

Supply chain strategies in response to a black-swan event: a comparison of USA, French and Polish firms

Supply chain strategies

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Matias G. Enz

Department of Supply Chain and Analytics, University of Missouri – Saint Louis, Saint Louis, Missouri, USA

Salomé Ruel

SPP – CERIM, Excezia Group, La Rochelle, France

George A. Zsidisin, Paula Penagos and Jill Bernard Bracy

Department of Supply Chain and Analytics, University of Missouri – Saint Louis, Saint Louis, Missouri, USA, and

Sebastian Jarzębowski

Logistics and Procurement Center, Kozminski University, Warszawa, Poland

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Abstract

Purpose – This research aims to analyse the perceptions of practitioners in three regions regarding the challenges faced by their firms during the pandemic, considered a black-swan event. It examines the strategies implemented to mitigate and recover from risks, evaluates the effectiveness of these strategies and assesses the difficulties encountered in their implementation.

Design/methodology/approach – In the summer of 2022, an online survey was conducted among supply chain (SC) practitioners in France, Poland and the St. Louis, Missouri region of the USA. The survey aimed to understand the impact of COVID-19 on their firms and the SC strategies employed to sustain operations. These regions were selected due to their varying levels of SC development, including infrastructure, economic resources and expertise. Moreover, they exhibited different responses in safeguarding the well-being of their citizens during the pandemic.

Findings – The study reveals consistent perceptions among practitioners from the three regions regarding the impact of COVID-19 on SCs. Their actions to enhance SC resilience primarily relied on strengthening collaborative efforts within their firms and SCs, thus validating the tenets of the relational view.

Originality/value – COVID-19 is (hopefully) our black-swan pandemic occurrence during our lifetime. Nevertheless, the lessons learned from it can inform future SC risk management practices, particularly in dealing with rare crises. During times of crisis, leveraging existing SC structures may prove more effective and efficient than developing new ones. These findings underscore the significance of relationships in ensuring SC resilience.

Keywords Supply chain resilience, COVID-19, Supply chain disruption, Black-swan,

Cross-country comparison

Paper type Research paper

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Introduction

The COVID-19 pandemic caused unprecedented uncertainties with international supply disruptions and high demand volatility (van Hoek, 2021). Virtually no country, region or industry was left unscathed, with the repercussions of this global disaster still rippling through our economies (Ruel and El Baz, 2023). Therefore, this pandemic can be considered a “black-swan” event (Dohale *et al.*, 2023) because they are defined as “*large-scale events that lie far from the statistical norm and were largely unpredictable to a given set of observers*” (Taleb and Blyth, 2011, p. 33).

Recent research using a wide range of methodological approaches has started to provide perspective as to how COVID-19 affected supply chains (SCs) and the strategies firms employed to ensure resilience (e.g. El Baz and Ruel, 2021; Khan *et al.*, 2022; Sharma *et al.*, 2020a). Some research was focused on single specific countries or geographical zones (e.g. Choi, 2020 – Hong Kong; Sharma *et al.*, 2020b – USA; Raj *et al.*, 2022 – India, Khan *et al.*, 2023 – Pakistan). However, few cross-country comparisons of the effects of COVID-19 and the strategies used to cope with it have been conducted to date (Seuring *et al.*, 2022). For example, Ali *et al.* (2023) compare Tanzania, Pakistan and Australia using a qualitative research method. Another example comes from Zhao *et al.* (2023), who conducted interviews with Spanish and Chinese SC managers. Hohenstein (2022) and Khan *et al.* (2023) highlight the need for more cross-country comparison studies to reach more generalizable results.

The purpose of this research is to investigate the challenges SC practitioners perceived during the COVID-19 pandemic, the strategies implemented and their effectiveness in preventing, mitigating and recovering from SC disruptions in France, Poland and the St. Louis region of the USA. This study is different from the few cross-country research on COVID-19 supply risk management because it mobilizes a unique set of developed countries (i.e. USA, France and Poland) using survey data. This study follows in the line of research comparing SC practices between and among geographic regions (Zhu *et al.*, 2017; Zsidisin and Hendrick, 1998; Zsidisin *et al.*, 2008). A cross-country comparison is relevant because different regions had different responses in attempting to ensure the welfare of their citizens in response to COVID-19. The heterogeneous government policy responses, in conjunction with cultural norms and practices –which also likely influence government policy– may influence how risk is perceived and the SC strategies considered and implemented that led to resilience. We chose to compare the COVID-19 effects and SC resilience strategies between the St. Louis, Missouri region of the USA, France and Poland because they have developed economies and large manufacturing and logistics bases.

To this end, we collected surveys from SC practitioners in those three regions and conducted descriptive statistical analyses, including Exploratory Factor Analysis (EFA), Correlations and ANOVA, to compare the results. The contributions of this article are several. Firstly, the results highlight the relevance of the relational view (Dyer and Singh, 1998) during a black-swan event in global SCs. Secondly, the managerial recommendations are developed at length, given the novelty of this type of event and the need for practitioners to draw conclusions from the pandemic outbreak. Thirdly, a cross-country comparison of managerial perceptions about the pandemic is provided, which can be useful to generalize the findings in different global contexts.

The article is structured as follows: Firstly, a review of the literature on SC resilience is presented. Then, the research methodology is described in terms of the reasons for choosing the three countries included in the study and the data collection procedures. The findings are provided next. The paper concludes with the theoretical and practical implications and an analysis of the limitations and further research opportunities.

Literature review

Supply chain resilience during the COVID-19 pandemic

The literature in Supply Chain Management (SCM) investigating the effects of the pandemic crisis on COVID-19 is extensive. The artificial intelligence application called “Dimensions” identifies over 100,000 publications [1] with the research strings “COVID” AND “supply chain”, with 38 publications as of the end of 2019, about 14,000 in 2020, more than 34,000 in 2021 and still more than 45,000 in 2022.

Several systematic literature reviews have sought to synthesize prior research on COVID-19 SC practices from different lenses. For example, [Hossain et al. \(2022\)](#) focus on the strategies of Small/Medium Enterprises in emerging countries, whereas [Kumar et al. \(2022\)](#) review the impact of COVID-19 on humanitarian SCs. [Spieske and Birkel \(2021\)](#) and [Naz et al. \(2022\)](#) synthesize the contribution of Industry 4.0 to SC resilience. Finally, [Ardolino et al. \(2022\)](#) highlight the COVID-19 impacts on manufacturing systems. Overall, a large part of the research about the pandemic in the SCM research field seeks to answer how SCs can become more resilient. Combining “COVID” AND “supply chain” AND “resilience” in Dimensions yields over 46,000 results, which illustrates the importance of resiliency for rapid and effective disruption recovery ([Behzadi et al., 2020](#)).

[Yao and Fabbe-Costes \(2018, p. 260\)](#) define SC resilience as follows: “*Resilience is a complex, collective, adaptive capability of organizations in the supply network to maintain a dynamic equilibrium, react to and recover from a disruptive event, and to regain performance by absorbing negative impacts, responding to unexpected changes, and capitalizing on the knowledge of success or failure*”. Supply chain resilience is desirable in times of uncertainty and is based on 14 capabilities ([Pettit et al., 2010](#)), among which adaptability, collaboration, efficiency, visibility and anticipation stand out.

Supply chain effects of the COVID-19 pandemic

Within the realm of industry development, extensive literature has focused on disruptions that affect SCs across various sectors which impact both firms and consumers. The COVID-19 pandemic, a significant subject in this discourse, has been studied intensively. [Chowdhury et al. \(2021\)](#) conducted a thorough analysis, highlighting disruptions across various sectors, with an emphasis on ramifications in food and healthcare. It is crucial to recognize that these effects extend beyond these sectors. The research has also concentrated on resilience strategies to manage and recover from disruptions, revealing widespread implications for global SCs. These consequences span areas such as demand and supply management, production planning, transportation, logistics and relationship management ([Chowdhury et al., 2021](#); [Paul et al., 2021](#)).

