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Shortening supply chains – the prospect of international exchange[1]

Skracanie łańcuchów dostaw – perspektywa wymiany międzynarodowej

Abstract

Due to the various crises and the geopolitical situation, it is emphasized that it is necessary to create resilient supply chains through nearshoring. The effect of this is the shortening of supply chains in the area of purchasing materials and components, i.e. in the sphere of supply management relations. This should result in changes at the level of trade in the area of purchases. The aim of the article is to diagnose whether there is a tendency to reduce the volume of supplies with the increase in the distance of supply sources from the perspective of their overall structure. The context of the considerations is the European Union, with special focus on Poland. Time series analysis was used as a research method to detect the nature of the phenomenon represented by a sequence of observations, as well as classic descriptive statistics. It was *inter alia* found that no reduction in the burden on international supply chains was observed in Poland and the EU, expressed in the volume of trade exchange in terms of value. Additionally, no positive structural changes towards shortening supply chains were observed, despite an increase in transport costs and pro-environmental policy. The research may support decision-making regarding ways to strengthen resilience in goods flows. Previously, research on this topic was usually conducted in an aggregate form. The new research contribution is an analysis that takes into account such moderators as short and long flows.

Keywords:
import, resilience, reshoring, shortening supply chains, transport, European Union, Poland, disruption, logistics, deglobalization

Streszczenie

Z uwagi pojawiające się kryzysy różnej natury i sytuację geopolityczną podkreśla się, że konieczne jest tworzenie odpornych łańcuchów dostaw poprzez nearshoring. Efektem tego jest skracanie łańcuchów dostaw w przestrzeni zakupów materiałów i komponentów, czyli w sferze relacji zarządzania dostawami. Powinno to skutkować zmianami na poziomie wymiany handlowej w obszarze zakupów. Celem badania jest zatem zdiagnozowanie, czy istnieje tendencja do mniejszego obciążenia łańcucha dostaw z punktu widzenia dostaw międzynarodowych, czyli importu towarów. Przedmiotem rozważań jest Unia Europejska ze szczególnym uwzględnieniem Polski. Jako metodę badawczą do odkrywania natury zjawiska reprezentowanej przez sekwencję obserwacji oraz klasyczną statystykę opisową wykorzystano analizę szeregów czasowych. Stwierdzono m.in., że w Polsce i UE nie obserwuje się zmniejszenia obciążenia międzynarodowych łańcuchów dostaw wyrażonego wartościowo wolumenem wymiany handlowej. Dodatkowo, pomimo wzrostu kosztów transportu i polityki prośrodowiskowej, nie zaobserwowano pozytywnych zmian strukturalnych w kierunku skracania łańcuchów dostaw. Badania mogą pomóc w podejmowaniu decyzji dotyczących sposobów wzmocnienia odporności w przepływach towarów. Dotychczas badania na ten temat były prowadzone przeważnie w formie zagregowanej. Nowym wkładem badawczym jest dokonanie analizy uwzględniającej takie moderatory jak przepływy krótkie i długie.

Słowa kluczowe:
import, odporność, reshoring, skracanie łańcuchów dostaw, transport, Unia Europejska, Polska, zakłócenia, logistyka, deglobalizacja

JEL: F14, Q56, R4, M2

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Introduction and theoretical framework

The cumulative effects of the COVID-19 pandemic, the Russian invasion of Ukraine, and the energy crisis have not only aggravated geopolitical friction, but also caused a profound redefinition of the architecture and dynamics of global supply chains (Arjona et al., 2023). As a result, there is a desire to configure supply chains by seeking closer sources of supply and carrying out imports within close trading relationships.

The greatest potential for simultaneously achieving positive environmental effects and increasing the fluidity of goods flows lies in redirecting imports to geographically proximate areas. Therefore, the need is seen to develop a policy on flows with the inclusion of reshoring, nearshoring, and within the framework of friendshoring. These issues, in connection with environmental aspects, are discussed by, among others, Di et al. (2023), Choudhary et al. (2023), Sarioglu (2023).

