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SECURITY OF LOGISTICAL PROCESSES OF SERVICE ENTERPRISES IN THE SUPPLY CHAIN UNDER THE CONDITIONS OF *GREEN REQUIREMENTS*

BEZPIECZEŃSTWO PROCESÓW LOGISTYCZNYCH PRZEDSIĘBIORSTW USŁUGOWYCH W ŁAŃCUCHU DOSTAW W WARUNKACH *ZIELONYCH WYMAGAŃ*

Abstract

The aim of the article was to analyze and assess the level of implementation of sustainable development goals on the examples of global logistics organizations and an attempt to diagnose the efforts of sample companies aimed at adapting supply chains to *green requirements*. Indicator analysis reviewed the attributes for measuring the effectiveness of supply chains using the SCOR model in terms of *green requirements*. It was found that this method requires modification of attributes because it is focused on economic considerations of the functioning of supply chains, without taking into account environmental requirements. The article identifies external factors disrupting supply chain security in 10 areas of the global macroenvironment using the PESTELMCFRME method (a modified version of the PESTEL method). An exemplary model of the external and internal supply chain system was developed, along with a sequence of connections between its various links and an information flow integrator that reduces the risk of disruptions. The comparative method was used to assess the degree of implementation of sustainable development goals in sample logistics organizations. Examples have demonstrated strong commitment of the logistics industry to achieving the Sustainable Development Goals – in some cases up to 80%.

Example analyses and patterns can serve as inspiration for building instruments for the effective operation of supply chains in the conditions of *green requirements*.

Streszczenie

Celem artykułu była analiza i ocena stopnia wdrożenia celów zrównoważonego rozwoju na przykładach globalnych organizacji logistycznych oraz próba diagnozy wysiłków przykładowych firm zmierzające do dostosowania łańcuchów dostaw do *zielonych wymagań* za pomocą wybranych wskaźników. Analizą wskaźnikową dokonano przeglądu atrybutów do pomiaru skuteczności funkcjonowania łańcuchów dostaw za pomocą modelu SCOR pod kątem *zielonych wymagań*. Stwierdzono, iż metoda ta wymaga modyfikacji atrybutów, ponieważ nastawiona jest na aspekty ekonomiczne funkcjonowania łańcuchów dostaw, bez szczególnego podkreślenia wymagań środowiskowych, istotnych dla Zielonego Ładu. W artykule zidentyfikowano zewnętrzne czynniki zakłócające bezpieczeństwo łańcucha dostaw w 10 obszarach globalnego makrootoczenia za pomocą metody PESTELMCFRME (zmodyfikowana wersja metody PESTEL). Opracowano przykładowy model układu zewnętrznego i wewnętrznego łańcucha dostaw wraz z sekwencją połączeń pomiędzy różnymi jego ogniwami oraz integratorem przepływu informacji zmniejszającym ryzyko zakłóceń. Metodę porównawczą wykorzystano do oceny stopnia wdrożenia celów zrównoważonego rozwoju w przykładowych organizacjach logistycznych. Wykazano

na przykładach silne zaangażowanie branży logistycznej w realizację celów *zielonych wymagań*. W niektórych przypadkach aż do 80%.

Przykładowe analizy i wzorce mogą stanowić inspirację do budowy instrumentów efektywnego działania łańcuchów dostaw w warunkach *zielonych wymagań*.

Keywords: *supply chain, risk, security, green deal, sustainability, green requirements*

Słowa kluczowe: *łańcuch dostaw, ryzyko, bezpieczeństwo, zielony ład, zrównoważony rozwój, zielone wymagania*

Introduction

One of the most important elements of the proper functioning of an enterprise is an organized and safe logistics network based on secure supply chains. The essence is the quality of risk management due to the requirements of the Green Deal, which form the basis of sustainable development promoted by AGENDA 2030. This is confirmed, for example, by a survey conducted by Willis Towers Watson among 800 senior decision-makers from various industries to understand the risks and challenges related to the supply chain (WTW Report 2023). For this reason, it is important to analyze current efforts to adapt supply chains to new conditions resulting from *green requirements*, with the awareness of occurring disruptions that may slow down these processes. They became the inspiration for the research presented in the article. This does not mean that the literature on the subject has not yet examined how logistics processes throughout the entire chain can be adapted to green requirements (European Order 2021, pp. 4-10). The work of Blanka Tundys is worth mentioning; in her article (Tundys 2017, p. 78) she proposed a number of interesting hybrid solutions for managing a sustainable and safe supply chain (including AHP, heuristic methods, fuzzy algorithms, simulations, LCA and LCC, MCDA). Another notable example is a study by Anna Baraniecka, who accurately pointed out the specificity of eco-logistics processes and the entities which constitute its links (Baraniecka 2015, p. 241). Although these are works from earlier years, they are important for further research.