The volatility in customer demand, characterized by sudden surges in the need for essential product and continuous decline in non-essential product acquisition, presented significant challenges in meeting customer needs ([Handfield et al., 2020](#)). Accurately forecasting and managing production processes became difficult, which are crucial aspects of supply management ([Gunessee and Subramanian, 2020](#)). The demand uncertainty led to product shortages and stockouts across various markets. Market losses and perceptions of scarcity among customers caused abrupt shifts in purchasing behaviour. These disruptions, attributed to factors like raw material shortages and restricted movement of goods due to lockdown measures, as well as transportation limitations, impacted production and manufacturing processes. Delays in supplier shipments and product unavailability and labour shortages due to policies and business closures significantly affected production capacities, transportation and logistics ([Richards and Rickard, 2020](#); [Leite et al., 2020](#)). Global disruptions, including the loss of distribution channels, infrastructure and labour ([Kumar et al., 2020](#)), along with delays at multiple SC levels ([van Hoek, 2020](#)), hindered effective planning and coordination among firms. This resulted in challenges such as information

ambiguity, limited engagement with suppliers and customers and decision mismatches (Gunessse and Subramanian, 2020; van Hoek, 2020).

In 2023, the effects of the pandemic crisis are not over: the rate of infection of the virus in China is at its highest [2], which disrupts the organization of work and, therefore, international trade. It is necessary to study the SC strategies implemented by firms to manage risk and facilitate resilience of their SC.

Supply chain resilience strategies

Research has identified numerous resilience strategies implemented in different disruptive contexts with varying levels of success (Pettit *et al.*, 2019). van Hoek (2020) examined resilience strategies employed by SC executives during the pandemic and suggested that these strategies align with generic recommendations found in the literature. Appendix 1 provides definitions for 15 SC resilience strategies commonly identified in the literature as important decision areas for SC continuity.

Creating redundancy is one of the most cited SC resilience strategies (Tukamuhabwa *et al.*, 2015), and acquiring redundant suppliers has been examined as a way to mitigate risk when demand is uncertain and supply is disrupted (Firouz *et al.*, 2017; Yoon *et al.*, 2018; Ali *et al.*, 2023; Salama and McGarvey, 2023). For example, Firouz *et al.* (2017) found that networks with lateral transshipments and multi-sourcing provide significant benefits. Saleheen and Habib (2023) claim that multi-sourcing from various countries is critical when an SC experiences rare and long disruptions. Firms may also *nearshore SC activities* or regionalize SCs to react to unanticipated disruptions (Hilletoft *et al.*, 2019), which may include utilizing closer locations or domestic suppliers to mitigate risk inherent to global SCs (Chopra and Sodhi, 2014; van Hoek and Dobrzykowski, 2021; Salama and McGarvey, 2023). Through interviews with SC executives, van Hoek (2020) found that both increasing the supplier base and balancing global sourcing with nearshore and local sourcing were key strategies employed to mitigate SC risk during the pandemic.

Forward buying also serves as a way to manage demand and supply uncertainty and can potentially lead to a more coordinated channel (Desai *et al.*, 2010). Desai *et al.* (2010) considered the effect of trade promotions, competition and demand uncertainty on forward buying and found that higher levels of inventory are carried, regardless of whether demand is high or low when demand uncertainty is present. Additionally, Salama and McGarvey (2023) suggested increasing inbound inventory when a pandemic affects the region where the firm's suppliers are located to hedge against a potential supply shortage and ensure the continuity of production. These authors recommend implementing a responsive decision support system to match active suppliers and buyers since a global pandemic could cause suppliers to lose their primary buyers and buyers to lose their suppliers. As a result, a buyer-supplier collaborative relationship during a disruption, such as the pandemic, is important (Sharma *et al.*, 2020a, b), particularly to guarantee supply (van Hoek, 2020).

The coordination of disparate incentives among SC partners is also necessary for successfully managing SCs (Cachon, 2003). *Modifying terms of trade with suppliers and customers*, such as price commitments and quantity commitments, can serve as an incentive-coordinating approach to reach such success (Cachon, 2003; Su and Zhang, 2008). Drawing upon interviews, van Hoek and Dobrzykowski (2021) reported that supplier terms were modified in the supplier's favour by expediting payments to secure order priority and maintain stable supply during the pandemic-induced shortages. It is apparent that coordination efforts, such as *contractual terms*, can be used to align policies, encourage information sharing and produce superior performance (Anderson and Narus, 1990; Moharana *et al.*, 2012).

Taking this further, collaborative arrangements undertake joint decisions and activities (Moharana *et al.*, 2012) to share risks and rewards (Min *et al.*, 2005). Fawcett *et al.* (2008) define

SC collaboration as “the ability to work across organizational boundaries to build and manage unique value-added processes to better meet customer needs” (p. 93). If successfully implemented (through the sharing of resources such as information, people and technology), potential benefits can be realized by participating members (Togar and Sridharan, 2002) which can help to strengthen the entire SC (Daugherty *et al.*, 2006). Through their examination of SC resilience strategies employed in the automobile and airline industries during the pandemic, Belhadi *et al.* (2021) concluded that sustainable, agile and resilient SCs can only be achieved through high levels of coordination and collaboration.

Collaboration includes *managing relationships within the firm, with key suppliers and key customers* to enhance problem-solving and increase customer value. For example, buyers and suppliers work together to utilize shared resources and minimize waste (Yan and Dooley, 2014). Strengthening buyer–supplier relationships was found to be a critical driver in mitigating the effects of COVID-19 and enhancing SC resilience (Ozdemir *et al.*, 2022; Shen and Sun, 2023) by optimizing material sourcing and maintaining production levels during times of disruption (Moktadir *et al.*, 2023). Additionally, collaboration with key customers is important for improvements such as inventory management, product assortment and customer satisfaction (Bowman, 2004). End-to-end SC visibility is imperative, and focusing on customer collaboration is needed for improved demand forecasts and quickly reacting to disruptions (Bechtsis *et al.*, 2022). By reducing the number of stock-keeping units (SKUs), firms can also improve forecast accuracy, which leads to improved sales, inventory levels and resource utilization (Simchi-Levi *et al.*, 2004). Yet, Sreedevi and Saranga (2017) report that firms are forced to *increase product offerings and customization* to enhance customer satisfaction and remain competitive.

To further create resilient competitive advantages, firms may also *expand channels into new markets* to utilize existing resources or develop new channels to access current or new markets (Watson *et al.*, 2015) based on product availability, service level, lead time and sales support (Stevens, 1989). The SC network is often restructured when entering new markets to ensure a successful launch (Petersen *et al.*, 2005). The existing infrastructure may be reconfigured, and warehousing and transportation networks may be redesigned to best satisfy customer demand while avoiding market uncertainties (Jahani *et al.*, 2018). For example, Salama and McGarvey (2023) developed a stochastic mixed integer linear programming model to understand how SC network designs are affected by pandemic disruptions. The authors found that SC resilience can be enhanced by increasing the number of nodes in the network, which enables alternative facilities to maintain production during potential shutdowns. Additionally, through simulations, Ivanov (2020) concluded that the timing of the closing and reopening of facilities throughout the SC significantly influences SC operations. While there are uncertainties and risks associated with network redesign decisions, a successful redesign can return significant financial improvements (Jahani *et al.*, 2018) if proper data collection and computation occurs (Ballou, 2001).

Firms increase the use of *business analytics* to analyse data, gain insights and inform and support decision-making to improve business performance (Power *et al.*, 2018) and increase SC resilience (Bag *et al.*, 2023). Bahrami and Shokouhyar (2022) found that big data analytics capabilities increase SC resilience by enhancing innovative capabilities and information quality.

A *risk management culture* helps firms achieve resilience through collaborative planning, information sharing and disruption preparation (Das and Lashkari, 2015; Bahrami and Shokouhyar, 2022). Gakpo (2021) found that risk management culture is positively correlated with risk management planning, which specifies the risks to address and how to address them to balance risk-return and available resources (Shi, 2004; Bromiley *et al.*, 2015). Hohenstein (2022) analysed the SC risk management approaches of 10 internationally operating logistic service providers that successfully mitigated pandemic-related risk. The authors found that all firms emphasized the utilization of risk handbooks or business

continuity plans and modified their risk management strategies and resilience to better prepare for future disruptions.

