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Supply chain risk mitigation strategies for small, medium and large firms: Lessons learned during COVID-19

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Orientation: Many firms were not prepared for the disruptions caused by the coronavirus disease 2019 (COVID-19) pandemic.

Research purpose: The study determines how small, medium and large firms successfully responded to the pandemic.

Motivation for the study: There are lessons to be learned on how different sized firms successfully implemented risk mitigation strategies in response to the pandemic. These lessons can be used to manage future disruptions.

Research design, approach, and method: The study used quantitative research using an online survey instrument. The respondents were employed in different sized firms in South Africa during the COVID-19 pandemic and were all experienced in and knowledgeable on their firms' supply chains. The research used analysis of variance procedures to compare the means of 230 small, medium and large firms across different research focus areas.

Main findings: Small, medium and large firms successfully mitigated supply chain disruptions caused by the pandemic by increasing flexibility, agility, collaboration, visibility and adaptability across their supply chains. As a strategy, redundancy was preferred by larger firms.

Practical/managerial implications: The findings identified increased flexibility, agility, collaboration, visibility and adaptability within different sized firms and across their supply chains as strategies to improve resilience and prepare for future disruptions. On redundancy, smaller firms used a low-diversification risk mitigation strategy, while larger firms implemented a high-diversification strategy, illustrating that both strategies can work.

Contribution/value-add: The lessons learned from the identified supply chain risk mitigation strategies can motivate firms to prepare better for future disruptions.

Keywords: supply chain disruption; supply chain risk mitigation; supply chain resilience; COVID-19; supply chain strategy; firm size; South Africa; quantitative research.

Introduction

In 2020, the world was in crisis. By March, the coronavirus disease 2019 (COVID-19) had impacted almost the entire world and was classified as a pandemic (Hossain, Akhter & Sultana 2022:1, 8; Mhonyera, Masunda & Meyer 2024:1). To control its spread, governments and individuals took measures that slowed down economic and business activities across the world (Marconatto et al. 2022:1370; Mhonyera et al. 2024:1). Although the disruptions impacted almost all firms and their supply chains (Zeiringer, Durst & Thalmann 2022:345), small- and medium-sized firms were impacted severely and were particularly vulnerable: more so than larger firms (Erdiaw-Kwasie et al. 2023:1–2; Foli et al. 2022:1; Gurbuz et al. 2023:1; Hossain et al. 2022:2; Marconatto et al. 2022:1369; Zeiringer et al. 2022:345). Firms had to adapt and reorganise their supply chain network designs (Modgil, Singh & Hannibal 2021:1246; Ramos, Patrucco & Chavez 2021:1).

In many countries, small, micro and medium enterprises (SMMEs) play a vital role in the social and economic development of the country by contributing to economic growth (Ali, Hannafiah & Mogindol 2023:3; Bak et al. 2023:328; Baral et al. 2023:1942; Isa, Nurohman & Qurniawati 2024:1; Iwara et al. 2021:2; Marconatto et al. 2022:1371; Van Wyk & Venter 2023:1). A large percentage of businesses come from these enterprises (Ali et al. 2023:2). However, small and medium enterprises

(SMEs) experience high failure rates (Van Wyk & Venter 2023:1–2) because they are less prepared than larger firms to cope with disruptions (Ali et al. 2023:10; Bak et al. 2023:328). Even before the pandemic, the growth of SMMEs in South Africa had declined (Iwara et al. 2021:1). The impact of the pandemic threatened the existence and performance of SMMEs and caused SMEs to face barriers and challenges in their internal and external supply chains (Hossain et al. 2022:2; Isa et al. 2024:1). Firms had to adapt to survive (Ramos et al. 2021:1; Sharif et al. 2024:1). Small and medium enterprises require regular cashflows, and sudden fluctuations in demand can adversely impact them (Hossain et al. 2022:2). In fact, the pandemic exposed how small the SMEs' working capital is (Marconatto et al. 2022:1372). These enterprises have little bargaining power and rely heavily on their suppliers and customers. Without the necessary cash reserves, their customer and supplier relationships further lack flexibility (Marconatto et al. 2022:1371).

On the one hand, it can be argued that SMEs' internal incapabilities (such as poor staff planning, lack of training and not being prepared for risk events) make it more challenging for them to be resilient (Ali et al. 2023:10). These enterprises need to assess their resilience and focus on improving internal operations and relationships with external supply chain partners. They need to be able to assess opportunities and risks in their supply chains because of the significant impact on their firm's performance (Ali et al. 2023:10). During the pandemic, larger firms were able to invest in technologies and had ample resources to respond better to the disruptions caused. Larger firms could also use Zoom, Google Meet and Skype to operate remotely (Erdiaw-Kwasie et al. 2023:2). On the other hand, some authors argue that SMEs can be more agile and flexible than larger firms to respond to supply chain disruptions and thus be more resilient. For example, SMEs experience less bureaucracy than larger firms and do not necessarily have to manufacture large quantities to cover overhead costs (Bak et al. 2023:328; Gurbuz et al. 2023:3; Zighan & Ruel 2021:236).

Lately, supply chain disruptions and supply chain resilience (SCRES) have received much attention in the literature (Safari et al. 2024:681). Supply chain resilience includes the actions that firms implement to resist and, if necessary, respond to (or adapt during) disruptions to recover and restore their business operations (Baral et al. 2023:1945; El Baz & Ruel 2021:1; Gligor et al. 2019:475–476; Queiroz, Wamba & Branski 2022:2002; Safari et al. 2024:681; Zighan & Ruel 2021:234). Current research on SCRES highlights the importance of understanding disruptions. The scale of the disruptions caused by COVID-19 highlighted the necessity to assess supply chain risk mitigation strategies to enable firms of all sizes to overcome future disruptions (Queiroz et al. 2022:1999, 2002). The pandemic caused firms to prioritise developing supply chain risk mitigation strategies (Ambulkar, Blackhurst & Grawe 2015:111; Gurbuz et al. 2023:1). However, many still struggle to implement such strategies (Min 2023:1765).

Firms have specific processes, structures and capacities that vary by size and industry, but research on how these aspects affect SCRES plans are lacking (Safari et al. 2024:681). Furthermore, most studies focusing on firm recovery during disruptions did not initially aim at SMEs and their recovery strategies (Hossain et al. 2022:2). Research on risk and resilience for SMEs therefore needs further development (Bak et al. 2023:329; Foli et al. 2022:1; Safari et al. 2024:681, 682; Zeiringer et al. 2022:346). Also, despite an increase over the last few years, research still lacks the crises that SMEs face and how they recover from these, especially from a developing country perspective. Moreover, SMEs' increased vulnerability over larger firms to respond and recover from a severe disruptive event such as COVID-19 makes it a suitable topic to study (Erdiaw-Kwasie et al. 2023:1; Hossain et al. 2022:2). Lessons learned from being resilient during the pandemic can be used to make firms more resilient for future disruptions (Kiers et al. 2022:1).