Modern organizations are aware that acting in accordance with the concept of sustainable development translates into the perception of their entities

in the context of competitiveness (Kraszewska, Pujer 2017, p.12). Conscious decision-making about implementing sustainable development strategies plays a key role in shaping corporate social responsibility (Płaczek 2010, pp. 79–80).

The effects of this adjustment have not yet been sufficiently explored. An important element of achieving the goal is to bring the essence and specificity of global supply chains closer to the sustainable development goals (CSRD 2022, p.45).

The need for sustainable development necessitates building new solutions or transforming existing models to ensure the safe flow of goods and services. This issue raises many doubts and questions regarding the causes and scale of supply chain disruptions in specific conditions and the determinants of supply chain security management. Is it possible to run supply chains effectively and efficiently across states? To convince customers of its ability to guarantee cargo safety, the operator is obliged to comply with regulations and good practices (Wieteska 2011, pp. 149–162).

The regulations specify security requirements, including critical aspects that may appear in the supply chain (Szymonik, Bielecki 2015, p. 47, CSRD, 2022/2464).

In light of the current pro-ecological situation, there is a lack of well-thought-out and binding supply chain security strategies, including the diversification of markets facing numerous disruptions, as highlighted in the article. The analyzed situations indicate the vulnerability of international supply chains to trade disruptions and economic shocks caused by restrictions such as the rhythmic flow of goods or supply interruptions. In a challenging global environment, supply chain security management is becoming increasingly important as the risk of supply chain disruption is most often cited as a major threat. It is assumed that the modern market of production, where trade and service processes are dominated by corporate systems and global supply chains, is more susceptible to disruptions. The aim of the article was to analyze and assess the level of implementation of sustainable development goals on the examples of global logistics organizations and to attempt to diagnose the efforts of sample enterprises to adapt supply chains to *green requirements*. Attributes for measuring the effectiveness of supply chains using the SCOR model were reviewed. The conclusion of the application of this method was that it was required to modify the attributes in terms of environmental

indicators. The PESTEL method (PESTELMCFRME) was modified from the same point of view and an information flow integrator in the supply chain was proposed on a selected example. Many publications draw attention to the adaptation of organizations to the requirements of AGENDA 2030 throughout the supply chain, but generally without examining specific service enterprises.

Selected attributes of supply chain vulnerability and the concept of sustainability

When considering the security of supply chains at the macro level, one should focus on the way supply chains function and the directions of their adaptation to the new conditions resulting from the Green Deal (European Green Deal 2021, pp. 1–10), knowing that they are strongly influenced by globalization (Ciesielski, Długosz 2010, pp. 39–42).

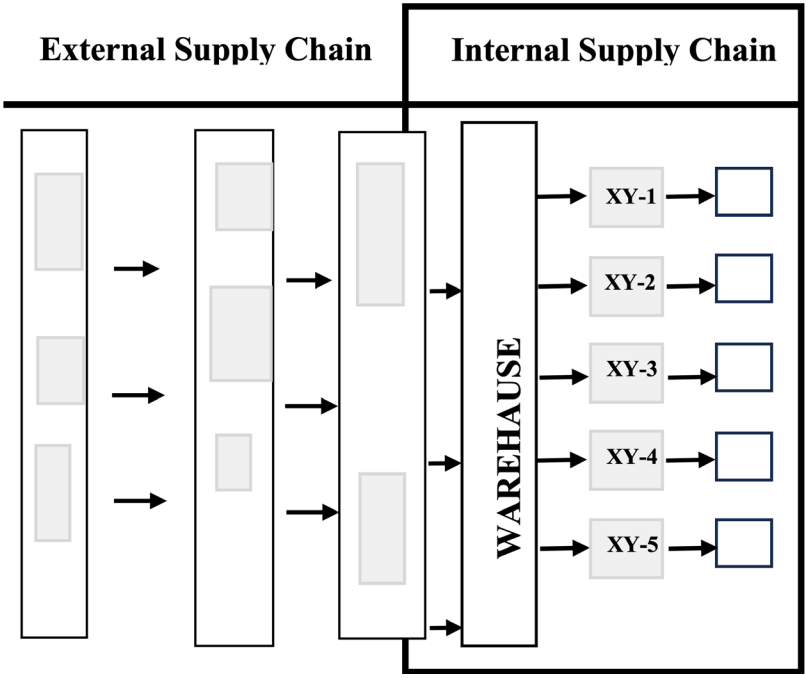
After analyzing publications on supply chain management, it is important to highlight the fact that some authors (e.g., Ch.C. Poirier's model, A.T. Kearney, Dobrzynski) did not take into account environmental aspects, relevant to the European Green Deal, in the selection of indicators for evaluation. For example, the Supply Chain Council organization has developed the Supply Chain Reference Model (SCOR) taking into account relevant indicators and metrics for measuring the performance of supply chains (Supply Chain Model 2012).