Research method

St. Louis, Missouri (USA), France and Poland as a relevant set for comparison

During the summer of 2022, a survey was created and disseminated online to SC practitioners in France, Poland and the St. Louis, Missouri region of the USA to assess how their firms were affected by COVID-19, and the SC strategies they employed to sustain operations. Those three geographic regions were selected because their SC development level – including infrastructure, economic resources and know-how – was different but still developed. In addition, those regions had different responses to ensure the welfare of their citizens in response to COVID-19.

To evaluate the SC development level, we focused on the EPIC approach (Srinivasan *et al.*, 2014), which allows the comparison of (E) Economic, (P) Political, (I) Infrastructural and (C) Competences dimensions of different regions from a SC activities point of view. For the comparison, we use the current EPIC update (Amling *et al.*, 2020). The purpose of the EPIC structure is to define and explain the conceptual dimensions of SC management and to identify the characteristics of those dimensions in different regions of the world. The structure is intended to help firms to manage SCs in these regions. Each of these dimensions evaluates a number of variables to arrive at a weighted score for that dimension. In turn, the scores on these dimensions are used to arrive at a weighted score for the region. The variables in the EPIC structure are assessed using results from various World Bank databases including Ease of Doing Business Index, Logistics Performance Index and World Governance Indicators.

The economy dimension (E) evaluates a country's economic output, growth potential, attractiveness for foreign direct investment (FDI) and its ability to yield consistent returns on investments. Key variables are the Gross Domestic Product and its growth rate, population, FDI, exchange rate stability, consumer price inflation and trade balance. The politics dimension (P) examines the political landscape's impact on nurturing SC activities. Variables include ease of doing business, bureaucracy and corruption, legal and regulatory framework, tariff barriers, political stability risk and intellectual property rights. The infrastructure dimension (I) tracks variables influencing SCM and operations. The variables considered in the infrastructure dimension are classified into three categories: physical, energy and telecommunication infrastructures. The physical infrastructure covers the roadways, the railway network and air and water transportation. The energy infrastructure captures the supply of electricity and fuel. The telecommunications infrastructure is captured by the extent of telephonic and internet-based activity. The competence dimension (C) evaluates the SC skill levels in a country's workforce and logistics industry. Variables encompass labour productivity, labour relations, skilled labour availability, education level of staff and management, competence of existing logistics service and efficiency in customs and security clearances.

The USA was characterized by the highest overall grade of EPIC, which is the result of the highest scores in almost all EPIC dimensions. This means that the USA has a good logistics infrastructure, well-skilled SC managers, a stable political situation and a growing economy. France was in the second position with also good infrastructure, skilled managers and stable economic situation. Poland was in the third position, having a stable and growing economy but still less developed infrastructure and managerial competence (see Appendix 2).

We analysed how those three regions responded to COVID-19. In the USA, the federal government largely allowed states and local governments to set their own different strategies to protect citizens, contain the spread of disease and support local economies during the pandemic (Donnelly and Farina, 2021; Gupta *et al.*, 2021). In this research, because of policy disparities between US states, we focused on Missouri (a state in the Midwestern region of the USA), which was ranked as the most average state in the USA in 2022 (Jones, 2022). We did

this to control for potential bias effects from heterogeneous policies among regions. In Missouri, Governor Mike Parson authorized local officials to set policies to combat the effects of COVID-19 for their jurisdictions (Weinberg, 2021). During this time, federal, state and local economic support and recovery resources were available to help St. Louis businesses (City of St. Louis, 2020). Stimulus from the Coronavirus State Local Fiscal Recovery Funds derived from the American Rescue Plan was used to assist St. Louis workforce development, increase small business grants, offer start-ups and small businesses technical assistance and provide special support to restaurants, venues and other hospitality sector businesses disproportionately impacted by the pandemic (City of St. Louis, 2021).

France's intervention in the French economy and towards firms during the COVID-19 crisis was significant and multifaceted (Lorié and Ciobica, 2021). From the beginning of the pandemic, the French government put in place measures to support businesses and employees affected by the economic consequences of the health crisis. These measures included: (1) the postponement or deferment of several tax payments for firms in financial difficulty; (2) the establishment of a solidarity fund to help small firms maintain their activity; (3) the implementation of a reinforced partial unemployment scheme, allowing firms to maintain part of their activity while benefiting from the state covering the majority of salaries; and (4) the introduction of state-guaranteed loans for firms experiencing cash flow difficulties (Cho *et al.*, 2020). Overall, the French state's intervention aimed at preserving economic activity and employment in the country (Clévenot and Saludjian, 2022).

In Poland, an anti-crisis shield was offered, which was a package of solutions prepared by the government to protect the Polish state and citizens against the crisis. It was based on five pillars: (1) Protection of jobs and safety of employees, (2) Financing entrepreneurs, (3) Health care, (4) Strengthening the financial system and (5) public investments. The anti-crisis shield stabilized the Polish economy and provided an investment impulse. The value of the support offered amounted to over \$40 billion (Krajewski, 2021). This amount was significantly lower than public support in the broad sense (i.e. also including government guarantees for loans, capital support and income foregone due to tax measures), mainly due to the extensive use of government guarantees to support the liquidity situation of firms affected by the pandemic. In Poland, public support in response to COVID-19, although intensive, was lower than in France.

Data collection

The data collected in the St. Louis, Missouri region of the USA, France and Poland included respondent characteristics, how COVID-19 affected the respondent firm's SCs, and the SC resilience strategies implemented in response, including their extent, difficulty and perceived effectiveness of implementation. Additional demographic data collected include industry, firm size and respondents' years of experience and position.

The survey items included in each question were developed from prior literature on SC resilience strategies (Appendix 1). The first question asked respondents to identify the disruption effects of COVID-19 on nine items using a Likert scale from 1 to 5, where 1 was "no effect" and 5 was "catastrophic effect". The second, third and fourth questions referred to 15 SC strategies listed in Table 1. The second question asked about the extent of implementation of the strategies using a Likert scale from 1 to 5, where 1 was "not implemented at all" and 5 was "implemented to a very large extent". The third question asked to assess the difficulty of implementation of these same strategies using a Likert scale from 1 to 5, where 1 was "not difficult" and 5 was "extremely difficult". The fourth question asked about the effectiveness of those strategies using a Likert scale from 1 to 5, where 1 was "not effective" and 5 was "extremely effective". In all questions, respondents were allowed to describe other options they considered the disruption affected their firms or other strategies that were not included in the survey or omit the ones presented in the questionnaire that did not apply to them.

Table 1.
Exploratory factor
analysis of COVID-19
effects

COVID-19 effects	Factor 1 Supply	Factor 2 Production	Factor 3 Distribution
Shortage of critical raw materials or supplies	0.789		
Increased cost of raw materials or supplies	0.610		
Supplier shipment delays	0.660		
Loss of labour		0.516	
Increased demand uncertainty		0.439	0.430
Loss of customer business		0.619	
Loss of manufacturing or operations productivity		0.649	
Reduction of transportation availability			0.500
Challenges planning and coordinating our supply chains			0.713

Note(s): *Loadings lower than 0.4 were not considered as significant and were disregarded from the analyses
Source(s): Authors' own work

Once the questions were selected, the instrument was pretested first by academic experts and then by experienced SC executives. Members of the research team translated and pretested the survey for language and cultural differences prior to submission in France and Poland. The survey was deployed on a web server at one of the universities, and invitations to participate were sent out in the three geographies using contact lists maintained at each academic institution. The survey was administered to a sample of 3912 SC practitioners in the USA, 2006 SC practitioners in France and 1520 SC practitioners in Poland. We received 101 surveys in the USA, 156 in France and 121 in Poland, indicating a response rate of 2.6%, 7.7% and 8% in each respective region. In the three regions, a full professional report was provided as an incentive to participate in the survey. Further, in the USA, we also provided an opportunity to participate in a drawing to receive a financial reward. Respondents in the USA were further incentivized to respond with donations to non-profit organizations in the study area under their names. The study of the use of economic incentives has been broadly applied in different disciplines; however, it is in a nascent state in the SCM dominion (Schoenherr *et al.*, 2015). In general, there is a lack of research about cross-country comparisons when applying incentives in surveys. From a medical standpoint, the vast part of the studies regarding monetary incentivisation in surveys are from the USA and the UK (Abdelazeem *et al.*, 2023). Research on this topic was not found in France and Poland.

