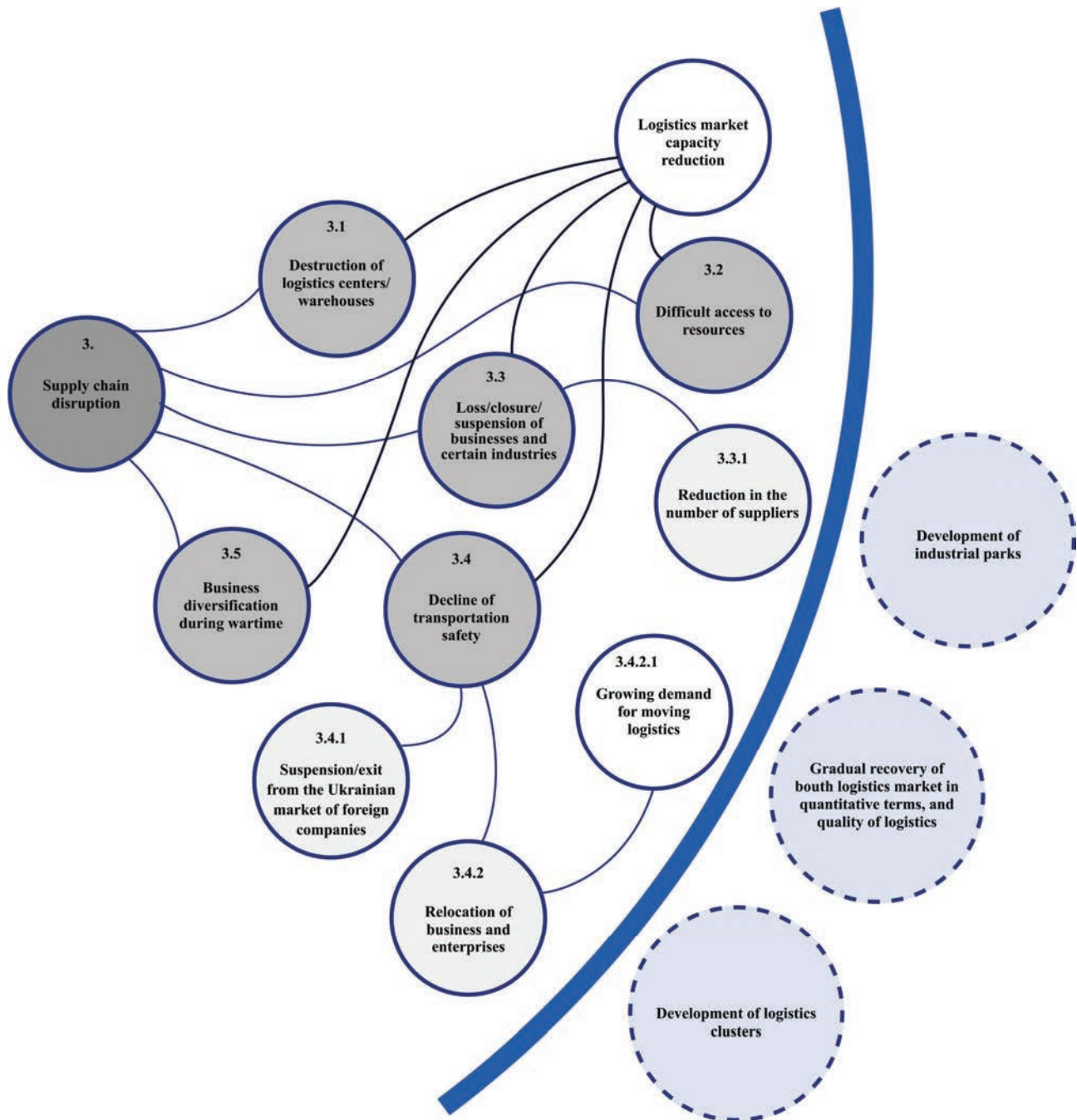


Fig. 5. Impact of russia-Ukraine war on logistics landscape: supply chain disruptions

International trading companies suspended their activities due to the war. In the first 2 months of the war alone, the losses of the country’s retail chains exceeded UAH 50 billion. Sales in home appliances and electronics stores decreased by 74 %, for fashion retailers – by 83 %, and in the jewelry segment – by 89 %. By the end of April, about 70 % of the total number of stores operated in Ukraine. At the same time, one fifth of retail chains did not work at all [38]. As of 01.06.22, since the beginning of the full-scale Russian invasion, about 17 % of businesses in Ukraine have completely suspended their activities, and up to 30 % have partially lost their activity compared to the pre-war state [39]. In August, 28 % resumed their work in full, 37 % – partially, and 16 % of SMEs are still not working. Among non-performing businesses, 12 % plan to resume work, and 4 % may close soon [40].

