










Restructuring Global Supply Chains: Navigating Challenges of the COVID-19 Pandemic and Beyond

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Abstract. *Problem definition:* The COVID-19 pandemic imposed unprecedented stresses on global supply chains (GSCs), compelling companies to reassess their supply chain structures and strategies. This crisis has also heightened awareness among businesses, consumers, and policymakers about the critical importance and far-reaching implications of GSC design and management. This unique moment presents a generational opportunity for Operations Management (OM) researchers to document and understand the ongoing restructuring of GSCs. *Methodology/results:* By analyzing microlevel data on U.S. customs import shipments (2019–2021), we uncover shifts in GSC strategies during the COVID-19 pandemic. Firms diversified suppliers within existing sourcing locations and reallocated volumes among them. Whereas dependence on China decreased, imports from other Asian nations like India and Vietnam, as well as North American countries like Canada and Mexico, increased. Industry-specific differences were pronounced, and a notable shift toward lower-frequency, higher-quantity shipments was also observed. *Managerial implications:* Beyond the challenges of COVID-19, recent years have witnessed other major supply chain disruptions, due to causes such as geopolitical tensions, natural disasters, and port worker strikes. We offer actionable insights for executives designing supply chain strategies to prepare for similar disruptions as they increase in frequency and severity. We identify future research avenues aimed at enhancing the resilience and adaptability of GSCs in a continuously evolving environment.

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1. Introduction

An earlier OM Forum paper by Cohen et al. (2018) drew upon a global field study conducted between 2014 and 2015 to demonstrate that companies within their data set frequently restructured their global supply chains (GSCs). Contrary to media reports suggesting a trend of reshoring operations (i.e., moving sourcing and production back to a company’s home market), the study did not find evidence of such a shift on a meaningful scale. Instead, the research indicated that reshoring was relatively infrequent. Notably, capital investments shifting from Asia to the United States were predominantly

Asian and European firms strategically investing for proximity to the U.S. market. At the time, China remained the most attractive production location, followed by Eastern Europe and Southern Asia.

Then the COVID-19 pandemic occurred. A timeline of COVID-19 is provided in Online Appendix OA. Ninety-four percent of the Fortune 1000 companies reported being affected by supply shocks related to COVID-19 (Sherman 2020). Automotive manufacturers throttled production because of shortages of semiconductors, FMCG (Fast-Moving Consumer Goods) brands lacked packaging and raw materials, and retailers could not keep toilet

paper stocked on their shelves (Frikkee 2020, Lee 2020, Sultan 2022). Resilience to supply chain disruptions became a top priority of executives (Sultan 2022), leading to reconsideration of standard practices. Manufacturers contemplated their dependence on single or at least geographically concentrated sources of supply (Krause 2021), especially when requiring long-distance imports (Graves et al. 2022). Many observers saw in these events the Achilles heel of lean-inventory systems premised upon just-in-time (JIT) replenishments (Lund et al. 2020).

Many of the challenges encountered during the COVID-19 pandemic will leave a lasting mark on the world. As the pandemic subsides, we find it timely to present this follow-up to Cohen et al. (2018), offering empirical evidence of the shifts in GSC restructuring that occurred during this period. Beyond COVID-19, recent years have witnessed a series of other significant “black swan” disruptions to supply chains, including the China-United States trade war since 2018, Brexit in 2020, the Suez Canal blockage in 2021, global inflation since 2021, the Russia-Ukraine conflict since 2022, the Middle East crisis since 2023, and frequent natural disasters. Our conversations with company executives indicate that many are preparing for such events to become more common in the future. Consequently, the goal of this article extends beyond documenting the changes in supply chains during the COVID-19 pandemic. We aim to provide practical guidelines for executives planning supply chain strategies in anticipation of increasingly frequent major disruptions and identify future research directions to strengthen the resilience of GSCs in the face of evolving challenges.

1.1. Case Examples

The observations reported in this article are based on U.S. customs import data. These come from a commercially sourced data set, comprising the bills of lading (BoL) of all shipments received by U.S. ports between 2019 and 2021, which we subjected to additional cleansing and then merged with Compustat data (Section 2 elaborates). For that epoch, the data include all shipments of 4,444 product categories recorded by U.S. importing companies that sourced from global suppliers in 235 countries of origin. Unless otherwise specified, the term “import” in this article refers to materials entering a country directly via sea, without implying that this constitutes the final stage of the associated supply chain. The data allow us to analyze supply chain configurations of United States-based companies before and during the COVID-19 pandemic. To illustrate changes in GSCs and demonstrate the capabilities of our shipment-data-driven methodology for GSC mapping, we present four case examples in this section. Specifically, we show how our data can reveal companies’ GSC restructuring without requiring them to disclose any information.

Our first example is the appliance manufacturer Honeywell (see panel (a) of Figure 1). Prior to the pandemic, the company imported materials from 44 different countries into U.S. ports. By 2021, this number had decreased to 37 countries. Notably, countries such as Pakistan and Brazil were dropped entirely, whereas others saw an increase in their share of imports. For example, whereas less than 5% of Honeywell’s imports by sea came from India in 2019, this figure rose to over 10% in 2021.

A more drastic shift occurred with the fashion company Ralph Lauren, our second example (see panel (b) of Figure 1). Within two years, the company increased its share of imports from Cambodia from 1.27% to 34.58% of total import weight. By 2021, 39% of Ralph Lauren’s direct imports came from newly onboarded suppliers, compensating for a reduction in imports from China.