The attributes reflect two perspectives of the supply chain:

- external (Customer side) with such attributes as reliability, responsiveness and flexibility;
- internal with such attributes as costs and resources.

Figure 1 illustrates the idealized arrangement of the external and internal supply chain by example, along with the sequence of connections between the various links.

Figure 1. *Example of a two-part supply chain arrangement*



XY-1 do XY-5 branches

Source: authors' own study.

Measures and indicators for assessing the effectiveness of supply chains identified in the SCOR model are assigned to three levels. They are helpful in monitoring the supply chain and controlling the achievement of specified goals. Environmental attributes are not considered at any level. Table 1 shows the layout of these levels.

Table 1. *Levels for measuring the supply chain in the SCOR model*

Level	Level type	Description
1	Strategic	For measuring the performance of the entire supply chain
2	Operational (on-going)	Focusing on measuring a piece of the supply chain and a slice of the business strategy
3	Detailed	Metrics and indicators at this level can be used for more accurate identification.

Source: (Supply Chain Operations. Reference Model — Revision 11.0, 2012)

Indicators and metrics from the strategic level are essential for assessing and monitoring the supply chain. It is important to measure every part of the supply chain at every stage of its life cycle.

In the SCOR model, metrics and indicators are assigned to one of five supply chain attributes. The attributes (Supply Chain Model 2012) are summarized in Table 2.

Table 2. *Examples of supply chain attributes and metrics play key role in the SCOR model*

A customer perspective of the supply chain		
Reliability	of ensuring a high level of customer service, timely delivery, correct quantity, quality, price, etc,	correct fulfillment of orders, quality
Reactivity	of the time required to respond to a customer requirement,	Improvement of the speed of delivery of products
Agility/Flexibility	Responsiveness and adaptability to change	Increase the ability to respond to change
Sustainable Development Perspective (European Green Deal)		
Supply chain carbon footprint	NONE	NONE
Internal supply chain perspective		
Indirect	Total costs related to operations	Cost rationalization related to supply chain management and operations
Resources	Efficiency of managing resources and supply chain assets	Improvement of efficiency of supply chain asset management, e.g., reducing inventory levels

Sustainable Development Perspective (European Green Deal)		
Packaging recycling rate	NONE	NONE
Attribute	**Metric ID**	**Metric name**
Eeactivity	RS 3.104	Average time of return of a damaged product from a customer
	RS 3.131 RS 3.137	Time it takes to reinitiate customer order fulfillment after changes are made
	RS 3.138	Average time for damaged products to pass through the supply chain link
Indirect	CO 3.1	Percentage of the cost of damaged products in relation to the total cost of purchases

Source: study based on: (Supply Chain Council, SCOR Framework 2.1, 2008; Supply Chain Council, SCOR: Version 10.0, 2010, pp. 127–137; Hentschne, Cyplik, et al. 2015, p. 57)

In logistics strategy and market segmentation, attention was paid to such typical factors as (Kempny 2001, p. 19):

- order fulfillment time and order convenience,
- complaint procedure,
- stock availability guarantee.

Irrespective of the level, attributes, metric or indicator perspective of the issue of supply chain efficiency no focus on European Green Deal goals will be seen. As can be noticed, these are indicators related to the basic parameters for evaluating logistics processes, which are geared more towards economic rather than environmental considerations.

