

Disruptions in Supply Chains in the Automotive Industry During the COVID-19 Pandemic. The Case of Polish Companies – the Perspective of the Main Supply Market

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Abstract

The main aim of this article is to present the supply chain disruptions experienced by automotive companies during the COVID-19 pandemic, with a particular focus on the characteristics of their primary supply markets. The automotive companies surveyed were links directly or indirectly with production in this industry. Disruptions in supply chains significantly affected planning and production continuity throughout the industry. The empirical data were sourced from a survey conducted in June 2023, involving 500 companies. During the COVID-19 pandemic, automotive companies encountered a series of disruptions within their supply chains, including constrained delivery timelines, prolonged lead times, and escalated operational costs. The character of a company's primary supply market significantly influenced the duration of these pandemic-induced supply chain disturbances and the pace of recovery towards normal business operations. Disruptions were more prevalent among companies reliant on global supply sources as opposed to those with predominantly local supply chains.

Keywords

Supply market; Disruptions in supply chains; Number of suppliers; Purchase from Asia; Stocks of materials and products; Limitations in timely deliveries.

Introduction

Issue outline and research gap

The COVID-19 pandemic, accompanied by fluctuations in supply and demand and the closure of international borders, wrought significant disruptions upon global supply chains (Dodd & Yengin, 2021). Numerous scholarly articles have been dedicated to examining this critical subject. For instance, Guan et al. (2020) observed that the extent of supply chain losses during the pandemic was more closely tied to the duration of border closures than to their strictness. The intricate nature of global supply chains also exerted a substantial impact. Ivanov (2020) notably highlighted the 'domino effect,' wherein disruptions cascaded throughout the supply chain, propagating a ripple effect of disturbance. Gunnessee & Subrama-

nian (2020) conducted research demonstrating that the pandemic simultaneously impacted all nodes and linkages within supply chains. In their comprehensive study, Chowdhury et al. (2021) shed light on various challenges manifesting in diverse supply chains. These included shortages of essential materials and products, delays in on-time deliveries, production interruptions, backlog accumulations, as well as transport and distribution delays, among others.

Given the multifaceted nature of these disruptions, it is imperative to investigate the empirical patterns that have emerged with a more extensive research sample. This endeavor will enable a comprehensive assessment of whether supply chain disruptions affected all stakeholders within the supply chain or primarily those with global sourcing networks. Of particular relevance is the automotive industry, distinguished by its sprawling and globally interconnected supply chains. Enterprises in this industry are directly or indirectly involved in production, so any kind of disruptions affect the planning and continuity of production throughout the automotive industry. The research presented herein serves to bridge an existing research gap by identifying and analyzing supply chain

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disruptions that occurred within a sizable research sample in the automotive sector, as well as proposing strategies to address these challenges.

Aims, and structure of the article

The primary objective of this article is to present the disruptions within the supply chains of automotive companies caused by the COVID-19 pandemic, with a particular emphasis on the characteristics of their primary supply markets. The automotive companies surveyed were links directly or indirectly with production in this industry. Disruptions or lack thereof in supply chains significantly affected planning and production continuity throughout the industry. The specific objectives include:

- the identification and characterization of the various typologies of companies participating in automotive supply chains,
- the determination of transformations within automotive companies during the pandemic, contingent upon the nature of their primary supply markets, and
- the exposition of the disruptions witnessed within automotive supply chains, along with proposed strategies to mitigate these adversities, contingent upon the nature of the primary supply market.

The article seeks the answers to one research hypothesis:

Supply chain disruptions during the COVID-19 pandemic in the automotive industry varied by type of the main supply market, with more frequent disruptions in companies sourcing globally than locally.

The organizational structure of this work is as follows: Section 1 introduces the reader to the subject matter, delineating the impact of COVID-19 on supply chain operations. This section also underscores the identification of a critical research gap and elucidates the article's objectives. Section 2 provides a comprehensive literature review on supply chain disruptions. Section 3 outlines the methodology employed to identify disruptions occurring within the supply chains of automotive companies differing in supply market size. Section 4 presents the research findings. Section 5 contextualizes the results by referencing other research outcomes that explored the tested relationships. Finally, the key conclusions drawn from this study are encapsulated in Section 6.

Literature review

Supply chain disruptions most often result from unintended and unexpected events occurring upstream in the supply chain (Bode & MacDonald, 2017). Both

natural and man-made disruptions are inherent aspects of global supply chains. The COVID-19 pandemic caused a disruption of unprecedented magnitude, putting the resilience of global supply chains to the test. Paramount in this context was the ability of supply chain operators to act effectively to recover from and adapt to disruptions of varying duration, impact, and probability (Golan et al., 2020). Moosavi et al. (2022) identified that the primary research themes related to supply chains during a pandemic were resilience and sustainability, with a particular focus on supply chains related to food and health. Mishra et al. (2022) delineated three types of problems encountered in supply chains: supply-side issues, demand-side challenges, and logistics constraints. These arose a pressing need for supply chains to enhance their resilience (Craighead et al., 2020). Companies were compelled to revise their inventory strategies in response to the pandemic (Sodhi et al., 2023). The ability to adapt, an acute awareness of knock-on effects, a swift recovery process, a readiness for change, and a commitment to sustainability emerged as pivotal factors in ensuring the smooth operation of supply chains (Queiroz et al., 2020). To bolster supply chain resilience, both short-term and long-term improvement plans were implemented (Belhadi et al., 2020).