A large role in the resumption of work was played by the relocation program. Since the beginning of its operation, 710 enterprises have been moved across Ukraine, 500 of them have already resumed their work. Most enterprises are relocated to the western regions. 576 enterprises refused to relocate due to the de-occupation of the territories in which they are located. As of 17.08.22, the Ministry of Economy was looking for a location or method of transportation for 515 enterprises [41]. 27 % of enterprises report that their financial reserves will be enough for several months, previously it was 34 %. Another 11 % have reserves for one month, and the other 20 % – for six months. Only 6 % have enough financial reserves for a year or more. However, more than half of companies, namely 53 %, continue to help financially, 19 % each with products and services, 4 % with medicines, and 3 % with protection/defense equipment. Another 11 %

of companies support employees who are currently defending the country [40, 41].

Due to the war, agriculture throughout Ukraine suffered greatly, and thousands of peasants were left without income. One in three families suffers from food insecurity (almost 18 million people in the country need humanitarian assistance to survive). After the partial destruction of the Ukrainian metallurgy, the agro-industrial complex can become the main driver of the economy in general and employment [25]. In the livestock industry, losses are estimated at 15 % but a number of large farms and meat processing plants are located near the areas of hostilities, so this percentage may be higher.

Along with negative factors, there are those that will help to restrain the crisis. Since the beginning of the full-scale Russian invasion, Ukrainians have opened about 150,000 enterprises. Of these, 134,000 are private entrepreneurs. The largest share of new businesses operates in retail (23.7 %), programming (17.4 %), and wholesale (6.4 %). The rest of the new enterprises (14,000) are legal entities, most of them are engaged in social assistance (32.8 %), wholesale trade (15.2 %), and work as public organizations (13.1 %) [28].

The global trend towards diversification of supply sources and building more sustainable and compact logistics chains initiated by logistical gaps during the pandemic may work in favor of Ukraine. This can add attractiveness to Ukraine as a “production site in Europe”, as well as increase the interest of Western investors in the existing potential of Ukraine in areas experiencing significant geopolitical influence. At this, it is important to integrate Ukraine into the production chains of the EU and other partners, as well as to use opportunities to replace the Russian Federation in world supply chains (food, metal, titanium, aluminum, rare earth metals, heavy engineering, in particular, turbines). It is also important to involve companies that have left the Russian Federation and Belarus to work in Ukraine. At least for some of them, Ukraine should replace Russian and Belarusian production sites, and in some industries Ukrainian market itself may be of interest [42].

The fourth main group – the consequences of the direct action of the trigger of the Russian-Ukrainian war on the logistics landscape of Ukraine is the non-kinetic warfare (Fig. 6).

Derivative effects (ripple effects):

4. 1. Cyber warfare.
 4. 1. 1. DoS-attacks on institutions and organizations, data loss.
 4. 1. 2. Negative cyber impact on various audiences.
 4. 1. 3. Combining cyber and physical attacks.
 4. 1. 3. 1. Rise of civil cyber front and digital defense.
 4. 1. 3. 2. The activities of the IT-army, cyber-teams.
 4. 1. 3. 3. Cooperation between business and government.
 4. 1. 3. 4. Cooperation of governments of different states.
4. 2. Information warfare.
 4. 2. 1. Persistent disinformation in the international arena.
 4. 2. 2. Propaganda.

The Russian invasion relies in part on a cyber strategy that includes at least three measures: destructive cyberattacks within Ukraine, network infiltration, and espionage outside Ukraine. As well as cyber influence operations aimed at people around the world [43]. Ukraine’s cyber defense is critical in relying on a coalition of countries, companies, and non-governmental organizations. According to the State Service for Special Communications and Information Pro-

tection of Ukraine, as of 30.06.22, Russia carried out 796 cyberattacks against Ukraine, which is three times higher than last year. Russia uses the Internet to attack in several directions, in addition to the DoS attack, in particular, “organized persecution through toxicity and deception, directed against prominent personalities and entire classes of people.” As well as disinformation about criminal activities related to refugees, about their allegedly privileged position compared to citizens of the country, as well as the use of disinformation and lies to incite and justify extreme violence. Relentless Russian propaganda aimed at its citizens is about the “Nazis” – it serves to dehumanize it in the eyes of the Russian military, which led to many war crimes [44].

