Journal Pre-proofs

Global supply chains risks and COVID-19: Supply chain structure as a mitigating strategy for Small and Medium-Sized Enterprises

Mustafa Cagri Gurbuz, Oznur Yurt, Sena Ozdemir, Vania Sena, Wantao Yu

PII: S0148-2963(22)00872-4
DOI: https://doi.org/10.1016/j.jbusres.2022.113407
Reference: JBR 113407

To appear in: *Journal of Business Research*

Received Date: 20 May 2021
Revised Date: 19 October 2022
Accepted Date: 26 October 2022

Please cite this article as: M. Cagri Gurbuz, O. Yurt, S. Ozdemir, V. Sena, W. Yu, Global supply chains risks and COVID-19: Supply chain structure as a mitigating strategy for Small and Medium-Sized Enterprises, *Journal of Business Research* (2022), doi: https://doi.org/10.1016/j.jbusres.2022.113407

Manuscript full title:

Global supply chains risks and COVID-19: Supply chain structure as a mitigating strategy for Small and Medium-Sized Enterprises

Authors:

Mustafa Cagri Gurbuz, PhD

Institution: Zaragoza Logistics Center
Address: Avenida Ranillas 5, edificio 5A (EXPO), planta baja - 50018,

Zaragoza Spain

Phone: +34 976 077 600

E-mail: mgurbuz@mit.edu

Oznur Yurt, PhD (Corresponding author)

1.Institution: The Open University
Address: The Open University Business School
Michael Young Building, Walton Hall, MK7 6AA, Milton Keynes
United Kingdom
Phone: +44 (0) 161 956 6886
E-mail: oznur.yurt@open.ac.uk

2.Institution: Izmir University of Economics
Address: Izmir University of Economics
Faculty of Business, Department of Logistics Management
Sakarya Cad. No: 156 35330
Balcova, Izmir, Turkey
Phone: +90 232 488 8126
E-mail: oznur.yurt@ieu.edu.tr

Sena Ozdemir, PhD

Institution: Lancaster University

Address: Lancaster University Management School,

Department of Marketing, Bailrigg, LA1 4YX, Lancaster, United Kingdom

Phone: +44 (0) 01524 510752

E-mail: s.ozdemir@lancaster.ac.uk

Vania Sena, PhD

Institution: Sheffield University
Address: The University of Sheffield Management School
Western Bank S10 2TN Sheffield United Kingdom

Phone: +44 (0)0114222200

E-mail: v.sena@sheffield.ac.uk

Wantao Yu, PhD

Institution: University of Roehampton
Address: Roehampton Business School

SW15 5SL London United Kingdom

Phone: +44 (0) 20 8392 7398

E-mail: wantao.yu@roehampton.ac.uk

Declarations of interest: *none*

Acknowledgments*: Authors thank Lur Textile managers for their continuous support during the project, and Simon Edward Mumford for proofreading our manuscript.*

Global supply chains risks and COVID-19:

Supply chain structure as a mitigating strategy for Small and Medium-Sized Enterprises

Abstract

After the COVID-19 pandemic, more research is needed to understand how the impacts of global events differ among alternative network structures in the presence of supply chain risks, and how relevant these potential risk mitigation strategies are for Small and Medium Enterprises(SMEs). Thus, our main motivation is to show how SMEs can configure their supply chains, and cost-effectively mitigate the risk created by major disruptions. We combined a case study with a simulation model. The results suggest the greater usefulness of certain network configuration strategies (e.g., collaboration, multi-sourcing) compared to others during catastrophic events. Our results indicate that SMEs can avoid suffering more harm than larger competitors by adopting strategies consisting of an adequate mix of proactive and reactive elements, and that an effective proactive strategy involves building flexibility by increasing the number of geographically spread supply chain partners, allowing for deeper discounts to preserve demand without hurting profits.

Keywords: supply chain disruptions, supply chain risks, textile industry, mitigation strategies, COVID-19, SMEs

Global supply chains risks and COVID-19:

Supply chain structure as a mitigating strategy for Small and Medium-Sized Enterprises

1.Introduction

Major supply chain disruptions have been reported by several companies as a result of the recent COVID-19 pandemic (Ali et al., 2022; Ivanov & Dolgui, 2020; Sharma et al., 2020), especially among Small and Medium-Sized Enterprises (SMEs). Indeed, around two-thirds of SMEs' operations have been significantly affected by disruptions to the supply chain, compared with 40% of larger companies (Manufacturing Growth Programme, 2020). However, even among SMEs, the impact of the supply chain disruptions on operations has been uneven, as some industries tend to be more exposed to supply chain risks. One such industry is textiles (Berg et al., 2020; ILO, 2020; Khlystova et al., 2022), characterized by very long and deep supply chains dominated by SMEs across a number of countries. The pandemic has obliged these firms to stop production for a number of reasons[1] (Berg et al., 2020; Lund & Krishnan, 2021) while at the same time, the cancellation of orders as a result of the falling consumer demand[2] has led to liquidity shortages among suppliers, causing them difficulties in navigating the crisis (Amed et al., 2020; ILO, 2020; Lund & Krishnan, 2021).

Unsurprisingly, developing global supply chain risk mitigation strategies has become a key priority for many companies in the aftermath of the COVID-19 outbreak (de Sousa Jabbour et al.,

[1] According to a recent study, suppliers in the textile industry have found it difficult to fulfil orders in the second quarter of 2020 (Berg et al., 2020).

[2] The fall in demand was driven by job losses, salary reductions, closure of bricks and mortar retail stores, health problems, as well as the lockdown and quarantine measures (ILO, 2020).

2020; Ivanov & Dolgui, 2020; Yu et al., 2019)[3]. The supply chain management literature has identified the structure of the supply chain network as an important component in a number of potential strategies for mitigating risks along the supply chain (Mostafiz et al., 2022; Parmigiani et al., 2011). However, Chowdhury et al. (2021) argue that more research is needed to understand how the impacts of global events such as COVID-19 pandemic differ according to supply chain network structures in the presence of both supply and demand risks, and how relevant and costly these potential risk mitigation strategies are for generally financially constrained SMEs. It is also important to study how the supply chain configuration facilitates/hinders other possible mitigation strategies mentioned in the literature.

Our study aims to answer the following questions to address this research gap in the literature: a) How can SMEs configure the structure of their supply chains to cost-effectively mitigate the risk created by major disruptions along the supply chain? Specifically, to achieve better risk mitigation, is there any justification for the increased operational costs for establishing supply chain configurations with multiple smaller suppliers and buyers, compared to serial supply chains with a single/larger supplier and buyer? b) When major global supply and demand related disruptions impact multiple supply chain entities, what is the additional benefit of the geographical dispersion of suppliers and/or buyers? and c) Are financial offers (e.g., discounts) to prevent order cancellations (demand disruptions) and maintain profitability more effective under particular network configurations, and are smaller discounts sufficient when dealing with multiple SMEs as buyers, as opposed to a single large buyer?

[3] Multi-sourcing, backup suppliers, flexible payment plans, Stock-Keeping-Unit (SKU) rationalization, improved visibility and collaborative planning and forecasting, capacity protection (reservation), building redundancy (e.g., inventories), insurance, and acceptance (no response) can be given as examples (Ivanov & Dolgui, 2020).

In order to address these research questions and ground our model in the reality of an SME, we first worked with a textile company based in Turkey to better understand the risks following the COVID-19 breakout, as well as to identify a number of mitigation strategies it adopted in its supply chain. This initial work has led to the development of a simulation model, which considers our case study firm's two most important mitigation strategies: (1) flexibility in sourcing/sales in supply chains and impact of partnering with multiple smaller firms and (2) financial offers as a reactive strategy to preserve demand. The value of these strategies is assessed under three alternative stylized supply chain configurations across three echelons (i.e., supplier(s) in the upper echelon, followed by the focal firm and buyer(s), respectively). In all these configurations, the intermediary (focal firm/case company) acts as an agent absorbing most of the shocks in the demand and supply processes (i.e., supplier disruption leading to lost sales in lower echelons (i.e., buyers), and demand shocks leading to order cancellations in upper echelons (i.e., suppliers)).

This study contributes to both theory and practice in three main ways. First, during catastrophic events, from a practical perspective, the case study results suggest that there are differences in the value of various network configuration strategies (e.g., collaboration, multi-sourcing, customer diversification) that connect an SME (the focal firm) with other SMEs . This further supports our finding that it is a simplification to state that the general claim that SMEs find it harder to cope with major disruptions because of the lack of financial resources and strong ties with supply chain partners (OECD, 2020), and that reality is more complex. Such network configuration strategies allow SMEs to deploy proper risk mitigation strategies as well.

Second, from a theoretical perspective, our simulation model, informed by the findings of the case study, extends the network configurations approach by analyzing how different supply chain types compare in mitigating risks of an environmental influence (such as disruptions occurred during COVID-19 pandemic), which by nature do not necessarily disrupt all diverse network actors simultaneously (Meyer et al., 1993; Kwak et al., 2019) and therefore provides insights into the benefits of partnering with reliable firms that function even under catastrophic situations. To the best of our knowledge, our simulation model is quite generic and the first to explicitly consider both major supply and demand disruptions, as well as minor fluctuations in cost/demand parameters during catastrophic events, even when an individual supplier/buyer may not be directly disrupted, accounting for conditional dependencies.

Finally, from a methodological perspective, combining an industrial case study with a simulation model yields a number of meaningful and timely insights for both researchers and practitioners during and post-COVID-19. The simulation model provides a practical tool, enabling firms to perform cost-benefit analysis (especially critical for SMEs) regarding relevant proactive and reactive mitigation strategies for networks subject to demand, supply, and transportation risks.

2. Literature Review

2.1 Supply chain risk and mitigation strategies in the aftermath of COVID-19

Scholarly interest has recently grown in supply chain disruptions and relevant risks (e.g. Ali et al., 2017; Chowdhury et al. 2020; Karmaker et al., 2021; Yu et al., 2019). Mitigation of the supply chain risks, viewed as a critical organizational capability, involves the management of the impact of unexpected network disruptions, as well as the capability to restore the operations (Ali et al., 2022; Ali et al., 2017; Raj et al., 2022; Tukamuhabwa et al., 2015; Yu et al., 2019). Several categories and classifications of supply chain risk and risk mitigation strategies have been proposed (e.g. Christopher et al., 2011; Ho et al., 2015; Manuj & Mentzer, 2008). Among these, the risk due to catastrophic events has received some attention (e.g. Chen et al., 2019; Meena &

Sarmah, 2014; Paul et al., 2019; Scholten et al., 2014; Shahed et al., 2021). Most work, however, has focused on the sources of relevant disruptions (e.g. Meena et al., 2011) and on the strategies to mitigate relevant risks (e.g. Kleindorfer & Saad, 2005; Christopher et al., 2020; 2011), rather than the key role of supply chain structure (e.g. Garvey et al., 2015)in the mitigation strategy, particularly when, as in the case of the COVID-19 pandemic, the supply chain is hit simultaneously by supply and demand shocks, (Chowdhury et al., 2021).