On the other hand, a factor limiting the possibility of shortening chains is the fact that many EU countries are dependent on many resources and components. The European Union is, above all, dependent on resources used in industry (such as manganese, nickel, aluminium, chromium, rare earth metals, molybdenum, boron, uranium, silicon, coal, petroleum coke and gases), on medical products (such as drugs or medical instruments and related to COVID), on renewable energy resources (such as those used for the production of photovoltaic cells or LED lamps) and on digital products (such as laptops, mobile phones, monitors) (Arjona et al., 2023). The European Union is mainly dependent on China, followed by the United States and Vietnam, for longer flows. Out of 204 most critical products, approximately 9.2 percent originate and is entirely imported from outside the EU. Studies have shown that network resilience is particularly low when a single exporter is key to a large number of countries within a given trading network and when global production is concentrated in one country (Arjona et al., 2023). All this makes the idea of limiting flows on longer routes difficult to implement. Therefore, one alternative is to strengthen flows through tracking, sharing information, using modern technologies or creating flexible and agile supply chains. A substantial amount of literature on the subject, concerning specific ways to make flows resilient of supply chains, can be found in reviews papers (Castillo, 2022; Shishodia et al., 2023; Solon & Silveira, 2022).

Changes in the structure of imports in terms of distance result from deglobalisation ideas and the need to eliminate disruptions in supply chains. The literature on the subject notes that many countries accelerated deglobalisation processes after the pandemic. According to Vargas-Hernández and Vargas-González (2021), priorities in terms of supply, production and distribution are changing. The location factors of import destinations change the hierarchy of importance: from the most economical to the most secure. The war in Ukraine has disrupted global supplies. Networks and nations now avoid contact with countries that do not share similar values. This highlights the fact that closer economic and financial ties fail to work without deeper social and political ties. A change in supply chain architecture is therefore needed. Dependence on critical raw materials is particularly important (Liedtke, 2022). On the other hand, it is also observed that nationalistic factors can disrupt supply chains and hinder the functioning of multinational companies (Charpin, 2022). Despite good intentions in terms of market protection, chain shortening and friendshoring, discriminatory practices can also occur. Notwithstanding a more multipolar configuration of economic and political power between countries, and increasing problems of disruption, the authors find it difficult to answer the question of whether the world is indeed entering another period of economic deglobalisation (Chase-Dunn et al., 2023). It is therefore difficult to clearly evaluate to what extent the dynamics of shortening commodity flows will be reflected in trade data. Therefore, the aim of the article is to diagnose whether there is a tendency to reduce the volume of supplies with the increase in the distance of supply sources from the perspective of their overall structure.

Research methodology

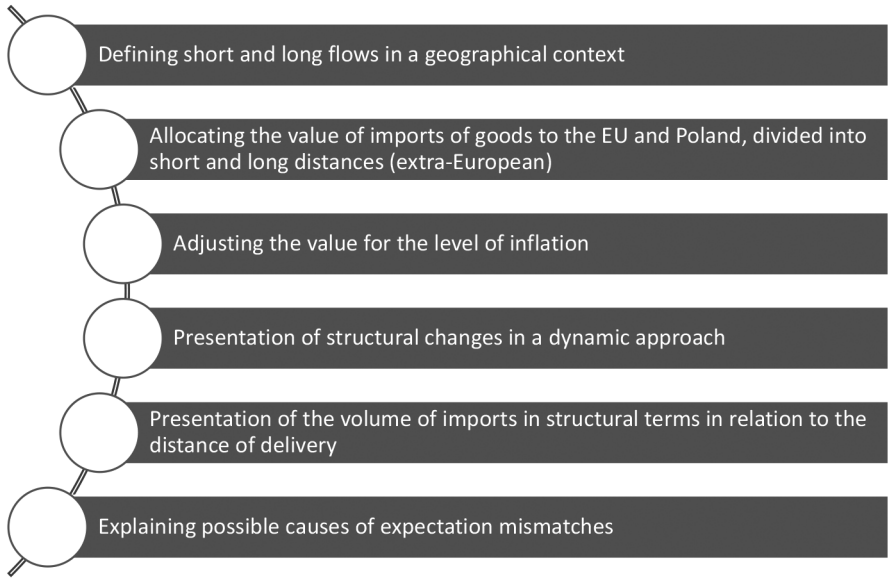
Supply chains can be shortened in a number of ways. For example, this can be done by:

- eliminating intermediaries,
- fragmentation of flows and locating critical inventory closer to sales markets,
- reducing time by locating supply links in countries with simple regulatory and customs procedures,
- locating suppliers closer to production and sales sites, so that goods are imported and transported over shorter distances.