This article focuses on firm size distinction. Different sized firms may have different approaches to SCRES. A systematic literature review by Safari et al. (2024:686, 693) named several common supply chain risk mitigation strategies that both SMEs and large firms use to manage their risks. This research focuses on some of those common strategies and investigates how they were used by different sized firms to mitigate supply chain risks. The primary research questions formulated for this article are:

- How did small, medium and large firms respond to supply chain disruptions caused by the COVID-19 pandemic?
- What did small, medium and large firms learn to prepare for future disruptions?

The *National Small Business Amendment Act* (*26 of 2003*) defines firm sizes across different sectors. Firm size can be determined in numerous ways, namely the number of employees, annual turnover and total gross asset value (Anonymous 2024). This article defines firm sizes by the number of employees in the firm because of the significant differences in annual turnover and total gross asset value among small, medium and large firms across sectors. The Banking Association South Africa distinguishes between small and micro firms which employ up to 50 employees and medium-sized enterprises which employ between 50 and 200 employees, with large firms employing more than 200 employees (Anonymous 2024). This article used these categories to distinguish between small, medium and large firms.

Dynamic capabilities theory (DCT) builds on the premise of firms' ability to innovate, adapt (to change) and create value (Erdiaw-Kwasie et al. 2023:7). Dynamic capabilities are the ability to integrate, build and reconfigure internal and external competencies to respond to a rapidly changing environment (Teece, Pisano & Shuen 1997:515). Activities allowing flexibility and adaptability within firms to change

their strategies result in dynamic capabilities (Erdiaw-Kwasie et al. 2023:7). Firms use dynamic capabilities to develop SCRES (Isa et al. 2024:2; Modgil et al. 2021:1251). Scholars have deployed the DCT beyond the firm's boundaries to investigate how the firm's supply chain partners mobilise cross-firm processes to create or change capabilities in response to a changing environment (El Baz & Ruel 2021:2). To improve their capabilities, SMEs continuously face challenges (Isa et al. 2024:2).

Figure 1 shows the research's theoretical foundation: different sized firms faced supply chain disruptions during the COVID-19 pandemic and used dynamic capabilities to implement supply chain risk mitigation strategies to be resilient. The remainder of the article is structured as follows. The literature review distinguishes between different types of disruption and supply chain risk mitigation strategies. The research methodology is then explained followed by the results, discussion and conclusion.

Literature review

In March 2020, the COVID-19 virus was declared a pandemic and governments across the world imposed lockdowns that severely restricted the movement of individuals and businesses to stop the virus from spreading (Kiers et al. 2022:1). These restrictions impacted firms globally by disrupting their supply chains and occurred anywhere in the upstream, internal or downstream sides of a firm's supply chain (Nel 2024:4; Wolmarans & Niemann 2023:2). This review identifies types of disruption that can occur and types of supply chain risk mitigation strategies that can be adopted by firms.

Types of disruption

Supply-side disruptions

Supply-side disruptions happen upstream (supplier side) of a firm's supply chain (Habermann, Blackhurst & Metcalf 2015:495; Hossain et al. 2022:2; Parast & Subramanian 2021:550) and often result in increased upstream uncertainties and complexities (Butt 2022:374, 378). Supply-side disruptions include sourcing, logistics and transportation disruptions caused by supplier failures, fulfilment errors or production disruptions; shipment or customs clearance delays; or transport interruptions (Babu, Bhardwaj & Agrawal 2020:225; Chopra & Sodhi 2004:54, 57; Erdiaw-Kwasie et al. 2023:6; Gurbuz et al. 2023:5; Hossain et al. 2022:2; Kiers et al. 2022:5; Min 2023:1766; Mohezar, Mohamad & Nor 2023:121; Singh, Kumar & Kumar 2023:6). Supply-side inventory shortages occur when suppliers do not have sufficient stock levels (Butt 2022:374, 378; Chopra & Sodhi 2004:57; Gurbuz et al. 2023:5; Hossain et al. 2022:2; Mohezar et al. 2023:121). Poor coordination between firms and their suppliers can all cause upstream disruptions (Parast & Subramanian 2021:551; Safari et al. 2024:689). Disruptions can also result from upstream supply chain partners underperforming because of supplier closures or restrictions that were imposed by governments because of the pandemic (Babu et al. 2020:225; Butt 2022:374, 378; Mohezar et al. 2023:121; Parast & Subramanian 2021:551, 553).

Internal process disruptions

Process disruptions occur within a firm's internal processes (Habermann et al. 2015:495; Parast & Subramanian 2021:551). Examples of these include inventory shortages; production failures resulting from machine breakdowns or operating challenges (Ambulkar et al. 2015:116; Babu et al. 2020:225; Chopra & Sodhi 2004:57; Erdiaw-Kwasie et al. 2023:6); disruptions related to quality and labour issues and increased waste because of supply and demand uncertainties (Babu et al. 2020:225; Erdiaw-Kwasie et al. 2023:6; Min 2023:1766; Singh et al. 2023:3, 12). Disruptions can also result from working capital (or cashflow) challenges (Chopra & Sodhi 2004:57; Erdiaw-Kwasie et al. 2023:6; Hossain et al. 2022:2).

Demand-side disruptions

Demand-side disruptions happen downstream (customer side) of a firm's supply chain (Habermann et al. 2015:495; Parast & Subramanian 2021:551). Coronavirus disease 2019 caused several demand-side disruptions. Examples of these

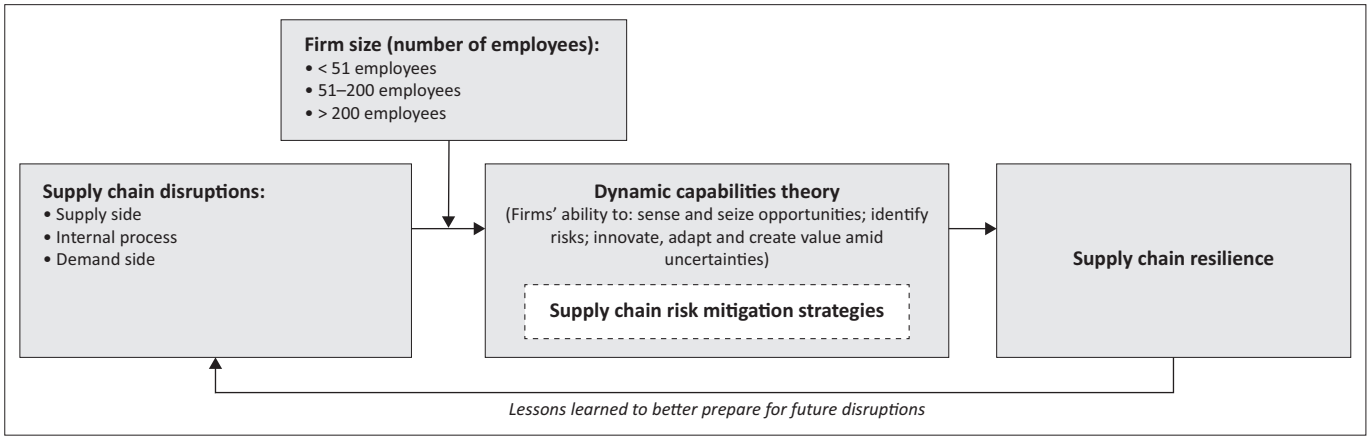

FIGURE 1: Theoretical foundation of the research.

include customer demand fluctuations resulting in either drastic demand increases or decreases such as customers cancelling their orders (Gurbuz et al. 2023:5; Hossain et al. 2022:2; Mohezar et al. 2023:121; Parast & Subramanian 2021:551). This results in forecasting complexities (Babu et al. 2020:225; Safari et al. 2024:689). Other demand-side disruptions include transportation delays or logistical inefficiencies in downstream distribution and logistics activities that could result in delivery delays (Mohezar et al. 2023:121; Parast & Subramanian 2021:551). Disruptions also occur when customers experience payment challenges (Mohezar et al. 2023:121).