Other countries are also negatively affected. Russia has stepped up cyber espionage against NATO member states in response to the Alliance’s support for Ukraine. Microsoft has detected attempts by Russia to infiltrate the network in 128 organizations in 42 countries. According to the company, cyberattacks often precede air and missile strikes. Russian agencies focus cyber influence on 4 different audiences – the population of different countries [43]. To counter the complex of cyber threats from the Russian Federation, the following was needed: achievements in the field of digital technologies and artificial intelligence, cooperation between the state and the private sector, multilateral cooperation of governments, freedom of expression [43, 44]. In June 2017, the European Union created a so-called “set of tools for cyber diplomacy” in order to jointly respond to malicious cyber activities [45]. This allows the EU and its Member States to impose, where necessary, restrictive measures, sanctions, and other tools to respond to and deter cyber threats against the EU and its Member States. At present, such sanctions, providing for asset freezes and travel bans, have been used by the EU against a number of individuals and institutions in Russia, China, and North Korea.

The fifth main group – the consequences of the direct action of the trigger of the Russian-Ukrainian war on the logistics landscape of Ukraine – is destruction of functional society (Fig. 7). Derivative effects (ripple effects):

5. 1. Decrease in the population of Ukraine.
 5. 1. 1. Reduction of consumer market.
5. 2. Mobilization of men.
 5. 2. 1. Lack of specialists (drivers, engineers and other specialists).
5. 3. Migration within the country and abroad.
 5. 3. 1. Human capital outflow.
 5. 3. 2. Development of a remote work model (on-line).
5. 4. Constant threat to life/normal activity.
 5. 4. 1. Acquisition of survival skills.
 5. 4. 2. Mindset change.
 5. 4. 3. A significant decrease in the standard of living and quality of life.
5. 5. Accumulation of ruins, military equipment, corpses, biohazards, and waste.
 5. 5. 1. Destruction/degradation of the environment.
 5. 5. 1. 1. Environmental problems.
 5. 5. 1. 2. Increase risk of diseases from waste and biohazards.
5. 6. Partial restoration/demining.
 5. 6. 1. Low level of life safety.

This group of consequences combines very heavy losses for Ukraine and many of them cannot be recovered. From 24.02.22 to 11.09.22, the Office of the United Nations High Commissioner for Human Rights (OHCHR) record-

ed 14,248 civilian casualties in the country: 5,827 dead and 8,421 wounded [46]. One-third of Ukrainians were displaced due to the war. Since February 24, more than 12.7 million movements from Ukraine have been recorded, of which more than 5.7 million have been moved back to the country [47–50]. According to UNHCR, as of 14.09.22, 7,278,696 refugees from Ukraine were recorded throughout Europe. 6,975,000 estimated number of IDPs in Ukraine. A protection cluster led by UNHCR has established a national coordination office in Lviv; it plans to establish sub-national coordinators in Dnipro, Lviv, Uzhhorod, and Vinnytsia [48].

Conscription of conscripts, reservists, and the involvement of vehicles to meet the needs of the Armed Forces of Ukraine and other military formations of Ukraine is achieved in the amounts determined by mobilization plans (labeled “secret”). Ukraine may lose its potential in the IT

sphere, and skilled workers of working professions in demand in the West can also leave [25].

The environment and natural resources, in particular, pollution of air, groundwater and surface water, and soil, suffer greatly from war. The long-term impact of the war will be even more harmful – not only for the health and safety of the population but also for ecosystems and biodiversity. Most environmental risks are associated with damage to industrial installations and homes, energy infrastructure and ecosystems [33]. The forest sector has been significantly affected (as of 01.06.22, about 3 % was lost due to forest fires, and 38 % are inaccessible due to the presence of mines). Almost 3 million ha of forests were damaged, 20 % of protected areas of Ukraine are affected, 8 reserves and 12 national parks are under occupation [46]. Forestry has a slow pace of recovery, and these losses can last for many years.