The structure of the supply chain imposes constraints on how risk mitigation strategies can be designed and deployed. Global disruptions have far-reaching impact on supply chains simultaneously on multiple interrelated dimensions (e.g., production, transportation, demand, finances), which makes the supply chain recovery challenging (Paul et al., 2021). The likelihood and impact of such disruptions heavily depend on the network structure. In our research, we discuss network structure's role in risk mitigation as a proactive strategy, and on the deployment of reactive strategies as a rapid response to supply chain disruptions. As such, we briefly discuss the relevant literature on network configurations, supplier/buyer concentration, geographical concentration, and impact of financial offers in mitigating demand risk in the remainder of Section

2.2.2. Network configuration theory in supply chain disruptions

This study examines network configurations as value-creating systems in which the focal firm configures the structure of its relationships with its suppliers and buyers to achieve a specific strategic goal or outcome, e.g. to mitigate supply chain disruptions (Corsaro et al., 2012; Kim, 2014; Pittaway et al., 2004). Such relationship structures may include triadic or more complex structures, comprising multiple dyadic and tiered relationships (Kim, 2014).

Networks may be configured to diversify the customer base in order to cater for changing states in customer orders due to ongoing shifts and disruptions in demand (Akanle & Zhang, 2008) and/or to diversify the supplier base in order to address changing supply conditions, such as restrictions, shortages or delays (Hendricks et al., 2009; Kaki et al., 2015). Consequently, different network configurations may facilitate different risk mitigation strategies to cope with the joint impact of supply and demand uncertainties. However, the simultaneous effects of these two types of uncertainty have received only limited attention in the literature (Golmohammadi & Hassini, 2020; Huang, Li, & Xu 2018, Kazaz, 2004). Our study contributes to the existing literature analyzing the deployment of network configurations that consider either end of the supply chain to be able to manage severe disruptions affecting multiple actors simultaneously (as opposed to focusing on more predictable or frequent disruptions caused by individual actors: see Lin & Wang, 2011; Namdar et al., 2018)).

Geographical spread of suppliers and customers is another key parameter in network configuration (Rudberg & Olhager, 2003), and a critical factor in the transformation of supply chain members' global supply chains in the aftermath of the COVID-19 (Ke at al., 2022). The theory developed so far has limited focus on the start point and duration of the period over which environmental influences (e.g., supply chain disruptions) may affect diverse network actors, and generally fails to consider whether or not such influences affect all network actors simultaneously. This is important, because, for instance, the timing of such disruptions and effects on various suppliers in the network partly determines the value of supply base diversification (Berger & Zeng, 2006; Burke et al., 2007; Lin & Wang, 2011; Namdar et al., 2018). Our study extends configuration theory by specifically considering the external environment of its network actors, in addition to how configurations should be deployed to fit a focal firm’s immediate environment.

2.3. Supplier and customer concentration in supply chain disruptions

The level of concentration of the supply chain defines the extent to which a firm depends on suppliers and buyers for business continuity. Supplier concentration indicates the number of suppliers and work distribution among these (Sako et al., 2016; Steven et al., 2014). Similarly, down the chain, customer concentration represents the degree of concentration of revenues across customers (Ke et al., 2022), ultimately defining the share of revenues from each (Saboo et al., 2016).

As far as the supply chain is concerned, greater supplier concentration (i.e., smaller number of suppliers as sources) has the following three major benefits: (1) it facilitates the development of stronger and longer term relationships, because a small group is able to meet sourcing criteria such as quality and cost of supplies, speed or timeliness of deliveries (Burke et al., 2007; Trevelen & Schweikhart, 1988; Yang & Yang, 2010); 2) it enables suppliers to become familiar with their buyers' needs and their requirements via continuous improvement initiatives (Namdar et al., 2018), and (3) it lowers administrative and transaction costs due to reductions in efforts to co-ordinate the supply base, and thus, in negotiating time, and in delays or disturbances in production schedules (Berger & Zeng, 2006; Yang & Yang, 2010). Not all firms, however, source from only one (or few) suppliers, and it is common practice to use multi-sourcing or backup suppliers in a supply chain network. For example, Samsung Electronics Co. Ltd. tries to always source from at least two suppliers within its network, even if the share of the second in total order volume is as low as 20% (Sodhi & Lee, 2007). The main driver for "reduced supplier concentration" is the ability to limit the dependency on individual suppliers, particularly in disrupted and highly uncertain environments (Yang & Yang, 2010). The use of, for instance, backup suppliers, even if costly, is particularly valuable when there is a need to prioritize dedicated supplier reliability (Kumar et al., 2018; Yin & Wang, 2018), and this approach is crucial in developing flexibility in sourcing.

On the demand side of the equation, greater customer concentration may have more potential in two respects: (1) strengthening the ability of supply chain risk mitigation against demand uncertainty in disruptions, such as COVID-19, due to the increased targeting efforts towards stronger relational ties with fewer customers (Saboo et al., 2016; Wang et al, 2021), and (2) increasing firm revenues through economies of scale by lowering overhead costs and selling expenses, and facilitating productions and transactions (Kwak & Kim, 2020; Wang et al., 2021). However, despite such attractive benefits, customer concentration also increases dependency on fewer customers, leading to higher cash flow risk, particularly in highly uncertain disruptions such as the pandemic (Huang et al., 2016; Wang et al., 2021). A study focusing on the COVID-19 has shown that customer concentration is negatively related to the sustainable growth of a supplier, unless it is under government protection (Wang et al., 2021). Yet another risk of greater customer concentration is major customers' bargaining power in relation to their suppliers. Therefore, firms with higher customer concentration may have a greater need for cash, and for flexibility to adapt their operations to the changing market requirements (Huang et al., 2016).

2.4. Geographical concentration in supply chain disruptions

Risk mitigation concerns must focus not only on the number of suppliers or buyers to work with, but also on ensuring that disruption does not affect all suppliers and customers within a supply chain network at the same time. Geographical spread of both is therefore critical, especially in situations in which major catastrophic events affect all supply chain entities within a particular region (Paul et al., 2021). In this study, geographical concentration indicates the degree of geographical spread of suppliers and customers (e.g., greater concentration means all suppliers are based in the same region and subject to similar risks).

From a sourcing perspective, adopting lower levels of geographical concentration enable the firm to reduce risk and mitigate the damaging effects of supply chain disruptions by diversifying the supply sources across regions (Hendricks et al., 2009). Benefits of a dispersed supply base exist even in global disruptions, such as the recent COVID-19 pandemic, because disruptions were not synchronized across regions. The advocates of geographical concentration in sourcing, however, argue that lower level of geographical concentration, i.e. greater dispersion, is a complexity driver, which reduces the service quality and transparency, and increases costs and uncertainty (Nakatani et al., 2018; Steven et al., 2014).

The disruptions in supply chain environments may also influence customer demand in global environments, as evidenced by dramatic purchasing behavior changes during the COVID-19 pandemic. There are few relevant studies, but one is Leung and Sun's (2021) research, showing that customer concentration reduces firm profitability and sales growth in the case of disruptions caused by political uncertainty; in contrast, for Chinese semiconductor firms, higher levels have been found to have a positive influence during an environmental disruption (Ding et al., 2021).

Irrespective of the size of the firm, the findings from previous research are inconclusive, as to the optimal level of network or geographical concentration, particularly with regard to major disruptive events. SMEs might not be able to operate cost-effectively with higher number of suppliers/customers in diverse regions of the world (Jaklic et al., 2012), but are more adaptable to changing environments due to their lighter bureaucracy and greater flexibility (Eggers, 2020). A larger firm with abundant resources and greater power in supply chain (Polyviou et al., 2020) can better exploit cost advantages from economies of scale in general, however, suffer more from the impact of a disruption.

All in all, there is a lack of agreement over how firms should configure their geographical concentration in engagements with suppliers and customers (or buyers) under a disruption, such as COVID-19, which may affect network actors differently over time. Our research aims to address these gaps in the extant literature, modeling both network and geographical concentration (taking conditional dependencies into account), which involve trade-offs between costs associated with establishing such networks and the expected improvements in supply chain risk mitigation.

2.5. Discount offers and demand cancellations

It is well known that an inventory system is often subject to various demand/supply uncertainties, where customers might, for example, cancel orders during the period of demand reservation, a far more common practice since the COVID-19 pandemic. Previous research sheds some light on the impact of demand reservation and cancellation on the replenishment processes. Yuan and Cheung (2003), for example, developed a periodic review inventory model in which all demands are to be reserved with one-period lead time, but cancellations are allowed during the reservation period to calculate order-up-to levels, dependent on the reserved demand and cancellation parameters. Yeo and Yuan (2011) extended the work by Yuan and Cheung (2003) by considering both supply uncertainty and demand cancellation.

The approach in the current research differs, mainly motivated by the strategy of our focal firm (i.e., LUR Textile), with a focus on incentivizing the buyer to avoid cancelation through financial offers (i.e., discount) rather than adjusting production quantities based on demand and cancellation distributions. Previous research (e.g. Pasandideh et al., 2014) suggests that permissible delay in payments and cash discounts are two assumptions that enable companies to attract new customers. Following this approach and noting the evidence that cash discounts helped maintain the previously committed orders at the firm, we examine the impact of a discount intended to prevent cancellations of placed orders under different network configurations. This is similar in nature to the work by You (2003), who examines an ordering and pricing problem for a dynamic programming model in which the advanced-selling systems promote a perishable product over a short sales season. In our model, the demand is also price-dependent (implicitly, through reduced cancellations as a result of the cash discount).

In the following two sections (Sections 3 and 4), we analyze in detail the risks and disruptions faced by our focal firm, along with their results, followed by the simulation model and the associated insights contributing to the general understanding of the impact of network structure and financial offer on disruption mitigation.

3. Case Study: Impact of Covid-19 on Textile Supply Chains and the Response

Aligned with our aims, the case company was selected on three criteria: 1) company size/being an SME, 2) membership of a global supply chain, 3) being in continuous operation since COVID-19 outbreak started.

3.1. The textile industry in Turkey and background of the case company

Turkey is the fifth largest exporter of textiles and clothing accounting for nearly four percent of all exports globally (Shahbandeh, 2020). As evidenced from the recent indicators, between2019 and 2020, amongst the world's top five textile and clothing exporters, Turkey experienced the second smallest contraction (-$279M), after China ($153M) (Euromonitor International, 2020).

Despite the challenges faced by the industry, especially during the COVID-19, Turkey is expected to play an increasing role in the global supply chains, as a value-added manufacturing hub due to its location midway between the U.S. and Far East, and as an efficient connection node between China and Western Europe through the Trans-Caspian International Transport Route- The Middle Corridor (Wara, 2020).

The case company chosen for this study; Lur Textile (LUR) is a member of the Aegean Clothing Manufacturers' Association[4] in Turkey. Based in Izmir, Turkey since its establishment in 2003, LUR has developed an increasingly wide range of products, and with 300,000 meters of annual production capacity, has become well known locally (Lur Textile, 2020). With its 40 white collar employees, and 120 factory staff, LUR is considered as an SME. Its customers range from global apparel market leaders to local retailers (mostly SMEs). 90% of its total export volume is to Europe (e.g., Denmark, Bulgaria, Romania), USA and Canada. LUR produces and sells two main product categories, non-denim, mainly sourced from local suppliers, and denim, supplied from both local and global suppliers (Lur Textile, 2020). Figure 1 shows the supply chain structure of LUR.