Supply chain risk mitigation strategies

Supply chain risk mitigation addresses supply chain risks through proper strategies and has become an essential capability (Gurbuz et al. 2023:2). Firms with effective supply chain risk mitigation strategies are more resilient and sooner return to their pre-disruption performance levels (Nel 2024:10). To be resilient, successful risk mitigation needs collaboration between supply chain partners (El Baz & Ruel 2021:3). Zighan and Ruel (2021:234) distinguish between short-term and long-term resilience. Short-term resilience aims to mitigate supply chain disruptions in the short term, while long-term resilience entails adjusting or adapting capabilities over the long term. Also, Marconatto et al. (2022:1372) distinguish between high-diversification and low-diversification risk mitigation strategies. On the one hand, high-diversification strategies imply increased flexibility and agility through increased number of suppliers, customers and inventories, but requires increased collaboration. On the other hand, low-diversification strategies imply working with less suppliers, customers and inventories, resulting in increased working capital efficiencies (Marconatto et al. 2022:1373). Firms need resilience to survive uncertainties, and SCRES enables firms to perform better under conditions of certainty or uncertainty (Ali et al. 2023:9). Zeiringer et al. (2022:345) and Min (2023:1771) emphasise that standardised supply chain risk mitigation strategies are not common. Yet, various authors have identified and implied supply chain risk mitigation strategies with broad themes. These include flexibility, agility, collaboration, visibility, adaptability and redundancy (Table 1).

Several authors also highlighted the interrelatedness of some of these strategies. For example, agile strategies aim to be responsive and flexible and should be implemented under conditions of uncertainty (Lee 2002:114). Irfan, Wang and Akhtar (2020:524) agree and conclude that supply chain flexibility and supply chain agility (SCA) are interlinked concepts. Consequently, this article discusses supply chain flexibility and SCA together as supply chain risk mitigation strategies.

Similarly, the concepts of information sharing, collaboration and visibility are closely related. Accurate information sharing is not only essential (and an enabler) for SCRES (Bak et al. 2023:338; Baral et al. 2023:1945) but also necessary for supply chain partners to collaborate (Durach, Wieland & Machuca 2015:125), which in turn also enhances SCRES (Baral et al. 2023:1947). Citing Christopher and Lee (2004), Durach et al. (2015:128) state that information sharing is necessary to enhance visibility across the supply chain and that communication and accurate information sharing enhance agility. Accordingly, this article discusses collaboration and visibility together.

Supply chain risk mitigation strategies require a dynamic supply chain risk management (SCRM) approach (Gurbuz et al. 2023:2). This may require firms to redesign and adapt their supply chain networks, which may include altering their customer and supplier bases. It may also require them to reposition stock across the supply chain or to adapt inventory levels and implement redundancy as strategies (Gurbuz et al. 2023:2).

This article focuses on some of the common supply chain risk mitigation strategies that Safari et al. (2024:686) identified in SMEs and large firms as part of their SCRES plans:

1. flexibility and agility
2. collaboration and visibility
3. adaptability and redundancy.

These strategies were implemented in response to supply chain disruptions and are considered dynamic capabilities for firms because they refer to the firm's ability to sense threats and seize opportunities (Teece et al. 1997:516).

TABLE 1: Some supply chain risk mitigation strategies.

Authors	Flexibility	Agility	Collaboration	Visibility	Adaptability	Redundancy
Safari et al. (2024:689)	X	X	X	X	-	-
Gurbuz et al. (2023:1)	X	-	X	-	-	X
Mohezar et al. (2023:125)	-	-	X	-	X	X
Brown et al. (2022:7)	X	-	X	X	X	X
Pimenta et al. (2022:651)	X	X	X	X	X	X
Scala and Lindsay (2021:674–675)	X	X	X	-	-	X
Weber (2021:6)	X	X	X	X	-	X
Zighan and Ruel (2021:236)	X	X	-	-	X	X
Zutshi et al. (2021)	X	X	X	X	-	-
Chowdhury and Quaddas (2017:187)	X	-	X	X	X	X
Chopra and Sodhi (2004)	X	X	-	-	X	X

Based on these selected strategies, the following secondary research questions were derived from the primary research questions (RQs):

RQ_1: How did small, medium and large firms respond to supply chain disruptions caused by the COVID-19 pandemic in terms of:

- **RQ_{1a}:** being flexible and agile?
- **RQ_{1b}:** collaborating and increasing visibility across their supply chains?
- **RQ_{1c}:** being adaptable and implementing redundancy as part of their supply chain risk management initiatives?

RQ_2: What did small, medium and large firms learn to prepare for future disruptions in terms of:

- **RQ_{2a}:** being flexible and agile?
- **RQ_{2b}:** collaborating and increasing visibility across their supply chains?
- **RQ_{2c}:** supply chain risk management practices in general?

And from these secondary research questions, the following hypotheses (H) were derived:

H_1: There is a significant difference in how small, medium and large firms responded to supply chain disruptions in terms of:

- **H_{1a}:** being flexible and agile.
- **H_{1b}:** collaborating and increasing visibility across their supply chains.
- **H_{1c}:** being adaptable and implementing redundancy as part of their supply chain risk management initiatives.

H_2: There is a significant difference between small, medium and large firms in the lessons learned to prepare for future disruptions in terms of:

- **H_{2a}:** being flexible and agile.
- **H_{2b}:** collaborating and increasing visibility across their supply chains.
- **H_{2c}:** supply chain risk management practices in general.