The option of providing other alternatives and scoring them was provided to the respondents in every block of questions: COVID-19 effects, strategies implemented, difficulty of implementation and effectiveness. In general, very few responses were provided, and most of those few were redundant with what was presented with the predetermined set of options. This low level of entries can be attributed to the pre-test the survey had with practitioners, in which we verified the existence of the items and their clarity. In the case where responses were provided, due to the inability to test them, the entries provide insight but no quantitative support.

In survey research, nonresponse bias has been widely assessed to determine the representativeness of the collected answers considering nonrespondents (Clotthey and Grawe, 2014; Wagner and Kemmerling, 2010). To provide evidence of the validity of the data collected for the three regions, nonresponse bias tests were conducted for randomly selected strategies for the last two dimensions measured by the instrument (i.e. the difficulty of implementation and effectiveness). These two dimensions had the lowest response rate on the survey due to the degree of implementation of the strategies in the different regions. The bias test was performed considering the comparison of early and late respondents who at least had strategies somewhat implemented (i.e. at least a score of 3 on the five-point Likert Scale),

assuming the latter would behave similarly to nonrespondents (Clotey and Grawe, 2014). This was done because firms that did not implement strategies cannot completely perceive the difficulty and effectiveness of the strategy adoption. The outputs lead to reject the hypothesis of existing differences between early and late respondents ($p > 0.05$); thus, the results of the tests allow the authors to conclude that there is no evidence of response bias in our sample.

Appendix 3 presents an overview of the sample characteristics, providing information about the industries and sizes of the firms, as well as the positions and experience of the respondents. In the St. Louis region, the sample primarily consists of firms from the transportation and warehousing sector (33.3%) and the manufacturing sector (27.5%), followed by the “other” category (11.8%). In France, the manufacturing industry takes the lead (51.2%), followed by the “other” category (15.9%). In Poland, the prominent sectors are retail trade (31.8%) and transportation and warehousing (13.6%), with the “other” category also making a notable contribution (13.6%). While additional industries were considered during the data collection and analysis, their presence was relatively lower. In Poland, most of the firms included in the sample are categorized as Small/Medium Enterprises (S/ME) (54.5%). This pattern contrasts with the samples from the USA and France, where the representation of S/ME is comparatively lower, with 34.8% and 23.8% respectively.

Across the three regions, the surveyed practitioners primarily consisted of middle and senior management personnel. France exhibits the highest proportion, with 93.4% of respondents categorized as such, comprising 19.5% middle managers and 73.2% senior managers. The USA follows with 86.3% of respondents falling into this category, with 25.5% classified as middle managers and 60.8% as senior managers. In Poland, the dynamics are somewhat different, as a significant portion of the respondents hold entry-level managerial positions. However, middle managers (14.6%) and senior managers (45.5%) constitute most of the sample. Regarding the respondents’ experience, practitioners in France have the highest level of experience compared to the other countries. In France, 79.3% of the respondents have more than 11 years of experience, while only 8.5% have less than 5 years of experience. Similarly, in the USA, most respondents (66.7%) have at least 11 years of experience, but 19.6% have between 6 and 10 years of experience, and 13.7% have less than 5 years of experience. In contrast, in Poland, half of the sample (50.0%) has less than 5 years of experience, followed by 22.7% with 11–20 years of experience and 18.2% with 6–10 years of experience.

Findings

Nine COVID-19 SC effects and 15 SC strategies were included as part of the questionnaire (see Appendixes 4-7 for individual item statistical analysis). To determine relationships among the observed variables, an EFA with Varimax rotation was conducted. The results of the analysis allow us to group the effects into three main categories: supply, production and distribution effects. Analogously, the SC strategies were grouped into four groups: collaboration, supply design, distribution design and contracts. Tables 1 and 2 reflect the loading factors for the different variables. Loading factors below 0.4, as well as cross-loadings, were discarded for interpretative purposes (Stevens, 1992). Cronbach’s alpha test was performed for each of the factors, with the findings showing moderate to high reliability (Hinton *et al.*, 2014). The mean values for the questions loading on each respective factor were then calculated for further analysis.

Effects of COVID-19 on the supply chain

Our overall findings indicate that SCs were affected in many ways during COVID-19 in the three geographic regions. After the factorization of the variables, the overall average score

Strategies	Factor 1 Collaboration	Factor 2 Supply design	Factor 3 Distribution design	Factor 4 Contracts
We increased our supplier base		0.675		
We nearshored or regionalized our supply chain(s)		0.548		
We reduced the number of products or services offered to customers*				
We increased the number of products or services offered to customers*				
We increased collaboration within our firm	0.886			
We increased collaboration with key suppliers	0.652			
We increased collaboration with key customers	0.557			
We developed new commercial channels such as e-commerce			0.824	
We developed alternative markets for our products			0.636	
We modified contractual terms with our suppliers				0.745
We modified contractual terms with our customers				0.710
We redesigned our warehousing and transportation network		0.559		
We increased the utilisation of business analytics	0.408		0.449	
We developed or improved a formal risk management programme	0.491			
We engaged in forward buying*				

Note(s): *Loadings lower than 0.4 were not considered as significant and deleted from the analyses
Source(s): Authors' own work

Table 2.
Exploratory factor
analysis of supply
chain strategy
implementation

range of the factors was from 2.31 to 3.16 on the individual items, meaning that none of the risks was perceived as having serious and catastrophic effects (see [Table 3](#)).

The overall ranking shows that “Supply” effects are considered the most significant SC issue by the respondents during COVID-19, especially in France and the USA. Disruptions in the suppliers’ operations meant that firms had difficulty replenishing their stocks, the cost of raw materials or supplies increased and shipment delays occurred from the supplier side. The rank continues with “Distribution” effects which was identified as the main challenge in France. This factor considers the reduction of transportation availability and the challenges in the coordination and planning of the SC. The less important effects were attributed to “Production”. This indicates that despite the difficulties introduced by the pandemic, firms were not as affected in their productivity and were able to protect their customer businesses to some extent. Significant differences were found for “Supply” effects between the USA and Poland, being the second country the one with the lowest score. There were no significant differences in how managers in the USA, France and Poland ranked the other two factors.

Supply chain strategies in response to COVID-19

The next part of the study involved analysing the SC strategies employed by SC practitioners in the three regions in response to COVID-19. Strategy implementation was examined with regard to their perceived extent, difficulty and effectiveness. After the EFA, the strategies were grouped into four factors based on an analysis of their eigenvalues.

COVID effect	USA		France		Poland		Overall		ANOVA		
	N	Mean	N	Mean	N	Mean	Mean	STD	F	Sig	Post hoc
Supply	66	3.10	119	3.34	51	2.84	3.16	0.98	5.186	0.006	US > POL
Production	66	2.54	119	2.20	51	2.27	2.31	0.90	2.942	0.055	
Distribution	66	2.92	119	3.09	51	2.78	2.98	1.06	1.643	0.196	

Note(s): Question: How did COVID-19 *initially affect* your supply chain?
 Scale: (1) no effect; (2) limited effect; (3) major effect; (4) serious effect; (5) catastrophic effect
Source(s): Authors' own work

Table 3.
Effects of COVID-19 on the supply chain

Extent of implementation. The first analysis was related to the extent of implementation of the individual strategies (see Table 4). The overall averages range from 1.96 to 2.20, which means that, overall, there was very little strategy implementation.