In the paper we try to analyse the last of these methods. The research process consists of several stages (Figure 1).

In the first stage, the Eurostat and GUS databases were used to extract the value of imports to the EU and Poland, for European countries that are not part of the EU, and the value of exchange assigned to other countries. The obtained data was then divided into two groups. The first one relates to the

Figure 1
Research stages



Source: own elaboration.

movement of goods over short distances (by adding the values of intra-community imports and flows between the EU and non-member countries). The second group concerns imports to the EU from non-European countries. In the next step, the data was adjusted for the inflation level of the euro area. The final results were shown in a structural approach, as the mere fact of recording an increase or decrease in the value of imports or exports would not allow for a transparent capture of changes in the discussed area.

In addition to generating data according to the methodological criterion of its division, we used the methods for econometric modelling of time series and test for structural breaks, to check whether there were substantial changes in the import structure due to the outbreak of COVID-19 pandemic.

In the future, it would be useful to go into more detail by examining the structure of imports in the two structural groups discussed at the level of individual countries. However, this would require a very extensive study. In its current form, the slogan „shortening chains" primarily has a macroeconomic dimension, which is expressed in the structure of import distances. Lowering the level of analysis would make the problem of logistics operations more visible.

Results and discussion

Over the span of twenty years – taking into account the value of goods – one can observe structural shifts towards longer supply routes in international EU trade by five percentage points (Figure 2). In this context, changes in favour of importing to Poland from distant locations are even more pronounced since, as over the period studied, the percentage has changed by 15 points (Figure 3).

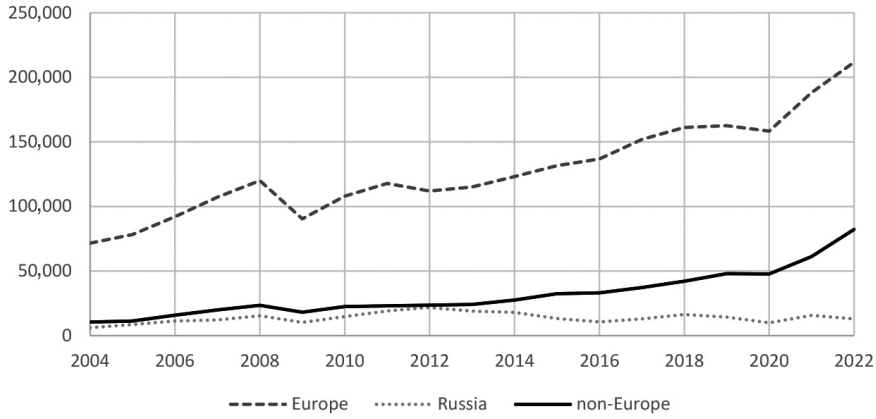
The largest exporters to the EU in 2002, in terms of value were as follows (numbers in EUR million): United States (138,751), China, excluding Hong Kong (73,608), Japan (60,520), South Korea (20,204). Two decades later, China excluding Hong Kong ranked first (626,519), followed by United States (358,704), South Korea (72,083), Japan (69,959). In 2002 and 2022, the Russian export of goods to EU achieved values of, respectively, EUR 61,147 million and EUR 203,365 million.

The largest exporters to Poland in 2004, in terms of value, were (numbers in EUR million): United States (138,751), China excluding Hong Kong (73,608), Japan (60,520), South Korea (20,204). In 2022, the leading exporters to Poland were: China excluding Hong Kong (626,519), United States (358,704), South Korea (72,083), Japan (69,959). The import of goods to Poland from Russia in 2004 was worth EUR 4,930 million and in 2022, the same increased to EUR 15,427 million.