Flexibility and agility

Flexibility is the ability of a firm to operate in conditions of uncertainty and leads to SCRES (Baral et al. 2023:1946). Flexibility is implemented across the supply chain and includes flexible sourcing, manufacturing and transportation (Ali et al. 2021:97; Babu et al. 2020:233; Irfan et al. 2020:520). Supply chain agility is the ability of a firm to respond internally and externally (with its supply chain partners) in conditions of uncertainty and successfully exploit business opportunities. Agility is a firm's ability to quickly sense, seize and respond (e.g. develop, produce and distribute products) to changing opportunities by exploiting internal and external competencies to add value to customers. As a dynamic capability, SCA has recently gained a lot of attention (Aslam et al. 2018:2267; Irfan et al. 2020:520, 521; Ramos et al. 2021:3) and has been key for firms in developing countries to survive the pandemic amid several uncertainties (Sharif et al. 2024:1–2). Process integration (integration internally and with external supply chain partners) and flexibility (regarding volumes and varieties) play a key role in SCA, which in turn improves business performance (Irfan et al. 2020:520, 522–523; Ramos et al. 2021:3). During the pandemic, firms with effective supply chain risk mitigation strategies were more flexible and agile than firms without (Nel 2024:10). Some supply chain risk mitigation strategies used to be more flexible and agile include:

1. Identifying and working with key suppliers to determine their flexibility (Rahman et al. 2021:3).
2. Implementing manufacturing flexibility (Baral et al. 2023:1946).
3. Increasing agile solutions in production lines (Erdiaw-Kwasie et al. 2023:6; Mohezar et al. 2023:125).
4. Adapting business models to be more flexible (Erdiaw-Kwasie et al. 2023:6).
5. Increasing delivery flexibilities (Butt 2022:374, 379).

Collaboration and visibility

Collaboration entails long-term partnerships between supply chain partners with common goals who work closely together (Cao et al. 2010:6617). Collaboration can increase SCRES and reduce the impact of supply chain risk events (Bak et al. 2023:335; Zeiringer et al. 2022:346). Firms that collaborate with supply chain partners across intra- and inter-organisational processes achieve supply chain integration (Siagian, Tarigan & Jie 2021:3). Internal integration involves collaboration and alignment of various business departments within the firm, while external integration refers to the degree of aligned collaboration of a firm with its suppliers and customers (Ramos et al. 2021:3). Information sharing is essential for effective collaboration and is the extent to which firms share accurate and relevant information in a timely manner (Cao et al. 2010:6616–6618). Firms that collaborate and share information experience reduced demand and supply uncertainties and increased agility (Lee 2002:108–111). Collaboration enhances visibility. *Visibility* refers to a firm's ability to enable access to information and share it across its entire supply chain from end to end (Weber 2021:6). Visibility provides firms with information about the firm itself as well as its external environment (Pimenta et al. 2022:651) and is closely related with information sharing (Dubey et al. 2018:132). For example, firms that are aware of where inventory is positioned in their supply chains are able to integrate all their efforts to react to rapid changes in customer demand. Supply chain mapping and information sharing across the supply chain enhance supply chain visibility (Kiers et al. 2022:6). Some supply chain risk mitigation strategies used to collaborate more and increase visibility across the supply chain include:

- Collaborating and building strong relationships with strategic suppliers (Butt 2022:374; Mohezar et al. 2023:125; Singh et al. 2023:17).
- Increasing visibility with upstream supply chain partners to enable increased accurate information sharing (Butt 2022:374).

- Fostering internal collaboration between departments or business functions (Baral et al. 2023:1947).
- Investing in digital and other technologies (Erdiaw-Kwasie et al. 2023:6; Singh et al. 2023:13).
- Increasing collaboration with customers to increase information sharing and communication (Mohezar et al. 2023:125; Singh et al. 2023:12).

Adaptability and redundancy

Supply chain risk management aims to reduce supply chain vulnerabilities and mitigate supply chain disruptions by identifying, assessing, mitigating and controlling the risks (El Baz & Ruel 2021:3; Foli et al. 2022:2 Nel & Simon 2020:154). Adaptability and redundancy are two concepts often linked to SCRM. *Adaptability* is a firm's ability to make changes in its supply chain design and business operations to address threats and challenges and seize opportunities (Aslam et al. 2018:2267; Pimenta et al. 2022:651) and has become an increasingly important topic (Bak et al. 2023:328). Khan, Piprani and Yu (2022:1334) cite Lee (2004:105) who defines adaptability as 'the capacity to adjust the supply chain's design to account for structural changes in markets and alter the supply network to account for variations in strategies, technologies and products'. Supply chain adaptability is essential in today's rapidly changing business environments (Khan et al. 2022:1334). It is radical and more long-term than changes pursued with SCA (Aslam et al. 2018:2267). *Redundancy* entails increased capacities to limit risks (Weber 2021:6) and is a prominent capability to enhance SCRES (Bak et al. 2023:328). Redundancy makes use of safety (or buffer) stocks or multiple suppliers to maintain capacities. It enables firms to respond to supply chain disruptions (Pimenta et al. 2022:651). Supply chain risk mitigation strategies focusing on adaptability and redundancy include:

- Considering alternative inbound routes and using alternative modes of transport if necessary (Butt 2022:374).
- Diversifying the supplier base by identifying alternative (or backup) suppliers (Mohezar et al. 2023:125; Rahman et al. 2021:3) and considering multiple sourcing (Butt 2022:374; Min 2023:1775; Singh et al. 2023:12).
- Considering local sources or nearshoring (Kiers et al. 2022:6; Min 2023:1775) or alternatively, reducing outsourcing while increasing insourcing activities (Min 2023:1775).
- Increasing stock levels (Mohezar et al. 2023:125).
- Increasing production by increasing capacities (Rahman et al. 2021:3).
- Adding (or investing in) control processes (Mohezar et al. 2023:125).
- Managing demand for high demand products and services (Rahman et al. 2021:3).

Research methods and design

This research focused on how different sized firms managed their supply chain disruptions during the COVID-19 pandemic. A questionnaire was informed by current literature on supply chain disruptions and supply chain risk mitigation strategies. The questionnaire obtained information about: (1) the respondent's position and job function in the firm, and the firm size in terms of number of employees; (2) the disruptions experienced by the firm during the pandemic; (3) supply chain risk mitigation strategies implemented by the firm to mitigate the disruptions and (4) lessons learned by the firms to enable them to prepare better for future disruptions. The questionnaire was pilot tested and refined by experts. It was then converted to an online survey instrument and distributed to 8500 respondents employed in supply chain-related positions in South Africa via email, from September 2023 to November 2023. The respondents had a lot of knowledge about their firm's supply chains and were employed in their positions during the COVID-19 pandemic. A database comprising 17 000 respondents was used as sample frame from which respondents were randomly selected. The respondents were assured of confidentiality and anonymity and willingly agreed to complete the survey. Initially 514 respondents participated in the online survey (i.e. a response rate of 6.05%). After cleaning the data, 230 completed questionnaires were used in the data analysis. Table 2 provides an overview of the participants.

The results confirm no non-response bias because the first 10% and last 10% of respondents who completed the survey showed similar responses in their mean scores ($p > 0.05$). The research overcame common method bias by including respondents who were experienced in and knowledgeable on their firms' supply chains and by using different Likert-type response scales in the survey.

The research investigated three main themes: (1) supply chain disruptions, (2) supply chain risk mitigation strategies and (3) lessons learned during the COVID-19 pandemic, with nine research focus areas grouped into these three themes. Although the analyses were conducted

TABLE 2: Profile of participants ($N = 230$).