Materials and methods

Data collection, processing, and limitations

This study examined 500 automotive companies in Poland, chosen through purposive sampling from a pool of approximately 2,000 enterprises in the automotive industry. The enterprises were selected deliberately from the database, and the structure of entities is similar to that in the industry. The research can therefore be considered representative. Data was collected via 500 questionnaires through face-to-face telephone interviews in June 2023, stored in an Excel spreadsheet, and presented in an aggregated form to protect company confidentiality. The survey questionnaire was verified by experts both dealing with this topic and conducting this type of research in the automotive industry. The main focus was categorizing companies by their primary supply markets: 38% sourced locally, 28% nationally, 13% regionally, 7% from national and neighboring countries, 9% from the European Union, and 5% from global markets. The size of the company was not taken into account. The study's limitation was the 15-minute interview duration (longer surveys were not accepted by respondents), necessitating a focus on key questions regarding supply chain disruptions.

Applied methods

The research encompassed two distinct stages. In the initial stage, we presented essential data about the surveyed companies, classifying them based on their primary supply markets. This method of aggregation remained consistent throughout the research phases. Across all research stages, we explored the correlation or independence between the companies' main sourcing market types and the distribution of specific responses. Our objective was to determine if the size of the sourcing market impacted supply chain disruptions and how companies addressed these irregularities. To accomplish this, we employed Pearson's χ^2 independence test, a statistical tool for analyzing two variables' characteristics. The null hypothesis (H_0) assumed the independence of these variables. We validated this hypothesis using critical values at a significance level of $\alpha = 0.05$ (Aczel & Sounderpandian, 2000). If the computed χ^2 value fell below the critical threshold, insufficient evidence existed to reject the null hypothesis, confirming the independence of the variables. Conversely, surpassing the critical χ^2 value led to null hypothesis rejection, signifying interdependence between the variables under scrutiny (Łapczyński, 2005). The second stage of our research aimed to identify disruptions in the automotive industry's supply chains and elucidate the surveyed companies' responses to these challenges. Identifying patterns within companies based on their primary supply markets was crucial to this objective.

Results

Basic data on the surveyed companies

Automotive companies that engaged in local, regional, and national sourcing typically operated with a workforce of up to nine employees, categorizing

them as micro-enterprises (Fig. 1). The size of the sourcing market increased in tandem with the size of the company. These patterns follow a logical trajectory, as smaller companies frequently lack the requisite resources and personnel for global procurement and, consequently, resort to intermediaries. Statistical tests conducted to validate this observation indicated a robust and statistically significant relationship between the primary sourcing market type and a company's size, measured by the number of employees ($\chi_{emp}^2 = 37.28$; $\chi_{0.05}^2 = 25.00$; p-value < 0.05).

Another crucial aspect is the number of suppliers (Fig. 2). Companies sourcing locally tend to work with a limited number of suppliers, typically fewer than five, predominantly obtaining parts and components from local centers and wholesalers. Conversely, global companies engage with a more extensive supplier network, with many sourcing from both the EU market and global sources having between 11 and multiple suppliers. Statistical analyses confirmed a strong and significant relationship between the primary sourcing market type and the number of suppliers ($\chi_{emp}^2 = 189.67$; $\chi_{0.05}^2 = 43.77$; p-value < 0.05).

Types of disruption in the supply chains of the companies studied

After presenting industry conditions and sourcing regularities, we addressed supply chain disruptions. Company representatives identified several reasons for these issues (Fig. 3). Remarkably, 36% of locally sourcing companies reported no supply chain problems, attributed to their absence from international trade. Within this group, 34% faced challenges due to lockdowns and official closures. Among companies sourcing regionally and nationally, 51% reported low material and product stocks. In contrast, among global sourcing companies, 58% cited issues arising from dependence on Asian supplies and low mate-