After adjusting the data in import for 27 EU countries, using the Harmonized Index of Consumer Prices (HICP), a very similar trend can be observed on both long and short routes (Figure 4) as in Poland (Figure 5). In order to expand the research perspective for the European Union, trends for individual continents were additionally highlighted.

The values for „Europe" contain import from all European countries (UE and non-UE), except for

Figure 5
Import to Poland (EUR million in 2015 prices)



Source: Statistics Poland (www.stat.gov.pl).

errors. The value of the parameter D denotes value of import in the initial year and the value of E measures yearly changes in import.

2. We have tested the hypothesis that the beginning of the COVID-19 changed the trend in the series. To this end, we used a Chow's test for the structural break[2]. To test for the structural change we assumed that both the slope and the intercept (thus: the level and the trend) had changed after the outburst of the COVID-19 pandemic (2020). The test allows to check if the following segmented model better describes the data:

for observations before the change
for observations after the change

The null hypothesis in the test is the lack of a structural break (i.e. $D_1 = D_2$ and $E_1 = E_2$ which means that there was no change in the trend).

Table 1 presents the results of the regression: estimated coefficients D and E, their standard deviations, R^2 of the regression and the results of Chow's test (test statistics and p-values).

As can be seen, the trend for all supply chains (both for export and import, and for all chain lengths) was positive. The coefficients E are interpreted as year-to-year average changes of the analysed variables. For example, the highest increase was observed for import from the European countries (short supply chains). On average, the value of this export has been increasing by EUR 62,057 million per year. The rate of increase of import from non-European countries (long supply chains) was slower. On average, the value of import in these chains has been increasing by EUR 30,660 million p.a., which is a half of the increase in the import from European countries. The lowest rate of increase was for import from Australia and Oceania (average yearly increase of EUR 100 million). However, the import from this region is negligible anyway.

The results of the Chow's test reveal that there was a structural change in the trends of all analysed chains (p-values are lower than 0.05), except for the import from Russia. The latter remains at the same level over all the period under analysis. There are no signs of any changes – neither increasing nor decreasing the trend.

We have done similar analysis for the values of import to Poland. The results of linear regression and tests for structural break are presented in Table 2. The results are very similar to the ones for the whole European Union. The values of imports are increasing, both for the short and long chains. The increase of import from European countries is faster. It has grown, on average, by EUR 6,165 million p.a., while the average growth of import from non-European countries was by half lower (EUR 2,915 million per year). The import from Russia, in the long run, remained at the same level (with many ups and downs due to political situation). The Chow's tests revealed that there were structural brakes in imports from European and non-European countries after the outbreak of COVID-19 pandemia – the trends have increased. There was no such a structural brake for the import from Russia. This result, however, can be due to lack of sufficiently long series of observations. Other analysis, based on monthly data, presented in previous research showed that there had been

Table 1
Time trends and the results of the Chow's tests for values of import to UE-27

Series	D(sd)	E(sd)	R_2	Chow's test: F-statistics (p-value)
From Europa (without Russia) – short chains	2,354,310*** (110,422)	62,057*** (8,794)	0.724	6.461*** (0.008)
From Russia	131,222*** (17,715)	1,346 (1,411)	0.046	1.970 (0.170)
From all non-European countries	730,805*** (57,787)	30,660*** (4,602)	0.700	15.902*** (0.000)
From Africa	109,603*** (11,459)	1,538 (913)	0.130	4.7903** (0.022)
From Asia	378,493*** (34,500)	23,100*** (2,748)	0.788	14.897*** (0.000)
From America	223,357*** (13,915)	5,922*** (1,108)	0.600	18.132*** (0.000)
From Australia and Oceania	19,351*** (1,885)	100 (150)	0.023	13.688*** (0.000)

(***) p-value below 0.01.

Source: own calculations.