Risk of supply chain disruptions

When analyzing the goals and assumptions of the European Green Deal, a clear and unambiguous connection is established with environmental aspects. These are based on strategic environmental elements (Komunikat 2018; Sens i Drogi Zielonego Ładu 2021), such as:

- energy efficiency and renewable energy sources for total energy decarbonization,
- clean mobility,
- a competitive industry and a circular economy and carbon capture and storage.

The greatest focus of sustainability is on those industries whose operation is fundamental to the security of supply chains, such as transport. According to European Commission calculations, transport is responsible for 25% of the EU's greenhouse gas emissions (Grendys 2021, p. 18).

The question arises: what benefits can be expected from the implementation of the European Green Deal? Will the market and industries cope with the transformation?

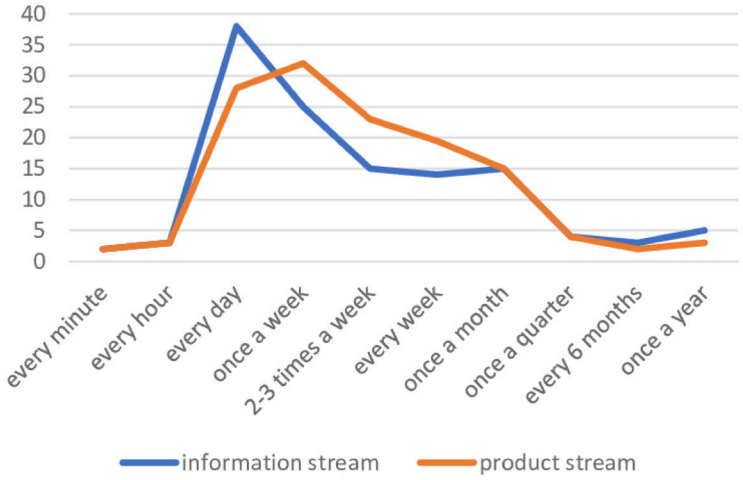
In order to try and tackle these issues, the mechanism for evaluating and monitoring processes through indicators and metrics related to the underlying attributes must again be evoked. Many authors conducting research on the risk of disruption in supply chain management indicate that the factors causing supply chains to become more vulnerable (e.g., Fincha 2004, pp.183–196; Singhal, 2012, p.14, et al) are:

– globalization (52% of respondents) and reducing inventory levels in supply chains as a result of breaking links in emergency situations (51% of respondents),

– reduced supplier base (38% of respondents) and outsourcing (30% of respondents).

Is disruption in the flow of goods and information a common phenomenon? Based on the research, Figure 2 illustrates the frequency of disruptions in the flow of goods and information.

Figure 2. *Frequency of disruption in the flow of goods and information*



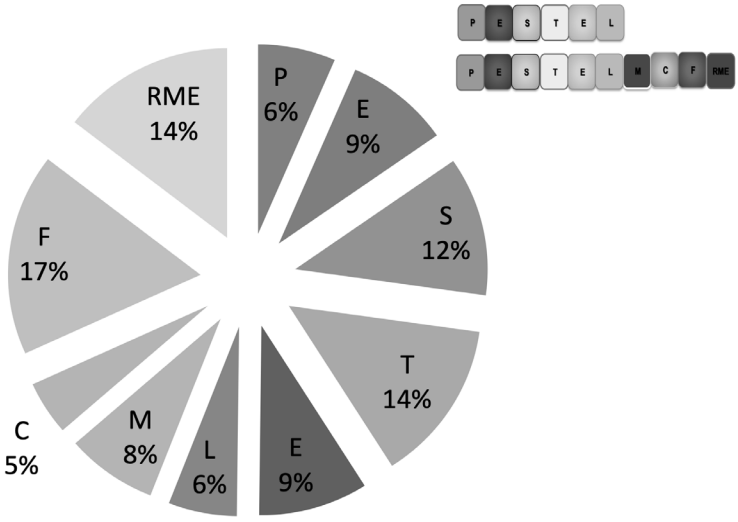
Source: (Konecka 2015, p. 184).