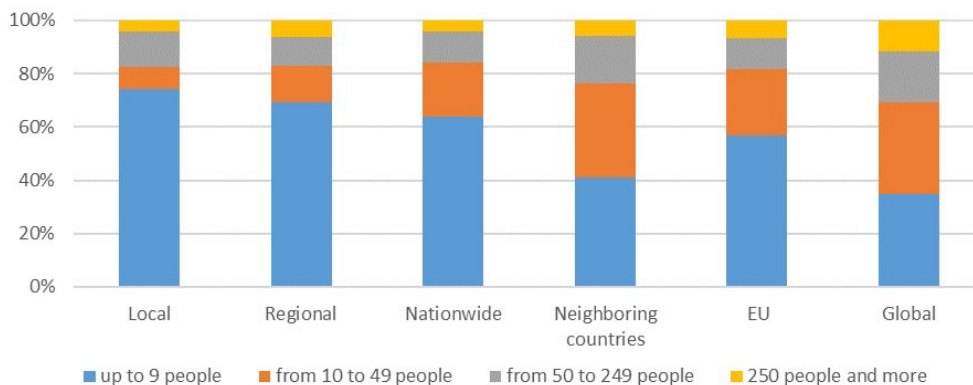


Fig. 1. Number of people employed in the surveyed enterprises

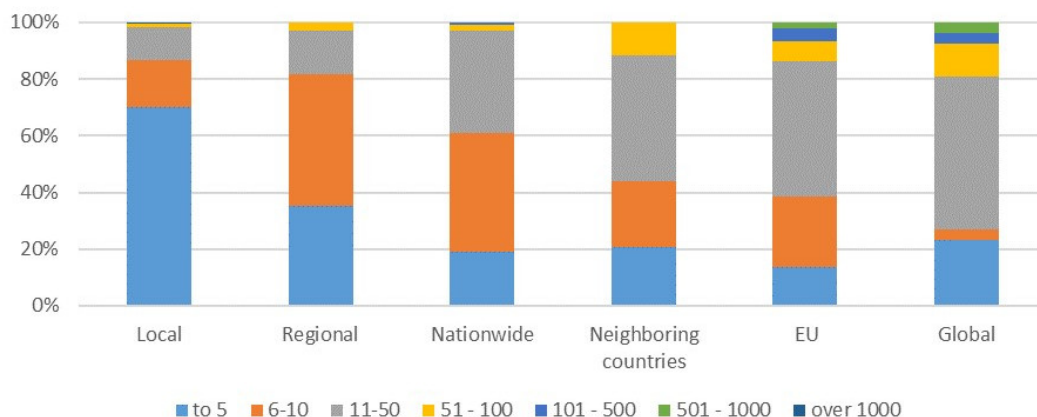


Fig. 2. The number of suppliers of the surveyed enterprises

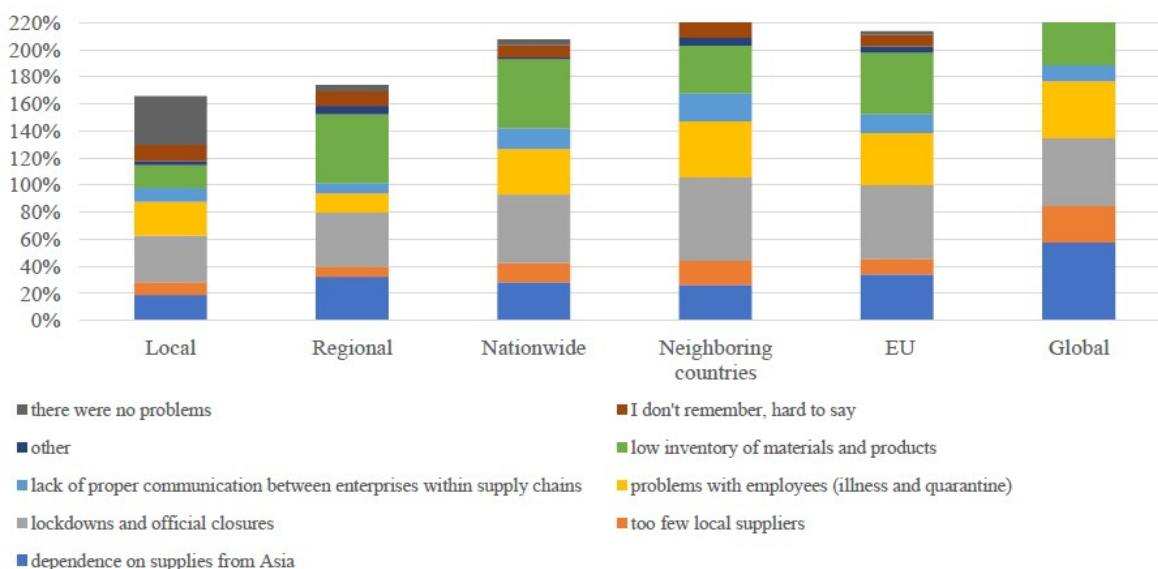


Fig. 3. The most important causes of problems in the supply chains in the surveyed enterprises (multiple selection)

rial and product stocks. Statistical tests confirmed a strong and significant relationship between the main sourcing market type and supply chain problem causes ($\chi^2_{emp} = 149.39$; $\chi^2_{0.05} = 55.76$; p-value < 0.05).

The following question can be described as a follow-up inquiry. It pertains to the disruptions or problems in the supply chain experienced by the surveyed companies (Fig. 4). Similarly, the pandemic's repercussions were least pronounced among companies that sourced locally. In contrast, a majority of companies in other categories experienced pandemic-related disruptions in their supply chains. These problems appeared irrespective of the size of the sourcing market. Statistical tests conducted confirmed a robust and statistically significant relationship between the

primary supply market type and the occurrence of supply chain disruptions or problems ($\chi^2_{emp} = 64.78$; $\chi^2_{0.05} = 18.31$; p-value < 0.05).