Table 2
Time trends and the results of the Chow's tests for values of import to Poland

Series	D(sd)	E(sd)	R_2	Chow's test: F-statistics (p-value)
From Europa (without Russia) – short chains	66,651*** (5,969)	6,165*** (524)	0.891	7.570*** (0.005)
From Russia	11,837*** (1,884)	195 (165)	0.076	1.325 (0.295)
From all non-European countries	2,612 (3,772)	2,915*** (331)	0.820	42.105*** (0.000)

(***) p-value below 0.01.

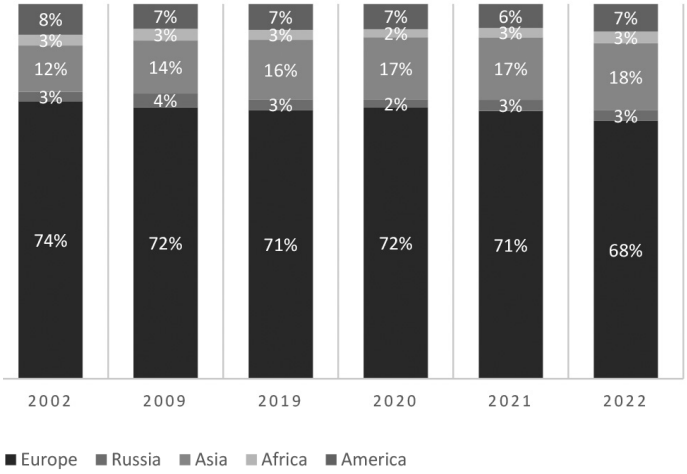
Source: own calculations.

a structural brake (decrease of trend) after the outburst of the war in Ukraine.

In terms of continents, the greatest differences compared to the base year, i. e. 2002, were observed in the case of imports to the EU from Asia, which increased by six percentage points. By exactly the same number has the from import European countries decreased (Figure 6). Australia and Oceania was omitted due to very small value of its import – around 0.5%).

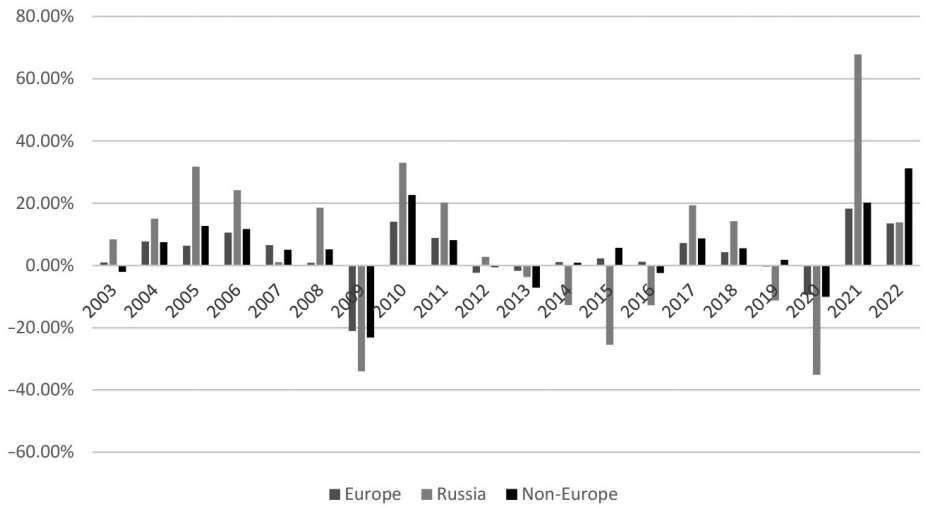
Taking into account year to year changes in the value of imports to the EU and Poland (Figures 7 and 8), one can observe that, in the case of EU, the 2009 crisis had a greater negative impact on imports from distant locations. The same applies to the pandemic crisis of 2020. Interestingly, the war that began 2022 did not negatively affect imports organized from distant geographical regions. One can see that in the year following each crisis, trade

Figure 6
Structure of import to EU-27 according to continents



Source: Eurostat

Figure 7
Year-to-year change in import to EU-27



Source: own calculation using Eurostat data.