Although Ralph Lauren maintained a focus on Asian suppliers despite changing the specific countries, other companies turned to suppliers outside Asia. Boeing, our third example, adopted a nearshoring approach (defined as relocating manufacturing to countries geographically closer to its headquarters). In 2019, China was the largest source of imports for the United States-based airplane manufacturer. By 2021, Canada became its largest source of imports, whereas imports from China decreased to less than half of Boeing’s 2019 level. The role of other Asian countries, apart from China, remained relatively stable (see panel (c) of Figure 1).

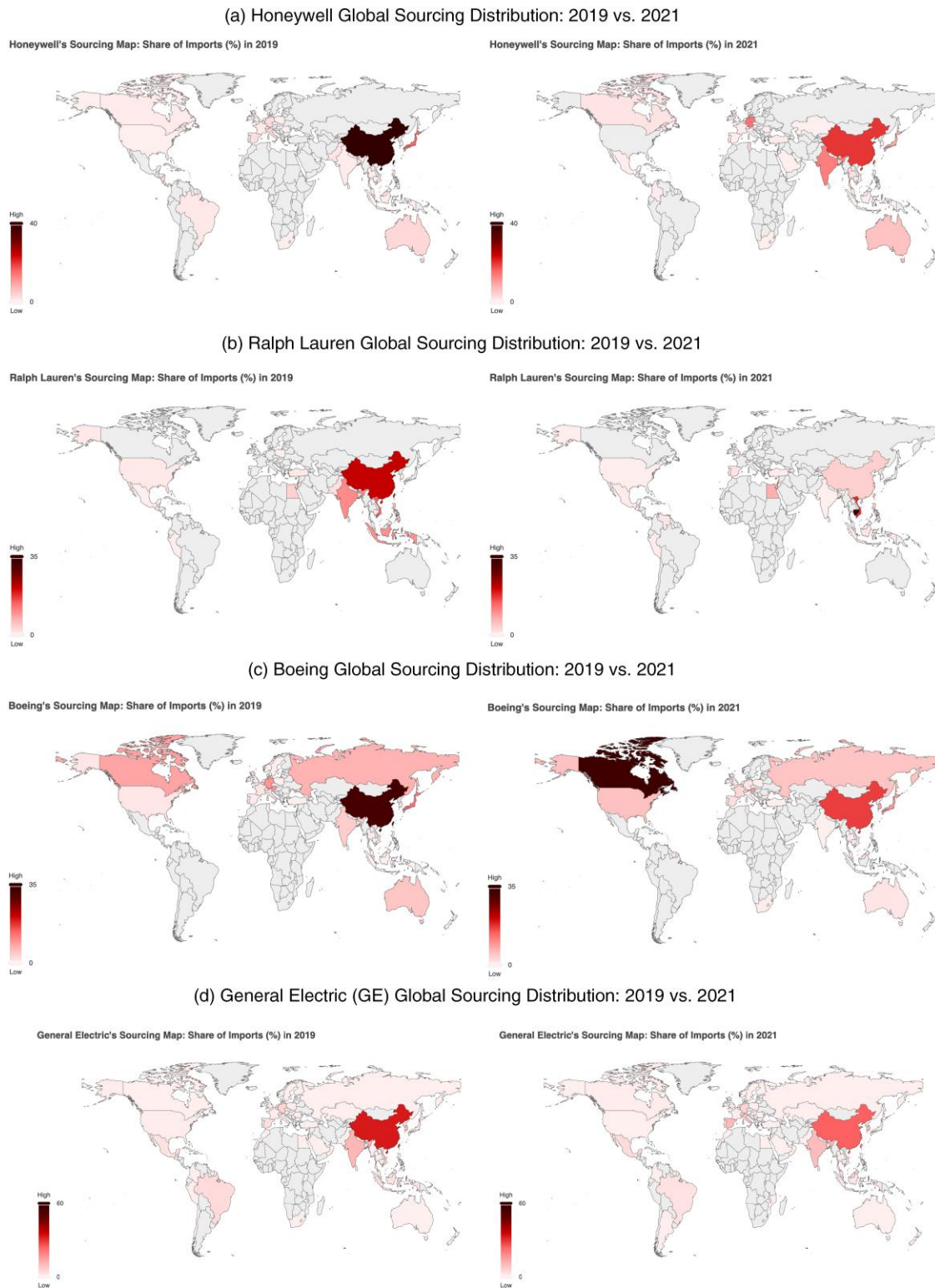
Although the first three case examples demonstrate significant changes in supply chains during the COVID-19 pandemic, there are also multinational companies that did not fundamentally alter their supply chains. One such company is General Electric: From 2019 to 2021, the firm continued to source the majority of its products from China and India, though its reliance on China slightly decreased (see panel (d) of Figure 1).

These illustrative cases offer a glimpse into the valuable insights our data can provide. We formally present our findings in Section 2, followed by implications for companies in Section 3. To conclude, we propose a research agenda for the Operations Management (OM) community in Section 4. For the remainder of this section, we review some recent GSC work in OM.