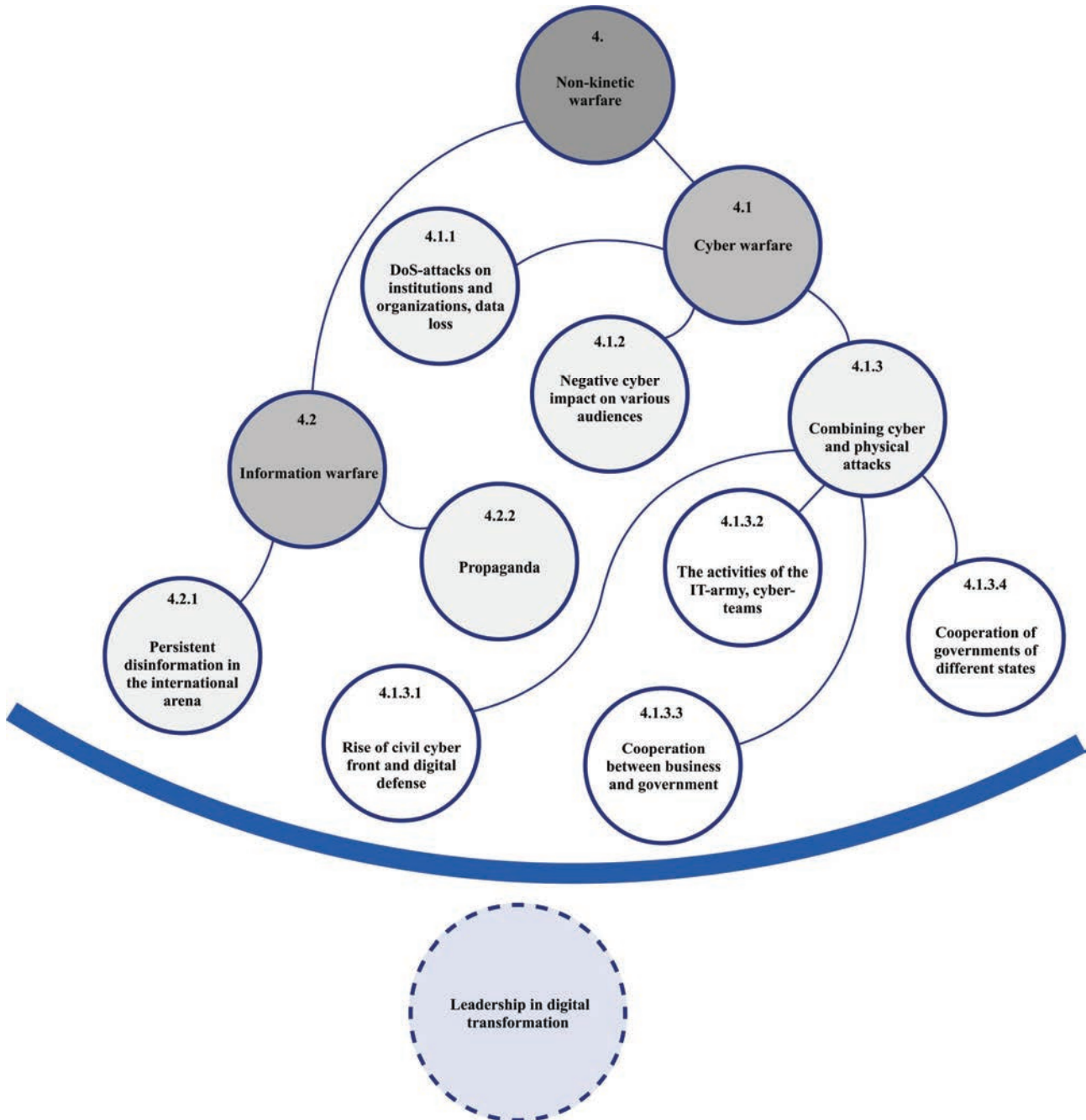


Fig. 6. Impact of russia-Ukraine war on logistics landscape: non-kinetic warfare

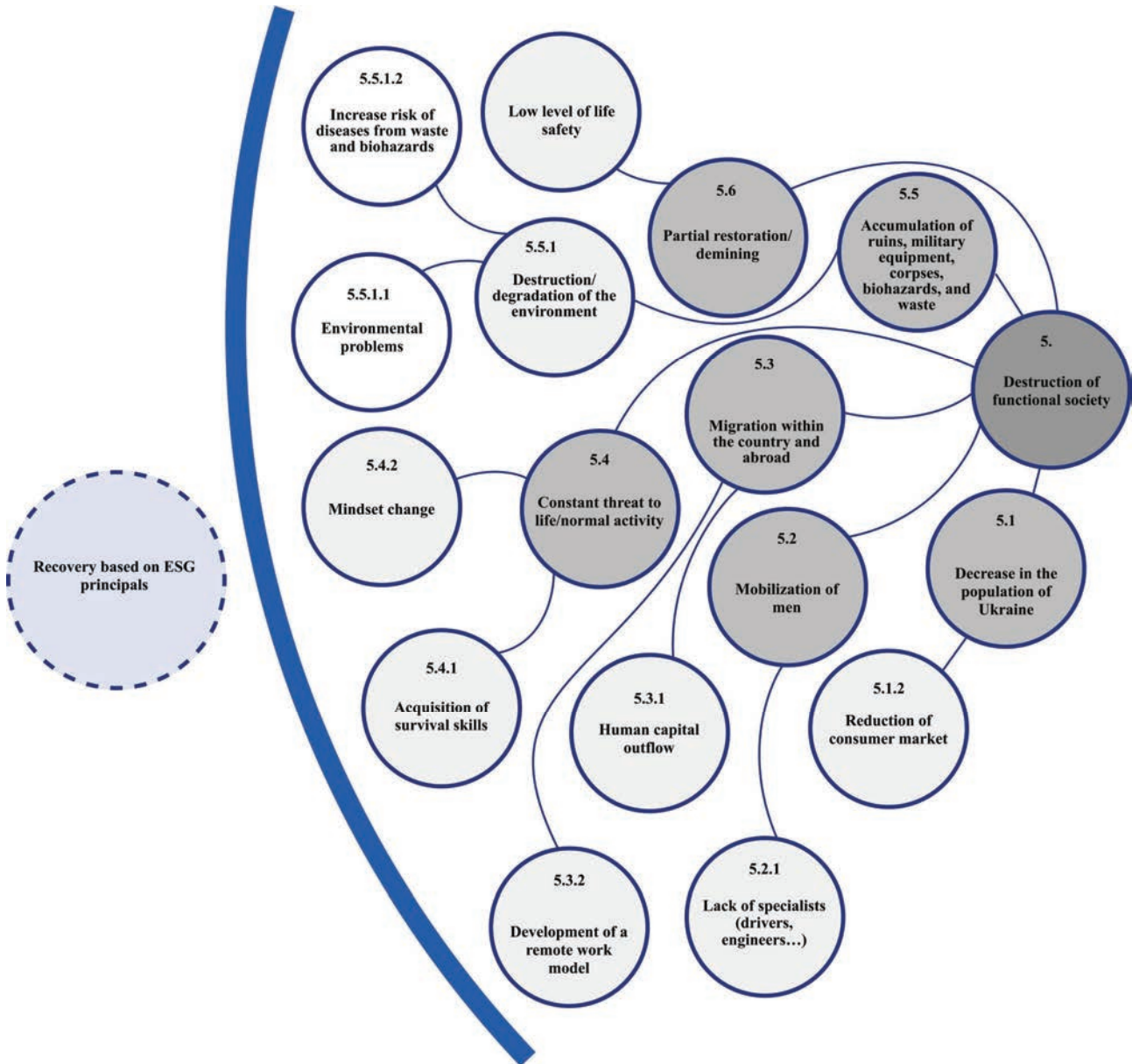


Fig. 7. Impact of Russia-Ukraine war on logistics landscape: destruction of functional society

After Ukraine's victory in the war, we predict the main Futures Wheel (circles depicted from the outside of the blue-yellow circle in Fig. 2), which we can distinguish now. These Futures-Wheel are more concerned with the topic of research, in particular, the trigger for the impact of war on the logistics landscape. However, they do not diminish the importance of other realistic events that will arise under the influence of unexplored factors in other areas.

