Why does omni-channel allow retailers to foster supply chain resilience? Evidence from sequential mixed methods research

Shaohua Song[a,b], Xianliang Shi[a], Elena Tappia[c], Guang Song[b,d], Marco Melacini[c] and T. C.E. Cheng[e]

[a]School of Economics and Management, Beijing Jiaotong University, Beijing, People's Republic of China;
[b]BeijingLaboratory of National Economic Security Early-Warning Engineering, Beijing Jiaotong University, Beijing, People'sRepublic of China;
[c]Department of Management, Economics and Industrial Engineering, Polytechnic University ofMilan, Milan, Italy;
[d]National Academy of Economic Security, Beijing Jiaotong University, Beijing, People's Republicof China;
[e]Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, Hung Hom, HongKong, People's Republic of China

This is the accepted version of:
Please cite this document as: Shaohua Song, Xianliang Shi, Elena Tappia, Guang Song, Marco Melacinic and T. C.E. Cheng (2022). Why does omni-channel allow retailers to foster supply chain resilience? Evidence from sequential mixed methods research. International Journal of Logistics: Research and Applications, https://doi.org/10.1080/13675567.2022.2159350

Published Journal Article available at: https://doi.org/10.1080/13675567.2022.2159350

Abstract

The omni-channel (OC) approach improves efficiency under normal conditions and fosters resilience when a crisis hits, e.g., COVID-19. We adopt the sequential mixed methods research to conduct a two-stage investigation to explore how OC retailers achieve supply chain resilience (SCR). In stage 1, three key capabilities of OC retailers to foster SCR are identified qualitatively, i.e., collaboration, flexibility, and redundancy, as well as the conceptual model is developed based on the dynamic capabilities view. In stage 2, the roles of key capabilities in fostering SCR in three phases, i.e., *preparedness*, *responsiveness*, and *recovery*, is quantitatively examined, by using partial least squares structural equation modelling to test the hypotheses based on a sample of 225 Chinese OC retailers. The findings indicate that flexibility and redundancy are more significant for responsiveness, whilst collaboration is more crucial for recovery, offering valuable insights for supporting retailers in OC transformation and in setting a capabilities portfolio to withstand supply chain disruptions.

Keywords: omni-channel retail; supply chain resilience; firm capabilities; dynamic capabilities view

Paper type: Research paper

1. Introduction

In today's highly connected global marketplace, unpredictable, low-probability, and high-impact disruption events like COVID-19 are becoming serious threats to retailers' long-term success and survival (Shekarian and Mellat Parast, 2021). The COVID-19 pandemic highlights how omni-channel (OC) retailers, by coordinating and integrating their multiple channels to provide seamless shopping services (Song et al., 2021), could have resilience capabilities with little additional cost thanks to the synergy in the back-end operations (Chopra et al., 2021; Zhang et al., 2021; Feng et al., 2022), although risks were not considered when such resilience structure was developed (Chopra et al., 2021; McKinsey, 2020). For example, Walmart and Target's took consumer orders online to be fulfilled using curbside pickup, leading to increasing market share and profits during the disruption. Similarly, small retailers operate the OC business with the support of third parties, increasing sales in normal times and providing resilience during a crisis. For example, Amazon used its online platform, along with its storage and fulfillment services, while Alibaba and Shopify provided warehousing and fulfillment services to their online platforms, enabling small retailers to pursue OC retailing (OCR) during the COVID-19 pandemic. However, retailers that did not establish the OC structure were not so lucky, e.g., Cecil McBee and Onward Holding struggled during the pandemic due to their high reliance on walk-in stores.

Despite an abundance of research on OCR owing to its popularity in the retail industry, the focus is on the benefits of the synergistic effect arising from channel integration, such as improved consumer satisfaction (e.g., Sorkun et al., 2020) and financial performance (e.g., Song et al. 2019). There is a lack of research on the phenomenon that OC retailers remain resilient and operate continuously in a turbulent environment. A few recent studies acknowledge that the resilience capabilities of OC retailers are currently under-studied in the academic literature (e.g., Zhang et al., 2021). They suggest the possible capabilities that enhance the OC retailers' resilience, such as internal information processing capability, flexible fulfillment activities and networks (e.g., Zhang et al., 2021), and efficient collaboration with supply chain partners (e.g., Chopra et al., 2021). The strategies for improving SCR are not new to supply chain management research, but new research

opportunities and contributions (e.g., Hosseini et al., 2019; Shekarian and Mellat Parast, 2021; Küffner et al., 2022; Kamalahmadi et al., 2022) are on the rise in the face of the COVID-19 pandemic and ongoing geopolitical tensions that are threatening to upend global supply chains (Sodhi and Tang, 2021). Therefore, exploring extensively and comprehensively the "key" capabilities of OC retailers that thrive when facing such long-term disruptions, while the others do not even survive, represents an interesting and open research issue at the intersection of OCR and SCR research streams.

Motivated by the above observations, this study aims to explore the mechanism by which the OC structure allows retailers to improve SCR, via applying the sequential mixed methods to conduct a two-stage investigation. First, three key capabilities of OC retailers that thrive when facing disruptions are captured, namely *collaboration*, *flexibility*, and *redundancy*. Then, SCR is studied considering three phases, namely *preparedness* (pre-disruption), *responsiveness* (during-disruption), and *recovery* (post-disruption), and the roles of different firm capabilities in different phases are explored quantitatively from the perspective of the dynamic capabilities view (DCV). In fact, as highlighted in the existing literature, SCR is not static but a phased process (Kamalahmadi and Parast, 2016; Sheffi and Rice, 2005), and focusing only on a part of the process (e.g., only during the disruption event) could yield an incomplete view of the issue.

To sum up, this study seeks to answer the following two research questions (RQs):

RQ1: What are the key capabilities of OC retailers to foster SCR?

RQ2: How do such capabilities foster SCR in different phases SCR development?

To answer to RQ1, a qualitative investigation of the previous literature on SCR drivers and retailers' OC practices is carried out and the conceptual model is developed accordingly. Then, a sample dataset of 225 OC retailers with different ages, sizes, and ownerships in China is used to investigate the relationships between the key capabilities and SCR in different phases, answering RQ2.

To the best of our knowledge, this study is the most recent attempt to investigate why OC retailers are resilient. Its theoretical contributions primarily consist in defining the key capabilities of OC retailers in encouraging SCR and verifying a theoretical linkage between such capabilities and SCR in various phases, hence expanding the examination of the benefits of OCR. Furthermore, the findings increase the confidence of both traditional and pure online businesses in implementing the OC strategy and suggest OC retailers to develop a capability portfolio to enhance their SCR.

The rest of the paper is organized as follows: Section 2 presents the theoretical background, followed by the research methodology of the two-stage investigation and research steps in each stage (Section 3). Section 4 presents the qualitative investigation in stage 1, while the quantitative investigation of stage 2 is discussed in Section 5. Section 6 discusses the research findings and their implications. Section 7 concludes the paper and provides suggestions for future research.

2. Theoretical background

2.1 Omni-channel retail supply chain

OC is an approach involving a seamless consumer shopping experience that requires integrated logistics and supply chain operations across channels (e.g., Yrjölä et al., 2018). Therefore integration" across channels is the key to develop the OC structure. However, channel alignment is a complex task, as each channel presents different functions and distinct characteristics, for

example, less order quantities and product self-pick-up of offline channels while larger order quantities and home delivery of online channels (Song et al., 2019). Therefore, the OC transformation requires not only internal integration but also a concerted effort at the entire supply chain level (Song et al., 2019).

Based on the high-level "integration" of the OC structure, we take a world-leading OC retailer mentioned in Adivar et al. (2019) as an example to depict the OCR business and supply chain network in Figure 1. From the operational perspective, OC retailers connect with consumers through multiple touchpoints (e.g., mobile devices, stores, social media), adopt integrated inventory management, consistent pricing mechanisms, and a circular network with high connectivity. From the perspective of the supply chain, the OC supply chain is consumer-focused, where OC retailers and their supply chain partners develop higher levels of interaction and collaboration, such as ordering from OC retailers and supplier drop-shipping, and sharing operational and demand information among them.

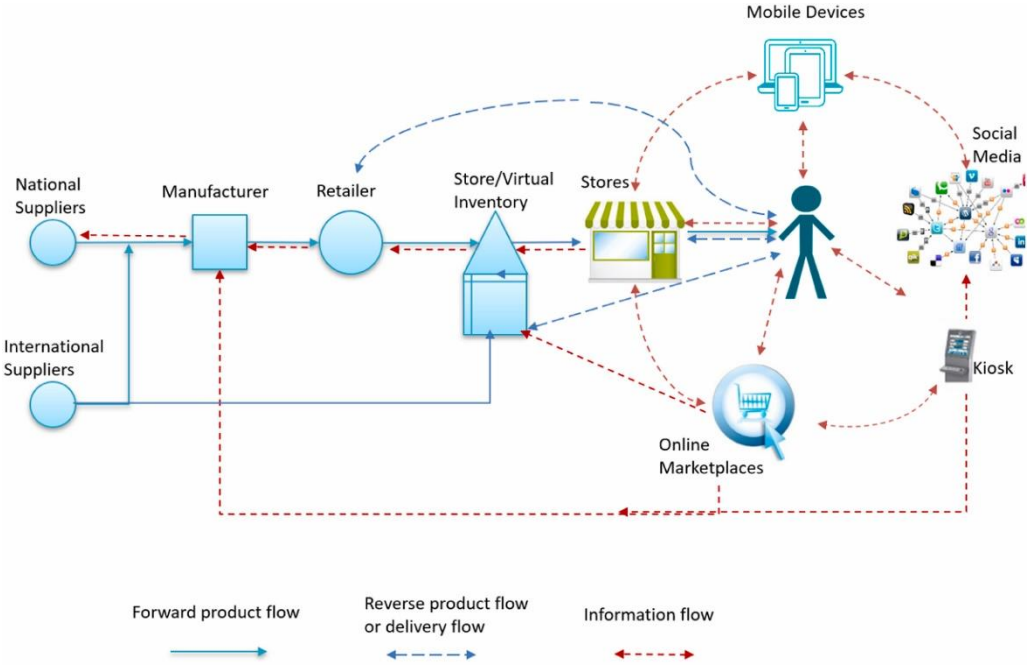


Figure 1. Omni-channel retail supply chain structure (Adivar et al., 2019)

The benefits of OC to retailers have been extensively studied. In this study, keywords and strings (e.g., "omni-channel retail", "omnichannel retail", "advantages", "performance", and their combinations) were sought in publication titles and abstracts. Table 1 presents several relevant articles by classifying the benefits that are widely mentioned in current OCR research into four categories, i.e., financial performance, operational performance, sustainable performance, and consumer experience. We notice that few studies explore SCR in the context of OCR. Despite that many researchers after the outbreak of COVID-19 have noticed the advantages of OCR in dealing with such large-scale and long-term disruptions (e.g., Zhang et al., 2021; Feng et al., 2022), the essential mechanism by which OC retailers cope with the risks and remain resilient is still unclear.