1.2. Recent GSC Work in OM

When exploring GSCs and their restructuring, it is important to recognize that research interest in GSCs is neither new nor limited to the OM community. Economists, for example, have long studied global trade, though they have been less likely to use the term “supply chain.” Online Appendix OB provides a brief literature review on recent economics research on GSCs and the difference between it and the OM literature. Whereas economics research provides important frameworks for understanding global trade and policy impacts, OM focuses on the operational “how” of implementation. Therefore,

Figure 1. (Color online) Sourcing Maps of Various Companies in 2019 and 2021



OM literature on GSCs is particularly valuable for practitioners, as it translates high-level observations into granular, firm-specific, actionable insights that can help managers make sourcing decisions and develop

strategies. In what follows, we review recent GSC research in OM, primarily focusing on three topics: *the impacts of COVID-19*, *resilience amid GSC disruptions*, and *supply chain risk frameworks*.

1.2.1. COVID-19 and Its Impacts on GSCs. Based on media coverage throughout 2020, Graves et al. (2022) identified the impacts of COVID-19 on the demand side as well as on the supply side. The demand side exhibited meaningful shifts in total demand volume, distribution patterns, and fulfillment channels. Supplier shutdowns and slowdowns were prominent consequences on the supply side because of safety protocols and illness affecting labor availability. Dohmen et al. (2023) observed increased volatility in both supply and demand during the pandemic. The study, based on data from a nonperishable food manufacturer, concluded that existing buffer inventories were insufficient to meet the surge in demand. In addition, production capacity limitations led to challenges in maintaining high service levels.

Based on a review of 49 papers, Xu et al. (2023) grouped pandemic-related disruptions into three categories: lockdowns impacting manufacturers and global value chains, unavailability of input materials due to resource shifts in the healthcare sector, and global logistics issues arising from transportation lockdowns. Han et al. (2022) reported in their study of Alibaba that after the Wuhan lockdown average package delivery time increased by 31%, suggesting a severe impact on the company's logistics capacity. The authors linked delivery times to sales quantity, explaining 60% of sales variation. However, despite initial challenges, the firm recovered sales within weeks as delivery times returned to prepandemic levels. Similarly, Shen and Sun (2023) analyzed JD.com, noting a drop in product availability by 10% during China's first lockdown. Travel restrictions caused a labor shortage, the closure of a central warehouse, and the need for new delivery methods that would preserve social distancing. Recovery to pre-COVID product availability occurred within two months despite ongoing lockdowns.

The pandemic also spurred the creation of "ad hoc" supply chains. According to Müller et al. (2023), these address specific, immediate, and time-limited needs, such as the production of personal protective equipment and medical supplies. Drawing on interviews with 34 German companies, the authors suggested that firms possessing dynamic capabilities, entrepreneurial orientation, and a temporary focus were able to establish new supply chains rapidly. Although most companies maintained ad hoc supply chains for the short term, five of the interviewed companies successfully transformed them into long-term businesses.

1.2.2. Resilience amid GSC Disruptions. With the offshoring of production to low-cost countries, supply chains have grown complex and susceptible to disruptions (Sodhi et al. 2012). Extensive research has addressed supply chain disruption, initially focusing on disruptions at single plant locations. For instance, Chopra and Sodhi (2004) studied the impact of a fire at a

semiconductor plant owned by Philips in New Mexico. Subsequent research focused on broader disruptions caused by natural disasters, such as floods and earthquakes. After the Great East Japan Earthquake in 2011, Durach et al. (2022) found that affected firms responded by increasing inventory levels and volume flexibility. Despite these measures, Japan's vehicle production still dropped by 80% in the following months because of the unavailability of input materials and production facilities. Similarly, Sheffi (2020) highlighted the impact of the Thai floods of 2011 on hard disk drive manufacturers. This disruption led to Western Digital losing market share to Seagate Technology, resulting in spiked hard disk drive prices and downstream ripple effects. Agca et al. (2021), upon examining credit default swap (CDS) spreads and supply chain links, observed that both favorable and unfavorable credit shocks propagate significantly through financial supply chains. Their study found that adverse credit shocks exhibited contagion effects approximately twice as large as those originating from natural disasters. More recently, Cohen et al. (2024) highlighted differences between geopolitical disruptions in GSCs and nonpolitical events, such as the COVID-19 pandemic or logistical issues like the Suez Canal blockage.

1.2.3. Supply Chain Risk Frameworks. In response to supply chain disruptions, a body of literature has emerged on supply chain risk management (Sodhi et al. 2012). Lee (2004) argued that competitive supply chains must be not only efficient but also agile, adaptable, and aligned (Triple-A). Agility refers to the ability to react quickly to sudden changes in supply or demand. Adaptation involves evolving supply chains over time with shifting market structures and strategies. Alignment is crucial for ensuring common interests and high performance in the supplier network. Subsequent publications have suggested specific strategies for preparing supply chains for disruptions. Sheffi (2007) highlighted the concept of supply chain resilience, emphasizing flexibility to enable a "bounce back" after disruptions. Cohen and Kouvelis (2021) extended the Triple-A framework to include robustness, resilience, and realignment (Triple-R). Whereas agility enables swift responses to short-term fluctuations, robustness prepares supply chains for low-probability, high-impact black swan events, addressing the risk of large-scale disruptions. Adaptability is extended by resilience, allowing supply chains not only to adapt to changed market circumstances but also to "bounce forward" after disruption, mitigating risks of future shocks. Realignment of incentives may be necessary to adjust to a "new normal" after large-scale disruptions. Although these frameworks noted above offered a general orientation for supply chain risk management, recent research, such as Cohen et al. (2022), emphasized the importance of differentiated, practice-oriented implementation strategies. Through an empirical study with

multinational companies, the authors recommended process standardization, visibility enhancement, and footprint diversification tailored to a company's product, partnership, and process complexity (Triple-P) to mitigate disruptions.