We believe that Ukraine, together with the help of the world community, will work on joining the EU and becoming its member - we single out the circle "Ukraine EU member". In the future, we also see "Integration of Ukraine's infrastructure into the EU transport space". Logistics and SCs are undergoing a significant transformation in Ukraine and abroad, so in peacetime there should be a "Gradual recovery of bouth logistics market in quantitative terms, and quality of logistics." As well as "Development of industrial parks", "Development of logistics clusters".

We envisage "Leadership in Digital Transformation" for Ukraine. As this area has been developing rapidly over the

past few years in Ukraine, both business and government agencies have increased the use of digital tools, and military needs have added impetus to certain sectors. We also expect "Recovery of society and environment based on ESG principals (environmental, social, governance)" in all areas, including those related to logistics and SCs.

6. Discussion of results of the study on future directions of development of the logistics landscape of Ukraine

The study builds on the opinions of scientists on the resilience of SCs in crisis situations and complements them with possible consequences. Actually, in earlier studies [1–7], the topic is more often considered in terms of factors of influence. The authors of scientific works conducted business surveys, the works provided individual recommendations or tools that could contribute to the resilience of SCs [8–11]. Nevertheless, there has not yet been such a massive destruction of infrastructure throughout the whole country. Everything

that worked during various crises in Ukraine became very limited or completely inaccessible. It is important to analyze in the works the impact of the pandemic on the resilience of SCs [12–14, 20–21] and the response in certain areas to this impact [15–19]. Although, during the pandemic and isolation, SCs underwent modifications but were not completely destroyed. The reviewed studies in the field of logistics and SCs do not highlight the impact of full-scale warfare on the resilience of SCs.

The paper also graphically visualizes the overall picture of the impact of the war on the logistics landscape of Ukraine (Fig. 2). The construction of Futures-Wheel uses the method of “brainstorming” [22]. The brainstorming technique contains certain requirements for the qualitative and quantitative composition of participants, experts. The requirements for the qualitative composition have been met, and with regard to the quantitative composition – it would be wise to include a larger number of specialists, including those who are not familiar with the problem at all and are specialists in other fields of science and technology. This can be considered a disadvantage of our study that should be considered in the future.

Also, the Futures-Wheel (Fig. 2) reflects only the consequences that occurred at the time of writing the article and have a direct impact on civilian SCs. That is, the limitation is an incomplete list of them. The diagram (Fig. 2) shows only the connections between the consequences of direct action, although, undoubtedly, the consequences of the 2nd, 3rd, and 4th levels are also interrelated (Fig. 3–7). This deserves special attention and may be the object of further research.

The war radically changed the logistics landscape of Ukraine, caused a “wave effect” on Europe and the world, and prompted to raise the topic of SC’s resilience to another level. Based on the investigated consequences of the war, the author’s vision of the future logistics landscape of Ukraine after the victory was formed for the first time. The prospects for further research are the justification of the strengths and weaknesses of new SCs and a deeper analysis of the activities of companies related to SCs. And at the same time, information, communication, other research methods and the selection of methods for assessing the impact of consequences on the activities of each participant in the SC are valuable.

The results of the focus group in this study demonstrate, in particular, the significant support of partners in SCs and the rapid response in various sectors of the economy to new dangers. The results of the study reveal breakthrough strate-

gies that have helped logistics companies cope with the challenges of hostilities. The disadvantage of the study is that only business experience has been worked out. Although, at the same time, humanitarian logistics is developing very rapidly. Volunteer movements with the help of charitable organizations and foundations demonstrate high performance in overcoming logistical obstacles. Therefore, their rich experience is also extremely valuable, and this should be taken into account in future research.

7. Conclusions

1. Under the conditions of war, the disruptions of SCs have specific characteristics, unlike any other types of disruptions. They are unforeseen in terms of localization, scale, accompanied by limited availability of resources and lack of logistics capacity, aggravated by the hazard factor. New types of disruptions require the search for new solutions. The demonstrated strategies and practices that have been used in the management of SCs, facing logistical obstacles caused by the war, could potentially come in handy in other crises.

2. The proposed Futures Wheel model is the first step towards a common vision of radical changes in Ukraine’s logistics landscape under the influence of war. It proposes a certain scenario of the future; some clues about events (factors) to focus on, to see their relationship with other events (factors); potential opportunities and threats.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

Funding

The study was conducted without financial support.

Data availability

All data are available in the main text of the manuscript.

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