What factors can disrupt the flow of goods and information streams? Figure 3 shows that the flow of information is more often disrupted than the flow of goods. Most often, it was indicated that disruptions in the flow of goods occur every day (28.7%) and 2-3 times a week (34.9%). The flow of information was considered disrupted every day (32.3%), 2-3 times a week (26.7%). Disturbances (Kulińska 2007, pp. 18–21) may result from:

- size and complexity of the organization,
- geographical scope of the network,
- customer relations and customer service.

Going further, the global environment was analyzed in terms of resistance to disruptions. Using the PESTELMCFRME analysis (a modified version of the PESTEL method), 261 external factors disrupting supply chain security were identified in 10 areas of the global macroenvironment. Which product groups have seen the most frequent disruptions over the past two years? Figure 3 summarizes the areas and percentage of disruptions in global supply chains in 2021–2022.

Fig. 3. *Identification of external factors in the global macro-environment of supply chains in 2021-2022*



Source: authors' own study.

An analysis of the data presented in Figure 4 shows that the largest number of situations threatening the functioning of global supply chains is in Area F (food) - at about 17%, in Area RME (raw materials and energy) about 14%, and in Area T (information and information technology). Threats in these areas can further destabilize processes in terms of the 4 areas of sustainable development, i.e., in institutional–political, social, environmental and economic processes.

Each of these factors generates certain types of risks. Table 3 shows example groups of risks resulting in possible supply chain disruptions.

Table 3. *Examples of risk group in supply chain links*

PROCESS/ SITUATION	SUPPLY CHAIN RISK GROUPS
Customer relations management	Inaccurate predictions of customer needs Inadequate level of services provided
Demand management	Imbalance between customer expectations and the capabilities of all links in the supply chain
Order fulfillment	Failure to meet order fulfillment times Failure of carriers, logistics operators, etc. to meet contract terms
Breaking supply chains	Natural phenomena: disasters, earthquakes, floods, volcanic eruptions, etc. Biological: epidemics and pandemics, Political: decisions by governments and international institutions, Technological: server room failures, data leaks, cyberattacks, etc.

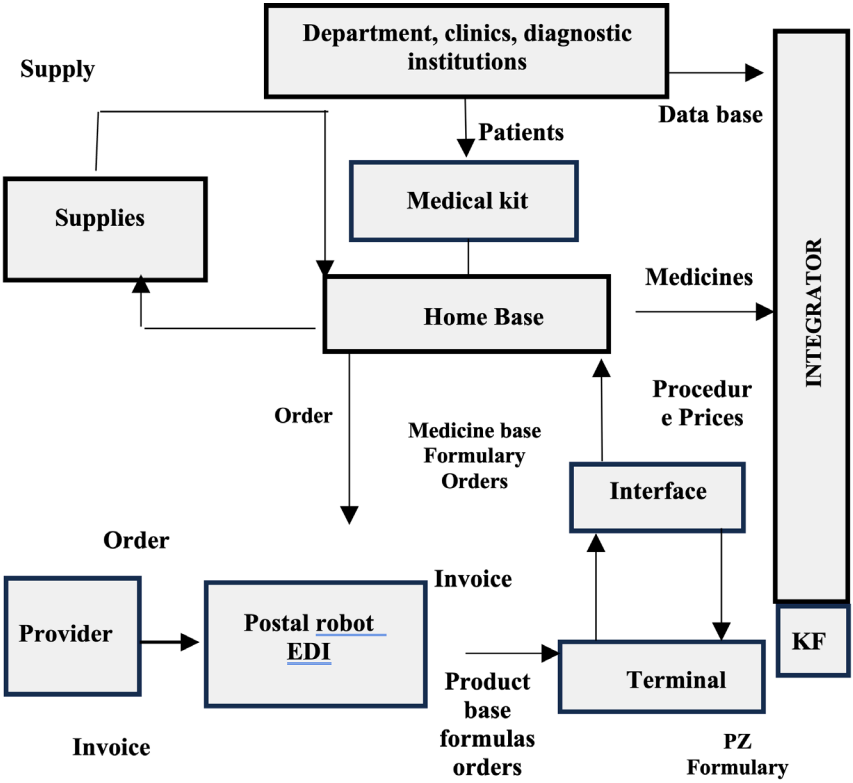
Source: authors' own study based on: (Kulińska 2007, pp. 18–21)

Awareness of the risk of disruption in supply chain management is critical to an appropriate approach. It is important to build a supply chain resilience strategy. The proposed strategies and related activities aim to strive to improve the security status of supply chains by, i.a., assessing the functioning processes in the chain and continuously inspecting individual links in the supply chain.