Our article contributes to the literature by addressing the call in Pichler et al. (2023) to map detailed global supply network data to support fast and well-informed decision making. We extend the findings in Cohen et al. (2018) by presenting the most recent dynamics in GSC management, and complement the economics literature, which primarily adopts a policymaker's perspective, by providing actionable implications for both OM practitioners and researchers. Although our data analyses focus on the COVID-19 pandemic, the insights we provide on GSC restructuring extend to supply chain disruptions beyond COVID-19, including those driven by the more recent geopolitical risks and other challenges.

2. GSC Restructuring Evidence

In this section, we present several key observations on companies' GSC restructuring during the COVID-19 pandemic, supported by empirical evidence. Our analysis draws on data from two primary sources. First, we utilize data obtained from S&P Panjiva, which include bills of lading for all sea-based imports into the United States. Each import transaction record provides detailed information, including the name and address of the importer and overseas supplier, the goods shipped (classified using the six-digit Harmonized System (HS) code), country of origin, written descriptions, number of containers, weight, quantity, units, volume (measured in 20-foot equivalent units (TEUs)), Panjiva's estimated value (in U.S. dollars (USD)), and transportation carrier and vessel details (name and International Maritime Organization (IMO) number). The government form capturing this information for individual transactions is shown in Online Appendix OC. The original data set is organized at the enterprise level, with the enterprise name serving as the identifier. We have refined the names and matched them to their respective listed parent firms, allowing us to merge them with a second data set focused on financial fundamentals. A detailed explanation of the matching process and data disclosure can be found in Online Appendix OC. The second data set from Compustat provides us with firm-quarter-level financial fundamentals. Limiting our analysis to publicly listed firms allows our analysis to control for firm attributes. Merging the two data sets and retaining firms with overlapping observations produced a final data set categorized at the firm-product (six-digit HS code)-quarter level. This encompasses 284,017 observations from 1,533 listed U.S. importing companies, representing 4,444 product codes, and spans from the first quarter of 2019 to the last quarter of 2021. Of the 1,533 listed U.S. importing companies in our final data set, 1,139 appear

in both the prepandemic and during-pandemic periods. A total of 276 companies were present in the prepandemic period but not in the during-pandemic period, whereas 118 companies emerged during the pandemic but were absent in the prepandemic period. A robustness check considering only the firms present both before and during the pandemic has validated all empirical observations in this section.

2.1. Sourcing Origin Countries

By comparing sourcing locations and the number of suppliers before and after the COVID-19 pandemic, we found no evidence of consolidation or diversification in supplier locations during the pandemic (see Table OD3 in Online Appendix OD for details). Specifically, the number of countries from which U.S. firms sourced remained largely unchanged. However, U.S. importing firms increased their total number of suppliers, driven primarily by the addition of new suppliers rather than retaining those from the preceding five years, as indicated by the rise in the number and proportion of new suppliers from our data.

Our observations offer a new perspective on the supplier diversification strategy, often advocated for enhancing supply chain resilience (Tomlin and Wang 2011). When examining diversification in sourcing locations versus suppliers, we found that these strategies do not always occur simultaneously. During the COVID-19 pandemic, firms neither diversified nor consolidated sourcing locations; instead, they expanded their supplier base within existing locations. Unlike prior supply chain disruptions, which typically affected specific suppliers (e.g., bankruptcy) or regions (e.g., natural disasters), COVID-19 impacted nearly all suppliers globally. As governments one after another implemented lockdowns and border closures, companies had few new sourcing locations to explore. Moreover, elevated costs and uncertain demand during the pandemic led firms to prioritize cost efficiency over resilience, avoiding diversification in sourcing locations.

Nevertheless, firms still faced the challenge of identifying alternative suppliers within their existing supply bases, a trend that intensified during the pandemic. This aligns with the theory presented by Sting and Huchzermeier (2010), which suggests that companies turn to backup suppliers primarily when their current suppliers falter—a scenario widely observed during COVID-19. Consequently, the overall number of suppliers and new suppliers within existing locations increased during the pandemic.

Our analysis also indicates that, all else equal, increased economic uncertainty in sourcing countries would drive U.S. importers to reduce their supplier bases. This reduction is characterized by fewer sourcing locations, a smaller number of suppliers, and limited onboarding of new suppliers, reflecting companies'

efforts to minimize supplier-related costs during the pandemic. In other words, economic uncertainty poses significant risks that constrain the expansion and development of GSCs. Concurrently, rising geopolitical risks likely encourage companies to diversify sourcing regions to mitigate exposure to affected areas. These two forces—economic uncertainty and geopolitical risks—persisting beyond the COVID-19 pandemic may at times lead importing companies to adopt cautious, inaction-oriented strategies.

2.2. Geographic Sourcing Distribution

Economists' analyses (e.g., Alfaro and Chor 2023) often focus on aggregated changes in import flows, which can partially obscure offsetting shifts in import volumes across industries and individual firms. By examining sourcing countries and exploring geographic reallocation, we uncovered significant changes in the import proportions from various countries (see Table OD4 in Online Appendix OD for details).

Notably, the geographic reallocation primarily occurred in China, Vietnam, India, and the Americas. In terms of offshoring, imports from China decreased, whereas imports from other Asian countries, such as Vietnam and India, increased. Regarding nearshoring and reshoring, U.S. importing firms increased their reliance on sources from North and Central America to shift production closer to home, though the absolute increase was small. These observations accounted for fixed effects related to firms and products, industry-time interactions, and various time-varying firm attributes and levels of uncertainty. As such, they captured a genuine shift in the geographic distribution of companies' sourcing behavior.