<< Figure 1 will be inserted here >>

3.2. Data collection

The case method was chosen for study as we aim to explore a relatively new phenomena suited to field study, particularly to case study research (Ketokivi and Choi 2014; Voss et al. 2002). First, we conducted exploratory in-depth semi-structured interviews with top managers of the focal company, LUR, which strongly supported simulation model development. Purposive sampling was used for selecting both the case company and the interviewees; LUR was chosen due to its

[4] https://egsd.org.tr/tr/(Accessed 10.04.2021).

characteristics (see Section 3.1), which are aligned with our research aims. The selection criteria for the interviewees were their level of knowledge and involvement in the supply chain management, as well as their managerial role. Interviewee details are given in Table 1.

<< Table 1 will be inserted here >>

All interview data were subsequently transcribed, validated, and coded. The interview questions (available upon request) were developed as an interview protocol based on previous literature (e.g., Gray et al., 2020; Ivanov & Dolgui, 2020), considering the aims of the research and research questions. Questions were designed to identify and explore the effect of COVID-19 on textile supply chains, and their response to the potential issues and challenges.

All questions were open-ended, and iterative questioning techniques, and probing questions were used to increase credibility. All researchers collaborated on the design of the initial interview protocol, and feedback was sought from academics and professionals in the operations and/or the supply chain management fields, after which revisions were made to clarify the questions. The questions were initially developed in English and back translated by two independent individuals, as the interviews were conducted in Turkish. Interviews were conducted by two researchers and recorded with participants' permission. Interviews with the CEO, general manager and deputy manager of the company lasted 49, 90 and 57 minutes, respectively.

As part of data triangulation, and with the aim of enhancing the trustworthiness (Eisenhart 1989; Yin 2003), we used multiple sources of evidence, including documentation such as company order and sales figures between March and July 2020. The company website[5] was also a source of relevant supporting data. Secondary sources of data were publicly available market reports particularly relevant to textile sector in Turkey and COVID-19. Such supporting sources are also

[5] http://www.lurtextile.com/en/stat/about-lur-fabric (Accessed 10.04.2021).

incorporated to the coding process. We reflected diverse perspectives on the findings through triangulation between researchers, which allowed us to control for potential biases of any one individual (Maylor & Blackmon 2005). Initially we analyzed data through open coding. After defining the first-level codes, following an inductive approach, we conducted axial coding to generate more abstract codes (Miles & Huberman, 1994; Strauss & Corbin 1990). Coding was continued until a definite agreement was reached. Our contact with the case company to collect and analyze different sources of data extended from April to December 2020. To ensure the quality of the research, we used the four design tests proposed by Yin (2003), with the relevant actions.

3.3. Case study results

Our analysis revealed disruptions and risks at all echelons of LUR's supply chain during/after COVID-19. Some customers, for example, canceled orders due to falling end-consumer demand, while some suppliers were unable to manufacture and/or transport goods. A summary of the relevant findings is given in Tables 2 and 3 (detailed information is available upon request).

<< Table 2 will be inserted here >>

All managers interviewed at LUR confirmed overestimating the impact of the disruptions/risks, partially due to their disruption management and risk mitigation strategies implemented since March 2020, designed, to minimize the effects of Covid-19. Table 3 below summarizes these strategies.

<< Table 3 will be inserted here >>

Our findings suggest that, if supported with the relevant characteristics and/or capabilities, several potential strategies can be implemented to mitigate the impacts of COVID-19 and similar adverse events on textile supply chains. Despite being an SME (and partnering mostly with SMEs), LUR was, in most cases, able to rapidly respond to minimize the adverse impact of COVID-19 on its supply chain. The effective management of such disruptions/risks was mainly facilitated by the establishment of relatively uncomplicated communication channels, because of their strong long-term, trust-based relations with supply chain partners. This result conflicts with the claimed slower responses for SMEs and/or companies with SME supply chain partners to disruptions, due to greater vulnerability to shocks, and also with the argument that the smaller size of the firms implies a lack of buffer to absorb the shock (e.g. Manufacturing Growth Programme, 2020; OECD, 2020).

Therefore, the findings from our case study generated new research questions aligned with the simulation model presented in Section 4. In addition to the focus on organizational capabilities, we aim to understand, via the simulation model, the two most relevant mitigation strategies (strategic/proactive network configuration choices and tactical/reactive actions), and how these can support LUR and similar firms cope with major disruptions caused by a global event such as COVID-19. Specifically, we investigate the value of *sourcing/product flexibility* (sourcing from multiple supplier partners, and the capability to customize and sell the product to multiple alternative buyers in case of order cancellation) and *financial offers* (markdowns offered to prevent order cancellation). Our generic simulation model, informed by key findings from our case study, is practical and realistic, in that it implicitly/explicitly considers the key disruptions/risks and mitigation strategies identified in our case study (given in *italic* in Tables 2 and 3).

4. Simulation

Although supply chains with merely a few big players concentrated in a certain region are cost efficient, COVID-19 outbreak (considered a "*catastrophic-event*" in this research) has raised awareness on the possibility of supply chain collapse because of a single risky event. As discussed in Section 3, management at LUR (i.e., our focal firm) partnering with multiple SMEs (as suppliers and buyers) secured supply flexibility, offered discounts or shifted demand to other potential customers when the original customer canceled orders during the recent global pandemic.

Partnering with multiple SMEs reduced LUR's exposure to such risky events, however, to a limited extent, as most of its suppliers were concentrated in Pakistan and buyers, in Europe. Such industrial concentration in general is cost efficient and requires reduced effort for marketing, localization of the goods, distribution costs, and after-sales services. Yet, when all partners are subject to the same underlying disruption risks, there is an inherent risk of losing simultaneously the total manufacturing capacity (e.g., an earthquake affecting all the suppliers in a certain country) and/or demand (e.g., importation restrictions or border closures impeding the distribution of the goods to all the customers in a certain region).

It is quite challenging mathematically to build a stochastic analytical model of such supply chains with multiple echelons, given the complexity of operating policies (for production, distribution, sales, etc.) and varying sources of uncertainties/disruptions and obtain steady-state results for system performance. Therefore, we believe simulation is the most appropriate tool for the analysis of the effectiveness of different network structures as a proactive risk mitigation strategy, and the analysis of the value of financial offer (i.e., *discount*) as a reactive plan to maintain the target profit levels, and understand the role played by the particular network structure.

4.1. Model details

We model three supply chain design alternatives, as shown below in Figure 2. The focal firm (e.g., LUR Textile) forms a partnership with one big supplier and one big buyer in the "triadic" supply chain, whereas there are two (smaller) suppliers and buyers in both the "concentrated" and "dispersed" supply chain configurations. In the concentrated supply chain, suppliers and buyers are based in the same region (possibly subject to the same risky events and resulting disruptions), but in the dispersed supply chain configuration, geographically spread out.

<< *Figure 2 will be inserted here* >>

There are three main shocks to the demand and supply processes in our simulation model: (1) disruption at a supplier, (2) demand disruption (a buyer requesting to cancel an already placed order), and (3) disruption of the transportation service (i.e., inbound and/or outbound transportation links broken). All three types of disruptions may be triggered simultaneously by the occurrence of a catastrophic-event (e.g., Covid-19 pandemic) or may simply happen as unique-events (individual disruptions), even without a catastrophic-event. Our approach to modeling supplier availability issues stemming from such disruptions is similar to Meena et al.'s (2011), but with major differences with respect to how the shocks arrive at the system and their duration, which can be tracked by continuous monitoring. Moreover, a catastrophic event like COVID-19 pandemic does not necessarily disrupt all supply chain entities in our study. This allows us to observe the benefits of partnering with more "individually reliable" firms under different conditions. However, we assume that the conditional probability of an individual disruption occurring following a catastrophic event is greater than it would be under normal conditions. Similarly, individual disruptions last longer on average in the aftermath of a catastrophic event.

We model the difference between the concentrated and dispersed configurations by synchronizing (or not) the time of occurrence of catastrophic events in concentrated (dispersed) supply chains. That is, in the concentrated network design, the start point and duration of the catastrophic event for buyers (or suppliers) coincides, whereas in the dispersed network design, catastrophic events may or may not coincide.

Below, we list additional assumptions made in our simulation model, followed by the timeline that shows the processing of each buyer's order in the simulation in Figure 3:

- A Make-to-Order (MTO) system is employed (as LUR does for a certain number of product categories) triggering production when buyers' orders are received at the beginning of each week, emphasizing the criticality of implementation of proper risk mitigation strategies to maintain high fill rates, as the company does not hold inventory.
- An order from a buyer is rejected if all the suppliers are disrupted at that moment (in line with events at LUR). Otherwise, the total order is split evenly across all available suppliers (no limit on production capacity). This practice is in line with our focal firm's philosophy of placing smaller, more frequent orders to create constant/continuous work (therefore revenue) for their suppliers, as opposed to less frequent larger orders. Moreover, the order splitting reduces the "production time" for each order, hence the likelihood of disruption during production and the resulting delay in delivery.
- A disruption at the supplier during production (order acceptance) delays delivery only. Similarly, delay is caused by a transportation-related disruption (either inbound from the supplier to the focal firm, or outbound from the focal firm to the customer). We impose no additional cost for such delays, but the simulation keeps track of the cumulative number of delays.
- There is no cancellation fee, and no partial cancellation (the whole order is cancelled). When a customer cancels an order "during production", the focal firm continues with the production at the supplier (in line with the strategy of LUR, epitomized by the quote: "*Production must continue*").

- A discount offered by the focal firm to the buyer to discourage order cancellation may have one of the following results:
    - The buyer may accept the discount and pay the lower rate,
    - The buyer cancels the order, and the product is sold to the second buyer with a given likelihood (in the dispersed or concentrated designs) in the absence of transport related (outbound) disruption,
    - The buyer cancels the order, and the product is salvaged in a secondary market if it is not possible to sell it to the second buyer.
- The unit revenue collected from the second buyer (for dispersed and concentrated designs) is significantly less than the full price charged to the original buyer, but more than the salvage value (on the secondary market). The reduction in unit revenue is not only due to a discount to incentivize alternative buyers (both second buyer and potential customers in secondary market) to purchase the product, but also a result of costs for additional transaction/administration and making changes on the product itself (e.g., repackaging).
- The variable (per unit) and fixed costs increase when there is a catastrophic event (i.e., the catastrophic event is “active”), even if there is no disruption at an individual supplier or buyer. This reflects most companies' situation during the recent pandemic, assuming they continued to function.
- Similarly, the variance of the demand increases (while keeping the mean constant) when there is a catastrophic event (even when there is no individual disruption), mainly due to reduced predictability, while the overall average demand might remain unchanged (with increases in some and decreases in others). Our focal firm also suffers from reduced visibility (and hence predictability of demand) due to changed orders as well as less

information available (e.g., being unable to attend the Paris show and visit customers in person).