Collaboration strategies (including within, with key suppliers and with key customers) were identified as the most extensively implemented strategies in each of the three geographic regions. The individual analyses indicate that SC practitioners primarily worked within their SC networks, both internally and externally, and the primary approach for overcoming the challenges posed by COVID-19.

“Supply design” was ranked overall in second place. That is, after the pandemic started managers in the three countries reacted by increasing their supplier base, nearshoring or regionalising their SCs and redesigning their warehousing and transportation networks. “Contracts” were ranked as the third most implemented; this includes the modification of contractual terms with suppliers and customers. Respondents did not focus on “distribution design” efforts, which include the development of new capabilities or restructuring of SCs such as new commercial channels and alternative markets. They rather focused on those that were already established in their firms. There were no significant differences in the degree of implementation of the different strategies in the three regions.

For the next analyses, the sample size was reduced to only include responses in which the degree of implementation of the different strategies was at least ‘somewhat implemented’ (a score of 3 or greater by the respondent).

Difficulty of implementation. Table 5 shows the results of implementation difficulty. The overall difficulty means range from 1.96 to 2.90, which indicates that most firms only implemented SC strategies that were considered slightly or somewhat difficult. The most difficult strategies identified by the respondents include “Distribution design” and “Supply design”. Among these, developing new and alternative commercial channels and markets, redesigning warehouse and transportation networks, increasing the supplier base, and nearshoring/regionalising the SCs stand out. It is noteworthy that “Collaboration” was considered the least difficult overarching strategy to implement, which also may be a reason why they were the most adopted ones (see Table 5). There were no differences in the perception of difficulty across regions.

Effectiveness of implementation. Table 6 shows the results of effectiveness of implementation. Overall, the perceived degree of effectiveness of the strategies is low (the values range from 1.75 to 2.09). The most effective strategies focused on collaboration; followed by distribution design and supply design. This shows that the perceived effectiveness is not directly related to the difficulty of implementation of the different strategies. Although the overall effectiveness scores are low (i.e. less than 3), the magnitude of the difference between these strategies and the most effective is not substantial. The least effective strategies were contracts. The effectiveness of the strategies did not vary significantly across countries. Only “Distribution design” was found significantly more effective in France than in Poland.

Correlating COVID-19 effects with strategy implementation. We analysed how COVID-19 affected the organization’s SCs with the extent to which they implemented various SC strategies.

The correlation matrix (Table 7) displays the correlation coefficients between the measured variables. There were significant relationships between certain variables. For instance, there is a moderate positive correlation of 0.282 and 0.261 between the factors about “supply effects” and the variables “supply design strategy” and “collaboration strategy”. This indicates that organizations facing strong supply disruptions favour strategies related to supply design and collaboration. Regarding “production effects”, the correlation matrix shows, for example, moderate positive correlation of “supply design” (0.419), “collaboration” (0.324) and “distribution design” (0.244) strategies. This indicates that companies facing production effects from the COVID-19 outbreak have implemented those resilience strategies.

Strategies	USA		France		Poland		Overall		ANOVA Sig	F	Post hoc
	N	Mean	N	Mean	N	Mean	N	Mean			
Supply design	58	2.34	106	2.12	36	2.18	200	2.20	0.879	0.417	
Collaboration	58	3.03	106	2.82	36	2.92	200	2.90	0.761	0.469	
Distribution design	58	1.96	106	1.85	36	2.26	200	1.96	1.706	0.184	
Contracts	58	2.13	106	2.03	36	2.06	200	2.06	0.136	0.873	

Note(s): Question: What strategies did your firm implement in response to COVID-19? Please indicate the *extent of implementation* of the supply chain strategies listed below
Scale: (1) not implemented at all; (2) to a very little extent; (3) somewhat implemented; (4) to a large extent implemented; (5) to a very large extent implemented
Source(s): Authors' own work

Table 4.
Supply chain strategy implementation

Table 5.
Difficulty of supply
chain strategy
implementation

Strategies	USA		France		Poland		Overall		ANOVA	
	N	Mean	N	Mean	N	Mean	Mean	STD	F	Sig
Supply design	58	2.30	106	2.12	36	2.18	2.19	0.99	0.611	0.544
Collaboration	58	1.97	106	1.85	36	2.26	1.96	1.17	1.700	0.185
Distribution design	58	3.03	106	2.82	36	2.92	2.90	1.06	0.761	0.469
Contracts	58	2.15	106	2.03	36	2.06	2.07	1.19	0.187	0.830

Note(s): Question: Please indicate the *difficulty of implementing* the supply chain strategies listed below
Scale: (1) not difficult; (2) slightly difficult; (3) somewhat difficult; (4) very difficult; (5) extremely difficult
Source(s): Authors' own work

Strategies	USA		France		Poland		Overall		ANOVA		
	N	Mean	N	Mean	N	Mean	Mean	STD	F	Sig	Post hoc
Supply design	55	1.95	95	1.68	27	1.72	1.77	1.45	0.605	0.547	
Collaboration	55	2.33	95	1.85	27	2.48	2.09	1.39	3.413	0.054	
Distribution design	55	2.03	95	1.57	27	2.31	1.83	1.34	4.274	0.015	FR > POL
Contracts	55	1.97	95	1.6	27	1.82	1.75	0.94	2.896	0.058	

Note(s): Question: Please indicate the *effectiveness of implementing* the supply chain strategies listed below
 Scale: (1) not effective; (2) slightly effective; (3) somewhat effective; (4) very effective; (5) extremely effective
Source(s): Authors' own work

Table 6.
Perceived supply chain strategy effectiveness

Last, looking at distribution effects, in the correlation matrix, this variable shows a moderate positive correlation with “supply design” (0.398) and “collaboration” (0.327) strategies.

Theoretical implications: relationships matter

Our research findings imply several theoretical implications for the field of SCM. Firstly, using EFA, it was possible to categorize the impacts of COVID-19 into three main groups: supply, production and distribution effects, providing a structured framework for understanding the multifaceted consequences of the pandemic on the SC. Such a categorization may be mobilized in future studies about major disruptions in SCM. Moreover, the resilience demonstrated by SCs during the pandemic underscores the importance of organizational preparedness and adaptability (Pettit *et al.*, 2010; Das and Lashkari, 2015; Bahrami and Shokouhyar, 2022) in navigating unforeseen challenges.

Geographically, the study identifies few differences between the regions investigated. For example, there are some differences in the perceived impact of “Supply” effects between the USA and Poland, adding a nuanced dimension to the exploration of how regional factors may influence SC dynamics. The emphasis on collaboration strategies as the most extensively implemented approach across different regions highlights the critical role of building and leveraging collaborative networks in response to disruptions.

Assessing the extent, difficulty and effectiveness of SC strategies provides insights into the practical challenges faced by organizations. The identification of “Distribution design” and “Supply design” as the most difficult strategies suggest that certain structural changes pose greater implementation challenges. Regarding collaboration strategies, which are the most implemented, are perceived as the less difficult to implement and also the most effective strategies. Such a result merits further discussion.

One possible reason for the predominance of collaboration strategies was that many firms simply did not have many other options available to pursue. One differentiating element of COVID-19 as a risk incident was that it affected most firms and their SCs. Most prior experiences and research investigating SC risk had focused on localized events, such as supplier bankruptcy (Yang *et al.*, 2015; Wagner *et al.*, 2009) and natural disasters affecting a specific region or firm (Norrmann and Jansson, 2004). Since most firms and individuals were affected, there have simply been few options available outside of their current networks. In times of crisis, it may also be a human phenomenon to rely upon the relationships already formed and serve as a “rallying cry” to work together to overcome adversity.