Although we observed no changes in the number of sourcing countries during the pandemic (as noted in Section 2.1), our empirical evidence clearly indicates changes in the distribution of import volumes, upon which we now elaborate. China's stringent COVID-19 policies, which disrupted operations for all China-based suppliers, led companies to reduce their import volumes from China, which has historically been a key origin for U.S. imports. This shift was further driven by ongoing United States-China tensions, which began before the pandemic and persisted afterward. Southeast and Southern Asian countries, often referred to as the "New China," captured orders previously dominated by China. For example, our empirical evidence highlights Vietnam and India as the largest beneficiaries in Asia, likely because of their cost-effective labor and substantial reserves of critical minerals, such as nickel, which are vital for producing electronics and electric vehicle batteries. Additionally, U.S. importing firms marginally increased their imports from North and Central America, reflecting a gradual shift toward nearshoring and reshoring. These observations align with

Alfaro and Chor (2023)'s conclusion that GSCs are undergoing significant restructuring but not necessarily in a way that deglobalizes.

2.3. Industry Variations

We also segmented our data by industry, revealing that the geographic distribution of imports varies significantly across industries (see Table OD5 in Online Appendix OD).

During the pandemic, the "China plus N" strategy was more prominent with the machinery and electrical, critical materials, textiles and apparel, and chemical industries, which highlights industry-specific differences in the feasibility of alternative sourcing locations. Among these industries, machinery and electrical goods have the most alternative sourcing locations, which facilitated sourcing less from China and sourcing more from Vietnam, India, North and Central America, and Western Europe. For critical materials (such as rare earth materials required for batteries, chips, or medicines) and textiles and apparel, Vietnam, India, and Western Europe were substituting locations during the pandemic. For chemicals, companies decreased their imports from China and increased their sourcing from India.

In contrast, some industries showed minimal geographic reallocation during the pandemic. The transportation industry and hygiene goods, for example, maintained stable sourcing patterns, as these industries prioritized supporting essential logistics and medical safety needs. Interestingly, the semiconductor industry deviated from the general trend. This sector exhibited a significant decrease in imports from Japan and South Korea and an increase in imports from Western Europe, indicating that U.S. importers shifted volumes to locations with lower lead times. This shift is unsurprising because given the substantial costs and time required to establish a new semiconductor fabrication plant, quickly relocating a semiconductor supply chain to new countries is challenging. Therefore, shifting volumes among manufacturers with existing chipmaking experience presents the only feasible option in the short term.

2.4. Delivery Patterns

OM researchers have long emphasized the importance of lead times and batch sizes. Our empirical findings reveal a significant shift in the size and frequency of companies' shipments during the COVID-19 pandemic. Specifically, batch sizes increased in both quantity and volume, whereas delivery frequency declined (see Table OD6 in Online Appendix OD for details). On average, we observed a 4.96% rise in quantity per shipment, a 2.08% increase in volume per shipment, and a 6.67% decrease in sourcing frequency.

These observations align with prior studies suggesting that disruptions tend to drive larger order sizes (Durach et al. 2022). Larger batch sizes enable

companies to increase safety stock, ensuring they maintain inventory levels higher than projected sales. During the COVID-19 pandemic, supply uncertainties made it critical for companies to secure adequate product stock, even at the expense of higher holding costs, such as extra warehousing expenses. This approach could be more cost-effective than potential revenue losses due to unmet customer demands.

Allon (2023) highlights an additional factor contributing to this trend: the increased costs of ordering during the pandemic, particularly shipping costs. Seaborne imports, in particular, faced sharp increases in ocean freight charges. To mitigate these rising costs, companies likely consolidated orders, opting for larger shipments with reduced frequency as a cost-saving measure.

2.5. Shifts in Corporate Practices

In addition to our data-driven approach, we conducted in-depth discussions with supply chain executives from various multinational companies. These conversations provided insights into the incentives behind corporate supply chain restructuring strategies and offered a closer look at current practices. We refer the interested reader to Cohen et al. (2024) for more details on how several prominent multinational companies have responded to recent GSC risks and made adjustments to manage their supply networks.

In the wake of COVID-19 and the reelection of U.S. President Donald Trump, geopolitical risks, including tariffs, have become major concerns. As a result, companies are systematically assessing country-level risks and government actions to evaluate the viability of their GSCs. Organizational changes are increasingly extending beyond traditional supply chain roadmaps. Companies are considering financial ownership of assets outside their firm boundaries and are rebalancing and derisking their supply chains by relocating existing facilities and operations, rather than simply adding future capacity. These shifts are driven by fears of catastrophic losses and diminishing public and political support. In particular, a recent study by Charoenwong et al. (2024) shows companies reduce sourcing from countries with significant ideological differences to align supply chain decisions with geopolitical realities.

One key takeaway from our discussions with many companies is that reliance on lower-tier suppliers (i.e., those additional layers upstream in the inbound supply chain) presents a significant barrier to supply diversification through GSC restructuring in new locations. Specifically, diversifying final assembly locations offers limited benefits if critical input materials are still sourced from concentrated regions. Unilateral changes in final production locations, such as nearshoring, are insufficient to mitigate country-level risks. Instead, companies are aligning their resilience strategies with those

of their suppliers to ensure that supply chain partners do not undermine the benefits of any footprint changes.