<< Figure 3 will be inserted here >>

4.2. Experimental design

We perform an extensive numerical analysis to understand how performance under different scenarios was impacted by supply chain structure (i.e., triadic, concentrated, and dispersed) and the financial offer (i.e., discount). Table 4 provides additional details regarding disruptions and summarizes the input parameters for the baseline scenario:

<< Table 4 will be inserted here >>

We tested system performance for different values of *interarrival time of catastrophic events, probabilities of individual disruption, cancellation, and of accepting the discount*. We also investigate the "cost of risk mitigation" by simulating the system for different *fixed ordering costs (*working with more supply chain partners to mitigate risks automatically increases the fixed costs of the network) and *discount level*. This leads to 48 different scenarios defined by the following subset of parameters: $\mu \in \{720, 180\}$; $P^C(SD) \in \{1, 0.5\}$; $P^C(RFC) \in \{0.2, 0.4\}$; $(P^{Accept}, \beta) \in \{(0,0), (0.16, 0.18), (0.50, 0.36)\}$; and $(F^C, F^N) \in \{(200, 175), (800,750)\}$ for all supply chain configurations, with one exception. Larger customers with more negotiation power over smaller companies can further reduce prices, therefore, we use 15% and 30% (instead of 18% and 36%) for the discounts offered to a "small" buyer, maintaining the same probability of accepting the discount offer (i.e., P^{Accept}). We assume an increasing marginal likelihood of accepting the discount with respect to the discount level (e.g., for the dispersed supply chain, the probability of accepting a 15% discount is 0.16, and with an additional 15% discount, 0.5).

The system is simulated for 100 years (discarding the data from the first 10 years to minimize the initialization bias) using the ARENA Software and 50 replications are taken for each scenario. The length of each simulation run is sufficient to ensure reasonably high probability of encountering several major global disruptions, and to see the long-term impact of the strategic and tactical decisions on the key performance indicators (i.e., fill rate and profit). “Profits” are defined as the “revenues from sales minus the production/distribution related costs” and the fill rates are defined as the percent of demand met (i.e., 100% minus lost sales ratio).

4.3. Numerical results

Fill rates are the highest (lowest) for the dispersed (triadic) supply chain configuration in all 48 scenarios, as it is less likely for two geographically spread suppliers being affected at the same time (see Table 5). However, it is more difficult to predict the impact of the supply chain configuration on the profits. Although the general trend is an increase in profits as disruptions decrease in frequency, Figure 4 shows that the profit function is non-monotonic; an increase in fill rate does not necessarily translate into increased profits, especially when fixed and variable costs grow at a higher rate than the revenues. This effect is more pronounced for the dispersed/concentrated supply chains due to the higher number of orders processed (two buyers instead of one, and order splitting among available suppliers). Consequently, the triadic supply chain with consistently lower fill rates yields highest profits in 50% of the scenarios, indicating that cost of risk mitigation might sometimes outweigh the benefits (see the graph on the right in Figure 4).

Concentrated supply chains yield lower profits (by 30% on average) than dispersed supply chains in all scenarios (Figure 4). This result might change, however, if one considers different values for the financial parameters when comparing the two configurations. Concentrated supply chain might be preferable because of reductions (increases) in fixed costs (unit profit margins), due to economies of scope/scale (e.g., stronger market position coordinated order fulfillment, and lower costs of reselling the product to another buyer when the two buyers/suppliers are co-located).

<< Table 5 will be inserted here >>

It seems more beneficial to seek partner firms in regions less prone to catastrophic events, rather than those that are "more reliable" in riskier regions (see Figure 4: bigger jump in profits (in scenarios when they are positive) and fill rates, when the interarrival time between catastrophic events changes). Yet, engaging in collaborative initiatives with the suppliers to improve "individual reliability" (i.e., reducing $P^C(SD)$ from 1 to 0.5) appears to significantly increase fill rates, especially when catastrophic events increase in frequency. The profits, on the other hand, are less sensitive to individual reliability.

<< Figure 4 will be inserted here >>

We now turn our attention to the effectiveness of the reactive measures (i.e., discounts) "alone" (horizontal dashed lines in Figures 5a&b show the effect of discounts while supply chain configuration remains the same) for scenarios with positive profits for all supply chain types. We remind the reader that while order cancellation has no impact on costs (already incurred, because cancellation occurs after order processing), it reduces the revenues (the products are sold elsewhere at a lower rate). As a result, triadic supply chains suffer more from order cancellations due to much lower "*effective* unit revenue" in case of order cancellation (the only option is to salvage in a secondary market). Similar arguments hold for the concentrated supply chain, because of the lower probability of selling to the alternative buyer when both buyers are simultaneously subject to the same catastrophic event. Consequently, discounts are clearly more critical for the profitability of triadic and concentrated supply chains, as observed in Figures 5a&b also.

<< *Figure 5 (5a & 5b) will be inserted here* >>

Efforts to maintain/increase sales by offering discounts (reducing the number of cancellations) and/or partnering with more buyers (keeping the option to sell to an alternative buyer) become more critical with increased probability of a cancellation request (percent profit improvements are significantly higher in Figure 5b). Higher levels of discounts inevitably mean lower profit margins. However, we observe that this could be compensated by an opting for a different supply chain configuration (e.g., the "dispersed supply chain and a discount of 30% is superior" to "concentrated supply chain and a discount of 15%").

In fact, "proactive (i.e., dispersed/concentrated supply chain structures) and reactive (i.e., discounts) measures deployed simultaneously" results in the highest improvements in both fill rate and profit, as shown on the diagonal arcs in Figures 5a&b. "*Establishing a dispersed supply chain and offering a 30% discount when a customer wants to cancel an order*" seems to be the best policy. "Proactive alone" measures result in a greater improvement compared to "reactive only" measures (values on vertical arcs are larger than the horizontal, as shown in Figures 5a&b). However, note that the "reactive alone" measures have a substantial impact on profits (between 6 and 59%), especially when there is a high probability of a cancellation request. This is important, as reactive measures to improve short term profits in all scenarios could be taken before considering whether new supply chain configurations are necessary, after a careful evaluation, and ensuring that profits would not suffer.

5. Conclusions, implications and further research

5.1. Theoretical implications

This study contributes to the literature (e.g., Amed et al., 2020; Berg et al, 2020; ILO, 2020; Lund & Krishnan, 2021) by revealing both the supply side and demand side supply chain disruptions and risks faced by textile companies, particularly the SMEs, and their supply chain partners, in the context of COVID-19.

Our study identifies previously discussed strategies (e.g., Ali et al., 2017; Berger & Zeng 2006) with the potential to mitigate the risks and related disruptions in a supply chain network. Some strategies (e.g., collaboration, multi-sourcing) appear to be more effective than others during catastrophic periods. The view that SMEs generally find it challenging to cope with major disruptions due of the lack of financial resources and strong ties with supply chain partners (OECD, 2020) may not be the case in all situations, this study indicates. During the COVID-19, our focal firm was clearly capable of rapidly responding to both supply and demand disruptions, due to the development of flexibility, the removal of bureaucratic obstacles to taking actions, and a balancing of power positions within the network, generally leading to win-all situations.

Motivated by these findings of the case study, we develop a generic simulation model to provide a better understanding of the impact of the risks most relevant to SMEs in a global supply chain, and the effectiveness of the mitigation strategies employed (different supply chain configurations and financial offers) in coping with major disruptions such as COVID-19. As such, our study contributes to the literature by considering both supply and demand disruptions, and conditional dependencies between general catastrophic events and individual disruptions.

From a theoretical perspective, this study builds on the network configurations approach which has neglected the comparison of different configurations (both supplier/buyer concentration and the geographical spread) in mitigating risks of an environmental influence such as a supply chain disruption. We particularly focus on disruptions which, at a particular point in time, may or may not directly have an impact on diverse network actors (Meyer et al., 1993; Kwak et al., 2019). Our model is generic in the sense that it allows analysis of cases where a global disruption such as the COVID-19 pandemic does not necessarily disrupt all entities in a supply chain simultaneously. It also provides insights into the benefits of partnering with a greater number of firms with proven reliability to meet the challenges under different conditions.

Our study, by showing how alternative supply chain structures/configurations lead to mitigation of supply chain disruptions at all stages (i.e., both supply and demand side), contributes to the ever-developing concept of the "ripple effect", originally proposed by Ivanov et al. (2014), particularly in the context of COVID-19. Recent research on this phenomenon, for example, looks at supplier selection and optimal order allocation problems (Hosseini et al., 2019), and identification of high-risk suppliers (Hosseini & Ivanov, 2019**).** We believe our simulation model could serve as a starting point for others analyzing risk mitigation strategies against the supply/demand disruptions discussed and examining the role of these strategies in counteracting the so-called ripple effect for suppliers/buyers in longer supply chains.

5.2. Managerial implications

Our research findings also provide several implications for supply chain managers.

Our study confirms that partnering with a greater range of smaller suppliers/buyers in geographically spread locations (i.e., dispersed supply chain) significantly reduces the risk of both demand and supply disruptions, contributing to an appreciable increase in *fill rates* (therefore revenues).

One interesting, and somewhat unexpected result from our simulation model is that an increase in *fill rate* does not necessarily translate into an increase in *profits*, which could be a critical point for managers, especially of SMEs. Cost to serve may actually outweigh the potential benefits of reduced vulnerability to both supply and demand disruptions, incentivizing managers to opt for the triadic supply chain configuration. This observation clearly shows the value of simulating such systems with stochastic non-linear and non-monotonic profit functions before making strategic decisions regarding supply chain structure, especially for those SMEs generally exposed to a wider range of financial constraints.

Another practical implication of our study is about the financial incentives. Our results show that such offers (discount offered as a "reactive" strategy) have greatest benefits for the focal firm in triadic supply chains, as these firms are particularly exposed to demand disruptions and deeper markdowns to salvage products in the secondary market. We also propose that, in dispersed supply chains, smaller discounts would suffice to deal with such demand disruptions, which is another potential benefit of dealing with smaller buyers with relatively lower levels of negotiation power, due to their smaller order sizes.

We also observe that a "mix of proactive and reactive measures" deployed simultaneously leads to the greatest improvements (*"dispersed supply chain with a 30% discount when a customer wants to cancel an order*" seems to be the best policy). Nevertheless, "reactive alone" strategy remains a strong option, with significant positive impact on profits (improvement between 6% and 59%). The managerial implication is worth mentioning here; firms might consider financial offers before committing to a change in the network structure. This is similar in nature to the general recommendation of modifying product price before changing capacity in revenue management models. A change in the structure of the supply chain is a strategic decision requiring time and greater investment/effort, whereas a financial offer is a convenient solution to demand disruptions with immediate impact and minimum effort/cost. We do not recommend, however, excessive discount levels or frequent repetitions. as these could cause alterations in the buyer's future purchasing behavior.

Although we study the impact of supply chain structure on the focal firm only, these decisions clearly have an impact on the other supply chain members, especially on relatively small supply chain partners. Accepting orders of smaller sizes from smaller buyers and order splitting across available suppliers leads to more stable and sustainable business for both the suppliers (i.e., less rejected orders) and the buyers.