From a theoretical perspective, building collaborative relationships with key customers and suppliers is an organizational capability that is essential for corporate success (Davis

		Effects			Strategies			
		F1 – Supply	F2 – Prod.	F3 – Distr.	F1 – Supply design	F2 – Collab.	F3 – Distr. Design	F4 – Contract
Effects	F1 – Supply	1						
	F2 – Production	0.324**	1					
	F3 – Distribution	0.506**	0.482**	1				
Strategies	F1 – Supply design	0.282**	0.419**	0.398**	1			
	F2 – Collaboration	0.261**	0.324**	0.327**	0.480**	1		
	F3 – Distrib. design	0.136	0.244**	0.072	0.244**	0.220**	1	
	F4 – Contracts	0.162*	0.191**	0.174*	0.441**	0.481**	0.357**	1

Note(s): **. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

Source(s): Authors’ own work

Table 7.
Correlation matrix

et al., 2019; Villena *et al.*, 2021). Therefore, it makes sense that firms struggling with COVID-19 outbreak first decided to enhance their collaborations with their SC partners. Indeed, according to the relational view of competitive advantage (Dyer and Singh, 1998; Dovbischuk, 2022), critical resources and capabilities extend beyond firm boundaries, and the management of interfirm relationships is a source of relational rent. Dyer and Singh (1998, p. 662) defined relational rent as “a supernormal profit jointly generated in an exchange relationship that cannot be generated by either firm in isolation and can be created only through the joint idiosyncratic contributions of the specific alliance partners”. Relationships may also be leveraged to enhance resilience within the SC (Christopher and Lee, 2004). Findings from our study provide support for the relational-based view (Dyer and Singh, 1998) with regard to upstream, downstream and within-firm collaboration to evaluate the extent of implementation and its benefits and challenges. Overall, this research also highlights the relevance of the relational view in a situation where a black-swan event occurs in an SC.

Finally, the correlation matrix (Table 7) shows that, for any kind of disruption effects faced by organizations, whether from their supply, production or distribution, they all favoured in priority two types of resilience strategies, i.e. collaboration strategies (that we have already discussed) and supply design strategies. Regarding supply design strategies, this result is particularly of interest. The COVID-19 outbreak has created unprecedented disruptions, particularly in the upstream part of the SC because the outbreak first appeared in China, a country that massively exports raw materials and components. Such upstream disruptions have rippled to the downstream entities in the SCs. The concept of the Ripple Effect (Ivanov and Dolgui, 2021) has been highlighted in such a context. Therefore, it appears that supply design resilience strategies, that can help mitigate the ripple effect (Brusset *et al.*, 2023) going from upstream to downstream, are relevant not only for organizations facing supply disruptions but also for production and distribution disruptions.

The positive significant correlations between supply and distribution effects on the SC with all SC strategies, except for distribution design, underscore the interconnectedness of disruptions and response strategies. This emphasizes the need for a holistic and integrated approach to devising effective SCM strategies. Additionally, the finding that the effectiveness of “Distribution design” varied significantly between France and Poland suggests that the outcomes of specific SCM strategies may be context-dependent, opening avenues for future research on contextual factors influencing strategy effectiveness in different countries.

Managerial implications

There is little debate that the COVID-19 pandemic can be labelled as a black-swan event. Our research findings offer insight as to how SCs were affected and the strategies SC practitioners in three countries employed in response to disruptions during this crisis. Managerial insights emerging from our study include a better understanding of the extent SC practitioners implemented various strategies in anticipating and reacting to risk during times of crisis, the focus and perceived success of collaboration for sustaining SC resilience and the relative homogeneity of SC strategy implementation among the three countries.

Supply chain strategy implementation

One of the unexpected findings from our study was that many firms did not extensively implement SC strategies in response to the changing conditions posed during the pandemic. There may be several reasons for this phenomenon. One reason may concern cash flow challenges. Many firms and industries experienced significantly lower cash flow from

customers due to the shutdowns of production and the inability of customers to purchase their normal array of products and services. These changes, as well as other challenges associated with supply availability (as also evidenced by the findings from our study as affecting firms more as compared with production and distribution), may have made it difficult for firms to make significant structural investments and changes in their SCs. Some of these difficult changes were identified by respondents as effective, for instance, redesigning warehousing/transportation networks and developing new commercial channels (e.g. e-commerce). The former involves how the different elements in the SC interact with each other, and the latter is boosted by the necessity of understanding and adapting to customers' consumption preferences. Although early in the pandemic it was reported that some firms were able to make changes in their production systems to provide critical products (e.g. ventilators and hand sanitizer), many of these changes did not radically alter their production processes or SC structures and only did for a short time.

Another possible explanation is that because COVID-19 was a "black-swan" occurrence, many SC practitioners simply did not know what to do or to change and may have simply opted to continue trying to operate as they were already doing, or at least not make significant changes to their SC strategies. In the last 2 decades, we have experienced smaller versions of disease outbreaks, such as SARS and the Avian Bird Flu epidemics. However, the last time a pandemic occurred was from 1918 to 1920; well before the time of SC practitioners today. Even though research and SC practice in terms of resiliency has seen tremendous advances during the past 25 years, there was little to no knowledge as to how to address a sustained disruption such as the pandemic. Supply chain practitioners indicated minimal changes to strategy implementation, and especially with regard to redesigning distribution channels, possibly because they did not know what to change in the first place. Since almost every firm's SC was affected by COVID-19 in some way, it may have just been impossible for many SC practitioners to pursue other options, and hence one reason collaboration strategies were the most implemented, as well as significantly associated with how COVID-19 affected supply, production and distribution.

Homogeneity among countries

Another managerial implication of our findings was that the differences in how COVID-19 affected firms in the three geographic regions we studied were minimal, as well as the SC practices implemented by the respondents. One reason for this finding could be that SC knowledge and practice are becoming more homogenous throughout the world, or at least in Western countries. This is evident with education programs such as PERSIST (<https://www.utwente.nl/en/persist/>) and in the commonality of material in textbooks that are published globally. All three geographic regions in this study are considered to have advanced SC practices. Hence, also the EPIC framework (Srinivasan *et al.*, 2014) provides insight as to how there may be some cultural differences existing among geographic regions. However, our findings, with a few minor exceptions, suggest the perceived effects and SC strategies implemented in response to COVID-19 were more similar than different.

Conclusions

COVID-19 continues to have devastating effects on human life and poses challenges to our economy. Yet, the pandemic has also created awareness of SCM in the general public due to the numerous SC disruptions that still plague us today. Our study found that COVID-19 affected SCs in a variety of ways. In response, many firms focused on increasing collaborative efforts with customers and suppliers to overcome challenges. These findings were generally congruent among USA (St. Louis, Missouri), French and Polish SC practitioners, while few

differences were found across geographic regions. For instance, Polish firms implemented more strategies than French firms, whereas the EPIC analysis shows that France is a country more developed than Poland. This unexpected result, at least from an EPIC analysis perspective, might be explained by the French government (high) intervention in the economy (Lorié and Ciobica, 2021) that did not push firms' executives to take action and implement strategies to face the disruptions.

As with all research, there are limitations to our study. First, the SC practitioners who responded came from firms that survived the pandemic and did not go bankrupt. A more holistic assessment as to how COVID-19 affected firms and the SC strategies would need to include firms that did not continue operations. A comparison of "survivors and non-survivors" would provide more insight as to how firms may be able to ensure resiliency given a black-swan occurrence.

A second limitation concerns the timing and method of data collection. The survey was developed and deployed approximately two years after the initial actions of governments to contain the virus. We intended to provide the respondents sufficient time to reflect as to how COVID-19 affected their SCs, and not during the midst of the pandemic itself. Too much time may have passed for the respondents to accurately remember the SC strategies used or their effectiveness during the pandemic. Further, the sample characteristics such as the industries represented, sizes of the firms, as well as the positions and experience of the respondents varied substantially across regions (see Table 3). We believe that this is also a reason why we had relatively small sample sizes, even given the incentives provided to the respondents in terms of a managerial report and, for the US participants, the chance to receive a financial reward.

COVID-19 is (hopefully) our black-swan pandemic occurrence during our lifetime. The lessons learned emerging from this tragedy can help inform practice as to how to best manage SC risk, particularly those rarely occurring crises, in the future. During times of crisis, it may be more effective and efficient to work within the currently established SC structures rather than to develop new structures, leading to the conclusion that relationships matter for ensuring SC resilience.