Variable	*n*	%*
Job title		
Director	48	20.9
Owner or president or vice president	55	23.9
Senior management position	52	22.6
Managerial position	43	18.7
Supervisor or specific supply chain-related position	24	10.4
Other	7	3.0
No response	1	0.4
Years' experience		
> 10	152	66.1
6–10	42	18.3
≤ 5	33	14.3
No response	3	1.3
Firm size – number of employees		
Less than 51 employees (Group I)	80	34.8
51–200 employees (Group II)	31	13.5
More than 200 employees (Group III)	119	51.7

*, Percentages are rounded off to one decimal.

at item (statement) level, overall validity and reliability were assessed using exploratory factor analysis (EFA) and the Cronbach alpha (CA) coefficient. The results of the EFA indicated unidimensionality in seven of the nine research focus areas. The only two areas that did not show unidimensionality (and split into two factors) were (1) supply-side disruptions, and (2) collaboration and visibility (Table 3). The CA coefficients ranged between 0.664 and 0.921 which is considered satisfactory for exploratory research (Cho & Kim 2015:217). One-way analysis of variance (ANOVA) procedures were used to compare the means of the three groups across the three main research themes, using SPSS v29. Glass, Peckham and Sanders (1972) showed that the *F*-test was robust and can be used to test ordinal data. Levene's test of homogeneity of variance was used to test the assumption of equal variances, and the assumption was supported for most of the tests. The Welch robust test (adjusted *F*-test) was used in those cases where the homogeneity of variance assumption was not supported.

Ethical considerations

An application for full ethical approval was made to the research ethics committee of the University of Pretoria and ethics consent was received on 13 March 2023. The ethics approval number is EMS027/23.

Results

This research article focused on three groups of respondents. Group I (n = 80) included firms with less than 51 employees and represented micro to smaller enterprises. Group II (n = 31) included firms with 51–200 employees and represented medium-sized enterprises. Group III (n = 119) included firms with more than 200 employees and represented larger firms. The findings are discussed from the perspective of these three groups, as they relate to the three main research themes.

TABLE 3: Main research themes and research focus areas.

Main research theme	Research focus area	Final research focus area label	CA
Supply chain disruptions	Supply-side disruptions	Upstream complexities	0.664
		Supplier performance	0.783
	Internal process disruptions	Internal process disruptions	0.706
	Demand-side disruptions	Demand-side disruptions	0.887
Supply chain risk mitigation strategies	Flexibility and agility	Flexibility and agility	0.804
	Collaboration and visibility	Investments to enhance visibility	0.839
		Information sharing and collaboration	0.729
	Adaptability and redundancy	Adaptability and redundancy	0.851
Lessons learned during the COVID-19 pandemic	Flexibility and agility	Flexibility and agility	0.921
	Collaboration and visibility	Collaboration and visibility	0.905
	Supply chain risk management	Supply chain risk management	0.844

CA, Cronbach alpha; COVID-19, coronavirus disease 2019.

Disruptions experienced during the pandemic

The firms experienced several supply-side, internal process and demand-side disruptions. Respondents were asked to indicate the extent to which their firms experienced either an increase or a decrease in terms of supply chain disruptions during the pandemic, using a 7-point Likert type response scale. Table 4 shows that all three groups experienced an increase in (1) supplier uncertainties, (2) suppliers' prices and (3) inbound logistics challenges ($p < 0.05$). Most firms across all three groups also experienced a decrease (or negligible increase) in supplier performance across four performance measurement items. In terms of firms' internal operations, all three groups experienced an increase in (1) stock shortages, (2) operations (or production) complexities ($p < 0.01$), (3) production (or operating) costs, (4) cash flow challenges and (5) waste in the firm. There were statistically significant differences in the means of the groups in terms of labour shortages ($p < 0.01$) where Groups I and II indicated a slight decrease. Group III indicated an increase in labour shortages. During the COVID-19 pandemic, the firms in all three groups on average experienced an increase in demand-side disruptions (Table 4). Only one statement showed a statistically significant difference between the groups.

TABLE 4: Disruptions experienced during the pandemic.

Supply chain risk disruption item	Mean score (M) (where 1 = large decrease, 4 = neither increase nor decrease, 7 = large increase)		
	Group I	Group II	Group III
Supply-side (upstream) disruptions			
Upstream complexities			
Supplier uncertainties	4.26	4.61	4.57
Suppliers' prices	4.90	5.26	5.36
Inbound logistics challenges**,‡	4.77	5.50	5.48
Supplier performance			
Suppliers' stock availability	3.84	3.35	3.66
Suppliers' quality (in terms of specifications)	3.96	3.94	3.92
Suppliers' flexibility	3.78	4.42	4.06
Suppliers' reliability	4.03	3.94	3.71
Internal process disruptions			
Stock shortages	4.19	4.19	4.30
Operations (or production) complexities***,‡	4.18	4.55	5.10
Production (or operations) costs	4.70	5.00	5.07
Cash flow challenges	4.78	4.67	4.62
Labour shortages***,‡,§	3.96	3.86	4.56
Waste in firm	4.18	4.32	4.41
Demand-side (downstream) disruptions			
Customer demand uncertainties	5.04	5.07	5.04
Demand for certain core products*,‡	4.34	4.81	4.88
Order cancellations from customers	4.38	4.26	4.52
Changing buying patterns	5.11	5.04	5.13
Forecasting complexities	5.19	5.37	5.34
Late deliveries to their customers	4.47	4.11	4.72
Customer expectations in terms of service delivery	4.82	4.63	5.11
Delayed payments from their customers	4.93	4.58	4.93
Challenges in their downstream supply chains	4.76	4.81	4.97

*, $p < 0.1$; **, $p < 0.05$; ***, $p < 0.01$.

‡, Statistically significant difference between Groups I and III; §, Statistically significant difference between Groups II and III.

Supply chain risk mitigation strategies

The findings in this section are discussed to align with the supply chain risk mitigation strategy themes selected for this article (Table 5 categorises the results accordingly). Respondents were asked to indicate the extent to which their firms implemented specific supply chain risk mitigation strategies and if there was an increase or decrease during the implementation of the strategies, using a 7-point Likert type response scale.

Flexibility and agility

The survey included seven questions to determine how firms implemented flexibility and agility as part of their supply chain risk mitigation strategies. Table 5 demonstrates that the firms in all three groups showed increased flexibility and agility practices in response to the disruptions caused by the pandemic and that the biggest increases in flexibility and agility were related to firms' interactions with upstream suppliers and downstream customers. The mean scores for the smaller firms (i.e. the firms in Group I) are the lowest for most statements. Only one statement showed a statistically significant difference.

H_{1a} is therefore not supported because there were no statistically significant differences between small, medium and large enterprises in terms of all the statements focusing on flexibility or agility to mitigate supply chain disruptions, except for the statement on inbound logistics challenges ($p < 0.01$) which was statistically significant.