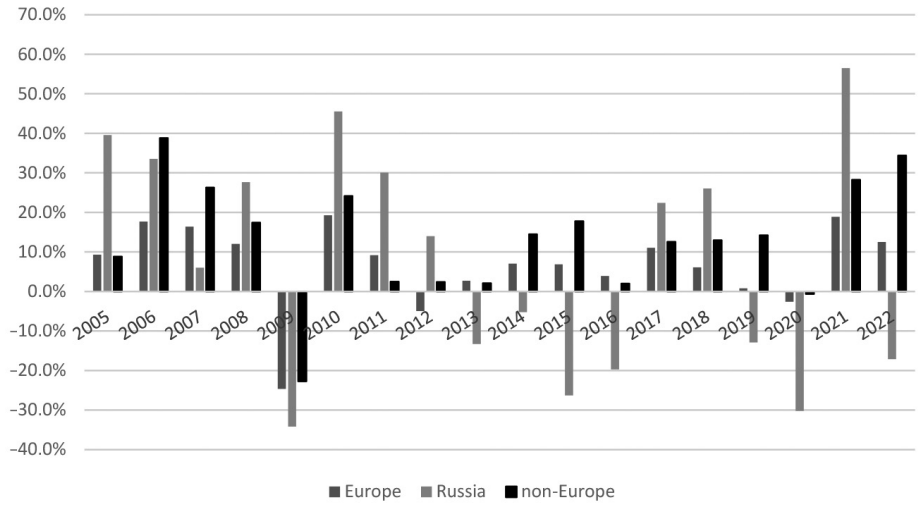
in longer trances increased dramatically. Therefore, subsequent crises are not expected to be related to the policy of reconfiguring supply chains. This is even more visible in the case of Poland.

Research limitations

In order to be able to discuss a wider range of issues in the future, it is worth extending the considerations to include issues of supply chain fragmentation and a detailed assessment, preferably at the level of primary data, of whether there have been significant shifts in supply chain links in international supply and whether there has been a diversification of supply locations. It may turn out that the volume of imports is at the same level in structural terms (long and short chains), but the long chains consist of a number of routes that are shorter than before. However, analysing exchange in terms of both value and volume has its limitations.

During the period covered by the study new countries made their accession to the EU. This does not seem to have a decisive impact on the final

Figure 8
Year-to-year change in import to Poland



Source: own calculation using Statistics Poland data.

results, but such categorization may be distinguished in the future.

Moreover, the research can be complemented by an operational perspective, in which the volume of international transport is considered in the same way as in the current research, i.e. divided into shorter and longer distances. According to preliminary data (not presented here due to the limited space), we can observe that, despite the crises, the trends in road, rail and maritime transport volumes have increased. It is unlikely that the expected slowdown in consumer demand after the pandemic and geopolitical crisis will result in a significant reversal of this trend.

Further discussion is needed to determine the impact of shortening international trade flows on the greenhouse gas emissions intensity of logistics operations. This is a complex issue, related to the emission intensity of the different means of transportation, effects of scale and the resulting opportunities to use environmentally friendly means of transport, fuel prices, redundancy of supply sources in terms of number of suppliers and location diversification.

Therefore, there is a complicated trade-off problem regarding the import of raw materials and goods from either closer or more distant sources, which is best discussed through case studies.

Conclusions

The considerations made have both theoretical and practical implications. At the theoretical level, the results of the research have allowed us to understand the how the geographical length of trade links in import supply chains change with time. At a practical level, the content presented can support decisions on the configuration of supply chains.

Based on the data obtained, it can be concluded that, despite the slogans about the need to reduce the load on chains over longer distances, in an aggregated form and in the longer term, a slow trend towards trading on longer destinations is noticeable. This fact may be related to:

- benefits arising from comparative advantages,
- the need to diversify supply and demand markets in order to reduce the level of business risk,
- high transaction costs in case of changing the subject links in the supply chain or moving them to other geographical zones,
- the growth of e-commerce trade largely based on distant markets,
- the need to take a long-term perspective on the reconfiguration of flows among vertically integrated entities.