3. Implications for Companies

In the previous section, we presented evidence that companies across industries restructured their supply chains during the COVID-19 pandemic. Building on these observations, this section outlines several key implications for companies contemplating GSC restructuring and resilience strategies for the future.

Implication 1. *The COVID-19 pandemic has heightened awareness of disruption risks from concentrated supply sources, making it essential for companies to proactively diversify their supplier geography.*

Despite press stories suggesting the demise of GSCs due to pandemic-related disruptions, our analysis indicates that companies continued to maintain a high share of imports from offshore suppliers during the pandemic. In addition, we observed a noticeable geographic shift away from China and toward other Asian countries like Vietnam and India. This shift away from China is not unexpected, considering the country's zero-COVID policy, which resulted in prolonged lockdowns at many manufacturing sites, coupled with uncertainties surrounding China's relationship with the United States and the broader Western world. However, dependence on China goes beyond just geography. Many GSCs remain deeply intertwined with Chinese suppliers, especially for critical raw materials and upstream components. Even when companies diversify final assembly locations, their operations may still hinge on inputs sourced from China, such as rare earth elements essential for electronics and battery production. This embedded reliance complicates efforts to fully decouple from China and underscores the structural challenges of supply chain reconfiguration.

Nevertheless, because of the allure of China as a massive market, foreign companies seldom completely sever their ties with China. Instead, they can consider employing "China plus one" or "China plus N" strategies to safeguard their previous investments and maintain market access in China. With competitive labor costs, Southeast and Southern Asian countries are reaping the benefits of this shift in GSCs. This trend aligns with the idea of companies striving for an enhanced supply chain response to disruptions while maintaining the cost advantage of GSCs. As such, companies aim to reduce their dependence on countries responsible for a large share of their supply and actively explore alternative, low-cost locations. The process of diversifying away from China is underway for many foreign companies, yet undertaking a full separation from the Chinese economy is both expensive and unnecessary in our view.

Implication 2. *Companies should consider moving beyond mitigating firm-level supplier risks to actively addressing and mitigating country-level location risks.*

Although traditional risk management strategies typically concentrate on the potential failure of individual suppliers, such as bankruptcy, the risks stemming from the COVID-19 pandemic are linked to government interventions at the country level and the viability of cross-border trade connections. In essence, decisions like implementing lockdowns or closing borders were made by the governments of respective countries, impacting every supplier within those regions. As a result, there has been a shift in focus from targeting specific suppliers to reducing dependence on high-risk locations within supply chains, aligning with the insights on country-level policy uncertainty discussed in Charoenwong et al. (2022). We anticipate the continuation of this trend after the COVID-19-pandemic. The ongoing and intensifying geopolitical conflicts, such as the sanctions and export controls imposed by Western countries in response to Russia's invasion of Ukraine and the continuing conflict in the Middle East, further emphasize the critical role of government decisions and international relations in GSCs. As economic sanctions broaden, trade relations gain prominence as tools of foreign and security policy. One example is the emerging concept of "friendshoring," wherein intercountry relationships significantly influence decisions about supply chain locations (Hsu et al. 2022).

Implication 3. *Companies should reconsider lean-inventory strategies and adopt a proactive approach by ordering larger quantities with reduced delivery frequencies to more effectively mitigate supply chain disruption risks.*

In response to the increased costs and uncertainties associated with moving inputs during the pandemic, companies should consider shifting from JIT replenishments to larger, less frequent shipments. This approach reduces transportation costs through bulk shipping and minimizes dependence on precise delivery schedules, providing a buffer against supply chain disruptions. Maintaining higher inventory levels enables companies to better withstand delays and adapt to demand fluctuations, thereby enhancing resilience and improving risk management in their supply chain operations.

Additionally, companies must prioritize contingency plans, particularly in sourcing products and materials. Although many have expanded their existing supplier base to increase diversification during the pandemic, the lack of sourcing from more locations indicates exposure to heightened risks. Indeed, managing an excessive number of suppliers across high-risk countries or regions can be counterproductive. To adapt to postpandemic market dynamics, companies can focus on diversifying suppliers within existing sourcing regions and

consolidating order shipments, which offers a more effective and balanced risk mitigation strategy.

Implication 4. *Companies need to recognize that disruption-response strategies must be tailored to the specific needs and dynamics of each industry.*

Our observations from data and interactions with companies revealed that there is no one-size-fits-all approach to responding to disruptions. In capital-intensive industries, such as semiconductors, we observe only minor changes in sourcing patterns. In contrast, companies in less capital-intensive sectors, such as apparel, exhibit more significant supply chain restructuring. For companies that cannot easily shift manufacturing locations because of high capital requirements, drastic supply chain changes have been unfeasible. This highlights the importance of preemptive resilience measures in building robust supply chains for capital-intensive companies. A similar conclusion applies to companies that are closely tied to existing production locations because of high expectations for quality and established supplier networks, as seen in the case of Apple.

Our observations also support the relevance of ongoing discussions about reshoring and nearshoring. Although the total quantity of imports from the Americas remains low, we observe a disproportionate increase in suppliers from North and Central America. This strategy is particularly significant for critical materials, suggesting that reshoring and nearshoring are preferred disruption-response strategies for vulnerable but essential inputs in supply chains. Additionally, nearshoring is especially relevant for high-tech industries, where necessary production capabilities are concentrated in just a few locations (e.g., Boeing).