5.3. Limitations and directions for future research

We believe that the results of our simulation model can be generalized to shed light on the decision-making process of firms with similar characteristics, and on the efficacy of proactive and reactive mitigation strategies. Despite its grounding in the reality of case study findings and the review of the related academic literature and managerial publications, it is important to acknowledge that our simulation model has limitations. For example, the values for the cost and demand related parameters were assumed to be identical for different supply chain configurations in our numerical study, mainly due to lack of such detailed data/information regarding these parameters. A fairer comparison among the three supply chain configurations would be facilitated by further empirical research on the estimation of fixed/variable costs and revenues.[6] This would take into account factors such as potential economies of scale/scope due to easier coordination/consolidation in sourcing, distribution, sales; additional transaction/administrative costs and costs of making changes on the product itself (e.g., repackaging) for sales to the

[6] (e.g., taking into account the following: potential economies of scale/scope due to easier coordination/consolidation in sourcing, distribution, sales; additional transaction/administrative costs and costs of making changes on the product itself (e.g., repackaging) for sales to the alternative buyer; and stronger position in the market in the concentrated supply chain)

alternative buyer; and stronger position in the market in the concentrated supply chain. Another interesting future research area, in our view, is the impact of improved visibility through advances in big data analytics in particular, providing more accurate estimates of demand changes and disruption frequency and duration, early detection of potential problems, and supplier disruption detection/sensors.

Another limitation of our work is the assumption that the buyer does not adopt a generally more "strategic" behavior to exploit the disruption (i.e., using the request to cancel an order as a tool to negotiate for generally lower prices rather than simply a means of obtaining a one-time discount.) We leave it to future research to explore a game-theoretic modeling of a change in buyer's behaviors in response to such discounts, and to examine how such strategic behavior may be prevented by specially designed smart contracts.

References

Akanle, O.M., & Zhang, D.Z. (2008). Agent-based model for optimising supply-chain configurations. *International Journal of Production Economics*, 115, 444–460. https://doi.org/10.1016/j.ijpe.2008.02.019

Ali, I., Arslan, A., Chowdhury, M., Khan, Z., & Tarba, S.Y. (2022). Reimagining global food value chains through effective resilience to COVID-19 shocks and similar future events: A dynamic capability perspective. *Journal of Business Research,* 141, pp.1-12. https://doi.org/10.1016/j.jbusres.2021.12.006

Ali, I., Nagalingam, S., & Gurd, B. (2017). Building resilience in SMEs of perishable product supply chains: enablers, barriers and risks. *Production Planning & Control*, *28*(15), 1236-1250. https://doi.org/10.1080/09537287.2017.1362487

Amed, I., Balchandani, A., Berg, A., Hedrich, S., Jensen, E., & Rölkens, F. (2020). The state of fashion 2021: In search of promise in perilous times, McKinsey & Company, Retrieved from: https://www.mckinsey.com/industries/retail/our-insights/state-of-fashion

Berg, L. Haug, L., Hedrich, S. &. Magnus, K.H. (2020). Time for change how to use the crisis to make fashion sourcing more agile and sustainable, McKinsey & Company, Retrieved from: https://www.mckinsey.com/industries/retail/our-insights/time-for-change-how-to-use-the-crisis-to-make-fashion-sourcing-more-agile-and-sustainable

Berger, P.D., & Zeng, A.Z. (2006). Single versus multiple sourcing in the presence of risks. *Journal of the Operational Research Society*, *57*, 250–261. https://doi.org/10.1057/palgrave.jors.2601982

Burke, G.J., Carrillo, J.E., & Vakharia, A.J. (2007). Single versus multiple supplier sourcing strategies. *European Journal of Operational Research*, *182*, 95–112. https://doi.org/10.1016/j.ejor.2006.07.007

Chen H.Y., Das A, & Ivanov D. (2019). Building resilience and managing post-disruption supply chain recovery: lessons from the information and communication technology industry. *International Journal of Information Management*, 49, 330– 342. https://doi.org/10.1016/j.ijinfomgt.2019.06.002

Christopher, M., Mena, C., Khan, O., & Yurt, O. (2011). Approaches to managing global sourcing risk. *Supply Chain Management: An International Journal, 16(2),* 67–81. https://doi.org/10.1108/13598541111115338

Chowdhury, P., Paul, S. K., Kaisar, S., & Moktadir, M. A. (2021). COVID-19 pandemic related supply chain studies: A systematic review. *Transportation Research Part E: Logistics and Transportation Review, 148,* 102-271. https://doi.org/10.1016/j.tre.2021.102271

Chowdhury, M., Sarkar, A., Paul, S.K., & and Moktadir, M. (2020). A case study on strategies to deal with the impacts of COVID-19 pandemic in the food and beverage industry. *Operations Management Research*, 1-13. https://doi.org/10.1007/s12063-020-00166-9

Corsaro, D., Ramos, C., Henneberg, S.C., & Naudé, P. (2012). The impact of network configurations on value constellations in business markets: The case of an innovation network. Industrial Marketing Management, 41, 54-67. https://doi.org/10.1016/j.indmarman.2011.11.017

de Sousa Jabbour, A.B.L., Jabbour, C.J.C., Hingley, M., Vilalta-Perdomo, E.L., Ramsden, G., & Twigg, D., (2020). Sustainability of supply chains in the wake of the coronavirus (COVID-19/SARS-CoV-2) pandemic: lessons and trends. *Modern Supply Chain Research and Applications*, *2 (3),* 117-122. https://doi.org/10.1108/MSCRA-05-2020-0011

Ding, L., Lam, H.K.S., Cheng, T.C.E., & Zhou, H. (2021). The contagion and competitive effects across national borders: Eviden-ce from the 2016 Kumamoto earthquakes. *International Journal of Production Economics*, 235, 108-115. https://doi.org/10.1016/j.ijpe.2021.108115.

Eggers, F. (2020). Masters of disasters? Challenges and opportunities for SMEs in times of crisis. *Journal of Business Research*, *116*, 199–208. https://doi.org/10.1016/j.jbusres.2020.05.025Get rights and content

Eisenhardt, K.M. (1989). Building theories from case study research. *Academy of Management Review, 14*(4), 532–550. https://doi.org/10.2307/258557

Euromonitor International (2020). Industry and economic and consumer data, Retrieved from: https://www.euromonitor.com/

Garvey, M.D., Carnovale, S., & Yeniyurt, S. (2015). An analytical framework for supply network risk propagation: A Bayesian network approach. *European Journal of Operational Research*, *243*, 618-627. https://doi.org/10.1016/j.ejor.2014.10.034

Gray, J.V., Helper, S., & Osborn, B. (2020). Value first, cost later: Total value contribution as a new approach to sourcing decisions. *Journal of Operations Management*, *66*(6), 735-750. https://doi.org/10.1002/joom.1113

Hendricks, K.B., Singhal, V.R., & Zhang, R. (2009). The effect of operational slack, diversification, and vertical relatedness on the stock market reaction to supply chain disruptions. *Journal of Operations Management*, *27*, 233–246. https://doi.org/10.1016/j.jom.2008.09.001

Huang, H., Li, Z. & Xu, H. (2018). Wholesale Price Auctions for Dual Sourcing Under Supply Risk. *Decision Sciences,* 49(4), 754–780. https://doi.org/10.1111/deci.12281

Huang, H.H., Lobo, G.J., Wang, C., & Xie, H. (2016). Customer concentration and corporate tax avoidance. *Journal of Banking and Finance*, *72*, 184–200. https://doi.org/10.1016/j.jbankfin.2016.07.018

Hosseini, S., & Ivanov, D. (2019). A new resilience measure for supply networks with the ripple effect considerations: A Bayesian network approach. *Annals of Operations Research*, 1-27. https://doi.org/10.1007/s10479-019-03350-8

Hosseini, S., Morshedlou, N., Ivanov, D., Sarder, M. D., Barker, K., & Al Khaled, A. (2019). Resilient supplier selection and optimal order allocation under disruption risks. *International Journal of Production Economics*, *213*, 124–137. https://doi.org/10.1016/j.ijpe.2019.03.018

Ho, W., Zheng, T., Yildiz, H., & Talluri, S. (2015). Supply chain risk management: a literature review. *International Journal of Production Research*, 53*(16),* 5031-5069. https://doi.org/10.1080/00207543.2015.1030467

ILO (International Labour Organization). (2020). COVID-19 and the textiles, clothing, leather and footwear industries, Retrieved from: https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/briefingnote/wcms_741344.pdf

Ivanov, D. (2020). Viable supply chain model: Integrating agility, resilience and sustainability perspectives – Lessons from and thinking beyond the COVID-19 pandemic. *Annals of Operations Research*, https://doi.org/10.1007/s10479-020-03640-6.

Ivanov, D., & Dolgui, A. (2020). Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak. *International Journal of Production Research*, *58*(10), 2904-2915. https://doi.org/10.1080/00207543.2020.1750727

Ivanov, D., Sokolov, B. & Dolgui, A. (2014) The Ripple effect in supply chains: trade-off 'efficiency-flexibility-resilience' in disruption management. *International Journal of Production Research, 52*(7), 2154-2172. https://doi.org/10.1080/00207543.2013.858836

Jaklic, A., Cirjakovic, J., & Chidlow, A. (2012). Exploring the effects of international sourcing on manufacturing versus service firms. *The Service Industries Journal*, *32*(7), 1193–1207. https://doi.org/10.1080/02642069.2012.662496

Kaki, A. Salo, A., & Talluri, S. (2015). Disruptions in Supply Networks: A Probabilistic Risk Assessment Approach. *Journal of Business Logistics*, 36(3), 273–287. https://doi.org/10.1111/jbl.12086

Karmaker, C.L., Ahmed, T., Ahmed, S., Ali, S.M., Moktadir, M.A. & Kabir, G. (2021) Improving supply chain sustainability in the context of COVID-19 pandemic in an emerging economy: Exploring drivers using an integrated model. *Sustainable Production and Consumption, 26,* 411-427. https://doi.org/10.1016/j.spc.2020.09.019

Kazaz, B. (2004). Production Planning Under Yield and Demand Uncertainty with Yield-dependent Cost and Price. *Manufacturing & Service Operations Management*. 6(3), 209–224. https://doi.org/10.1287/msom.1030.0024

Ke, J.Y.F., Otto, J. & Han, C. (2022). Customer-country diversification and inventory efficiency: Comparative evidence from the manufacturing sector during the pre-pandemic and the COVID-19 pandemic periods. *Journal of Business Research*, *148*, 292-303. https://doi.org/10.1016/j.jbusres.2022.04.066

Ketokivi, M., & Choi, T. (2014). Renaissance of case research as a scientific method. *Journal of Operations Management*, *32* (5), 232–240. https://doi.org/10.1016/j.jom.2014.03.004

Khlystova, O., Kalyuzhnova, Y. & Belitski, M. (2022). The impact of the COVID-19 pandemic on the creative industries: A literature review and future research agenda. *Journal of Business Research*, *139*, 1192-1210. https://doi.org/10.1016/j.jbusres.2021.09.062

Kim, D-Y. (2014). Understanding supplier structural embeddedness: A social network perspective. *Journal of Operations Management*, 32, 219-231. https://doi.org/10.1016/j.jom.2014.03.005

Kleindorfer, P.R., & Saad, G.H. (2005). Managing disruption risks in supply chains. *Production and Operations Management*, *14*(1), 53–68. https://doi.org/10.1111/j.1937-5956.2005.tb00009.x