Moreover, in the long run, the digitalization of supply chains (e-invoicing, e-CRM), the development of the market for ecological and autonomous vehicles (reducing their prices and increasing their potential to be used over longer distances), the implementation of technologies (IoT, blockchain, ChatGPT, etc.) will not stimulate shortening of chains.

There is no definite verdict on the effectiveness of building resilience through proximity. An example of this is the situation in which

a smartphone manufacturer lost liquidity flows during the COVID period due to the localization of the latest models on its domestic market (Miroudot, 2020). A middle ground solution is supplier diversification. In the literature, it is emphasized that globalization has been seen as something obvious for too long (Javorcik, 2020). Even the global crisis that reached Europe did not lead to a resurgence of protectionism and trade wars. The stability of trading rules encouraged manufacturers to localize production in distant locations. From time to time, supply chains were disrupted due to natural causes. It was only the imposition of disruptions related to COVID and fears of access to critical resources that changed the perception of the existing import policy. It is not excluded that globalization processes will weaken in conjunction with arguments put forward for the purpose of justifying protectionism. Tariffs imposed on various resources and problems with their access during crises exacerbate this problem. For example, this can been seen in the dependence of the supply of chips to cars or substances for medicines from Asian regions, even though there is already a spectacular transfer of production sites, e.g. chip factories from Asia to Germany. This is currently a problem of European markets, still unsolved. Vargas-Hernández (2023) states that although global chains are economically efficient, they are becoming increasingly less secure. Periods of expansive free trade are interspersed with periods of protectionism and deglobalization to protect national interests. The environment of economic, social, political and health instability intensifies the rise in economic transaction and coordination costs of international company branches, and a higher level further exposes chains to disruption. In addition, the increase in labour costs in developing countries makes relocation of closer links to home countries increasingly profitable.

Therefore, awareness of the increasing probability of natural, pandemic and geopolitical crises will force companies to redesign their sources of supply (Roscoe et al., 2022). An additional incentive to regionalize activities is the increase in transport costs (drivers' wages, road tolls, fuel prices), increased possibilities of work automation, shortage of drivers. The growing role of ESG and CBAM in the context of the carbon tax is also important in this process. Additionally, it is becoming less and less profitable for companies to locate production in distant countries, where it was easier to evade the law.

The very idea of fragmenting chains and importing individual components from distant countries also has a pejorative connotation. Entities become very dependent on strong corporations and their development is limited to specializations which are easy to substitute. In this situation, technological, capital and organizational convergence may be slow. Locating supply sources in accordance with comparative advantages may be primarily beneficial for entities with a strong position in the supply chain.

Therefore, in the future, due to the need to create shock-resilient flows, trials to shorten supply chains in order to protect the environment leads to a controversial question about the justified level of interference in flows of goods at the systemic level of economies and international groups. On the other hand, radically shortening supply sources may reduce the development potential of weaker and distantly located entities for whom the diffusion of knowledge is an opportunity for development.

Significantly, Poland is even more dependent than the European Union on distant sources of supply. Subsequent crises have not changed this trend, despite temporary upheavals. Weakening economies force us to look for cheaper products. Increased penalties for CO_2 emissions and the pursuit of component independence may slowly contribute to the reconfiguration of supply chains and imports from closer locations. The possibility of exploiting third countries and the natural scarcity of resources are likely to hamper this process.

Undoubtedly, the image of trade exchange and the reconfiguration of supply chains in European countries, including Poland, will be influenced by global trends indicated in the latest research. In scientific studies and reports by reputable consulting organizations, the necessity of reconfiguring supply chains in the context of trade exchange is emphasized, pointing to the need for regionalization of activities, friendshoring, shortening supply chains, and greening operations (Deloitte, 2024; Munteanu, 2024; The Economist Group, 2024; Walkowski, 2024). It is currently stated that „fragmentation is already a reality" (Gopinath, 2023). This, in turn, may lead to both the shortening and the lengthening of flows. Therefore, the structure of trade exchange, divided by geographical distances, will result from the described conflicting trends.

Notes/Przypisy

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[2] This is a standard econometrics procedure. See for example: Greene, 2008, chapter 6.4.

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