Business representatives also identified the types of disruptions and issues they encountered in their supply chains during the COVID-19 pandemic (Fig. 5). Among companies sourcing locally, the most prevalent problem was delays in deliveries, indicated by 49% of operators. Conversely, 79% of companies sourcing from Poland and neighboring countries cited increased freight, storage, and labor costs as the primary issue. Interestingly, in the case of companies with global sourcing markets, the fewest respondents (29% of companies) reported constraints on timely deliveries. Prolonged lead times were a significant issue

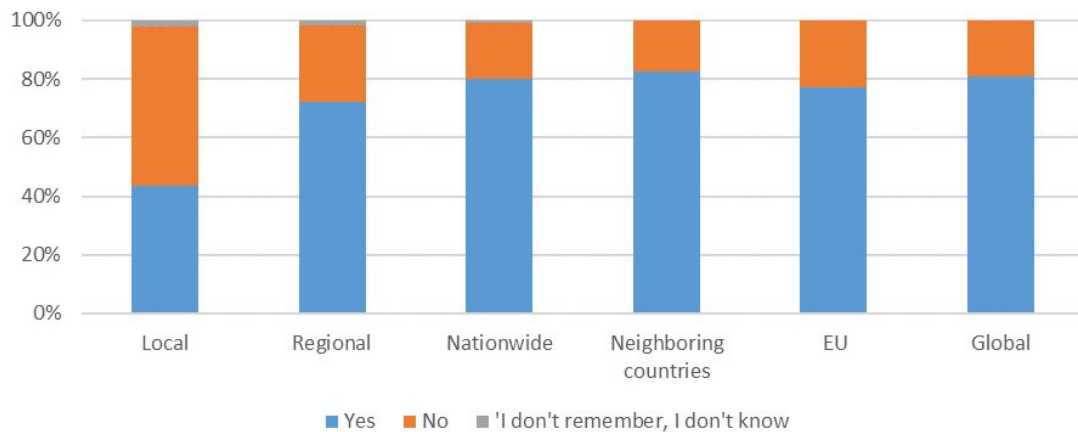


Fig. 4. The most important causes of problems in the supply chains in the surveyed enterprises (multiple selection)

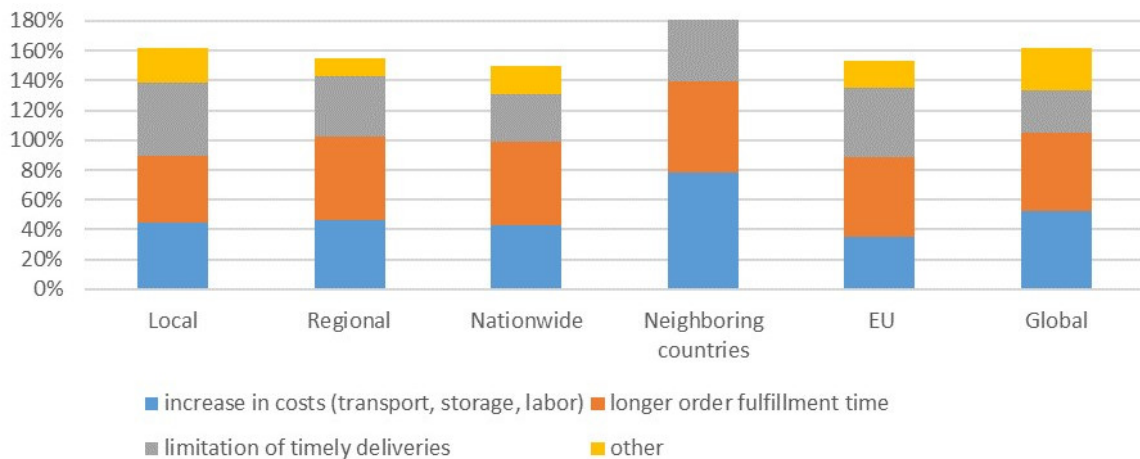


Fig. 5. Types of disruptions (problems) related to the supply chain during the pandemic in the surveyed enterprises (multiple choice)

across all groups of companies. Statistical tests conducted did not establish a correlation between the primary sourcing market type and the specific disruptions and issues in the supply chain ($\chi_{emp}^2 = 14.05$; $\chi_{0.05}^2 = 25.00$; p-value < 0.52).

Another question concerned the duration of the disruptions (Fig. 6). A noteworthy 61% of locally sourcing companies experienced disruptions lasting up to six months. Among companies sourcing domestically, the majority (45%) reported disruptions lasting between six months and one year. For companies sourcing globally, disruptions spanning one to two years were most frequently reported (29% of companies). This trend also extended to disruptions exceeding two years, with 5% of companies in this category reporting such prolonged disruptions. Generally, the duration of disruptions increased with the scope of the sourcing

area. Statistical tests conducted confirmed a strong and statistically significant relationship between the primary sourcing market type and the duration of supply chain disruptions or problems ($\chi_{emp}^2 = 53.81$; $\chi_{0.05}^2 = 37.65$; p-value < 0.05).