Table 1 Summary of related OCR literature

Benefit of OCR	Measurement	Main reference
Financial performance	e.g., Return on Investment, Return on Assets, operations cost,	Feng et al. (2022); Jones et al. (2022); Sousa et al. (2021); Li et al. (2020); Song et al. (2020);

	revenue, profit margin	Melacini and Tappia (2018); Ishfaq et al. (2016)
Operational performance	e.g., service level, responsiveness, flexibility	Ishfaq et al. (2022); Song et al. (2020); Adivar et al. (2019); Song et al. (2019); Kembro et al. (2018)
Sustainable performance	e.g., greenhouse gas emissions, sustainability strategy, the amount of waste	Sousa et al. (2021); Adivar et al. (2019); Giuffrida et al. (2019); Melacini and Tappia (2018)
Consumer experiences	e.g., convenience, consumer empowerment, trust, satisfaction	Shi et al. (2020); Lee et al. (2019); Xu and Jackson (2019); Adivar et al. (2019); Yrjölä et al. (2018)
Supply chain resilience	e.g., response to risks	Zhang et al. (2021); Chopra et al. (2021); **this study**

2.2 Supply chain disruptions, resilience and drivers

Supply chain disruptions are unforeseen events that disrupt the normal flow of goods and materials within a supply chain, thereby exposing firms within the supply chain to operational and financial risks (e.g., Craighead et al. 2007; Hendricks and Singhal 2003). Unlike previous supply chain disruptions, such disruptions caused by long-term, large-scale catastrophic events such as the COVID-19 pandemic and ongoing geopolitical tensions have the potential to upend global supply chains (Sodhi and Tang, 2021). Although supply chain risk has been extensively studied in the literature since the early 2000s, the current approaches are not adequate to address the extreme conditions caused by large-scale, long-term supply chain disruptions (Sodhi and Tang, 2021). For small and short-term disruptions, one specific capability is often enough to enable firms to survive, such as using redundancy to deal with short-term supply disruptions. However, in extreme cases, one firm capability is inadequate to enable firms to successfully deal with the risks as multiple capabilities are required (Craighead et al. 2007; Flynn et al. 2021). Therefore, it is worthwhile to re-think supply chain risk under the extreme conditions.

Enhancing SCR is one of the top priorities to respond to supply chain disruptions (e.g., Shekarian and Mellat Parast, 2021). In the field of supply chain management, SCR is defined as the ability of a supply chain to return to normal operating performance, within an acceptable period, after being disturbed (e.g., Chowdhury and Quaddus, 2017). With the passage of time, considering the heterogeneity of capability requirements in different phases of disruptions, the phenomenon of defining SCR as a multi-phase term occurred. Ponomarov and Holcomb (2009, p.31) claimed that SCR refers to the ability of supply chains to "prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function". Similarly, Kamalahmadi and Parast (2016) proposed a conceptual framework for SCR, which describes SCR in three phases of pre-disruptions, during-disruptions, and post-disruptions. They provided an important theoretical basis for the definition of SCR in this study (see Figure 2).

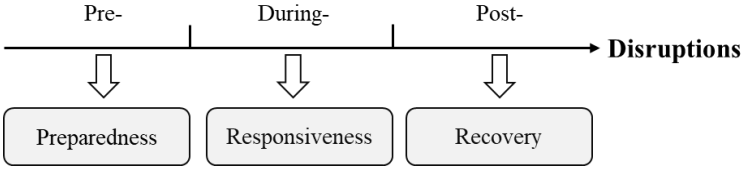


Figure 2. SCR in different phases

The existing literature has also extensively identified the key antecedents to SCR (see Table

2). SCR has been a popular topic in supply chain management research for a long time. In order to obtain comprehensive research information as much as possible, we mainly checked the related review articles. For example, Hosseini et al. (2019) outlined the key characteristics and enablers to improve SCR, including agility, visibility, flexibility, collaboration, and information sharing. As shown in Table 2, flexibility, agility, and collaboration have been widely discussed in previous studies, followed by redundancy and visibility.

Despite that the existing studies apply various approaches to explore the drivers to improve SCR, they do not consider the differences in SCR in the different phases of a long-term disruption event. To ensure operational continuity, it is worthwhile to re-think SCR when such extreme disruption occurs. Therefore, this study proposes to identify the key capabilities of OC retailers to develop SCR and examine the effects of such drivers on SCR in different phases (see the last row in Table 2).

Table 2 Summary of related SCR literature

Reference	Research methodology			Driver										Considering different phases of SCR	
	Qualitative	Empirical	Modeling	Agility	Collaboration	Digital capabilities	Flexibility	Information Sharing	Redundancy	Risk Management Culture	Risk and revenue sharing	Trust	Visibility	Yes	No
Kamalahmadi et al. (2022)			√				√		√						
Shekarian and Mellat Parast (2021)	√			√	√		√		√						√
Kumar et al. (2020)		√		√						√					√
Ivanov and Dolgui (2020)	√					√									√
Hosseini et al. (2019)	√			√	√		√	√					√		√
Ivanov et al. (2019)	√					√									√
Pettit et al. (2019)	√					√							√		√
Dubey et al. (2017, 2018)		√		√	√		√	√					√		√
Jain et al. (2017)		√		√	√	√	√		√	√	√	√	√		√
Kamalahmadi and Parast (2016)	√			√	√					√				√	
Tukamuhabwa et al. (2015)	√			√	√		√		√						√
Pettit et al. (2013)		√			√		√						√		√
Sheffi and Rice (2005)	√			√	√					√		√			√
Christopher and Peck (2004)	√			√	√		√		√	√					
This study		√			√		√		√					√	

3. Methodology

3.1 Research design

To answer the two questions on the "what" and "how", our study design comprises two consecutive stages (see Figure 3). In the first stage where we undertook a qualitative investigation, a comprehensive review of the literature on SCR drivers and OCR practice was conducted, to identify the key capabilities of OC retailers affecting SCR. Consequently, we established the conceptual model and developed the hypotheses based on the identification results. In the second stage, we performed empirical analysis of the survey data to examine the relationships between the critical capabilities and SCR in different phases of disruptions. Therefore, we adopt the sequential mixed methods that integrating qualitative and quantitative analyses to explore the novel phenomenon that OC retailers show resilience against disruptions.

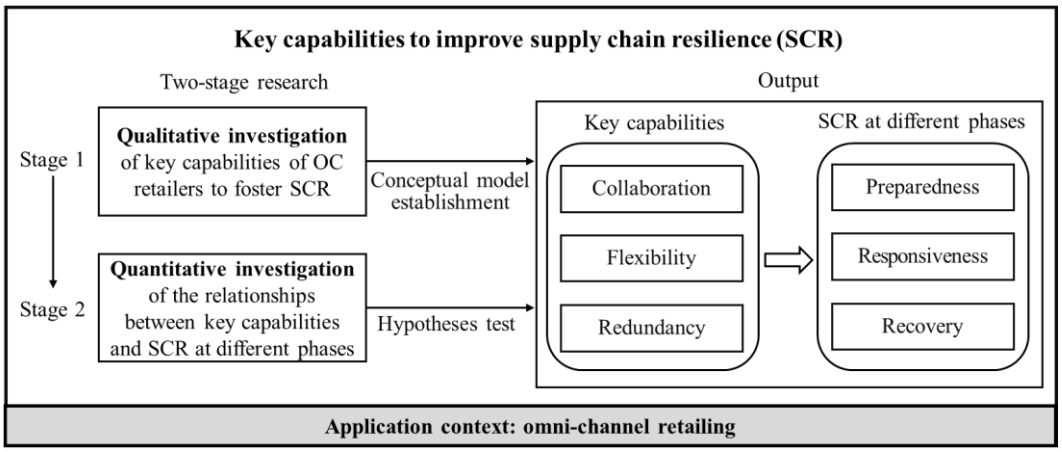


Figure 3. Research design

3.2 Research steps of stage 1

To collect the key capabilities that affect OC retailers' SCR, the process used to identify relevant articles followed the stages suggested by Srivastava (2007). First, the classification context of the literature analysis was OC structure capabilities to survive from supply chain disruptions. Second, the unit of analysis was defined as a single academic article published in an international peer-reviewed journal. Third, a keyword search of library databases was conducted. After obtaining the collection of target references, we identified the key capabilities of OC retailers, i.e., collaboration, flexibility, and redundancy, on the basis of in-depth review. Consequently, the conceptual model and hypotheses were developed according to the identified factors. The research steps in stage 1 are shown in Figure 4.