Kumar, M., Basu, P., & Avittathur, B. (2018). Pricing and sourcing strategies for competing retailers in supply chains under disruption risk. *European Journal of Operational Research*, *265*, 533–543. https://doi.org/10.1016/j.ejor.2017.08.019

Kwak, H., Anderson, R.E., Leigh, T.W., & Bonifield, S.D. (2019). Impact of salesperson macro-adaptive selling strategy on job performance and satisfaction. *Journal of Business Research*, 94, 42-55. https://doi.org/10.1016/j.jbusres.2018.09.015

Kwak, K., & Kim, N. (2020). Concentrate or disperse? The relationship between major customer concentration and supplier profitability and the moderating role of insider ownership. *Journal of Business Research*, *109*, 648–658. https://doi.org/10.1016/j.jbusres.2019.09.033

Leung, W.S., & Sun, J. (2021). Policy uncertainty and customer concentration. *Production and Operations Management*, 30(5), 1517-1542.. https://doi.org/10.1111/poms.13335

Lewis, M.W. (1998). Iterative Triangulation: A Theory Development Process Using Existing Case Studies. *Journal of Operations Management*, *16*(4), 455–469. https://doi.org/10.1016/S0272-6963(98)00024-2

Lin, C-C., & Wang, T-H. (2011). Build-to-order supply chain network design under supply and demand uncertainties. Transportation Research Part B, 45, 1162-1176. https://doi.org/10.1016/j.trb.2011.02.005

Lund, S., & Krishnan, M. (2021). Risk, resilience and rebalancing in the apparel supply chain: Will a heightened awareness of risk alter global sourcing strategies?, The Business of Fashion, Retrieved from: https://www.businessoffashion.com/opinions/retail/risk-resilience-and-rebalancing-in-the-apparel-supply-chain

Lur Textile (2020) http://www.lurtextile.com/en/stat/about-lur-fabric (Last accessed: 25.03.2021)

Manufacturing Growth Programme (2020). Weaker supply chains are hitting SMEs looking to recover from Covid-19, https://www.manufacturinggrowthprogramme.co.uk/weaker-supply-chains-are-hitting-smes-looking-to-recover-from-covid-19/

Manuj, I., & Mentzer, J.T. (2008), Global supply chain risk management. *Journal of Business Logistics*, 29: 133-155. https://doi.org/10.1002/j.2158-1592.2008.tb00072.x

Maylor, H., & Blackmon, K. (2005). *Researching Business and Management*. London, UK: Palgrave Macmillan.

Meena, P.L. & Sarmah, S.P. (2014). Mitigating the risks of supply disruption under stochastic demand, *International Journal of Management Science and Engineering Management,* 9:3, 157-168. https://doi.org/10.1080/17509653.2014.882799

Meena, P.L., Sarmah, S.P., & Sarkar, A. (2011). Sourcing decisions under risks of catastrophic event disruptions. *Transportation Research Part E, 47,* 1058-1074. https://doi.org/10.1016/j.tre.2011.03.003

Meyer, A.D., Tsui, A.S., & Hinings, C.R. (1993). Configurational Approaches to Organizational Analysis. *Academy of Management Journal*, 36(3), 1175-1195. https://doi.org/10.2307/256809

Miles, M., & Huberman, M. (1994). *Qualitative data analysis*. Thousand Oaks, CA: Sage.

Mostafiz, M.I., Musteen, M., Saiyed, A., & Ahsan, M. (2022). COVID-19 and the global value chain: Immediate dynamics and long-term restructuring in the garment industry. *Journal of Business Research*, *139*, pp.1588-1603. https://doi.org/10.1016/j.jbusres.2021.10.078

Nakatani, J., Tahara, K., Nakajima, K., Daigo, I., Kurishima, H., Kudoh, Y., Matsubae, K., Fukushima, Y., Ihara, T., Kikuchi, Y., Nishijima, A., & Moriguchi, Y. (2018). A graph theory-based methodology for vulnerability assessment of supply chains using the life cycle inventory database. *Omega, 75*, 165–181. https://doi.org/10.1016/j.omega.2017.03.003

Namdar, J., Li, X., Sawhney, R., & Pradhan, N. (2018). Supply chain resilience for single and multiple sourcing in the presence of disruption risks. *International Journal of Production Research*, *56*(6), 2339-2360. https://doi.org/10.1080/00207543.2017.1370149

Organisation for Economic Co-operation and Development (OECD) (2020), OECD Policy Responses to Coronavirus (COVID-19), Coronavirus (COVID-19): SME policy responses, https://www.oecd.org/coronavirus/policy-responses/coronavirus-covid-19-sme-policy-responses-04440101/

Pasandideh, S.H.R., Niaki, S.T.A., & Vishkaei, B.M. (2014). A multiproduct EOQ model with inflation, discount, and permissible delay in payments under shortage and limited warehouse space. *Production & Manufacturing Research, 2* (1), 641-657. https://doi.org/10.1080/21693277.2014.955214

Parmigiani, A., Klassen, R.D., & Russo, M.V. (2011). Efficiency meets accountability: Performance implications of supply chain configuration, control, and capabilities. *Journal of Operations Management, 29*, 212-223. https://doi.org/10.1016/j.jom.2011.01.001

Paul, S.K., Chowdhury, P., Moktadir, M.A. & Lau, K.H. (2021) Supply chain recovery challenges in the wake of COVID-19 pandemic. *Journal of Business Research*, *136*, 316-329. https://doi.org/10.1016/j.jbusres.2021.07.056

Paul, S.K., Sarker, R., Essam D., Lee, P.T.W. (2019). A mathematical model ling approach for managing sudden disturbances in a three-tier manufacturing supply chain. *Annals of Operations Research, 280,* 299–335. https://doi.org/10.1007/s10479-019-03251-w

Pittaway, L., Robertson, M., Munir, K., Denyer, D., & Neely, A. (2005). Networking and innovation: a systematic review of the evidence*. International Journal of Management Reviews*, 5/6 *(3&4),* 137–168. https://doi.org/10.1111/j.1460-8545.2004.00101.x

Polyviou, M., Croxton, K.L., & Knemeyer, A.M. (2020). Resilience of medium-sized firms to supply chain disruptions: the role of internal social capital*. International Journal of Operations & Production Management*, 40*(1),* 68-91. https://doi.org/10.1108/IJOPM-09-2017-0530

Raj, A., Mukherjee, A.A., de Sousa Jabbour, A.B.L., & Srivastava, S.K. (2022). Supply chain management during and Post-Covid-19 pandemic: mitigation strategies and practical lessons Learned. *Journal of Business Research*, *142,* 1125-1139. https://doi.org/10.1016/j.jbusres.2022.01.037

Rudberg, M., & Olhager, J. (2003). Manufacturing networks and supply chains: an operations strategy perspective. *Omega*, 31, 29 – 39. https://doi.org/10.1016/S0305-0483(02)00063-4

Saboo, A.R., Kumar, V., & Anand, A. (2016). Assessing the impact of customer concentration on initial public offering and balance sheet–based outcomes. *Journal of Marketing*, *81*, 42–61. https://doi.org/10.1509/jm.16.045

Sako, M., Chondrakis, G., & Vaaler, P.M. (2016). How do plural-sourcing firms make and buy? The impact of supplier portfolio design. *Organization Science*, *27*(5), 1-22. https://doi.org/10.1287/orsc.2016.1079

Shahbandeh, M. (2020). Textiles and clothing industry in Turkey - Statistics & Facts. Statista, https://www.statista.com/topics/4844/textiles-and-clothing-industry-in-turkey/

Sharma, A., Adhikary, A., & Borah, S.B. (2020). Covid-19′ s impact on supply chain decisions: Strategic insights from NASDAQ 100 firms using Twitter data. *Journal of Business Research*, *117,* 443-449. https://doi.org/10.1016/j.jbusres.2020.05.035

Scholten, K.; Scott, P.S.; Fynes, B. (2014). Mitigation processes – antecedents for building supply chain resilience. *Supply Chain Management: An International Journal, 19,* 211–228. https://doi.org/10.1108/SCM-06-2013-0191

Shahed, K.S., Azeem, A., Ali, S.M., & Moktadir, M. (2021). A supply chain disruption risk mitigation model to manage COVID-19 pandemic risk. *Environmental Science and Pollution Research*, 1-16. https://doi.org/10.1007/s11356-020-12289-4

Sodhi, M., & Lee, S. (2007). An analysis of sources of risk in the consumer electronics industry. *Journal of Operational Research Society*, *58*(11), 1430-1439. 10.1057/palgrave.jors.2602410

Steven, A.B., Dong, Y., & Corsi, T. (2014). Global sourcing and quality recalls: An empirical study of outsourcing-supplier concentration-product recalls linkages. *Journal of Operations Management*, *32*, 241–253. https://doi.org/10.1016/j.jom.2014.04.003

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Newbury Park, CA: Sage.

Trevelen, M., & Schweikhart, S.B. (1988). A risk / benefit analysis sourcing strategies: Single vs. multiple sourcing. *Journal of Operations Management*, *7*(4), 93-114. https://doi.org/10.1016/0272-6963(81)90007-3

Tukamuhabwa, B.R., Stevenson, M., Busby, J. & Zorzini, M. (2015) Supply chain resilience: definition, review and theoretical foundations for further study. *International Journal of Production Research*, *53*(18), 5592-5623. https://doi.org/10.1080/00207543.2015.1037934

Voss, C., Tsikriktsis, N. & Frohlich, M. (2002). Case research in operations management. *International Journal of Operations & Production Management, 22* (2), 195–219. https://doi.org/10.1108/01443570210414329

Wang, L., Liao, Y., Ding, Y., & Peng, T. (2021). The effect of customer concentration on supplier sustainable growth: evidence from China. *Applied Economics*, *53*(17), 2015-2025. https://doi.org/10.1080/00036846.2020.1854670

Wara, I. (2020). Post-pandemic supply chain shift. The Financial Express, https://www.thefinancialexpress.com.bd/views/post-pandemic-supply-chain-shift-1589295483

Yang, B., & Yang, Y. (2010). Postponement in supply chain risk management: a complexity perspective. *International Journal of Production Research*, *48*(07), 1901-1912. https://doi.org/10.1080/00207540902791850

Yeo, W.M., & Yuan, X.M., 2011. Optimal inventory policy with supply uncertainty and demand cancellation. *European Journal of Operational Research, 211*, 26-34. https://doi.org/10.1016/j.ejor.2010.10.031

Yin, R. K. (2003). *Case Study Research: Design and Methods* (3rd ed). London, UK: Sage.