Figure 4 presents an example of a graphical model of a system solution using a selected example of a facility.

The proposed strategies and related activities are aimed at improving the security of supply chains, including assessing the processes occurring in the chain and continuous control of individual links in the supply chain. Figure 4 shows an example graphic model of the system solution based on the selected example. The connections between the facility's modules creating an integrated IT management system supporting *green requirements* were indicated. The main function of the *Integrator* module is to collect data from the facility, laboratory, warehouses, supplies and departments. After implementing the proposed solutions, a decrease in product inventories was observed by over 60% at the Central Supply Point and by over 40% in the branches. The inventory coverage ratio decreased from 19 days to 6 days.

Figure 4. *An example diagram of an integrated IT system supporting the company's basic activities in the supply chain*



Source: authors' own study

Selected examples of sustainable supply chain management in logistics companies

The logistics industry's offering of *green products* or *green services* is becoming important and necessary due to legal, state-corporate and social pressures. These trends emerging in logistics result primarily from changes that will take place in the economy and society (Chodyński 2016, pp. 15–25).

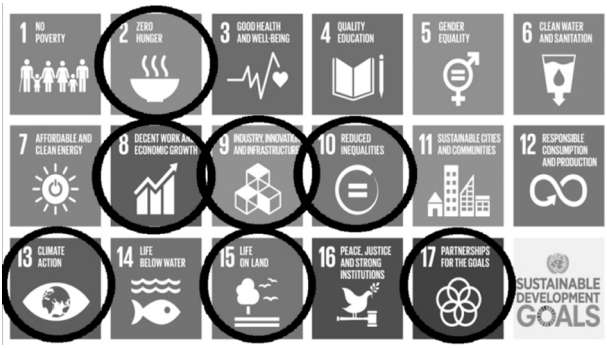
A large portion of corporate logistics companies already operate under sustainable development conditions, meaning that they take into account ecological rationality, economic viability as well as social legitimacy. Directions for such development are outlined in the White Paper (Gołembska 2002, pp. 303–304).

There are three basic sustainability criteria for logistics companies (Borys 2009, p. 174):

a. environmental dimension,
b. economic dimension,
c. social dimension.

Logistics companies are striving to meet the goals set by Agenda 2030. Of all the sustainable supply chain goals, the most prioritized for the logistics industry are: 2, 8, 9, 10, 13, 15 and 17, as described above and shown in Figure 5.

Fig. 5. *Sustainable development goals with highlighted priority targets for logistics companies*



Source: authors' own study based on: https://www.gov.pl/web/rozwój-praca-technologia/cele-zrownowazonego-rozwoju (accessed: 17th June 2023)

When selecting indicators to monitor sustainability for logistics companies, it is essential to ensure that the final selection relates to specific environmental, economic and social sustainability principles and goals.

A total of 15 indicators were selected that can be influenced by logistics companies A, B and C as part of sustainable development. These are:

- 5 indicators in the social dimension,
- 4 indicators in the economic dimension,
- 5 indicators in the environmental dimension,
- 2 indicators in the institutional-political dimension.

Table 4 presents aggregate data on the alignment of 3 logistics companies – A, B and C – with the sustainable development goals. Areas marked with an *X* mean that the company is taking into account the given criteria and adjusting its activities to them (red color is company A, yellow – company B, and blue – company C), while – means that presently, i.e., in the first half of 2023, the company has not taken any actions in the given area.

Table 4. *Adaptation of selected logistics companies A, B and C to the criteria of sustainable development*

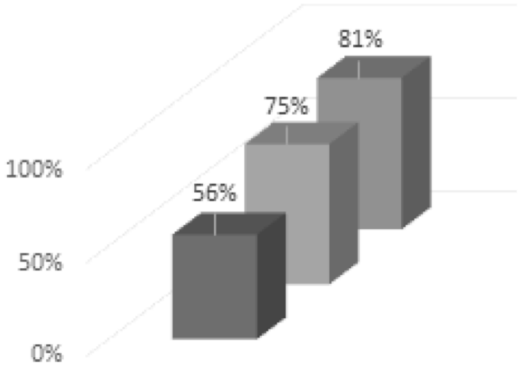
Criteria	A	B	C
Social governance			
Threat of persistent poverty	X	-	-
Continuing education of adults	X	X	X
Unemployment rate	X	X	
Gender pay gap	-	X	X
Road fatalities	X	-	-
Economic governance			
Employment rate of people aged 20–64	-	X	-
Innovative products	X	X	X
Human resources for science and technology	X	X	X
Intermodal transport of cargo by standard-gauge rail transport	X	X	X