Another question pertained to the return of businesses to pre-pandemic levels of activity (Fig. 7). Remarkably, 55% of locally sourcing companies reported a swift recovery, typically within three months. This suggests that these businesses, which did not engage in international trade, may have been less affected by the global nature of the pandemic. A return to pre-pandemic levels of activity within three months to one year was reported by the majority of domestically sourcing companies (38%). Notably, a longer recovery period, exceeding one year, was more commonly reported by companies sourcing from neighbor-

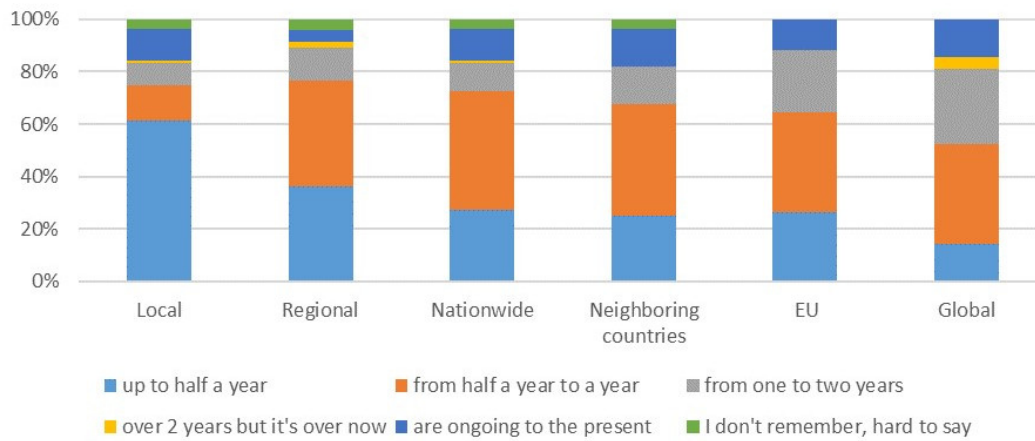


Fig. 6. Duration of supply chain disruption during the pandemic in the surveyed companies

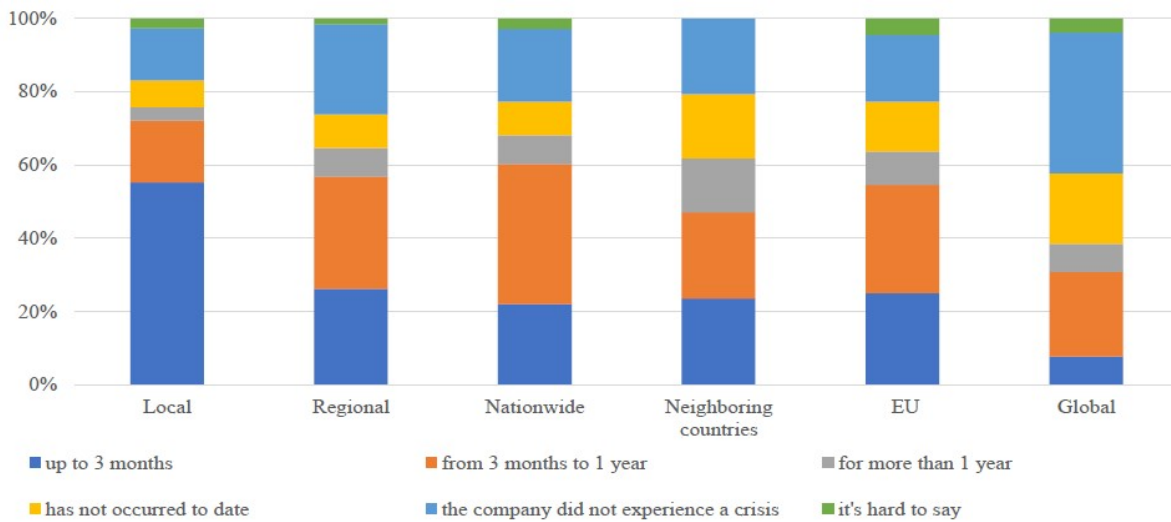


Fig. 7. The time of return to activity from before the crisis caused by the pandemic in the surveyed enterprises

ing markets (15%). Surprisingly, 19% of companies with global sourcing indicated that they had not yet returned to pre-pandemic activity levels, highlighting the pandemic's enduring impact. Interestingly, within this global sourcing group, 38% indicated that they had not experienced a crisis. Statistical tests confirmed a strong and statistically significant relationship between the primary supply market type and the time required to return to pre-pandemic activity levels ($\chi_{emp}^2 = 77.00$; $\chi_{0.05}^2 = 37.65$; p-value < 0.05).