Yin, Z., & Wang, C. (2018). Strategic cooperation with a backup supplier for the mitigation of supply disruptions. *International Journal of Production Research*, *56*(12), 4300-4312. https://doi.org/10.1080/00207543.2017.1410246

Yu, W., Jacobs, M.A., Chavez, R., Yang, J., 2019. Dynamism, disruption orientation, and resilience in the supply chain and the impacts on financial performance: A dynamic capabilities perspective. *International Journal of Production Economics*, *218*, 352-362. https://doi.org/10.1016/j.ijpe.2019.07.013

Yuan, X.M., & Cheung, K.L. (2003). Optimal inventory policy for systems with demand cancellations. *Institute of Industrial Engineers Transactions*, *35*, 739-747. https://doi.org/10.1080/07408170304353

You, P.S. (2003). Dynamic pricing of inventory with cancellation demand. *The Journal of the Operational Research Society, 54* (10), 1093-1101. https://doi.org/10.1057/palgrave.jors.2601619

Tables

Table 1. Details of the interviewees

Initials of the interviewees used in quotations	**Interviewees' position in the company**
S.G.	CEO
E.G.	General manager
E.Y	Deputy manager

Table 2. Main disruptions and risks during/after COVID-19

Risk group (demand/supply side)	**Disruptions & risks**
Supply side	*Production disruptions at suppliers' sites (labor or raw material shortages due to governmental restrictions)*
	Factory closures at suppliers' sites/supplier being shut down
	Supply disruptions due to shortages and scarcity on critical raw materials (i.e. organic cotton)

	Geographical concentration of supply (e.g. Pakistan, India)
Demand side	*Order cancellations by the first-tier customers*
	Bullwhip effect/order cancellation propagation caused by the demand shocks in the consumer market
	Difficulties on reaching early market information as demand forecasting sources
	Concentration of demand on a specific geographical region (mainly EU countries)
	Factory closures-at customers' site
Both sides	Fluctuations in the exchange rate
	Impact of each country's different paces managing the pandemic/ governmental restrictions
	Political risks due to potential border closures and/or restrictions on foreign trade
	Transportation failures/Transportation links broken and/or more expensive
	Container shortages due to slow flow of freight and/or border closures

** Disruptions/risks in italic in the above table are implicitly/explicitly considered in the simulation model in Section 4.*

Table 3. Disruption management and risk mitigation strategies

Group of strategies	**Disruption management and risk mitigation strategies**
Collaboration	Offering flexible/delayed payment plans, *discounts to buyers*
	Collaborative planning and forecasting
	Sharing best practices with the supply chain partners
	Implementing early supplier involvement strategy
	Having strong relations particularly with small-scaled supply chain partners
Flexibility	Implementing agile strategies
	Temporary solutions such as direct shipments
	Choosing different sized firms (mostly SMEs) as supply chain partners
	Postponement and delayed differentiation
Responsiveness	Switching mindset to sell more to the e-retailers or their suppliers
	Switching to sustainable products
	Decreasing the minimum order quantities at all stages of the supply chain
	Re-evaluating the criticality of their supply chain partners
	Re-evaluating the current suppliers' performance
	Resilient human resources management practices
	Internal process redesign
	Downsizing (the capacity) when needed
Multi-sourcing & multi-shoring	*Working with alternative suppliers*
	Keeping back-up suppliers
	Local & global sourcing
Customer base diversification	*Working with a range of customers/retailers having different sizes, and characteristics, regions*
Political advantage & trade agreements & certifications	Tax reduction for supplies from certain countries
	Country specific certifications (e.g. Cotton Council International-Cotton USA trademark)
Digitalization	On-time information sharing & digitalization (as a future mitigation strategy)

** Mitigation strategies in italic in the above table are implicitly/explicitly considered in the simulation model in Section 4.*

Table 4. Simulation parameter settings (baseline)

Description	Value
Catastrophic event inter-arrrival time (μ)	*Exponential random variable with a mean of 720 days*
Catastrophic event duration (τ)	*Triangular random variable with parameters 60, 180 and 300*
Probability of unique-event (supplier disruption) given catastrophic-event ($P^C(SD)$)	*1*
Probability of unique-event (supplier disruption) under normal conditions ($P^N(SD)$)	*0.1*
Probability of unique-event (inbound/outbound logistics) disruption given catastrophic-event ($P^C(IOD)$)	*1*
Probability of unique-event (inbound/outbound logistics) disruption under normal conditions ($P^N(IOD)$)	*0.1*
Unique-event duration given catastropic-event	*Exponential random variable with a mean of 60 days*
Unique-event duration under normal conditions	*Exponential random variable with a mean of 30 days*
Weekly demand for a small customer (SME) under normal conditions	*Uniform random variable with parameters 50 and 100*
Weekly demand for a large customer under normal conditions	*Uniform random variable with parameters 100 and 200*
Weekly demand for a small customer (SME) given catastrophic-event	*Uniform random variable with parameters 25 and 125*
Weekly demand for a large customer given catastrophic-event	*Uniform random variable with parameters 50 and 250*
Probability of a request for order cancellation by a customer given catastrophic-event ($P^C(RFC)$)	*0.2*
Probability of a request for order cancellation by a customer under normal conditions ($P^N(RFC)$)	*0.1*
Probability of a customer accepting the discount offer (P^{Accept})	*0*
Probability of selling to the second customer in case of cancellation	*0.4*
Percent discount offered to the customer to discourage order cancellation (β)	*0*
Percent reduction in revenue per unit with sales to the second customer in case of cancellation	*40*
Percent reduction in revenue per unit with sales at the secondary market (markdown)	*60*
Production rate (number of units per week)	*10*
Unit selling (full) price	*50*
Unit cost (production+transportation) given catastrophic event	*40*
Unit cost (production+transportation) under normal conditions	*35*
Fixed cost of an order (independent of quantity) given catastrophic event (F^C)	*200*
Fixed cost of an order (independent of quantity) under normal conditions (F^N)	*175*

** Equal values for large and small customer/supplier as well as inbound and outbound logistics operations unless stated otherwise*

Table 5. Performance measures for different network structures

Performance measures for different network structures for all numerical tests						DISPERSED		CONCENTRATED		TRIADIC	
Average catastrophic event inter-arrrival time (μ)	Probability of unique-event (supplier disruption) given catastrophic-event ($P^C(SD)$)	Probability of a request for order cancellation by a customer given catastrophic-event ($P^C(RFC)$)	Probability of a customer accepting the discount offer (P^{Accept})	Percent discount offered to the customer to discourage order cancellation (β)	Fixed cost of an order (independent of quantity) given catastrophic event (F^C)	**Fill Rate**	**Profit**	**Fill Rate**	**Profit**	**Fill Rate**	**Profit**
720	1	0.2	0	0	200	0.73	50569	0.65	43439	0.48	36239
720	1	0.2	0	0	800	0.73	-7327	0.65	-14684	0.48	21719
720	1	0.2	0.16	0.15	200	0.73	53016	0.65	45602	0.48	38993
720	1	0.2	0.16	0.15	800	0.73	-5042	0.65	-11553	0.48	24365
720	1	0.2	0.5	0.3	200	0.73	55619	0.65	48272	0.48	40737
720	1	0.2	0.5	0.3	800	0.73	-2349	0.65	-9692	0.48	26242
720	1	0.4	0	0	200	0.73	33245	0.65	28213	0.48	21154
720	1	0.4	0	0	800	0.73	-25022	0.65	-29872	0.48	6661
720	1	0.4	0.16	0.15	200	0.73	37853	0.65	32389	0.47	25268
720	1	0.4	0.16	0.15	800	0.73	-20178	0.65	-25161	0.47	10932
720	1	0.4	0.5	0.3	200	0.73	42344	0.66	36374	0.48	29742
720	1	0.4	0.5	0.3	800	0.73	-15879	0.66	-22026	0.48	15200
720	0.5	0.2	0	0	200	0.76	50423	0.71	45550	0.51	37035
720	0.5	0.2	0	0	800	0.76	-12097	0.71	-16702	0.51	21512
720	0.5	0.2	0.16	0.15	200	0.75	52833	0.71	47687	0.51	39590
720	0.5	0.2	0.16	0.15	800	0.75	-8678	0.71	-14319	0.51	24083
720	0.5	0.2	0.5	0.3	200	0.76	55973	0.71	50185	0.51	42176
720	0.5	0.2	0.5	0.3	800	0.76	-6690	0.71	-11895	0.51	26656
720	0.5	0.4	0	0	200	0.76	32974	0.70	28203	0.50	21267
720	0.5	0.4	0	0	800	0.76	-29155	0.70	-33581	0.50	5869
720	0.5	0.4	0.16	0.15	200	0.76	37664	0.71	33068	0.50	25784
720	0.5	0.4	0.16	0.15	800	0.76	-24492	0.71	-29137	0.50	10372
720	0.5	0.4	0.5	0.3	200	0.76	41564	0.71	37385	0.51	30384
720	0.5	0.4	0.5	0.3	800	0.76	-20436	0.71	-25152	0.51	14868
180	1	0.2	0	0	200	0.34	22678	0.28	16902	0.19	12965
180	1	0.2	0	0	800	0.34	41	0.28	-6859	0.19	7089
180	1	0.2	0.16	0.15	200	0.34	24792	0.28	18314	0.19	14018
180	1	0.2	0.16	0.15	800	0.34	1638	0.28	-5179	0.19	8187
180	1	0.2	0.5	0.3	200	0.35	26557	0.27	19144	0.19	15201
180	1	0.2	0.5	0.3	800	0.35	2962	0.27	-4027	0.19	9408
180	1	0.4	0	0	200	0.35	10810	0.28	7099	0.19	3612
180	1	0.4	0	0	800	0.35	-13113	0.28	-16912	0.19	-2290
180	1	0.4	0.16	0.15	200	0.35	13607	0.27	9286	0.20	5961
180	1	0.4	0.16	0.15	800	0.35	-9756	0.27	-13911	0.20	20
180	1	0.4	0.5	0.3	200	0.35	16549	0.28	11479	0.19	8187
180	1	0.4	0.5	0.3	800	0.35	-6978	0.28	-12133	0.19	2388
180	0.5	0.2	0	0	200	0.46	25099	0.41	20200	0.27	14945
180	0.5	0.2	0	0	800	0.46	-8421	0.41	-13334	0.27	6423
180	0.5	0.2	0.16	0.15	200	0.46	27295	0.42	22220	0.27	16550
180	0.5	0.2	0.16	0.15	800	0.46	-6546	0.42	-11633	0.27	7993
180	0.5	0.2	0.5	0.3	200	0.46	28796	0.41	23730	0.27	17885
180	0.5	0.2	0.5	0.3	800	0.46	-4689	0.41	-9989	0.27	9507
180	0.5	0.4	0	0	200	0.46	8347	0.41	5334	0.27	2328
180	0.5	0.4	0	0	800	0.46	-25357	0.41	-28146	0.27	-6125
180	0.5	0.4	0.16	0.15	200	0.46	12355	0.42	8884	0.26	5444
180	0.5	0.4	0.16	0.15	800	0.46	-21267	0.42	-25086	0.26	-2902
180	0.5	0.4	0.5	0.3	200	0.46	15798	0.41	11860	0.27	8415
180	0.5	0.4	0.5	0.3	800	0.46	-17780	0.41	-21665	0.27	12

**Note that the percent discounts for the triadic scenario are 0, 0.18, and 0.36.*

Figures

Fig. 1. Supply chain structure of LUR[7]