Collaboration and visibility

Prior to the COVID-19 pandemic, all three groups agreed that they collaborated with their suppliers ($p < 0.05$) and that their suppliers' performance met the agreed-upon performance levels. In addition, the firms in all three groups indicated that there was internal collaboration between their firm's departments and that they were at least meeting their set performance objectives ($p < 0.1$). All three groups also indicated that they were collaborating with their customers ($p < 0.05$) and that they were at least meeting the performance targets set for them by their customers.

Eight statements determined the extent to which collaboration and visibility were used as part of risk mitigation strategies during the pandemic. There were statistically significant differences for five of the eight statements, and the mean scores were the lowest for the firms in Group I for most statements, which indicates a lower increase than in the other groups. Table 5 shows that:

- Firms collaborated more: with their suppliers ($p < 0.01$), among their internal departments ($p < 0.01$) and with their customers ($p < 0.05$).
- Accurate information sharing with suppliers increased in all three groups ($p < 0.1$).
- Firms made additional investments to increase upstream visibility across their supply chains ($p < 0.01$), enhance operations and visibility across their internal departments, and enhance visibility across their downstream supply chains.

H_{1b} is supported by the findings because there were statistically significant differences between small, medium and large enterprises in terms of five of the eight statements that focused on collaboration and visibility. H_{1b} is not supported for the statements on: (1) additional investments to increase visibility across internal departments; (2) additional investments to increase downstream information visibility; and (3) for negotiations with customers because there were no statistically significant differences between the groups for these three statements.

TABLE 5: Supply chain risk mitigation strategies implemented during the pandemic.

Supply chain risk mitigation measurement item	Mean score (*M*) (where 1 = large decrease, 4 = neither increase nor decrease, 7 = large increase)		
	Group I	Group II	Group III
Flexibility and agility			
Flexibility in sourcing or inbound logistics arrangements***,†,‡	4.44	5.11	5.10
Manufacturing flexibility – quantities produced	4.08	4.40	4.29
Manufacturing flexibility – varieties produced	4.03	4.40	4.35
Flexibility with delivery arrangements with customers	4.88	4.96	5.06
Agile solutions to meet customer demands	5.32	5.00	5.32
Selling prices	4.50	4.89	4.83
Promotions or incentives to customers	4.32	4.48	4.36
Collaboration and visibility			
Information sharing and collaboration			
Accurate information sharing with suppliers*,‡	4.04	4.60	4.48
Collaboration with strategic suppliers***,‡	4.58	5.10	5.22
Internal collaboration across departments***,‡	4.65	5.13	5.45
Collaboration with strategic customers**,‡	5.00	5.11	5.46
Negotiations with customers	5.12	4.96	5.22
Investments to enhance visibility			
Technology investments to enhance upstream information visibility***,‡	4.32	4.90	5.22
Technology investments to enhance internal information visibility	4.74	4.77	5.15
Technology investments to enhance downstream information visibility	4.69	4.81	5.05
Adaptability and redundancy			
Number of suppliers (supply base)***,†,‡	3.76	4.57	4.25
Insourcing	4.21	4.68	4.34
Stock levels or safety stock	3.91	4.00	4.28
Capacity utilisation of current capacities	3.94	4.35	4.36
Capacity requirement (in terms of employees or hours or working shifts)***,‡	3.35	3.90	4.08
Focus on employee health and safety**,‡	5.18	5.74	5.74
Training to multi-skill or upskill employees	4.88	5.10	5.16
Capacity requirement (in terms of facilities or capital equipment)	3.95	4.29	4.28
Capacity requirement (in terms of sub-contracting)*,‡	3.52	3.65	4.01
Postponement	4.10	4.19	4.35
Repositioning of stock across the supply chain to optimise operations***,‡,§	4.16	4.10	4.80
Distribution channels (which can include online selling options)	4.50	4.89	4.83
Identification and elimination of waste**,‡	4.57	4.87	4.97

*, $p < 0.1$; **, $p < 0.05$; ***, $p < 0.01$.

†, Statistically significant difference between Groups I and II; ‡, Statistically significant difference between Groups I and III; §, Statistically significant difference between Groups II and III.

Adaptability and redundancy

The survey instrument included 13 statements for adaptability and redundancy. When analysing the groups' mean scores, the disruptions were managed primarily by implementing the following strategies, namely, the firms in:

- Groups II and III slightly increased their supply base, while the firms in Group I slightly decreased their number of suppliers ($p < 0.01$).
- All three groups increased their insourcing activities.
- The firms in Group III increased their stock levels, while the firms in Group I slightly decreased their stock levels. There was neither an increase nor a decrease for the firms in Group II.
- Groups II and III slightly increased the use of their current capacities, while the firms in Group I slightly decreased theirs.
- Group III slightly increased capacity by increasing working hours and shifts, while the firms in Groups I and II had a slight decrease in these areas ($p < 0.01$).
- All three groups increased their focus on employee health and safety ($p < 0.05$) and increased training programmes to multi-skill or upskill their employees.
- Groups II and III slightly increased their capacities in terms of facilities and acquiring capital equipment, while the firms in Group I slightly decreased these capacities.
- Groups I and II decreased their sub-contracting initiatives, while the firms in Group III had an almost negligible increase in these activities ($p < 0.1$).
- The firms in all three groups implemented postponement (or delayed configuration of products and services) slightly more.
- All three groups increased their efforts to reposition stock across the firm's supply chain to optimise operations ($p < 0.01$).
- All three groups indicated an increase in the number of distribution channels (which may include online selling options) used by their firms.
- All three groups proactively tried to identify and eliminate waste to be more efficient ($p < 0.05$).

H_{1c} is supported for six of the statements that determine adaptability and redundancy because there were statistically significant differences between small, medium and large enterprises in terms of these statements (see Table 5). These measurement items are number of suppliers, capacity requirements (in terms of employees or hours or working shifts and sub-contracting), a focus on employee health and safety, repositioning of stock across the supply chain and the identification (and elimination) of waste. H_{1c} is not supported for seven of the statements about adaptability and redundancy.

Lessons learned during the pandemic

Table 6 presents the lessons learned during the pandemic to help firms prepare for future disruptions. Respondents were asked to indicate the extent to which they agreed or disagreed with statements in terms of lessons learned from mitigating disruptions caused by the pandemic using a 5-point Likert-type response scale.

Flexibility and agility

Six questions determined the lessons firms learned during the COVID-19 pandemic in terms of flexibility and agility. Table 6 shows the mean values for each group. All six measures showed statistically significant differences between the groups. From Table 6, it would appear as though the firms in all the groups are more flexible and agile to respond to future disruptions with the firms in Group I portraying the lowest mean scores. The measures that showed significant differences between the smaller firms (Group I) and the larger firms (Group III) were:

- The firm was flexible and agile to affectively respond and manage the disruption caused by the pandemic ($p < 0.01$).
- The firm is more flexible in terms of responding to changing sourcing needs (supply side) ($p < 0.05$).

TABLE 6: Lessons learned during the coronavirus disease 2019 pandemic.