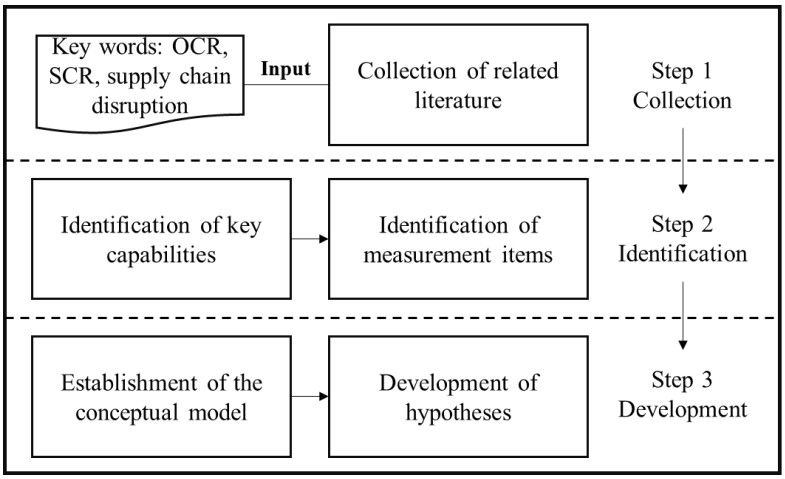


Figure 4. Research process of stage 1 (qualitative investigation)

3.3 Research steps of stage 2

Based on previous empirical studies (e.g., Brusset and Teller, 2017), our research steps include sample collection, a preliminary test, and a hypothesis test, as shown in Figure 5. Note that we used partial least squares structural equation modelling (PLS-SEM) to test the hypotheses. Our empirical study possesses the following characteristics: achieving high levels of statistical power with small sample sizes, handling complex models with many structural model relationships, and no causal loops are including in the structural model (Hair and Sarstedt, 2021). Therefore, PLS-SEM is suitable for the empirical analysis of our study.

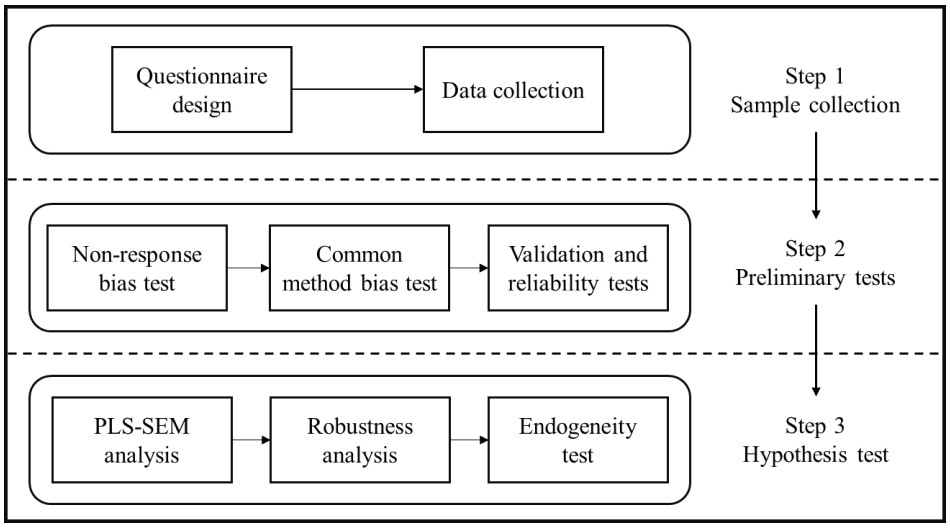


Figure 5. Research process of stage 2 (quantitative investigation)

4. Stage 1: qualitative investigation

4.1 Identification of key capabilities

Through seeking keywords and strings, i.e., “omni-channel retail” & “supply chain resilience”, “omni-channel retail” & “supply chain disruptions”, in publication titles and abstracts, and limiting the search period to 2017 to 2022, a number of relevant papers were found. To ensure that the central theme was highly relevant and the selected papers could provide abundant theoretical

analysis and practical examples, we reviewed the whole content of each paper. Finally, eight key reference papers were selected. On the basis of an in-depth examination of the useful information derived from these papers, the key capabilities of OC retailers and their measurements were identified as shown in Table 3.

Collaboration. Retailers with the OC structure tend to achieve greater trust and collaboration among the business partners, maximizing the benefit-cost ratio and increasing the safety of all the business processes (Sousa et al., 2021). First, the OC structure is an integrated database of inventory and consumer information across all the channels (Adivar et al., 2019). For example, in JD.com's integrated supply chain, information is shared within the company due to a high degree of collaboration, not only that, JD.com collects consumer feedback and shares information with suppliers, which can quickly identify disruptions and effectively adjust the operational strategies for procurement, distribution, and promotion. Second, sharing inventory and facilities is the other main part of OC retailers' collaboration practice. For example, OC retailers shorten delivery times and provide products timely even during disruptions by sharing inventory and logistics facility resources with supply chain partners, e.g., Amazon and *P&G* share facilities, and Zalando and Adidas Group share inventory. Last, joint operations enable OC retailers to collect real-time information on the market and make optimal decisions. For instance, working with suppliers through the Supplier Portal, *Delta* can effectively monitor product flow and coordinate activities with real-time visibility.

Flexibility. OC retailers invest in removing silos within the organization to integrate products, information, and facilities across different channels to ensure a uniform vision, leading the improved flexibility in operating their OC business (Lim and Srai, 2018). First, OC retailers can easily change the product assortment. For example, several OC retailers allow the consumer to add, delete and/or change product features and to request alterations in delivery points as well as delivery time windows (Sorkun et al., 2020). Second, the flexibility of their distribution networks allows OC retailers to provide consumers with various delivery options, e.g., buy online & instant delivery, order in-store & home delivery (Lin et al., 2022). Another example is when inventory in a specific channel is not available when the disruption event occurs, OC retailers can find available inventory of the same product from other channels to fulfill consumer orders. Flexible allocation of delivery resources is also achieved by OC retailers. A successful case of flexibility is Aurora Fashions, which realized that 91% of online orders could be delivered in less than 90 minutes from local stores through flexible arrangement of last-mile delivery staff.

Redundancy. The high integration across multiple channels in the OC structure creates redundancy that can be flexibly used for various purposes when needed (Zhang et al., 2021). In a stable market environment, such redundancy resource is used for common value-added activities, such as flexibly meeting customer needs across online and offline channels, while when market conditions are turbulent, it can be quickly mobilized to deal with fluctuations in supply and demand and to protect the business from disruptions. Summarily, we identify three types of redundancy of OC retailers. The first type is back-up suppliers. To reduce the delivery cost, improve delivery efficiency, and be close to demand zones, OC retailers tend to choose multiple suppliers to provide the same product, such as *Delta* in Lim et al. (2018). The second type is buffer stock, owing to the demands faced by each supply node in the OC structure are diverse and dynamic. For example, Gamma Company in Sousa et al. (2021), typically adopted relatively conservative stock coverage to minimize stock disruptions. The third type is excess logistics

capacity. To avoid discontinuity, OC retailers' distribution networks are usually decentralized and multi-set covering. For example, Amazon's information infrastructure allows small retailers to use an alternate warehouse for fulfillment if a particular item is not available in the nearest warehouse (Chopra et al., 2021).

Table 3 List of identified firm capabilities and their measurement items

Key capability	Measurement item	Reference
Collaboration	Information and data	Shen et al. (2021), Sousa et al. (2021), Adivar et al. (2019); Lim and Srai (2018)
	Inventory and logistics facilities	Chopra et al. (2021) ; Sousa et al. (2021); Lim and Srai (2018)
	Operations	Chopra et al. (2021) ; Sousa et al. (2021); Lim and Srai (2018)
Flexibility	Product	Sousa et al. (2021)
	Fulfillment	Lin et al. (2022) ; Zhang et al. (2021); Sorkun et al. (2020)
	Delivery resource	Zhang et al. (2021); Lim and Srai (2018)
Redundancy	Back-up supplier	Lim and Srai (2018)
	Buffer stock	Sousa et al. (2021)
	Excess logistics capacity	Chopra et al. (2021) ; Sousa et al. (2021); Zhang et al. (2021)

4.2 Establishment of the conceptual model

As a theoretical extension of RBV, DCV reveals unique and difficult-to-replicate dynamic capabilities to create sustainable competitive advantage for firms in rapidly and unpredictably changing dynamic market (Teece et al., 1997). The basic assumption of DCV is that organizations with higher dynamic capabilities will demonstrate superior performance and vice-versa. These dynamic capabilities were elaborated in Teece (2007), which summarize as follows: (1) sensing opportunities and threats, (2) seizing opportunities, and (3) managing threats and reconfiguration when necessary. Firms obtain dynamic capabilities through organizational skills, processes, procedures, and disciplines etc., in order to be able to create, deploy, and protect the intangible assets that support superior long-run business performance.

By incorporating DCV (Teece, 2007), SCR and OCR, and the findings from our qualitative study (stage 1 investigation), we develop the conceptual model in Figure 6. DCV provides a strong theoretical basis for our study. First, based on DCV, SCR is an output indicator that can be understood as "performance outcome" (Brandon-Jones et al., 2014), which depends on various firm capabilities, such as collaboration, flexibility, and redundancy. Second, DCV provides insight on the mechanism of how OC retailers' capabilities lead to SCR, i.e., OC retailers develop dynamic capabilities that enable them to sense, grasp, and reconfigure through such key capabilities, consequently effectively and efficiently identify, prevent, resist, and recover from disruptions. Last, DCV claims that dynamic capabilities are especially important when organizations face considerable uncertainty because they must sense and plan to overcome the challenges posed by these risks. Therefore, DCV is suitable for the research setting of our study.