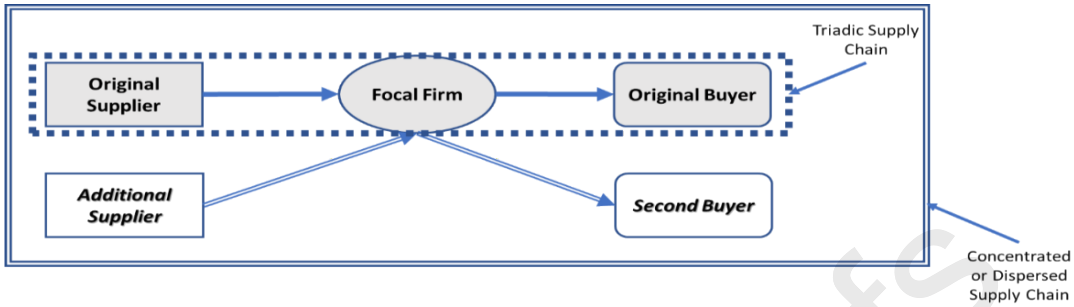

Fig. 2. Network structures for triadic, concentrated, dispersed supply chains

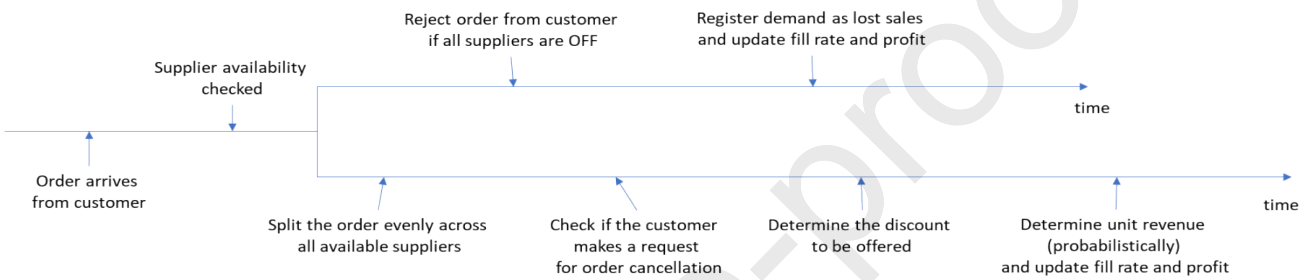

Fig. 3. The timing of events for each order during the simulation (for the focal company- LUR)

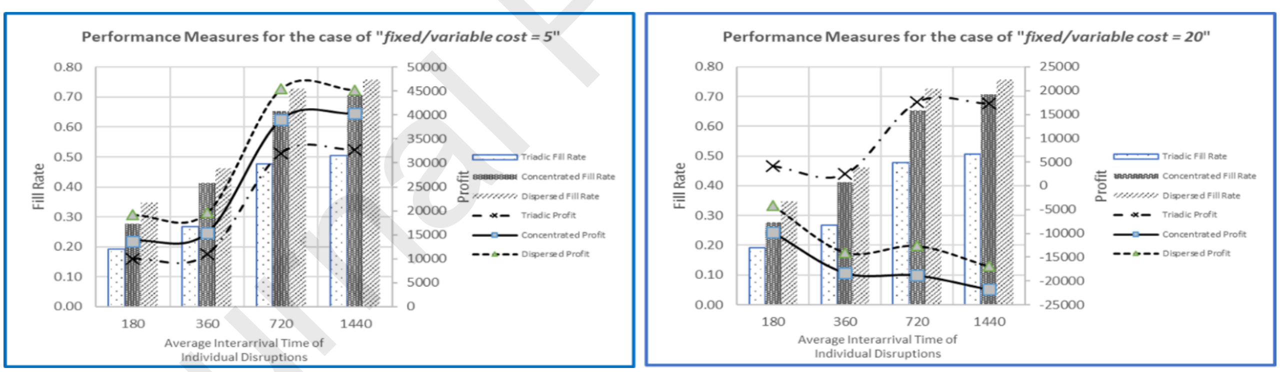

Fig. 4. Performance measures for given levels of disruption frequencies

---

[7] In the simulation model, we only include LUR (the focal company), and immediate global suppliers and distributors as the impact of Covid-19 related disruptions were more visible for this section of the network.

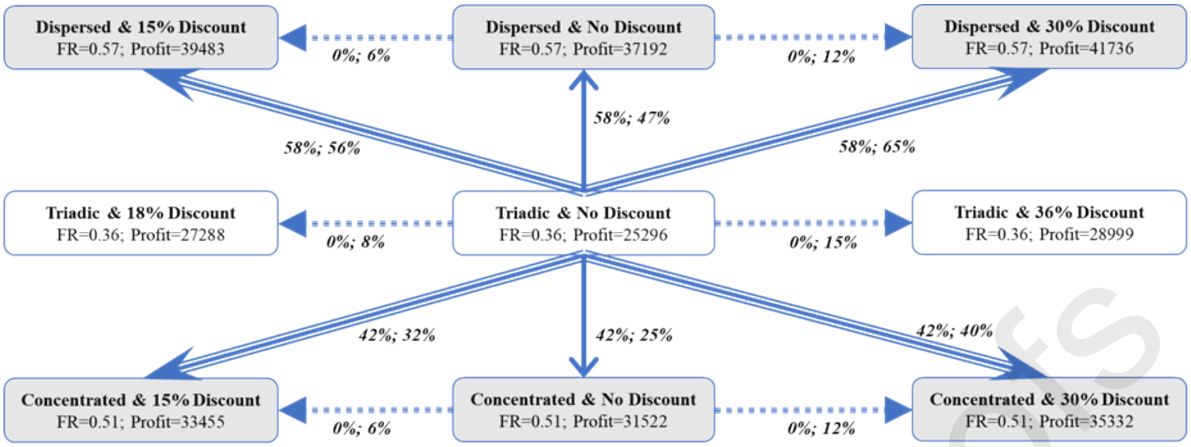

FIGURE 5a Impact of proactive and reactive strategies when Probability(Cancellation Request)=0.2 and "fixed cost/variable cost"=5. Values on the arcs represent percent improvement in "fill rates and profits" when supply chain configuration and/or discounts change, respectively.

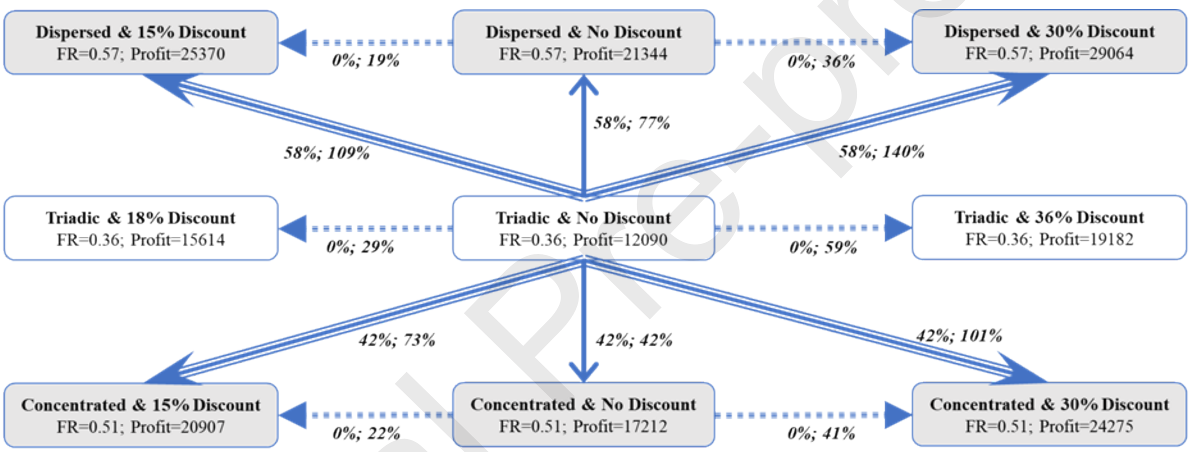

FIGURE 5b Impact of proactive and reactive strategies when Probability(Cancellation Request)=0.4 and "fixed cost/variable cost"=5. Values on the arcs represent percent improvement in "fill rates and profits" when supply chain configuration and/or discounts change, respectively.

Fig. 5. Impact of proactive and reactive strategies

Dr. Mustafa Çagri Gürbüz is **Professor of Supply Chain Management** at the MIT-Zaragoza International Logistics Program. He is also a **Research Affiliate** at the MIT Center for Transportation and Logistics. He completed his PhD at the Department of Management Science at the University of Washington in July 2006. He earned his BS and MS degrees from the Department of Industrial Engineering at Bilkent University, Turkey in 1999 and 2001, respectively. His main **research interests** are inventory and supply chain management, optimizing distribution systems, behavioral operations management, contracts, and modeling operations systems.Dr. Gurbuz has been a consultant to AT&T Wireless, AREX, and RENFE. He has led research projects with companies such as Roche, Philips, Halliburton, to name a few. He also participated as a principal investigator in a number of EU Projects related to supply chain management. He has been a visiting professor at MIT CTL in 2009 and City University of Hong Kong in 2014. He has also published in **journals** such as *Management Science, Production and Operations Management, European Journal of Operational Research, International Journal of Production Economics, and Operations Research Letters.*

Dr. Oznur Yurt is a Senior Lecturer in Operations & Supply Chain Management at the Open University, United Kingdom. She is also an Adjunct Professor of Marketing and Supply Chain Management at Izmir University of Economics, Turkey. Her research interests include service supply chains, purchasing management, business-to-business marketing, food supply chains and sustainable supply chain management. Her work has been published in journals such as *International Journal of Operations & Production Management, Industrial Marketing Management, Production Planning & Control, Supply Chain Management: An International Journal, European Journal of Marketing, Service Industries Journal, Journal of Service Theory and Practice, The Service Industries Journal, and Resources, Conservation & Recycling, Journal of Global Mobility.*

Dr. Sena Ozdemir (PhD, University of Portsmouth, UK)is a Senior Lecturer in Marketing at Lancaster University Management School, United Kingdom. Her research focuses on strategic new product alliances, global product development, B2B marketing, the use of Big Data and digital technologies for innovation, inter- firm cross-functional NPD team integration, and social innovation. She currently serves as an editorial board member for the Journal of Business to Business Marketing. Her publications have appeared in journals such as *Journal of Business Research, Industrial Marketing Management, British Journal of Management, Journal of Business to Business Marketing, Qualitative Market Research: An International Journal, International Marketing Review, and Innovation: Organization & Management, and so forth.*

Professor Vania Sena is the Chair of Enterprise and Entrepreneurship and Director of the Centre for Regional Economic and Enterprise Development (CREED) at the University of Sheffield. Her research focuses on productivity, Big Data, innovation and intellectual property. Her work has been published by the *Journal of Economic Literature, Journal of Corporate Finance, Journal of Banking and Finance, Small Business Economics, Journal of Comparative Economics, The Economic Journal, Scandinavian Journal of Economics, European Journal of Operational Research, Oxford Bulletin of Economics and Statistics and Regional Studies, amongst others. Her work has been funded by several bodies including ESRC, Nuffield Foundation, NESTA, Leverhulme Trust, IPO, UKTI and British Academy.*

Dr. Wantao Yu is Professor of Supply Chain Management at the University of Roehampton. His research interests include digital supply chain, supply chain analytics, supply chain integration, sustainable supply chain management, and retail operations and logistics. His work has been published in journals such as *International Journal of Operations & Production Management, British Journal of Management, International Journal of Production Economics, International Journal of Production Research, Industrial Marketing Management, Production Planning & Control, Supply Chain Management: An International Journal, and Decision Support Systems.*