In conclusion, addressing disruptions should not be a one-size-fits-all endeavor, given the differences in companies' value chain positioning, operational complexity, and political sensitivity. COVID-19 will not be the last unforeseen disaster to disrupt GSCs. As a result, companies are increasingly investing in supply chain resilience strategies tailored to their specific needs.

4. Future Agenda for OM Researchers

Economics often relies on aggregate data and provides policy proposals, but it does not necessarily do so with the goal of directly informing company decisions. Engineering approaches tend to focus on highly detailed models that are often intractable and impractical for GSC planning. OM research, however, can bridge the gap between general economics policy-driven approaches and concrete engineering solutions, offering operational strategies to support effective decision making when restructuring supply chains. Importantly, the increasing availability of customs, trade, and supply networks data

opens up new opportunities for empirical research that can uncover firm-level supply chain strategies without relying upon companies' willingness to disclose proprietary information.

Although we have outlined several implications for companies based on our findings (see Section 3), significantly more work is necessary for OM researchers to assist companies in navigating the continually evolving supply chain risks in the post-COVID-19 era. In what follows, we propose several key research directions and specific questions to explore.

Research Direction 1. *Explore supply chain objectives beyond cost efficiency and a broader range of efficiency-resilience trade-offs.*

We advocate for future research that delves beyond mere supply chain efficiency and cost to explore the intricate trade-offs among diverse objectives. The development of GSCs from the 1980s to recent years has experienced three phases. In the first phase, *striving for cost efficiencies via offshoring* was the core. In the second phase, companies managing GSCs were *chasing growth in new emerging markets*. In the third phase, COVID-19 sparked a paradigm shift toward *balancing cost efficiency and security or resilience of supply chains*. Yet, it remains challenging for companies to strike the right balance between mitigating disruption risks and maintaining cost-effectiveness. We believe that heightened disruption risks will continue to play an important role beyond the COVID-19 pandemic. Understanding how companies can navigate the trade-offs associated with production location choices, supplier selections, and technology investments under uncertainty therefore merits further research. Here are some specific research questions to consider:

- How should companies develop frameworks to quantify and evaluate trade-offs between cost efficiency and supply chain resilience benefits?
- How do the trade-offs between resilience and efficiency vary across industries?
- How should companies optimize trade-offs between cost efficiency and supply chain resilience when selecting production locations, suppliers, or technologies under high uncertainty?

Research Direction 2. *Explore the adaptation of reactive versus anticipatory strategies and the balance between short-term and long-term planning horizons to meet the new supply chain objectives.*

Although many established approaches to enhancing supply chain efficiency and resilience, such as dual sourcing, natural hedging, and real options, are well documented, tailoring these strategies to address recent trade-offs and disruption risks remains an open challenge.

Our primary recommendation is to balance anticipatory strategies with reactive adaptations (Cohen et al.

2024). Anticipatory strategies are proactive measures designed to mitigate risk before disruptions occur. These can include short-term inventory or capacity adjustments, and long-term supply chain restructuring efforts. By preemptively addressing potential risks, anticipatory strategies help reduce a supply chain's exposure to disruptions and enable effective reactive responses when needed. Reactive strategies are responsive measures activated during or after a disruption. These often leverage the foundation established by anticipatory strategies, which act as investments in real options. Examples include reallocating production volumes, switching to backup suppliers, utilizing reserve capacity, or adjusting inventory policies. We posit that future supply chain strategies will likely emerge not as entirely new methodologies but as optimized combinations of existing reactive and anticipatory approaches. Here are some specific research questions to consider:

- If a disruption, risk, or uncertainty has some predictability, how can a company determine the equilibrium between the anticipatory and reactive strategies to achieve the best balance between supply chain resilience and efficiency?
- To what extent do industry-, product-, and company-specific characteristics, such as product complexity and supply chain network structure, impact the optimal balance between the anticipatory and reactive strategies?
- How do different types of disruptions (e.g., natural disasters, geopolitical events, epidemics, and pandemics) affect the effectiveness of anticipatory and reactive strategies in supply chains?
- When restructuring a GSC, how should a company choose among switching suppliers, adjusting import patterns within existing brownfield locations, and investing in new greenfield facilities?

Our second recommendation is to evaluate the balance between short-term and long-term outcomes. The speed and persistence of adaptation play a critical role in determining supply chain resilience. Although our article highlights shifts in sourcing patterns, it does not address the time required for companies to implement these changes or the financial impacts and implications for their long-term competitiveness. Although it may be too early to fully assess these effects, we encourage future research to investigate:

- How does GSC restructuring influence companies' long-term financial performance and competitiveness, including factors such as cost structures, market share, profitability, innovation, talent acquisition, and technological advancement?

Research Direction 3. *Explore the implementation of GSC strategy adaptations by leveraging rich cross-sectional variations in large-scale, granular supply chain data sets,*

along with machine learning techniques and scenario planning tools.

Analyzing the impacts of GSC disruptions is a complex task requiring high levels of data availability and transparency. Yet, supply chain data can be leveraged to develop superior resilience strategies and connect decisions to performance outcomes including cost, revenue, profits, customer satisfaction, and competitive advantage. The results of this article show the value of employing cross-sectional empirical data sets to derive insights into supply chain decisions. Considering a large sample of companies from different industries allows avoidance of two common issues in empirical OM research: (1) generalized results that do not consider industry-specific differences and (2) single case studies that cannot identify industry-related variables, limiting the transferability to other contexts. As our observations shed light on significant differences in supply chain changes between industries as well as within industries, we suggest making use of data sets such as trade data to analyze the impact of intercompany differences.