Notes

1. See <https://app.dimensions.ai/discover/publication>. Research on Dimensions was conducted on 8th July 2023, showing 117,942 articles.
2. See <https://www.theguardian.com/world/2023/jan/09/life-is-moving-forward-china-enters-new-phase-in-COVID-fight-as-borders-open> (Consulted on 8th May 2023)

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Corresponding author

George A. Zsidisin can be contacted at: gzsidsin@umsl.edu

Strategy	Definition	References
Increase the supplier base	The number of suppliers from which a firm purchases is increased	Yoon <i>et al.</i> (2018), Ali <i>et al.</i> (2023), Salama and McGarvey (2023)
Nearshore or regionalize the SC	The firm uses closer locations or domestic suppliers to undertake SC activities, which may include local sourcing and distribution with manufacturing sites and supply networks located near the customer	Chopra and Sodhi (2014), Hilletofth <i>et al.</i> (2019), van Hoek and Dobrzykowski (2021)
Reduce the number of products/services offered	The number of SKUs or products/services competing in the same market is reduced	Simchi-Levi <i>et al.</i> (2004)
Increase the number of products/services offered	New products/service offerings are introduced	Sreedevi and Saranga (2017)
Increase collaboration within the firm	Members of the firm work together across boundaries and increase the extent of information shared, benefits shared and joint decisions made to meet customer needs better	Min <i>et al.</i> (2005), Fawcett <i>et al.</i> (2008), Ozdemir <i>et al.</i> (2022), Shen and Sun (2023)
Increase collaboration with key suppliers	The buyer and supplier work together and increase the extent of information shared, resources shared, and joint decisions made to meet customer needs better	Yan and Dooley (2014), Sharma <i>et al.</i> (2020a, b), van Hoek (2020), Ozdemir <i>et al.</i> (2022), Shen and Sun (2023)
Increase collaboration with key customers	The extent of information shared, joint decisions made, and synchronization of operations with key customers is increased	Bowman (2004), Daugherty <i>et al.</i> (2006), Ozdemir <i>et al.</i> (2022), Shen and Sun (2023)
Develop new commercial channels	The configuration of the intermediate organizations that make goods and services available to consumers is modified	Watson <i>et al.</i> (2015), Salama and McGarvey (2023)
Develop alternative markets for products	New markets, based on product availability, service level, lead time and sales support, are served	Stevens (1989), Watson <i>et al.</i> (2015), Salama and McGarvey (2023)
Modify contractual terms with suppliers	Terms of trade with suppliers are modified to incentivize actions to achieve optimal SC performance	Cachon (2003), van Hoek and Dobrzykowski (2021)
Modify contractual terms with customers	Terms of trade with the customer, such as price-commitments and quantity-commitments, are modified	Su and Zhang (2008), van Hoek and Dobrzykowski (2021)
Redesign the warehousing and transportation network	Existing and alternative facilities and infrastructure are evaluated and redesigned to best satisfy customer demand	Jahani <i>et al.</i> (2018)

Table A1.
Description of supply chain strategies

(continued)

Strategy	Definition	References
Increase the utilization of business analytics	The use of qualitative, quantitative and statistical computational tools and methods to analyse data, gain insights, inform and support decision-making is increased	Power et al. (2018) , Bag et al. (2023)
Develop or improve a formal risk management program	An action plan that specifies which risks to address and how to address them is developed or improved	Shi (2004) , Bromiley et al. (2015) , Gakpo (2021) , Hohenstein (2022)
Engage in forward buying	Items are purchased in advance of requirements	Lee et al. (1997) , Salama and McGarvey (2023)

Source(s): Authors' own work

Table A1.

Appendix 2

Country	Region	USA	France	Poland
		Midwest of North America	Western Europe	Central and Eastern Europe
EPIC dimensions	Economy	3.03	3.10	3.00
	Politics	3.10	2.55	2.70
	Infrastructure	3.78	3.50	2.85
	Competence	3.67	3.02	2.87
	Overall grade	3.39	3.09	2.87

Note(s): The assessments utilizing the EPIC framework range from 1 (lowest score) to 4 (highest score)

Source(s): Own elaboration based on [Amling et al. \(2020\)](#)

Table A2.
Comparison of USA (St. Louis), France and Poland based on EPIC approach

	USA	France	Poland
<i>Industry</i>			
Information technology	2.0%	0.0%	4.6%
Health care and social assistance	3.9%	6.1%	0.0%
Manufacturing	27.5%	51.2%	0.0%
Mining, and oil and gas extraction	2.0%	2.4%	0.0%
Professional, and technical services	2.0%	0.0%	4.6%
Public administration	2.0%	1.2%	0.0%
Retail trade	5.9%	8.5%	31.8%
Transportation and warehousing	33.3%	3.7%	13.6%
Utilities	2.0%	0.0%	0.0%
Wholesale trade	7.8%	7.3%	9.1%
Construction	0.0%	3.7%	9.1%
Finance and insurance	0.0%	0.0%	4.6%
Real estate, rental and leasing	0.0%	0.0%	4.6%
Art, entertainment and recreation	0.0%	0.0%	4.6%
Other	11.8%	15.9%	13.6%
<i>Small-medium enterprise</i>			
Yes	34.8%	23.8%	54.5%
No	65.2%	76.3%	45.5%
<i>Position</i>			
Entry-level management	13.7%	7.3%	40.9%
Middle management	25.5%	19.5%	13.6%
Senior management	60.8%	73.2%	45.5%
<i>Years of experience</i>			
0-5	13.7%	8.5%	50.0%
6-10	19.6%	12.2%	18.2%
11-20	27.5%	36.6%	22.7%
21 or more	39.2%	42.7%	9.1%

Table A3.
Sample characteristics
in the USA (St. Louis),
France and Poland

Source(s): Authors' own work

COVID effect	USA			France			Poland			Overall			ANOVA		
	N	Mean	STD	N	Mean	STD	N	Mean	STD	N	Mean	STD	F	Sig	Post hoc
Supplier shipment delays	65	3.37	1.01	118	3.53	0.97	47	2.96	1.23	230	3.37	1.06	5.035	0.007	FR > POL
Increased cost of raw materials or supplies	63	3.13	1.09	117	3.40	1.08	49	3.27	1.02	229	3.30	1.07	1.377	0.254	
Increased demand uncertainty	66	3.15	1.09	116	3.24	1.21	50	2.96	1.25	232	3.16	1.19	0.985	0.375	
Challenges planning and coordinating our SC	65	3.06	0.97	118	3.19	1.03	48	3.13	1.16	231	3.14	1.04	0.307	0.736	
Shortage of critical raw materials or supplies	65	3.03	1.00	117	3.24	1.01	45	3.00	1.21	227	3.13	1.05	1.267	0.284	
Reduction of transportation availability	65	2.88	1.11	117	3.08	1.21	47	2.85	1.34	229	2.97	1.21	0.879	0.416	
Loss of labour	66	2.98	1.06	115	2.63	1.10	46	2.46	1.26	227	2.70	1.13	3.466	0.033	US > POL
Loss of manufacturing or operations productivity	63	2.57	0.96	114	2.46	1.07	48	2.65	1.18	225	2.53	1.07	0.603	0.548	
Loss of customer business	65	2.20	1.03	111	1.85	0.96	48	2.25	1.21	224	2.04	1.05	3.679	0.027	POL > FR

Note(s): Question: How did COVID-19 initially affect your supply chain?
 Scale: (1) no effect; (2) limited effect; (3) major effect; (4) serious effect; (5) catastrophic effect
Source(s): Authors' own work