Tackling disruption in automotive supply chains

Subsequently, we examined how companies addressed supply chain problems resulting from the pandemic (Fig. 8). Strikingly, as many as 79% of locally

sourcing companies did not seek or employ alternative suppliers or customers. In other categories of companies, this passive approach was observed in approximately 50% of cases. This might be attributed to an 'await and see' strategy, as some anticipated that the problems would eventually subside without requiring drastic measures. Approximately 33% of companies sourcing regionally and globally explored and utilized alternative suppliers and customers, with the highest percentage among globally operating companies. In some cases, certain companies within these groups sought alternatives but were unable to implement them. Statistical tests confirmed a strong and statistically significant relationship between the primary supply market type and the approaches adopted during the pandemic ($\chi_{emp}^2 = 56.70$; $\chi_{0.05}^2 = 25.00$; p-value < 0.05).

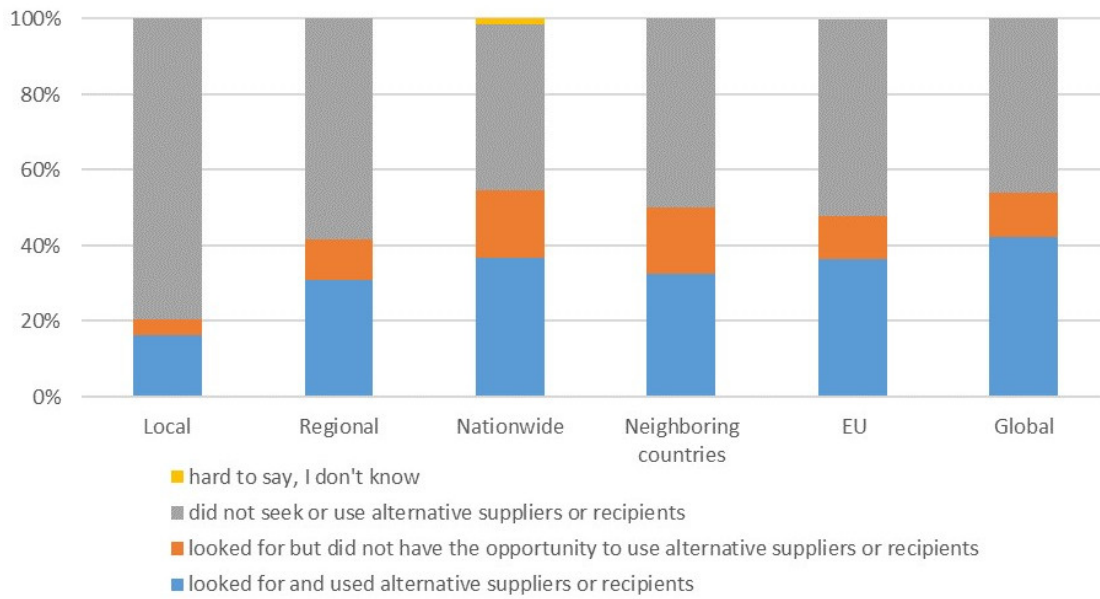


Fig. 8. Actions taken during the pandemic in the surveyed enterprises

Another aspect of our investigation concerned the nature of supply chain activities and decisions made during the pandemic (Fig. 9). In the majority of companies, operational decisions predominated, focusing on short-term actions in the immediate future. Only companies with global suppliers exhibited a dominance of strategic decisions (42% of entities). These strategic decisions encompassed longer-term changes and actions that would significantly impact the company's future. The overall trend suggests that companies predominantly implemented short-term adjustment measures. However, as the scope of sourcing expanded, strategic decisions became more prevalent.

Statistical tests revealed a weak but statistically significant relationship between the primary sourcing market type and the nature of actions and decisions taken by companies during the supply chain disruptions caused by the pandemic ($\chi_{emp}^2 = 25.39$; $\chi_{0.05}^2 = 25.00$; p-value < 0.04). Another question focused on the duration of adjustments made in response to the COVID-19 pandemic (Fig. 10). The vast majority of companies indicated that these adjustments were of a short-term nature. This trend was most pronounced among companies sourcing locally, with 80% of them reporting short-term adjustments, and the proportion decreasing as the scope of the sourcing market ex-

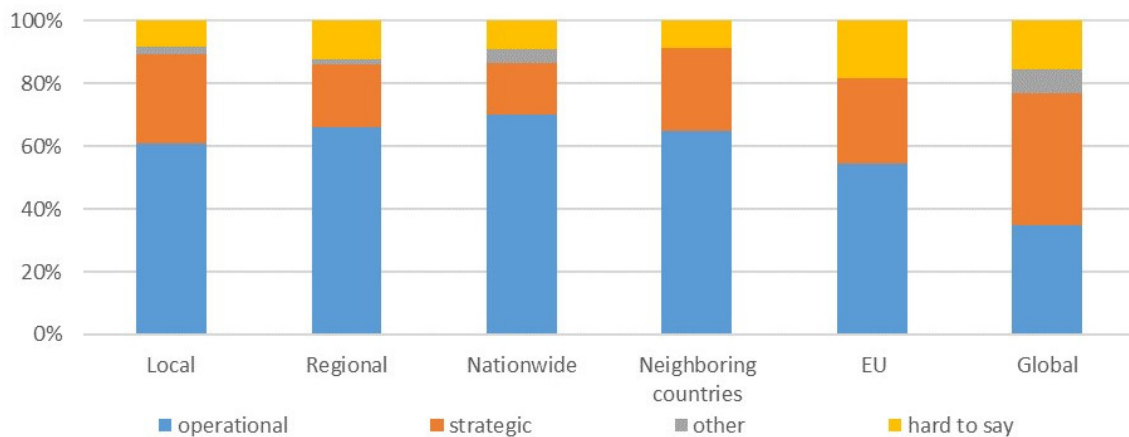


Fig. 9. The nature of activities and decisions regarding the supply chain during the pandemic in the surveyed enterprise