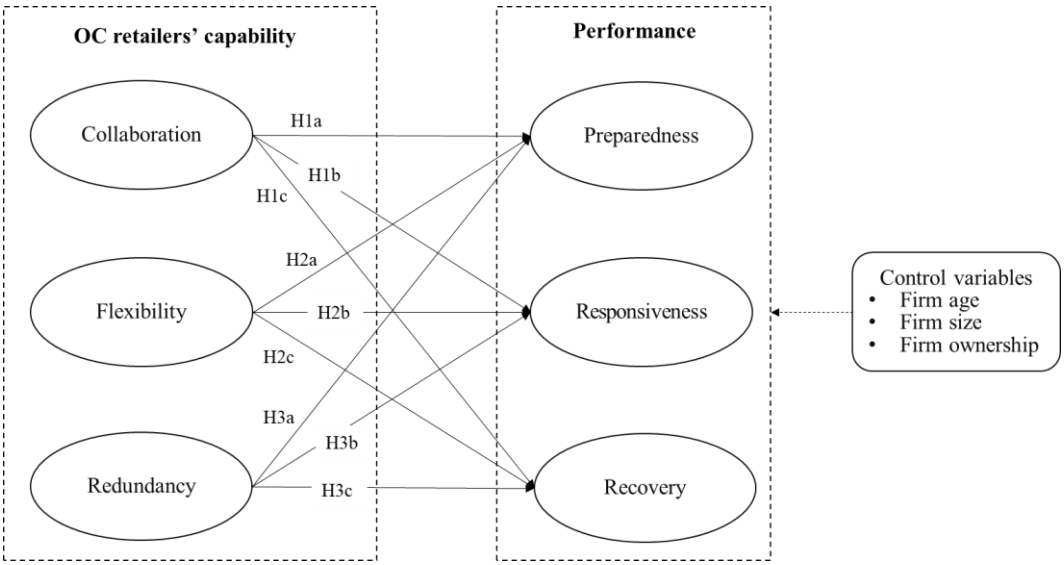


Figure 6. Conceptual model

4.3 Hypothesis development

4.3.1 The relationships between collaboration and SCR in different phases

Collaboration across channels and along the supply chain provides an opportunity to develop dynamic capabilities, consequently helping OC retailers foster SCR (Teece, 2007; Brusset and Teller, 2017). First, when OC retailers share real-time data of different channels and implement joint decision-making with their supply chain partners, they can collect comprehensive information about the current business ecosystem. This enables OC retailers to forecast, identify, and assess risks, sensing the early warning signal to prepare for disruption mitigation (Jain et al., 2017).

Second, sharing information and joint operations across channels and with OC retailers' supply chain partners can ensure the visibility of the supply chain, which allows them to align their supply chains with changing circumstances during disruptions. For example, JD Fresh extensively coordinated with over 300 suppliers and over 30 warehouses across China to effectively respond to the surging demand for fresh products (Shen et al. al., 2021).

Third, in the post-disruptions phase, a high level of collaboration across channels and among supply chain partners helps OC retailers view the environmental dynamics, analyze changeable scenarios in real time, and nurture innovative solutions to address post-disruption challenges, consequently maintaining business continuity. For example, the in-depth collaboration between OC retailers and their 3PLs allows the quick recovery of order fulfillment, and close collaboration with upstream suppliers allows OC retailers to have timely information on the supply process and reasonably allocate resources, eventually ensuring recovery of product availability. Thus, we develop the following hypotheses:

H1a. OC retailers' collaboration fosters preparedness in the pre-disruptions phase.

H1b. OC retailers' collaboration fosters responsiveness in the during-disruptions phase.

H1c. OC retailers' collaboration fosters recovery in the during-disruptions phase.

4.3.2 The relationships between flexibility and SCR in different phases

The SCR literature claims that flexibility enables firms to adapt to changes in the competitive environment quickly and cost-effectively (Hosseini et al., 2019). First, flexibility-oriented firms are more able to sense disruptions early, allowing them to be fully prepared for identified threats (Lee and Rha, 2016). Moreover, flexible product attributes and fulfillment methods imply near decomposability, allowing organizations to effectively and efficiently coordinate or integrate available resources to prepare for possible disruption events (Teece, 2007).

Second, the role of flexibility is significant in reconfiguration and realignment during disruptions. For example, based on real-time outbreak scenarios, JD.com could allocate resources to areas with large demand gaps and flexibly cover regional variations, such as using the distribution centers (DC) in Beijing, Shanghai, Guangzhou and Xi'an to fulfill orders that should have been operated by the DC in Wuhan, which improved delivery performance by about 9.26% and reduced costs by more than 3% (Shen et al., 2021).

Third, flexible processes and resources can not only improve day-to-day work but also help rapidly redesign supply chains to reduce the impact of disruptions and facilitate recovery (Sorkun et al., 2020). Walmart adopted integrated management of its website and retail stores, allowing it to pivot store sales during COVID to online ordering and curbside pickup (Chopra et al., 2021). Several OC retailers adjusted their product assortment in response to market changes caused by the pandemic, such as increasing the inventory of personal protective equipment to meet growing consumer demand. Thus, we develop the following hypotheses:

H2a. OC retailers' flexibility fosters preparedness in the pre-disruptions phase.
H2b. OC retailers' flexibility fosters responsiveness in the during-disruptions phase.
H2c. OC retailers' flexibility fosters recovery in the during-disruptions phase.

4.3.3 The relationships between redundancy and SCR in different phases

The OC structure creates redundancy for retailers because multiple channels themselves and resources belonging to different channels can be substituted for one another (Zhang et al., 2021). First, before the disruption occurs, the redundancy caused by the integrated management of multiple channels helps OC retailers cope with daily demands and supply fluctuations (Chopra et al., 2021), as well as preparing them for potential disruption risks. For example, Amazon and Target widely set up stock and delivery resources in different channels to improve order acceptance and fulfillment efficiency during normal times, which also allow them to obtain back-up resources in a timely manner when a specific channel is interrupted.

Second, redundancy, such as buffer stocks and warehousing capacity, can act as short-term "shock absorbers" for supply chain disruptions, ensuring continuity of their operations (Sausa et al., 2021). For example, when Amazon had to shut down a warehouse because of the pandemic, the integrated management in the OC structure provided alternate warehouses and delivery services to serve the customers who were served by the affected warehouse.

Third, redundancy can help OC retailers smoothly transition to normal operations in the shortest time possible after a disruption, ensuring continuity of operations (Sorkun et al., 2020). For example, *Next* worked with Aviva to set up three spare warehouses in Yorkshire in the form of a lease agreement to remain resilient and keep business running after the disruption caused by the pandemic (Walton, 2020). Thus, we develop the following hypotheses:

H3a. OC retailers' redundancy fosters preparedness in the pre-disruptions phase.

H3b. OC retailers' redundancy fosters responsiveness in the during-disruptions phase.

H3c. OC retailers' redundancy fosters recovery in the during-disruptions phase.

4.3.4 Control variables

Previous studies and reports have shown that SCR can vary across firms (Nikookar and Yoshio, 2021). To avoid spuriousness and enhance confidence in our findings, we use firm characteristics as control variables, including firm age, size, and ownership. Theoretically, these three variables affect SCR as follows. Large firms tend to have access to more resources that enable them to be more resilient to supply chain disruptions. A firm with a greater age is expected to create a higher level of risk management, while the level of such management increases with accumulation of experience. In the socialist market economy of China, firm ownership has a significant effect on development, so we consider the effect of firm ownership (as a control variable) on SCR.

5. Stage 2: quantitative investigation

5.1 Questionnaire design

Stage 1 research provides the measurement approach of the three key competencies of OC retailers. Measurements on SCR are mainly based on well-established scales from the literature and we modify them based on the characteristics of the OCR business, ensuring the reliability and validity of our measurements. Noting that SCR of this study is divided into three aspects, preparedness pre-disruptions (PRE), responsiveness during-disruptions (DR), and recovery post-disruptions (POST).

The measurement scales are Initially in English, based on the original literature. Then, we design our questionnaire in Chinese because our study focuses on the Chinese market. In this regard, we invite knowledgeable professors in this field to review the questionnaire and improve its reliability. Table A1 in the Appendix lists all the items of the constructs. Except for the control variables, all scales are assessed on a 5-point rating scale with 1 = strongly disagree and 5 = strongly agree.

5.2 Data collection

We conduct an empirical study on the Chinese retail market. The Chinese market has matured into one of the world's largest and consistently growing consumer markets, with total retail sales of consumer goods of approximately 44.08 trillion CNY, including 13.09 trillion CNY from e-commerce, in 2021 (National Bureau of Statistics, 2021). Moreover, the OCR wave has rapidly transformed the retailing business in China through digitalization, sensory marketing, and numerous innovative components (Mckinsey, 2020). Hence, the Chinese market provides an appropriate setting for our empirical study.

We take the database for this study from the China General Chamber of Commerce (CGCC). After communication with the CGCC about the research objectives and types of firms to be investigated, we obtained a list of 700 retailers (as potential interviewees) that are registered members of CGCC and have pursued OCR. Before conducting the survey, we carried out pilot tests, with interviews of three experts in supply chain management and three practitioners in retail operations, after which we made necessary modifications to the questionnaire based on their

feedback.

To acquire the sample data, we ran a multi-respondent survey. The main reason is that the survey questions are multi-faceted, and selecting numerous suitable respondents allows us to successfully eliminate the subjective bias induced by a single respondent while also ensuring alignment between the research questions and the suitable respondent. In the beginning, we emailed a survey invitation to possible interviewees and asked them to choose a coordinator as the contact person and assist in identifying eligible responders for the questionnaire (e.g., supervisors, managers, and direct laborers with knowledge or experience regarding the specific questions). We asked that the coordinator have been with the organization for at least five years and be SCM specialists. Each questionnaire came with a cover letter that introduced the research endeavor and guaranteed anonymity. We obtained 225 usable questionnaires after administering the e-questionnaire over a four-week period (from November 1 to 28, 2021), generating a 32.1% response rate at the firm level, with at least three respondents in each questioned organization completing the questionnaire. Table 4 summarizes the characteristics of our sample retailers, demonstrating that the sample is diverse in terms of firm age, firm size, firm ownership, and SKU. Given that most Chinese industries have progressively resumed work and output from the second half of 2020, the post-pandemic age with regular pandemic prevention and control can be regarded as the“"post-disruption”" phase discussed in this study.