Table A4.
 Disaggregated effects of COVID-19 on the supply chain

Table A5.
Disaggregated supply chain strategy implementation

Strategies	USA			France			Poland			Overall			ANOVA		
	N	Mean	STD	N	Mean	STD	N	Mean	STD	N	Mean	STD	F	Sig	Post hoc
Increase collaboration with key suppliers	56	3.50	1.08	103	3.18	1.05	33	3.03	1.19	192	3.25	1.09	2.370	0.096	
Increase collaboration within the firm	55	3.20	1.13	104	3.17	1.24	34	3.21	1.34	193	3.19	1.22	0.010	0.986	
Increase collaboration with key customers	56	3.34	1.21	98	2.80	1.21	34	3.41	1.05	188	3.07	1.21	5.500	0.005	US & POL > FR
Develop/improve a risk management program	53	2.72	1.25	102	2.58	1.32	32	3.00	1.30	187	2.69	1.30	1.310	0.272	
Increase the utilization of business analytics	58	2.95	1.26	101	2.36	1.39	32	2.94	1.34	191	2.63	1.37	4.550	0.012	US > FR
Increase supplier base	55	2.84	0.86	104	2.36	0.94	31	2.65	1.17	190	2.54	0.98	4.720	0.010	US > FR
Engage in forward buying	55	3.02	1.39	95	2.37	1.31	21	1.57	0.93	171	2.48	1.37	10.180	0.000	US > FR > POL
Redesign warehousing/transportation network	55	2.62	1.31	104	2.13	1.23	26	2.62	1.53	185	2.35	1.31	3.140	0.046	US > FR
Modify contractual terms with suppliers	51	2.49	1.17	100	2.22	1.11	30	2.33	1.12	181	2.31	1.13	0.970	0.380	
Modify contractual terms with customers	48	2.50	1.24	97	2.14	1.14	32	2.44	1.13	177	2.29	1.17	1.800	0.169	
Develop new commercial channels	57	2.14	1.17	101	2.05	1.37	31	2.81	1.47	189	2.20	1.35	3.910	0.022	POL > FR
Nearshore/regionalize SC	53	2.17	0.96	103	1.99	1.12	29	2.59	1.24	185	2.14	1.11	3.400	0.036	POL > FR
Develop alternative markets for products	56	1.88	1.11	101	1.83	1.12	30	2.53	1.17	187	1.96	1.15	4.700	0.010	POL > US & FR
Increase number of products/services offered	56	1.89	1.07	104	1.62	0.99	31	2.55	1.41	191	1.85	1.14	8.800	0.000	POL > US & FR
Reduce number of products/services offered	56	2.02	1.18	104	1.47	0.88	32	1.69	0.90	192	1.67	1.00	5.670	0.004	US > FR

Note(s): Question: What strategies did your firm implement in response to COVID-19? Please indicate the extent of implementation of the supply chain strategies listed below

Scale: (1) not implemented at all; (2) to a very little extent; (3) somewhat implemented; (4) to a large extent implemented; (5) to a very large extent implemented

Source(s): Authors' own work

Strategies	USA			France			Poland			Overall			ANOVA		
	N	Mean	STD	N	Mean	STD	N	Mean	STD	N	Mean	STD	F	Sig.	Post hoc
Redesign warehousing/transportation network	25	3.28	1.308	35	2.57	1.313	12	3.67	1.073	72	3.00	1.332	4.216	0.019	POL > FR
Increase supplier base	36	3.22	0.959	42	2.95	1.011	16	2.19	1.682	94	2.93	1.175	4.651	0.012	US > POL
Nearshore/regionalize SC	20	3.45	1.276	27	2.70	1.589	14	1.79	1.672	61	2.74	1.611	4.988	0.010	US > POL
Modify contractual terms with suppliers	25	3.00	0.913	38	2.45	1.389	10	2.50	1.716	73	2.64	1.306	1.438	0.244	
Modify contractual terms with customers	24	2.75	1.189	35	2.43	1.668	13	2.08	1.754	72	2.47	1.538	0.831	0.440	
Develop/improve a risk management program	30	2.60	1.070	51	2.31	1.257	20	2.35	1.496	101	2.41	1.250	0.515	0.599	
Increase the utilization of business analytics	39	2.62	1.206	38	2.21	1.189	20	2.35	1.599	97	2.40	1.288	0.970	0.383	
Reduce number of products/services offered	17	2.65	1.656	13	2.08	1.553	5	2.20	2.168	35	2.37	1.664	0.448	0.643	
Engage in forward buying	35	2.54	1.172	39	2.23	1.111	2	2.00	2.828	76	2.37	1.176	0.746	0.478	
Develop alternative markets for products	16	2.44	1.315	27	1.85	1.703	15	2.53	1.685	58	2.19	1.605	1.138	0.328	
Develop new commercial channels	22	2.05	1.618	31	2.06	1.209	16	2.50	1.461	69	2.16	1.400	0.611	0.546	
Increase number of products/services offered	14	2.43	1.222	19	2.11	1.197	14	1.79	1.672	47	2.11	1.355	0.780	0.465	
Increase collaboration with key suppliers	47	2.32	1.163	77	1.99	1.153	22	2.00	1.380	146	2.10	1.194	1.217	0.299	
Increase collaboration within the firm	41	2.37	1.113	74	1.84	1.034	22	2.00	1.272	137	2.02	1.115	3.055	0.050	US > FR
Increase collaboration with key customers	42	2.19	1.131	57	2.02	1.329	26	1.65	1.522	125	2.00	1.314	1.357	0.261	

Note(s): Question: Please indicate the *difficulty of implementing* the supply chain strategies listed below
 Scale: (1) not difficult; (2) slightly difficult; (3) somewhat difficult; (4) very difficult; (5) extremely difficult
Source(s): Authors' own work

Table A6.
 Disaggregated difficulty of supply chain strategy implementation

Table A7.
Disaggregated
perceived supply chain
strategy effectiveness

Strategies	USA			France			Poland			Overall			ANOVA		
	N	Mean	STD	N	Mean	STD	N	Mean	STD	N	Mean	STD	F	Sig	Post hoc
Increase collaboration within the firm	41	3.51	1.306	74	2.73	1.754	22	2.45	2.041	137	2.92	1.72	3.845	0.024	US > FR & POL
Redesign warehousing/transportation network	25	3.2	1.443	35	2.37	1.629	12	3.5	1.314	72	2.85	1.571	3.5	0.036	
Develop new commercial channels	22	2.86	1.726	31	2.71	1.697	16	2.94	1.731	69	2.81	1.691	0.108	0.898	
Engage in forward buying	35	2.91	1.483	39	2.69	1.688	2	1.5	2.121	76	2.76	1.599	0.815	0.447	
Increase collaboration with key suppliers	47	3.15	1.414	77	2.68	1.689	22	2.18	1.967	146	2.75	1.672	2.751	0.067	
Increase the utilization of business analytics	39	3	1.573	38	2.74	1.519	20	2.2	1.963	97	2.73	1.649	1.575	0.212	
Increase supplier base	36	3.08	1.105	42	2.5	1.55	16	2.06	1.731	94	2.65	1.464	3.232	0.044	
Reduce number of products/services offered	17	3.18	1.425	13	2.23	2.166	5	1.4	1.342	35	2.57	1.803	2.433	0.104	
Develop/improve a risk management program	30	3	1.313	51	2.51	1.605	20	1.95	2.012	101	2.54	1.64	2.559	0.083	
Modify contractual terms with suppliers	25	3	1.291	38	2.29	1.487	10	2.3	1.703	73	2.53	1.473	1.952	0.15	
Increase collaboration with key customers	42	2.86	1.646	57	2.37	1.779	26	2	2.02	125	2.46	1.803	1.969	0.144	
Modify contractual terms with customers	24	3.13	1.329	35	2.23	1.457	13	1.85	1.725	72	2.46	1.528	4.04	0.022	US > POL
Nearshore/regionalize SC	20	2.7	1.302	27	2.26	1.831	14	2.29	1.816	61	2.41	1.657	0.449	0.64	
Increase number of products/services offered	14	2.5	1.506	19	1.89	1.853	14	1.79	1.968	47	2.04	1.781	0.663	0.52	
Develop alternative markets for products	16	2.44	1.711	27	1.67	1.687	15	1.87	1.807	58	1.93	1.726	1.017	0.368	

Note(s): Question: Please indicate the effectiveness of implementing the supply chain strategies listed below
Scale: (1) not effective; (2) slightly effective; (3) somewhat effective; (4) very effective; (5) extremely effective
Source(s): Authors' own work