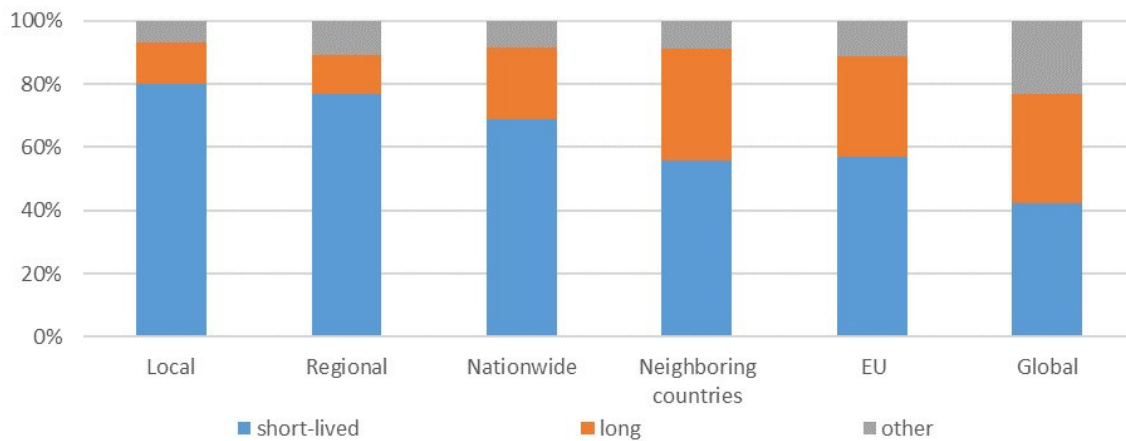


Fig. 10. The nature of activities and decisions regarding the supply chain during the pandemic in the surveyed enterprise

panded. Conversely, a different pattern emerged concerning long-term changes. This response was most commonly chosen by companies utilizing global sourcing markets (35%), while it was the least frequent choice among locally operating companies. Statistical tests confirmed a strong and statistically significant relationship between the primary sourcing market type and the nature of changes and adjustments made by companies in response to the pandemic ($\chi^2_{emp} = 31.74$; $\chi^2_{0.05} = 18.31$; p-value < 0.05).

Discussion

Farooq et al. (2021) emphasized the imperative of scrutinizing supply chain operations as a strategic response to mitigate the adverse effects of pandemic-induced disruptions. In our study, we similarly demonstrated how automotive companies strategically navigated operational decisions in the midst of a pandemic crisis. Building upon these insights, Leite et al. (2020) posited that the alterations witnessed in supply chain dynamics during pandemics are often characterized by their short-term and abrupt nature, a phenomenon mirrored in the behavior of the surveyed automotive companies. Mohammadi (2020) delved into the spatial distribution of disruptions within supply chains during pandemics, revealing a predominant concentration of disruptions upstream. Swierczek (2020) further expounded on this theme by asserting that disruptions occurring at lower echelons of the supply chain were efficiently counterbalanced. Our own research substantiates these claims by elucidating how disruption levels tend to escalate proportionally with the expansion of the principal supply market. Notably,

a substantial cohort of locally-operating companies attested to their resilience against disruption, aligning with the findings of Ivanov and Dolgui (2020). The latter scholars also underscored the relevance of the bullwhip effect within supply chains and its consequential impact on the occurrence and perception of disruptions.

Conclusions

The following conclusions can be drawn from the research carried out:

- Representatives of enterprises underscored a spectrum of disruptions and challenges that manifested within supply chains during the COVID-19 pandemic. These included constraints on delivery times, elongated order fulfillment durations, and amplified operational costs.
- The duration of the pandemic's influence on supply chains and the celerity of their return to antecedent levels were intricately tied to the geographical scope of a company's supply market.
- During the pandemic, enterprises predominantly resorted to short-term and operational adaptive strategies, as opposed to formulating and implementing strategic responses.
- Disruptions within supply chains amid the COVID-19 pandemic within the automotive sector exhibited disparities contingent upon the primary supply market type. Disruptions were more prevalent among enterprises engaged in global sourcing as opposed to those operating at a local level. This hypothesis was confirmed by empirical evidence.

Enterprises from the automotive sector should review their connections in the supply chain, which then directly or indirectly affect production. The pandemic has shown which relationships turned out to be flawed. In such a case, companies should try to look for new suppliers that could replace the companies that failed. On the other hand, cooperation with suppliers who did not disappoint during the crisis should be strengthened. Greater flexibility and cooperation in supply chains is also advisable. Thanks to this, it will be possible to implement production plans and assumptions. It is also crucial to monitor flows in supply chains, which will allow for early response to any irregularities.