Table 4. Profile of the sample firms

Demographic characteristic	Number (n = 225)	Percentage
Age of firm (years)		
< 5	5	2.2%
5–10	11	4.9%
11–15	71	31.6%
16–20	99	44.0%
> 20	39	17.3%
Annual turnover (millions of RMB)		
< 50	43	19.1%
50–100	30	13.4%
100–200	29	12.9%
200–2,000	48	21.3%
> 2,000	75	33.3%
Firm ownership		
State-owned	86	38.2%
Local private	116	51.6%
Foreign	8	3.5%
Joint venture	15	6.7%
SKU		
< 500	105	46.7%
500–1,000	42	18.7%
1,000–5,000	18	8.0%
5,000–10,000	10	4.4%
> 10,000	50	22.2%

Number of respondents per sample firm		
3	102	45.3%
4	98	43.6%
5	25	11.1%

5.3 Preliminary tests

5.3.1 Non-response bias test

The possible non-response bias is tested by comparing the late third (49 in total) versus the early third (74 in total) respondent firms, along with their firm characteristics, i.e., firm age, annual turnover, ownership, and responses to measurement items of the latent constructs. The results of both the *t*-test and the chi-square test on these items are not significant ($p > 0.05$), so non-response bias caused by random filling of respondents is not deemed to be present in the dataset. The overall result of the Kaiser-Meyer-Olkin (KMO) test is 0.895 and the Bartlett's test for sphericity shows a satisfactory result, indicating that the data set is suitable for factor analysis.

5.3.2 Common method bias test

While multi-respondent surveys can reduce random and systematic errors to some extent, common method bias (CMB) is probably the most troublesome. To examine and eliminate the negative impact of CMB, we did the following work. First, exploratory factor analysis shows six factors accounting for 75.9% of the cumulative variance, while the first factor accounts for only 21.6%. Meanwhile, the single-factor model through confirmatory factor analysis (CFA) shows the unaccepted fit indices. Thus, the Harman's one-factor test shows that CMB is not an issue (Craighead et al., 2011). Second, we applied the CFA-MTMM procedure, as an extension of the traditional multitrait-multimethod (MTMM) proposed by Campbell and Fiske (1959), to further test CMB. We used the occasion-based method to divide the 225 responses into three groups equally according to the questionnaire return time. According to Craighead et al. (2011) and Lance et al. (1993), the results indicate that CMB could not pose a threat (see Appendix Table A2).

5.3.3 Validity and reliability tests

In this study we mean-center the variables to mitigate the effects of multicollinearity, outliers, and non-normality. First, the highest value of VIF is 3.158, showing that multicollinearity is not a concern. Second, the values of composite reliability (CR) and Cronbach's α of all of the constructs are greater than the expected threshold of 0.8, ensuring the reliability and internal consistency of the scales and constructs (see Table 5). Third, the results in the Appendix Table A1 indicate that the outer loadings of CFA are between 0.846 and 0.952 ($p < 0.001$), showing the presence of convergent validity. In addition, both the Fornell-Larcker criterion, i.e., all the inter-construct correlations are lower than the square root of the average variance extracted (AVE) for each factor, and the Heterotrait-monotrait ratio (HTMT) < 0.850 (Henseler et al., 2016) demonstrate discriminant validity (see Table 5). We also tested the outer weights of the indicators on their constructs, i.e., the extent to which the construct is explained by each of its indicators (see Appendix Table A1). The findings ensure that all the paths are significant at $p < 0.001$. We discuss the implications of these results in the discussion section.

Table 5. Convergent validity, composite reliability, and discriminant validity

Variable	1	2	3	4	5	6
1. Collaboration	**0.884**					
2. Flexibility	0.649 (0.693)	**0.885**				
3. Redundancy	0.628 (0.764)	0.656 (0.712)	**0.863**			
4. Preparedness	0.663 (0.678)	0.532 (0.662)	0.611 (0.730)	**0.927**		
5. Responsiveness	0.513 (0.747)	0.399 (0.718)	0.568 (0.784)	0.630 (0.765)	**0.913**	
6. Recovery	0.583 (0.684)	0.436 (0.646)	0.501 (0.720)	0.549 (0.703)	0.629 (0.760)	**0.914**
Mean	3.788	3.893	3.707	3.536	3.619	3.773
SD	0.831	0.780	0.943	0.930	0.883	0.838
Cronbach's α	0.861	0.862	0.829	0.918	0.901	0.901
CR	0.915	0.916	0.898	0.948	0.938	0.938

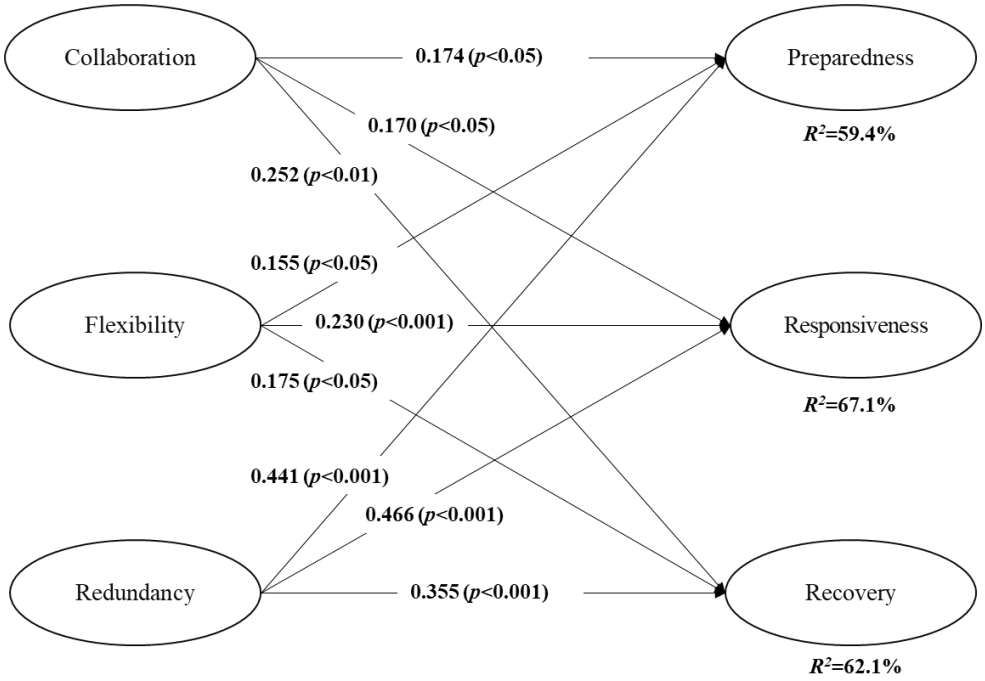
Note: The square root of the average variance extracted (AVE) values are shown in the diagonal. The correlation matrix for the constructs is shown below the diagonal and HTMT ratio are in parentheses.

5.4. Hypothesis testing

5.4.1 PLS-SEM analysis

We apply the PLS-SEM analysis with a bootstrapping option, in which 5,000 random observations with replacements are generated from the dataset. We show the results of the path analysis in Figure 7. Three capabilities explain 59.4% of the variance of the OC retailer's preparedness, and 67.1% and 62.1% of the variance in responsiveness and recovery, respectively. The tests reveal that all the direct relationships are positively significant, so hypotheses H1a-H1c, H2b-H2c, and H3a-H3c are supported, except for H2a, which is moderately supported ($\beta\_preparedness = 0.155$, $p < 0.1$) (see Table 6). The results also show that the proposed structural model adequately meets the model fit criteria, predictive relevance, and unobserved heterogeneity (Henseler et al., 2016), with a goodness of fit (GoF) value of 0.593, a standardized root mean square residual (SRMSR) value of 0.029, a normed fit index (NFI) value of 0.938, and $Q^2 > 0.400$. For the PLS-SEM approach that we deploy in our study, according to Tenenhaus et al. (2005), the goodness of fit (GoF) value is defined as the geometric mean of the average communality and average R^2 of the endogenous constructs. Based on this definition, Wetzels et al. (2009) derived the following GoF criteria: $GoF_{small} = 0.100$, $GoF_{medium} = 0.250$, and $GoF_{large} = 0.360$. Therefore, the GoF value in our study is acceptable.

Moreover, for the control variables, firm age positively impacts SCR in different phases ($\beta\_preparedness = 0.231$, $p < 0.001$; $\beta\_responsiveness = 0.230$, $p < 0.001$; $\beta\_recovery = 0.214$, $p < 0.01$), while firm size only positively affects preparedness ($\beta\_preparedness = 0.096$, $p < 0.05$). However, the relationship between firm ownership and SCR is statistically non-significant.



Note: All *R* square values are in percentages.

Figure 7. Tested model

Table 6. Summary of the results

	PLS-SEM			Robust regression			Results
	β	SD	*t*-value	*β*	SD	*t*-value	
H1a: Collaboration→ Preparedness	0.174*	0.086	2.020	0.205*	0.088	2.331	Supported
H1b: Collaboration→ Responsiveness	0.170*	0.073	2.317	0.175*	0.076	2.309	Supported
H1c: Collaboration→ Recovery	0.252**	0.086	2.935	0.263**	0.079	3.305	Supported
H2a: Flexibility→ Preparedness	0.155	0.081	1.921	0.158	0.084	1.880	Moderately supported
H2b: Flexibility→ Responsiveness	0.230***	0.068	3.386	0.246***	0.072	3.409	Supported
H2c: Flexibility→ Recovery	0.175*	0.085	2.064	0.150*	0.076	1.983	Supported
H3a: Redundancy→ Preparedness	0.441***	0.081	5.424	0.424***	0.092	5.702	Supported
H3b: Redundancy→ Responsiveness	0.466***	0.071	6.614	0.478***	0.079	6.052	Supported
H3c: Redundancy→ Recovery	0.355***	0.082	4.325	0.362***	0.083	4.361	Supported

Note: The *t*-value and *p*-values are calculated by applying a bootstrapping procedure with 5,000 samples. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

We then conducted a slope test to further examine the relationships between the significant control effects and SCR (see Figure 8). For firm age, we divided the samples into two categories: high (>10 years) and low (⩽10 years). Likewise, the retailers were classified into high (>200M) and low (⩽200M) scales based on firm size. We illustrated two-way controlling effects in Figure 8, which indicates that the higher the age of a retailer, the better is its SCR in all phases, while the larger retailers have better preparedness than their smaller counterparts.