Supply chain risk mitigation: lessons learned	Mean score (*M*) where 1 = strongly disagree and 5 = strongly agree		
	Group I	Group II	Group III
Flexibility and agility			
The firm was flexible and agile to affectively respond to disruptions caused by the pandemic***,†,‡	3.39	3.93	3.92
The firm is more flexible in terms of responding to changing sourcing needs**,†,‡	3.60	4.13	3.90
The firm is more flexible in terms of responding to changing operations needs**,†,‡	3.55	4.10	3.92
The firm is more flexible in terms of responding to changing delivery needs**,†,‡	3.66	4.23	3.99
The firm is more agile in terms of leveraging people to manage disruptions***,‡	3.61	4.23	4.02
The firm is more agile in terms of leveraging technologies to manage disruptions**,‡	3.56	3.97	3.97
Collaboration and visibility			
The firm collaborates more with its supply chain partners.**,†,‡	3.71	4.19	4.02
The firm has increased visibility (i.e. access to information) across its supply chain.***,‡	3.45	3.74	4.15
The firm understands its processes and relationships better.***,†,‡	3.71	4.35	4.11
The firm is better equipped to identify opportunities and threats across its supply chain.***,†,‡	3.73	4.21	4.11
Supply chain risk management (in general)			
The firm managed its supply chain risks effectively.**,‡	3.51	3.77	3.91
The firm had an adequate risk management programme for the pandemic.**,†,‡	2.94	3.55	3.47
The firm effectively managed supplier (inbound) disruptions during the pandemic.***,†,‡	3.27	3.87	3.75
The firm effectively managed internal (process) disruptions during the pandemic.	3.70	3.97	3.94
The firm effectively managed customer demand (outbound) disruptions.*,‡	3.45	3.90	3.74
The firm adapted its supply chain network design to meet customer demand.***,†,‡	3.60	4.13	4.11
The firm recovered relatively quickly to its pre-COVID-19 position.***,†,‡,§	3.26	4.13	3.68

COVID-19, coronavirus disease 2019.

*, $p < 0.1$; **, $p < 0.05$; ***, $p < 0.01$.

†, Statistically significant difference between Groups I and II; ‡, Statistically significant difference between Groups I and III; §, Statistically significant difference between Groups II and III.

- The firm is more flexible in terms of responding to changing operations' needs (internal processes) ($p < 0.05$).
- The firm is more flexible in terms of responding to changing delivery needs (demand side) ($p < 0.05$).
- The firm is more agile in terms of leveraging people ($p < 0.01$) and technologies ($p < 0.05$) to manage disruptions.

H_{2a} is therefore supported because there were statistically significant differences between small, medium and large enterprises in terms of all six lessons learned during the pandemic related to being flexible and agile.

Collaboration and visibility

Four statements measured the lessons firms learned during the COVID-19 pandemic in terms of collaboration and visibility. Table 6 shows that the differences were statistically significant between the smaller and larger firms for all four of these statements. It is furthermore evident that the mean scores were the lowest for the smaller firms. The findings show that:

- Firms collaborate more with their supply chain partners ($p < 0.05$).
- Firms have increased visibility (i.e. access to information) across their supply chains ($p < 0.01$).
- Firms understand their processes and relationships better ($p < 0.01$).
- Firms are better equipped to identify opportunities and threats across their supply chains ($p < 0.01$).

H_{2b} is thus supported because there were statistically significant differences between small, medium and large enterprises in terms of lessons learned during the pandemic as to how collaboration and increased visibility can be used to mitigate supply chain disruptions.

Supply chain risk management (in general)

Table 6 shows that all three groups agreed that they managed their supply chain risks effectively prior to the COVID-19 pandemic ($p < 0.5$). When asked if they had an adequate risk programme to manage the disruptions caused by the COVID-19 pandemic, the firms in Groups II and III at least agreed to some extent with the statement, while Group I disagreed ($p < 0.05$). It can thus be concluded that the smaller firms may have been less prepared for the disruptions caused by the pandemic than the larger firms in Groups II and III, which implies that they may have been more reactive in responding to the disruptions. This finding aligns with Ali et al.'s (2023:10) statement on SMEs in general. The firms in all three groups mentioned that their firms:

- Effectively managed supplier-related disruptions ($p < 0.01$).
- Effectively managed internal disruptions.
- Effectively managed customer-related disruptions ($p < 0.1$).
- Adapted their supply chain network designs to meet customer demand ($p < 0.01$).

The mean scores for the firms in Group I were the lowest for all the four abovementioned statements, which means that the firms in Group I may have felt that they were less effective than the firms in the other groups in managing supply chain disruptions caused by the pandemic. The firms in all three groups indicated an increase in their customers' satisfaction measures during the pandemic. This means that customers were satisfied with the performance of their suppliers' (i.e. the firms included in the research). It can thus be argued that firms' SCRM strategies were successful, especially when considering that the firms in all three groups indicated that they recovered fairly quickly to their pre-COVID-19 performance levels ($p < 0.01$).

H_{2c} is supported because there were statistically significant differences between small, medium and large enterprises in terms of all the statements that represented SCRM lessons learned during the COVID-19 pandemic and how these lessons would help them prepare for future disruptions. H_{2c} is not supported for the statement about how the firm effectively managed internal disruptions during the pandemic, because there was no statistically significant difference between the groups.

Discussion

The discussion presents the conclusions that emerged from the results and is structured around the three main themes presented in Figure 1: supply chain disruptions across the supply chain, supply chain risk mitigation strategies (as part of the DCT) and lessons learned about resilience across the supply chain.

Supply chain disruptions during the pandemic

The firms in all three groups experienced increased supply-side disruptions. Supplier uncertainties increased as suppliers' stock availability decreased while their prices increased. There was also an increase in inbound logistics challenges ($p < 0.05$) with the largest impact on the firms in Groups II and III and the smallest impact on the firms in Group I. Internal disruptions also increased for all three groups of firms. The increases in internal disruptions were the smallest for the smaller firms for all the statements except one, namely cash flow challenges. From the mean scores, the smaller firms experienced the highest increase in cashflow challenges, while the larger firms experienced the lowest increase (even though these increases were not statistically significant). Statistically significant differences were evident with increased production complexities ($p < 0.01$) and labour shortages ($p < 0.05$). The conclusions align with the literature, stating that supply-side disruptions typically embody, among others, increased uncertainties, supplier-related disruptions and inbound logistics challenges. This may have resulted from poor communication and coordination, and decreased supplier performance.

All three groups of firms also experienced increased demand-side disruptions. The biggest increases were for forecasting

complexities, which most probably developed from changed customer demand patterns. There was also a significant difference in demand for core products ($p < 0.1$) and an increase in challenges in firms' downstream supply chains and late deliveries made to customers. Customers were also cancelling more orders and delaying payments to firms while expecting more in terms of service delivery. The mean scores were the highest for the larger firms except for delayed payments, which affected the smaller firms the most. These conclusions align with the literature emphasising that demand-side disruptions result from customer demand fluctuations, downstream logistical inefficiencies and customer delivery delays.