Furthermore, it is essential to incorporate emerging risk factors into scenario planning while utilizing advanced technologies to support operational decision making. Scenario planning should now account for evolving risks, such as deteriorating intercountry relationships, and developing new disruption scenarios. Future research should support scenario planning that integrates machine learning and optimization techniques to develop strategies for mitigating risks and exploiting opportunities associated with future scenarios. Here are some specific research questions to consider under this research direction:

- How can data sets on shipments, logistics, services, finance, and recruitment be integrated to provide a comprehensive view of the impact of GSC disruptions on companies' supply chains and intercompany differences?
- How can machine learning tools be used to map the network of connected resources (products, labor, finance) and the interaction of decisions to hedge against uncertainty?
- How can a firm evaluate the impact of supply chain strategies across different scenarios, including material flows, cash, and labor flows?
- How can scenario planning include an analysis of competitor vulnerabilities to identify strategic initiatives for timely and effective countermeasures?

Research Direction 4. *Explore the mitigation of disruption risk through the alignment of complete supply ecosystems that extend beyond direct suppliers.*

Although supply chain complexity can complicate the development of resilience strategies, the network of connected resources and the interaction of decisions

over time and geography can be an advantage by providing a hedge against uncertainty. Successful resilience strategies thus optimize how to deploy resources throughout the supply chain network and leverage the breadth of potential options. Although this article reveals significant changes in companies' imports to the United States, it does not account for shifts among lower-tier suppliers. Given the widespread lack of supply chain visibility at these lower tiers, it remains unclear whether observed changes impact entire industrial ecosystems and whether supply chain resilience improves solely by diversifying final assembly locations. Several research questions are promising for future investigations:

- How do indirect supply chain links (e.g., through intermediary countries like Vietnam and Mexico) reshape global trade patterns and supply chain dependencies? One relevant ongoing study is Hsu et al. (2024), which explores the indirect supply chain links between the United States and China through Vietnam and Mexico, considering firm and product heterogeneity.
- How can an end-to-end view of the supply chain be developed to enhance transparency regarding tier-1 and tier-2 suppliers and their exposure to GSC risks?
- How do supply chain disruptions impact long-term relationships and collaboration between companies and their lower-tier suppliers?
- How do a company's supply chain restructuring decisions influence similar decisions made by its lower-tier suppliers, and vice versa?

Research Direction 5. *Explore the roles of non-supply-chain actors involved in supply chain decisions.*

In the postpandemic era, company risk management has shifted from company-specific risk factors to country-level risk factors such as geopolitical risk. With increasing geopolitical tensions and widespread concern about sustainability, government policies can become an even greater consideration for supply chain decisions in the immediate future. The source of geopolitical risk often lies in the decisions of a small number of government officials. For supply chain managers, anticipating government actions and adapting accordingly has become a crucial competency.

Governments alone are unable and sometimes unwilling to sufficiently prioritize issues like resilience and sustainability, leading non-supply-chain actors, such as nongovernmental organizations (NGOs), to play an increasingly significant role in GSC negotiations. These organizations are influencing key areas such as human rights, innovation regulations, and carbon emissions. As companies navigate these evolving pressures, their supply chain restructuring strategies must adapt to incorporate the expectations and regulations set forth by these non-supply-chain actors. This, in turn, complicates decision making and drives the need

for more comprehensive risk management approaches. Here are some specific research questions to consider under this research direction:

- How do sudden government-imposed actions (e.g., lockdowns, trade restrictions, export bans) affect short-term supply chain resilience and long-term structural decisions? For example, a recent study by Hsu et al. (2022) discovered that, because of the stricter regional value content (RVC) rules under the United States-Mexico-Canada Agreement (USMCA) following the North American Free Trade Agreement (NAFTA) renegotiation, U.S. car manufacturers significantly increased their procurement from Mexican and Canadian suppliers.
- In light of recent geopolitical tensions and the incentives to “decouple” or “derisk” supply chains from high-risk regions, how should supply chain resilience strategies adapt to government interventions, such as trade sanctions, export restrictions, or carbon tariffs? For example, ongoing research by Li et al. (2024) finds firms in sanctioning countries reduced exports of sanctioned goods to Russia, whereas firms in neutral countries increased such exports following the 2022 invasion of Ukraine. This divergence underscores the complexity of navigating government policies and compliance in GSCs.
- How can firms collaborate with government organizations to hedge against predicted supply chain risks? One such ongoing study by Cen et al. (2024) finds that government-linked firms increase sourcing from sanctioned nations because of tariff exemptions provided by their government connections.
- What role do nongovernmental organizations play in promoting nearshoring, reshoring, or diversification strategies for GSCs, and what mechanisms can they design to support these efforts?

In summary, our analysis of data and discussions with supply chain executives from multinational companies have revealed that GSC restructuring introduces several key objectives in supply chain decision making. Granular data, machine learning techniques, and scenario planning tools hold significant potential to support decision making. Alongside managing supply chain pressures through operational adjustments and direct linkages, overseeing a comprehensive supply chain ecosystem that extends beyond tier-1 suppliers remains an emerging competency. Moreover, non-supply-chain actors are increasingly influencing companies’ supply chain decisions.

It is our hope that this article can contribute to both research agendas and practical applications. We conclude with a quote from a supply chain executive we interviewed:

We cannot predict the future, but we can plan hundreds of scenarios ahead of time to be ready.

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