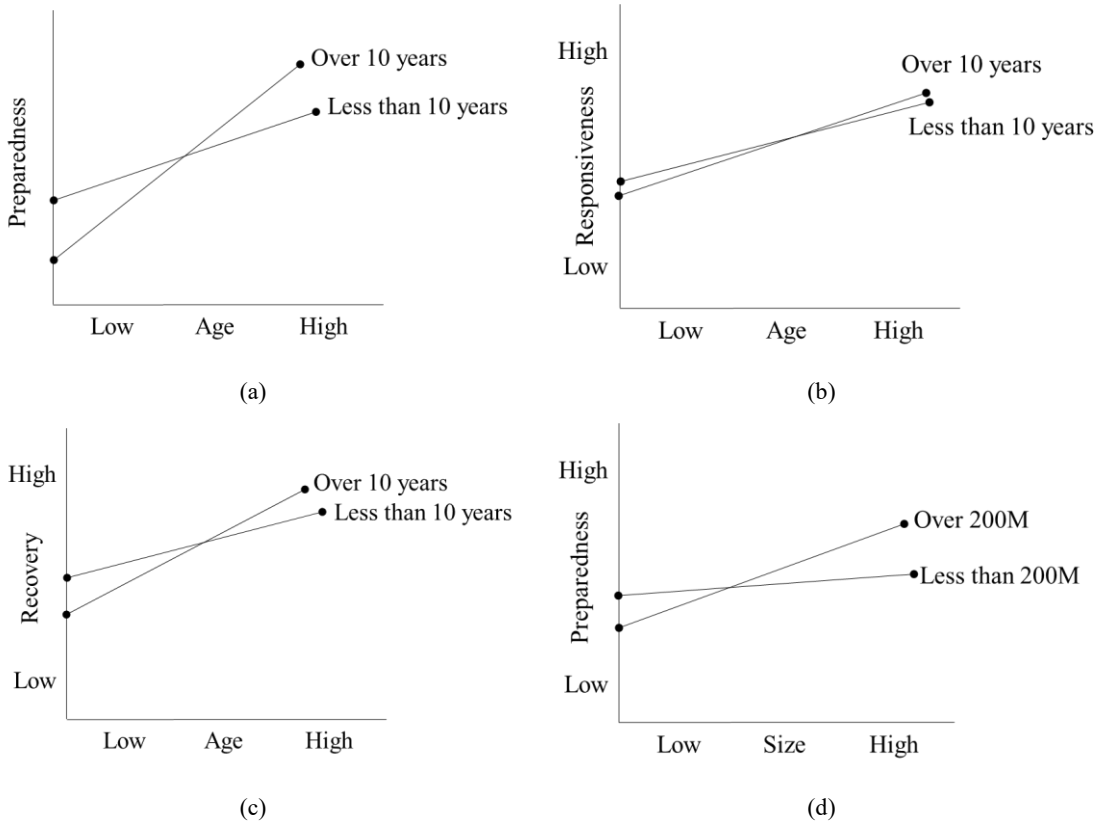


Figure 8. Slope test

5.4.2 Robustness analysis

To verify the robustness of the findings, we chose robust regression (*M*-estimators) to re-conduct the hypotheses testing as it can avoid being unduly affected by the assumptions violated by the underlying data generation process, and the *M*-estimators are considered as a useful tool to avoid data imperfections and ignore outliers. OC retailers' three capabilities are the independent variables in the regression model, while the three phases of SCR are the dependent variables. As shown in Table 6, all of the hypotheses testing results are consistent with PLS-SEM.

5.4.3 Endogeneity tests

Given that our study's design is non-experimental, simultaneity (reverse causality) and omitted variables could be a source of endogeneity. Hence, we addressed this concern by introducing the two-stage least squares (TSLS) method. Considering that an instrumental variable (IV) should be correlated with the independent variable but weakly correlated with the dependent variable (Wooldridge, 2009), after the correlation test shown in Table 7, we applied the level of omni-channel integration (OCI) as the instrumental variable. OCI is measured by the level of pricing integration, fulfillment integration, inventory integration, and return integration (Yrjölä et al., 2018). However, the only relevant literature, Zhang et al. (2021), claimed that the OCR strategy improves the information processing ability of the OC retailer, consequently enhance its SCR. As a result, the study argues that OCI improve SCR through increasing OC retailers' collaboration, flexibility, and redundancy after channel integration, rather than directly acting on their SCR.

Table 7. Correlation test

Independent variable	Pearson correlation		Dependent variable	Pearson correlation	
	Coefficient	*p*-value		Coefficient	*p*-value
Collaboration	0.262	0.028	Preparedness	0.239	0.094
Flexibility	0.153	0.022	Responsiveness	0.152	0.291
Redundancy	0.339	0.016	Recovery	0.207	0.150

There were three steps in the endogeneity test. First, we conducted Hansen's *J* test to measure the IV's appropriateness. In this regard, the result of $p > 0.05$ indicates the validity of the IV. Second, we used OC retailers' capabilities as the explanatory variables, OCI as the IV, and different phases of SCR as the explained variables for the TSLS method. All correlations are consistent with those in Table 8. Third, the results of Durbin-Wu-Hausman (DWH) test are not significant, indicating that the variables can be considered exogenous (see Table 8). Therefore, we conclude that the findings are robust, and this study does not suffer from potential biases caused by endogeneity.

Table 8. Endogeneity tests

	Preparedness		Responsiveness		Recovery	
	β	DWH test	*β*	DWH test	*β*	DWH test
Collaboration	0.489 (*p*=0.049)	$p > 0.05$	0.667 (*p*=0.003)	$p > 0.05$	0.581 (*p*=0.009)	$p > 0.05$
Flexibility	1.102 (*p*=0.091)	$p > 0.05$	1.504 (*p*=0.036)	$p > 0.05$	1.309 (*p*=0.045)	$p > 0.05$
Redundancy	0.559 (*p*=0.004)	$p > 0.05$	0.763 (*p*=0.001)	$p > 0.05$	0.664 (*p*=0.007)	$p > 0.05$

6. Discussion and implications

Observing that OC retailers showed strong resilience during the COVID-19 pandemic, we adopt the sequential mixed methods research methodology to conduct a two-stage investigation to study this novel phenomenon. In the stage 1, we identify three critical capabilities that allow OC retailers to foster SCR, namely collaboration, flexibility, and redundancy. In the stage 2, through the lens of DCV, we test the relationships between OC retailers' capabilities and SCR in different phases of disruptions. Our major findings and their implications are as follows.

6.1 Discussion of main findings

6.1.1 The positive effect of collaboration on SCR

In line with the extant SCR literature, collaboration positively impacts SCR in all three phases of disruptions (e.g., Dubey et al., 2018). Based on DCV, collaboration enables OC retailers to search for comprehensive information within the supply chain and have easier access to the required resources, thereby improving their ability to sense disruptions early, enabling them to quickly respond and recover (Brusset and Teller, 2017). From the profile of the sample firms (see Table 4), nearly 65% the respondents have fewer than 1,000 SKUs, implying that they are very simple supply chains. Thus, such OC retailers are likely to collaborate effectively at a lower transaction cost, with corresponding less complexity in the preparedness, responsiveness, and recovery phases. Moreover, the positive impact is greatest in the phase of recovery (0.252), which provides new insight to the existing SCR literature. As shown in Appendix Table A1, the construct of

collaboration in this paper is mainly explained by jointly managed inventory (outer weight = 0.539, $p < 0.001$). As supply chain members directly facing the end consumers, OC retailers' inventory availability is the cornerstone of operational continuity. Hence, sharing inventory with supply chain partners enables OC retailers to quickly obtain inventory and resume normal operations.

6.1.2 The positive effect of flexibility on SCR

The results show that OC retailers' flexibility significantly and positively affects responsiveness and recovery, which are consistent with by prior studies (Lee and Rha, 2016), while flexibility only moderately and positively affects preparedness. Based on DCV, flexibility enables OC retailers to reconfigure and realign quickly, thereby increasing their dynamic capability of managing threats, so allowing them to respond and recover more efficiently. Moreover, flexibility has a higher impact on responsiveness (0.230) than recovery (0.175), which is also consistent with real practice. Flexibility allows OC retailers to flexibly allocate and quickly adjust available resources in line with changes in supply and demand during disruptions, such as using physical stores to fulfill online orders during the lockdowns. Moreover, the finding that the most significant effect of flexibility on responsiveness can be explained from the viewpoints of previous studies, according to which flexibility is a kind of reactive capability in the response and recovery phases, instead of preparing for or withstanding unexpected events.

6.1.3 The positive effect of redundancy on SCR

The results confirm the positive relationships between OC retailers' redundancy and SCR at the three phases, and its positive effects are greater than collaboration and flexibility. As stated by Shekarian and Mellat Parast (2021), building redundancy is an effective means to create resilience and mitigate disruption risks. A highly integrated OC structure creates redundancy resource, allowing retailers to shift to other channels for order delivery when one sale channel is unavailable, which enables OC retailers to improve their order response rates and delivery service rates during normal times, as well as maintaining continuous operations after disruptions. Specifically, the impact is greatest on responsiveness (0.466). It is because during the response phase, OC retailers' redundancy provides the foundation for executing the response plans, such as providing delivery resources for flexible shifts among multiple fulfillment options, and available store stocks to meet surging online demand.

6.1.4 The effect of control variables on SCR

There are some interesting insights concerning the control variables, i.e., firm age, size, and ownership. According to Table 4, more than 90% of the sample retailers have been in business for more than ten years. When compared to younger retailers (i.e., less than ten years in business), they tend to be better at dealing with disruption and building resilience, which is consistent with previous research. It is worth mentioning that the growth of responsiveness in the younger group and the older group is similar. It happens because responsiveness in this study is mostly tied to the organization's decision-making speed and execution competence. Young retailers can increase their responsiveness during disruptions as long as they have a stable and efficient operating system.

Firm size positively impacts preparedness, since large retailers with stronger financial strength and supply chain power tend to make adequate preparations, e.g., adopting big data,

artificial intelligence, and other advanced technologies to monitor and predict potential supply chain disruptions. Meanwhile, the finding that firm size does not affect responsiveness and recovery is contradictory to that in manufacturing. Given that that approximately 70% of Chinese retailers implement mature risk management strategies (China Chain Store & Franchise Association, 2020), most retailers have successfully embedded risk management into their organizational cultures to ensure SCR, so they show similar levels of responsiveness and recovery, regardless of firm size.