The ripple effect of these disruptions may be explained as follows. Increased supplier uncertainties (e.g. supplier stock shortages), inbound logistics challenges and increased customer demand for core products could have accounted for internal stock shortages, which could have contributed to increased production complexities and late deliveries to customers. Increased supplier prices and the delayed payments from customers would have impacted firms' cash flows. Smaller firms, which indicated the highest increases in: (1) cash flow challenges; and (2) delayed payments from customers, were most likely impacted more severely. Furthermore, increased customer demand uncertainties and customers' changing buying patterns probably contributed to forecasting challenges and increased waste.

Supply chain risk mitigation strategies

In response to the increased disruptions, the firms in all three groups were more flexible and agile despite the mean scores for Group I being lower than for Groups II and III. However, there were no real statistically significant differences between the groups. Therefore, H_{1a} is not supported for all the measurement items except for increased flexibility in sourcing or inbound logistics arrangements ($p < 0.01$). This aligns with the higher increased disruptions experienced by larger firms with their inbound logistics. It follows that small, medium and large enterprises were flexible and agile (and increased their flexibility and agility initiatives) in their response to supply chain disruptions with no statistically significant differences between the different sized firms for most statements. It would therefore appear that the firms in Groups II and III are slightly more flexible and agile than the firms in Group I. However, it may be that the firms in Group I also experienced an increase in flexibility and agility practices. These conclusions align with the literature stating that increased flexibility and agility are required to mitigate supply chain disruptions. This applied to all three groups.

The firms in all three groups collaborated more with supply chain partners across the supply chain. This included increased collaboration (1) with suppliers, (2) among internal departments within a firm and (3) with customers. There were statistically significant differences between the three groups with the firms in Group I showing the lowest increase in collaborative efforts. The firms in all three groups also increased their visibility across their supply chain. Visibility was increased in terms of firms' (1) supply-side, (2) internal processes and (3) demand-side supply chains. The firms in Group I increased their visibility the least. There were statistically significant differences in most statements. Therefore, H_{1b} is supported for information sharing and collaboration initiatives (except negotiations with customers and technological investments to enhance internal and downstream information visibility). It can be concluded that SMEs and large enterprises collaborated more and increased visibility across their supply chain in their response to supply chain disruptions with the firms in Group I showing the lowest increase when mean scores are analysed. The conclusions about collaboration and visibility also align with the literature, stating that increased collaboration and visibility across the supply chain are required to mitigate supply chain risks. However, the smaller firms participated to a lesser extent with their external supply chain partners than the larger firms.

There was an interesting distinction between the groups regarding adaptability and redundancy. The firms in Groups II and III implemented redundancy as a supply chain risk mitigation strategy, while the firms in Group I did not. There was also a decrease in capacity requirements for the firms in Group I while they were implementing a low-diversification strategy (Marconatto et al. 2022:1373). This can be derived from the following observations (Table 5):

- The smaller firms (Group I) reduced the number of their suppliers and their stock levels. (Usually, firms increase their supply base and increase stock levels during uncertainties to ensure that they meet customer demand.) The increase in supplier prices and stock shortages could have contributed to this decision.
- The smaller firms (Group I) decreased their use of current capacities: in terms of facilities, capital equipment and subcontracting (even though there was a slight increase in their insourcing activities). They also did not increase working hours or add working shifts.
- The low-diversification strategy may have been implemented because of increased cash flow challenges which could have limited them in terms of investing in, for example, more inventories.
- Considering that the demand for their core products increased slightly, the smaller firms seem to have managed supply and demand uncertainties without implementing redundancy. They preferred implementing flexible and agile solutions such as slightly increasing the delayed configuration of their final products and using more distribution channels while collaborating more with their supply chain partners. They also increased their efforts to reduce waste and increase efficiencies. They did not really increase their efforts to reposition stock across their supply chains.

The study recommends that smaller firms increase their cash reserves. This can be a daunting task because of banks' hesitancy to lend money to smaller firms because of the risks involved (Marconatto et al. 2022:1373).

The medium-sized and larger firms seem to be implementing a high-diversification strategy. This can be derived from their efforts to (Table 5):

- Increase their supply base (i.e. the firms in Groups II and III) and safety stock (i.e. the firms in Group III).
- Increase insourcing.
- Increase their current capacity utilisation as well as their capacity requirements in terms of facilities and capital equipment.
- Reposition stock across their supply chains to optimise operations ($p < 0.01$).
- Increase the number of distribution channels they were using to reach their customers.
- Increase their efforts to identify and eliminate waste.

Notably, SMEs and large firms increased their focus on employee health and safety ($p < 0.05$) and used training to multi-skill or upskill their employees.

By applying the DCT, the firms in all three groups could identify risks and sense opportunities to manage their risks. However, it would appear that only the larger firms in Groups II and III could seize opportunities by adapting and creating value amid uncertainties while the smaller firms did not necessarily have the capabilities to seize opportunities and create value.

Lessons learned during the pandemic

Regarding the mean scores of the groups: the firms in all three groups effectively managed their supply chain risks prior to the pandemic. The mean scores for all three groups also indicate that the firms recovered fairly quickly to their pre-pandemic performance positions and that the medium and larger firms recovered slightly better and managed their supply chain disruptions more effectively than the smaller firms. Firms also indicated an increase in customer satisfaction. Therefore, it can be concluded that the supply chain risk mitigation strategies during the pandemic were implemented successfully. In addition (and in terms of future disruptions), firms learned that they now:

- Have more flexibility and agility to respond to disruptions in the supply side, internal processes and demand side of their supply chains.
- Collaborate more with their supply chain partners and have more visibility across their supply chains. This enables them to understand their processes and relationships better.
- Are better equipped to identify opportunities and threats in their supply chains.
- Are able to effectively manage disruptions in the supply side, internal processes and demand side of their supply chains.

Conclusion

The study recommends that SMEs and larger firms try to be more flexible and agile across their supply chains. These enterprises should collaborate more internally and externally with their strategic supply chain partners by forging relationships built on trust and accurate information sharing. This should enhance visibility across the supply chain. Lastly, both a high-diversification and a low-diversification risk mitigation strategy can be adopted, depending on access to resources. Small and medium enterprises should strive to be more adaptable and implement redundancy to mitigate supply chain disruptions. They should try to improve their working capital and increase their number of suppliers and customers (even though this requires added management efforts), which aligns with findings by Marconatto et al. (2022:1379).

The study was limited by a relatively small sample of firms and only 31 firms represented in the medium-sized category. In addition, although the research makes some valuable contributions in terms of (1) flexibility and agility, (2) collaboration and visibility and (3) adaptability and redundancy as supply chain risk mitigation strategies, the results do not show how these can be implemented. Some insights are given (e.g. to increase investments in technologies that can improve visibility across the supply chain or to increase efforts to identify and eliminate waste), but more specific guidelines can be provided as to how this can be achieved.

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Data availability

The data that support the findings of this study are available from the author, J.D.N., upon reasonable request.

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