Environmental governance			
Greenhouse gas emissions	-	X	-
Biofuels in transport fuel consumption	-	X	X
Emissions of air pollutants by means of transport	X	X	X
Developed and urbanized area	X	-	-
Forest cover	X	X	-
Institutional and political governance			
E-government — availability of online services	X	X	X
Community service engagement	X	X	X
Total:	**11**	**12**	**9**

Source: authors' study based on: *Sustainability indicators for Poland*, GUS, Statistics Poland, Katowice 2011, pp.18–176; *Sustainable development reports of companies A, B and C for 2022*

According to an analysis of the reports, the selected companies (A, B and C) declare that they are adapting to sustainability criteria. Figure 6 summarizes what number of selected eco-development criteria individual companies include in their strategies.

Fig. 6. *Commitment of the analyzed companies to sustainable development*



Source: authors' own study

Out of the 15 criteria selected, company A pays attention to and aligns its activities with 11 of them, accounting for 75%; company B does so with 12 criteria, accounting for 81%, and company C with 9 of them, accounting for only 56%.

Out of the 15 indicators selected, 7 of them are affected simultaneously by all three logistics companies analyzed. There are three indicators related to the economy, two related to institutional and political governance, and one each from environmental and social governance. There are also four aspects influenced by two of the three companies analyzed.

The supply chain sustainability activities undertaken by the companies surveyed have a positive impact on the environment, the economy and society.

Table 5. *Collected examples of such activities*

Company	Type of activities – examples
A	Paying particular attention to employee safety, the goal is *zero* accidents at work
B	Investing in courses and development programs for employees — environmental awareness, 3% reduction in traffic accidents,
C	Introducing digital tools such as applications for optimizing vehicle routes, saving energy and reducing CO2 emissions

Source: authors' study based on: (*Sustainable development reports of companies A, B and C for 2022* and on-site interview)

Conclusions and recommendations

In the article, a multifaceted focus is given to several issues relevant to the security of modern supply chains in the conditions of sustainable development. Companies face enormous logistical challenges. On the one hand, the needs and expectations of markets for the predictability and security of supply chains, on the other, the constraints and disruptions associated with external factors and their risks as pointed out in the article. Risks can impede flows within international supply chains. They can expose not only the logistics operator to losses, but also institutional buyers and individual

customers. Organizations using global or other small–scale supply chains are looking for guarantees of their security.

Identification of factors that threaten the functioning of supply chains and awareness of the disruptions that cause them is important, but the most important and even necessary is the transformation of logistics areas with an emphasis on ecological aspects. The purchasing area, considered an important element related to environmental protection, brings significant added value to the entire supply chain. As many as 261 threats to global supply chains have been identified in 10 areas of the macro-environment in the last 3 years. Organizations, if they comply with mandatory (legal, reporting) and optional (certificates and notifications) *green requirements*, can be sure of achieving sustainable development goals and safe operation of supply chains on global markets. The article presents an example of such activities in three organizations implementing sustainable development goals and setting directions for others.

The article identifies external factors disrupting supply chain security in 10 areas of the global macroenvironment using its own, modified PESTEL method (PESTELMCFRME), extending the analysis to new areas of potential supply chain disruptions. An exemplary model of the external and internal supply chain system was developed, along with a sequence of connections between its various links and an information flow integrator reducing the risk of disruptions in green orders (time and method of implementation, reducing waste and packaging, and others). The degree to which their activities are adapted to green requirements within the framework of the sustainable green deal was assessed on the example of three global organizations. Such analyzes and patterns may constitute an inspiration for research on the construction of instruments for the safe operation of logistics processes within supply chains in the conditions of *green requirements* for organizations and industries, e.g. as part of non-financial reporting in accordance with the CSRD directive, enabling organizations to precisely adapt their activities to sustainable goals. using ESG factors.

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