6.2 Main implications

6.2.1 Theoretical implications

The primary theoretical implications of this study are threefold.

(1) This study advances knowledge in the advantages of the OCR strategy, i.e., in addition to financial and operational benefits, the OCR strategy can implicitly foster SCR that enables OC retailers to respond to large-scale, long-term supply chain disruptions.

(2) Through linking OCR and SCR, our pioneering research systematically explains why OC retailers have SCR, despite that they did not consider disruption risk when they developed multiple channels. Specifically, this study identifies the key capabilities of OC retailers in fostering SCR, i.e., collaboration, flexibility, and redundancy.

(3) This study confirms the positive impacts of the key capabilities on SCR, which is in line with the existing literature that focused on supply chain disruptions (e.g., Kumar and Anbanandam, 2020). Differently, considering the dynamic process of such long-term disruptions, this study defines SCR as a multi-phase concept and comprehensively identifies the roles of different firm capabilities in SCR in different phases, i.e., preparedness, responsiveness, and recovery.

6.2.2 Practical implications

The study findings offer valuable insights for practitioners and are summarized as follows:

(1) This study provides a roadmap for OC retailers to craft a capability portfolio to heighten their SCR, based on the differences in the positive effects of the key capabilities, e.g., flexibility and redundancy are more important in the response phase, while collaboration is more important in the recovery phase.

(2) This study motivates OC retailers to pay more attention to redundancy. Practices corresponding to redundancy should be encouraged, such as buffer stock and multiple suppliers, which are straightforward and effective solutions for managing supply chain risk in today's increasingly turbulent and unpredictable marketplace.

(3) This study proves the advantages of OC retailers in cultivating SCR, so enhancing the confidence of traditional retailers and pure online players to adopt the OC strategy. The pursuit of OCR allows retailers to become resilient without the need for special investment in building SCR in practice.

7. Conclusion, limitations, and future research

We conduct a two-stage investigation to study why OC retailers show SCR. Identifying three key capabilities of OC retailers to foster SCR, namely collaboration, flexibility, and redundancy, we validate their relationships based on data from 225 OC retailers in China. The results show that the

three key capabilities of OC retailers do foster SCR to varying extents.

There are also some limitations. First, the respondents in this study are OC retailers who do business in the Chinese market, and the average operating duration is relatively long (i.e., more than 10 years), so the findings may be biased towards a specific supply chain and market. We propose that future studies use other respondents with varied characteristics to replicate or contrast our findings. Second, we do not differentiate between different sub-sectors and supply chain stages, even though it might yield additional insights. Third, in the context of OCR, there are other important capabilities, e.g., digitalization, which may affect the level of SCR (Flynn et al., 2021). Therefore, future research should include more potential capabilities in the conceptual model to further explore the link between OCR and SCR and produce additional findings.

Acknowledgment

This work was supported by the Fundamental Research Funds for the Central Universities under (Grant number 2021YJS062); the Fundamental Research Funds for the Central Universities (Grant number 2019JBM111); the China Scholarship Council under (Grant number 202107090046). This research was also supported by Beijing Laboratory of National Economic Security Early-warning Engineering, Beijing Jiaotong University.

Disclosure statement

No potential conflict of interest was reported by the authors.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to the privacy.

References

Adivar, B., Hüseyinoğlu, I.Ö.Y. and Christopher, M. (2019) A quantitative performance management framework for assessing omni-channel retail supply chains. *Journal of Retailing and Consumer Services*, 48, 257-269.

Bag, S., Rahman, M.S., Srivastava, G., Chan, H.L. and Bryde, D.J. (2022) The role of big data and predictive analytics in developing a resilient supply chain network in the South African mining industry against extreme weather events. *International Journal of Production Economics*, 251, Article 108541.

Brandon-Jones, E., Squire, B., Autry, C.W. and Petersen, K.J. (2014) A contingent resource-based perspective of supply chain resilience and robustness. *Journal of Supply Chain Management*, 50(3), 55-73.

Brusset, X. and Teller, C. (2017) Supply chain capabilities, risks, and resilience. *International Journal of Production Economics*, 184, 59-68.

Campbell, D.T. and Fiske, D.W. (1959) Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin*, 56, 81-105.

China Chain Store & Franchise Association. (2020) China retail risk management report. available at: http://www.ccfa.org.cn/portal/cn/xiangxi.jsp?id=442414&type=33.

Chopra, S., Sodhi, M. and Lücker, F. (2021) Achieving supply chain efficiency and resilience by using multi-level commons. *Decision Sciences*, 52(4), 817-832.

Chowdhury, M.M.H. and Quaddus, M. (2017) Supply chain readiness, response and recovery for resilience. *Supply Chain Management: An International Journal*, 21(6), 709-731.

Christopher, M. and Peck, H. (2004) Building the resilient supply chain. *International Journal of Logistics Management*, 15(2), 1-13.

Craighead, C.W., Blackhurst, J., Rungtusanatham, M.J. and Handfield, R.B. (2007) The severity of supply chain disruptions: Design characteristics and mitigation capabilities. *Decision Sciences,* 38(1), 131-156.

Craighead, C.W., Ketchen, D.J., Dunn, K.S. and Hult, G.T.M. (2011) Addressing common method variance: guidelines for survey research on information technology, operations, and supply chain management. *IEEE Transactions on Engineering Management*, 58(3), 578-588.

Dubey, R., Gunasekaran, A. and Childe, S.J. (2018) Big data analytics capability in supply chain agility: The moderating effect of organizational flexibility. *Management Decision*, 57(8), 2092-2112.

Dubey, R., Gunasekaran, A., Childe, S.J., Papadopoulos, T., Blome, C. and Luo, Z. (2017) Antecedents of resilient supply chains: An empirical study. *IEEE Transactions on Engineering Management*, 99, 1-12.

Flynn, B., Cantor, D., Pagell, M., Dooley, K. and Azadegan, A. (2021) From the editors: Introduction to managing supply chains beyond Covid-19-preparing for the next global mega-disruption. *Journal of Supply Chain Management*, 57(1), 3-6.

Feng, Y., Zhang, J., Feng, L. and Zhu, G. (2022) Benefit from a high store visiting cost in an omnichannel with BOPS. *Transportation Research Part E: Logistics and Transportation Review*, 166, Article 102904.

Goraya, M.A.S., Zhu, J., Akram, M.S., Shareef, M.A., Malik, A. and Bhatti, Z.A. (2020) The impact of channel integration on consumers' channel preferences: Do showrooming and webrooming behaviors matter? *Journal of Retailing and Consumer Services*, Article 102130.

Giuffrida, M., Mangiaracina, R., Miragliotta, G., Perotti, S. and Tumino, A. (2019) Modelling the environmental impact of omni-channel purchasing in the apparel industry: The role of logistics, *International Journal of Logistics Systems and Management*, 34(4), 431-456.

Hair, J.F. and Sarstedt, M. (2021) Explanation plus prediction - The logical focus of project management research. *Project Management Journal*, 52(4), 319-322.

Hendricks, K.B. and Singhal, V.R. (2003) The effect of supply chain glitches on shareholder wealth. *Journal of Operations Management*, 21(5), 501-522.

Henseler, J., Ringle, C.M. and Sarstedt, M. (2016) Testing measurement invariance of composites using partial least squares. *International Marketing Review*, 33(3), 405-431.

Hosseini, S., Ivanov, D. and Dolgui, A. (2019) Review of quantitative methods for supply chain resilience analysis. *Transportation Research Part E: Logistics and Transportation Review*, 125, 285-307.

Ishfaq, R., Davis-Sramek, B. and Gibson, B. (2022) Digital supply chains in omnichannel retail: A conceptual framework. *Journal of Business Logistics*, 43(2), 169-188.

Ishfaq, R., Raja, U. and Rao, S. (2016) Seller-induced Scarcity and price-leadership: Impact on Product Returns in the Internet Retail Supply Chain. *International Journal of Logistics Management*, 27 (2), 552-569.

Ivanov, D. and 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.

Ivanov, D., Dolgui, A., Das, A. and Sokolov, B. (2019) Digital supply chain twins: Managing the ripple effect, resilience, and disruption risks by data-driven optimization, simulation, and visibility. In *Handbook of Ripple Effects in the Supply Chain* (pp.309-332). Springer, Cham.

Jain, V., Kumar, S., Soni, U. and Chand, C. (2017) Supply chain resilience: model development and empirical analysis. *International Journal of Production Research*, 55(22), 6779-6800.

Jones, A.L., Miller, J.W., Griffis, S.E., Whipple, J.M. and Voorhees, C.M. (2022) An examination of the effects of omni-channel service offerings on retailer performance. *International Journal of Physical Distribution & Logistics Management*, 52(2), 150-169.

Kamalahmadi, M. and Parast, M. (2016) Developing a resilient supply chain through supplier flexibility and reliability assessment. *International Journal of Production Research*, 54, 302-321.

Kamalahmadi, M., Shekarian, M. and Mellat Parast, M. (2022) The impact of flexibility and redundancy on improving supply chain resilience to disruptions. *International Journal of Production Research*, 60(6), 1992-2020.

Kembro, J.H., Norrman, A. and Eriksson, E. (2018) Adapting warehouse operations and design to omni-channel logistics: A literature review and research agenda. *International Journal of Physical Distribution & Logistics Management*, 48(9), 890-912.

Küffner, C., Kopyto, M., Wohlleber, A.J. and Hartmann, E. (2022) The interplay between relationships, technologies and organizational structures in enhancing supply chain resilience: Empirical evidence from a Delphi study. *International Journal of Physical Distribution & Logistics Management,* (ahead-of-print).

Kumar, S. and Anbanandam, R. (2020) Impact of risk management culture on supply chain resilience: An empirical study from Indian manufacturing industry. *Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability*, 234(2), 246-259.

Lee, S.M. and Rha, J.S. (2016) Ambidextrous supply chain as a dynamic capability: Building a resilient supply chain. *Management Decision*, 54(1), 2-23.

Lee, Z.W., Chan, T.K., Chong, A.Y.L. and Thadani, D.R. (2019) Customer engagement through omnichannel retailing: The effects of channel integration quality. *Industrial Marketing Management*, 77, 90-101.