Further research in the automotive industry may concern the efficiency of supply chains in times of crisis (war in Ukraine and other disruptions). The research can be performed on the basis of a case study, e.g. for a specific car manufacturer. It would be interesting to present the existing network of connections, as well as the response to disruptions in a specific supply chain. In the case of disruptions in supply chains, further research could be carried out in other industries, also key to the economy. Thanks to this, it will be possible to point out certain general regularities, but also specific reactions tailored to specific industries.

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References

- Aczel, A.D. & Sounderpandian, J. (2000). *Statistics in Management* [in Polish]. PWN Scientific Publishing House. Warsaw. Poland.
- Belhadi, A., Kamble, S., Jabbour, C.J.C., Gunasekaran, A., Ndubisi, N.O., & Venkatesh, M. (2021). Manufacturing and service supply chain resilience to the COVID-19 outbreak: Lessons learned from the automobile and airline industries. *Technological Forecasting and Social Change*, 163, 120447.
- Bode, C. & Macdonald, J.R. (2017). Stages of supply chain disruption response: Direct, constraining, and mediating factors for impact mitigation. *Decision Sciences*, 48(5), 836–874.
- Chowdhury, P., Paul, S.K., Kaiser, S., & Muktadir, M.A. (2021). COVID-19 pandemic related supply chain studies: A systematic review. *Transportation Research Part E: Logistics and Transportation Review*, 148, 102271.
- Craighead, C.W., Ketchen Jr, D.J., & Darby, J.L. (2020). Pandemics and supply chain management research: toward a theoretical toolbox. *Decision Sciences*, 51(4), 838–866.
- Dodd, T., & Yengin, D. (2021). Deadlock in sustainable aviation fuels: A multi-case analysis of agency. *Transportation Research Part D: Transport and Environment*, 94, 102799.
- Farooq, M.U., Hussain, A., Masood, T., & Habib, M.S. (2021). Supply chain operations management in pandemics: A state-of-the-art review inspired by COVID-19. *Sustainability*, 13(5), 2504.
- Golan, M.S., Jernegan, L.H., & Linkov, I. (2020). Trends and applications of resilience analytics in supply chain modeling: systematic literature review in the context of the COVID-19 pandemic. *Environment Systems and Decisions*, 40(2), 222–243.
- Guan, D., Wang, D., Hallegatte, S., Davis, S.J., Huo, J., Li, S., & Gong, P. (2020). Global supply-chain effects of COVID-19 control measures. *Nature Human Behaviour*, 4(6), 577–587.
- Gunessee, S. & Subramanian, N. (2020). Ambiguity and its coping mechanisms in supply chains lessons from the Covid-19 pandemic and natural disasters. *International Journal of Operations & Production Management*, 40(7/8), 1201–1223.
- Ivanov, D. (2020). Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case. *Transportation Research Part E: Logistics and Transportation Review*, 136, 101922.
- Ivanov, D., & Dolgui, A. (2020). Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak. *International Journal of Production Research*, 58(10), 2904–2915.
- Leite, H., Lindsay, C., & Kumar, M. (2020). COVID-19 outbreak: Implications on healthcare operations. *The TQM Journal*, 33(1), 247–256.
- Łapczyński, M. (2005). Analiza porównawcza tabel kontyngencji i metody CHAID. *Zeszyty Naukowe/Akademia Ekonomiczna w Krakowie*, (659), 149–163.
- Mishra, R., Singh, R.K., & Subramanian, N. (2022). Impact of disruptions in agri-food supply chain due to COVID-19 pandemic: contextualised resilience framework to achieve operational excellence. *The International Journal of Logistics Management*, 33(3), 926–954.
- Mohammadi, M. (2020). Designing an integrated reliable model for stochastic lot-sizing and scheduling prob-

- lem in hazardous materials supply chain under disruption and demand uncertainty. *Journal of Cleaner Production*, 274, 122621.
- Moosavi, J., Fathollahi-Fard, A.M., & Dulebenets M.A. (2022). Supply chain disruption during the COVID-19 pandemic: Recognizing potential disruption management strategies, *International Journal of Disaster Risk Reduction*, 75, 10298.
- Queiroz, M.M., Ivanov, D., Dolgui, A., & Fosso Wamba, S. (2022). Impacts of epidemic outbreaks on supply chains: mapping a research agenda amid the COVID-19 pandemic through a structured literature review. *Annals of Operations Research*, 319(1), 1159–1196.
- Sodhi, M.S., Tang, C.S., & Willenson, E.T. (2023). Research opportunities in preparing supply chains of essential goods for future pandemics. *International Journal of Production Research*, 61(8), 2416–2431.
- Swierczek, A. (2020). Investigating the role of demand planning as a higher-order construct in mitigating disruptions in the European supply chains. *The International Journal of Logistics Management*, 31(3), 665–696.