Li, G., Zhang, T. and Tayi, G.K. (2020) Inroad into omni-channel retailing: Physical showroom deployment of an online retailer. *European Journal of Operational Research*, 283(2), 676-691.

Lim, S.F.W. and Srai, J.S. (2018) Examining the anatomy of last-mile distribution in e-commerce omnichannel retailing: A supply network configuration approach. *International Journal of Operations & Production Management*, 38(9), 1735-1764.

Lin, Y.H., Wang, Y., Lee, L.H. and Chew, E.P. (2022) Omnichannel facility location and fulfillment optimization. *Transportation Research Part B: Methodological*, 163, 187-209.

Melacini, M. and Tappia, E. (2018) A critical comparison of alternative distribution configurations in Omni-channel retailing in terms of cost and greenhouse gas emissions. *Sustainability*, 10(2), 307.

Shekarian, M. and Mellat Parast, M. (2021). An Integrative approach to supply chain disruption risk and resilience management: a literature review. *International Journal of Logistics*

Research and Applications, 24(5), 427-455.

Mckinsey (2020) Reimagining stores for retail's next normal. available at: https://www.mckinsey.com/industries/retail/our-insights/reimagining-stores-for-retails-next-normal.

National Bureau of Statistics. (2021) Statistical communiqué of the People's Republic of China on national economic and social development in 2020. available at: http://www.stats.gov.cn/tjsj/zxfb/202102/t20210227_1814154.html.

Nikookar, E. and Yoshio, Y. (2021) Preparing supply chain for the next disruption beyond COVID-19: managerial antecedents of supply chain resilience. *International Journal of Operations & Production Management*, 42(1), 59-90.

Pettit, T.J., Croxton, K.L. and Fiksel, J. (2019) The evolution of resilience in supply chain management: a retrospective on ensuring supply chain resilience. *Journal of Business Logistics*, 40(1), 56-65.

Pettit, T. J., Croxton, K.L. and Fiksel, J. (2013) Ensuring supply chain resilience: Development and implementation of an assessment tool. *Journal of Business Logistics*, 34(1), 46-76.

Sheffi, Y. and Rice Jr, J.B. (2005) A supply chain view of the resilient enterprise. *MIT Sloan Management Review*, 47(1), 41.

Shen, Z.M. and Sun, Y. (2021) Strengthening supply chain resilience during COVID-19: A case study of JD. Com. *Journal of Operations Management*, https://doi.org/10.1002/joom.1161.

Sodhi, M. S. and Tang, C. S. (2021) Supply chain management for extreme conditions: research opportunities. *Journal of Supply Chain Management*, 57(1), 7-16.

Song, G., Song, S. and Sun, L. (2019) Supply chain integration in omni-channel retailing: A logistics perspective. *The International Journal of Logistics Management*, 30(2), 527-548.

Song, S., Shi, X. and Song, G. (2020) Supply chain integration in omni-channel retailing: a human resource management perspective. *International Journal of Physical Distribution & Logistics Management*, 50(1), 101-121.

Song, S., Shi, X., Song, G. and Huq, F.A. (2021) Linking digitalization and human capital to shape supply chain integration in omni-channel retailing. *Industrial Management & Data Systems*, 121(11), 2298-2317.

Sorkun, M.F., Yumurtacı Hüseyinoğlu, I.Ö. and Börühan, G. (2020) Omni-channel capability and customer satisfaction: Mediating roles of flexibility and operational logistics service quality. *International Journal of Retail & Distribution Management*, 48(6), 629-648.

Sousa, P.R.D., Barbosa, M.W., Oliveira, L.K.D., Resende, P.T.V.D., Rodrigues, R.R., Moura, M.T. and Matoso, D. (2021) Challenges, opportunities, and lessons learned: Sustainability in Brazilian omnichannel retail. *Sustainability*, 13(2), 666.

Srivastava, S.K. (2007) Green supply-chain management: A state-of-the-art literature review. *International Journal of Management Reviews*, 9(1), 53-80.

Teece, D.J. (2007) Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, 28(13), 1319-1350. DOI:10.2307/20141992.

Teece, D.J., Pisano, G. and Shuen, A. (1997) Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7), 509-533.

Tenenhaus, M., Vinzi, V.E., Chatelin, Y.M. and Lauro, C. (2005) PLS path modeling. *Computational Statistics & Data Analysis*, 48(1), 159-205.

Tukamuhabwa, B.R., Stevenson, M., Busby, J. and Zorzini, M. (2015) Supply chain resilience: Definition, review and theoretical foundations for further study. *International Journal of Production Research*, 53(18), 5592-5623.

Wetzels, M., Odekerken-Schröder, G. and Van Oppen, C. (2009) Using PLS path modeling for assessing hierarchical construct models: Guidelines and empirical illustration. *MIS Quarterly*, 177-195.

Wooldridge, J.M. (2009) *Introductory Econometrics: A Modern Approach*. South-Western Cengage Learning, Mason, OH.

Xu, X. and Jackson, J.E. (2019) Examining customer channel selection intention in the omni-channel retail environment. *International Journal of Production Economics*, 208, 434-445.

Yrjölä, M., Saarijärvi, H. and Nummela, H. (2018) The value propositions of multi-, cross-, and omni-channel retailing. *International Journal of Retail & Distribution Management*, 46(11/12), 1133-1152.

Zhang, L., Wu, L., Huang, L. and Zhang, Y. (2021) Wield the power of omni-channel retailing strategy: a capability and supply chain resilience perspective. *Journal of Strategic Marketing*. DOI: 10.1080/0965254X.2021.1972440.

Appendix

Table A1. Questionnaire based on latent constructs and indicators

Measurement item	Outer loading	Outer weight
Collaboration: OC retailers… (see Table 3 for references)		
C1: Share data in real time data across channels and with supply chain partners	0.874***	0.211**
C2: Jointly manage inventory and facilities across channels with supply chain partners	0.900***	0.539***
C3: Jointly operate business with supply chain partners	0.879***	0.370***
Flexibility: OC retailers… (see Table 3 for references)		
F1: Flexibly adjust product attributes across different channels, e.g., type, packaging	0.862***	0.189*
F2: Flexibly allocate orders to suitable nodes of the OC distribution network	0.896***	0.384***
F3: Flexibly configure delivery resources, e.g., vehicles, couriers	0.896***	0.542***
Redundancy: OC retailers… (see Table 3 for references)		
R1: Have back-up suppliers to supplement products across channels	0.867***	0.480***
R2: Have buffer stock in the whole the OC distribution network	0.877***	0.362***
R3: Have excess logistics capacity (e.g., warehousing capacity)	0.846***	0.312***
Preparedness pre-disruptions: OC retailers… (Kamalahmadi and Parast, 2016; Shekarian and Mellat Parast, 2021)		
PRE1: Have sufficient resources	0.911***	0.327**
PRE2: Effectively control the configuration of supply chain and business	0.934***	0.150*
PRE3: Be highly aware of potential supply chain disruptions	0.935***	0.592***
Responsiveness during-disruptions: OC retailers… (Kamalahmadi and Parast, 2016; Shekarian and Mellat Parast, 2021)		
DR1: Become aware of an exception immediately	0.911***	0.400***
DR2: Make the best decisions quickly	0.901***	0.475***
DR3: Executive upon the response plan immediately	0.928***	0.220*
Recovery post-disruptions: OC retailers… (Kamalahmadi and Parast, 2016; Hosseini et al., 2019)		
POST1: Quickly recover to normal operations	0.855***	0.480***
POST2: Quickly recover to normal performance	0.952***	0.362*
POST3: Quickly recover to the normal state of the supply chain	0.933***	0.312*

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A2. MTMM correlations

Trait		Method 1						Method 2						Method 3					
		C	F	R	PRE	DR	POST	C	F	R	PRE	DR	POST	C	F	R	PRE	DR	POST
Method 1	C	1.000																	
	F	0.788	1.000																
	R	0.823	0.765	1.000															
	PRE	0.708	0.743	0.784	1.000														
	DR	0.759	0.774	0.782	0.868	1.000													
	POST	0.666	0.650	0.692	0.772	0.789	1.000												
Method 2	C	**0.150**	0.030	0.039	0.045	0.025	0.022	1.000											
	F	0.080	**0.191**	0.071	0.108	0.036	0.034	0.633	1.000										
	R	0.043	0.030	**0.113**	0.050	0.022	0.019	0.716	0.648	1.000									
	PRE	0.111	0.101	0.112	**0.218**	0.105	0.093	0.712	0.650	0.729	1.000								
	DR	0.041	0.023	0.034	0.071	**0.135**	0.008	0.786	0.711	0.804	0.801	1.000							
	POST	0.052	0.031	0.043	0.091	0.011	**0.196**	0.757	0.684	0.774	0.773	0.850	1.000						
Method 3	C	**0.053**	0.014	0.018	0.021	0.011	0.010	**0.006**	0.001	0.001	0.002	0.001	0.001	1.000					
	F	0.000	**0.040**	0.000	0.001	0.000	0.000	0.000	**0.007**	0.000	0.000	0.000	0.000	0.658	1.000				
	R	0.027	0.019	**0.058**	0.031	0.014	0.012	0.001	0.002	**0.008**	0.002	0.001	0.001	0.753	0.724	1.000			
	PRE	0.013	0.012	0.014	**0.046**	0.013	0.011	0.000	0.001	0.000	**0.006**	0.001	0.001	0.615	0.592	0.678	1.000		
	DR	0.011	0.006	0.009	0.019	**0.039**	0.002	0.000	0.000	0.000	0.001	**0.005**	0.000	0.696	0.669	0.766	0.627	1.000	
	POST	0.036	0.021	0.029	0.032	0.008	**0.041**	0.001	0.002	0.001	0.005	0.000	**0.007**	0.628	0.605	0.693	0.565	0.640	1.000

Notes: Monotrait-Heteromethod coefficients are shown in “shaded in grey”; validity coefficients are shown in “underlined & bold”; χ^2=185.525; df=102; NFI=0.867; TLI=0.886; CFI=0.932; RMSEA=0.060