University of Nottingham
UK | CHINA | MALAYSIA

The Role of Digital Techniques in Supply Chain Resilience: Exploration in the Logistics Sector

Xinbing Gu

A Thesis Submitted in Fulfilment of the Requirements

for the Degree of Doctor of Philosophy of the

University of Nottingham

September 29, 2024

The Role of Digital Techniques in Supply Chain Resilience: Exploration in the Logistics Sector

Abstract

With the increasing need to transport quickly and efficiently, logistics companies have played a crucial role in overcoming the time and distance constraints in modern supply chains over the past years. However, unpredictable supply chain disruptive events such as economic crises, extreme weather and pandemics have caused unparalleled disruptions in the logistics industry. Given the high level of socialised services and strong conductivity and linkage roles of logistics firms, the impact of any supply chain disruptive events on the logistics industry will be transmitted and significantly affect the production and operation of upstream and downstream enterprises such as manufacturing and retailer companies, as well as the normal social life of residents.

To address the insufficiency of traditional risk management practices, logistics companies focus on building supply chain resilience (SCR) strategies that identify, monitor, and reduce supply chain risks and disruptions and react and recover quickly and cost-effectively. The digitisation of the supply chain has been one potential driver that can enable the development of SCR and mitigate the negative impacts of disruptions in the digital era. Logistics firms are trying to redesign their supply chain operations and adjust their scheme with digital techniques to maintain essential services in the face of the unavailability of materials and transportation restrictions due to unpredictable disruptions. Advanced digital techniques make tracking changes, implementing responses, and accurately monitoring the business more manageable, which can be a valuable tool for enhancing SCR.

However, the role of digital techniques in SCR remains unclear. The SCR actualisation process using digital techniques needs to be further explored. Unlike industry-embedded

technologies that are more specific, digital techniques are tightly integrated with usage scenarios, behavioural subjects, and goal orientation to achieve diverse goals for organisations and industries. There is still limited empirical evidence about the affordance of SCR and digital techniques. Besides, few studies have highlighted how digital techniques can influence SCR and mitigate the disruption. The interplay of digital techniques (digital orientation and digital competency) and SCR in disruptive events is under-researched. Moreover, the literature often treats digital innovation and resources as isolated variables, ignoring multiple conjunctive causation relationships.

Therefore, this thesis applied multiple methods (such as thematic analysis, structural equation model, and fuzzy-set qualitative comparison analysis) to explore how digital techniques afford SCR goals, help firms deal with disruptions, and combine resources with digital innovation to achieve and develop SCR in the logistics sector. China was selected as the study area. China has the largest logistics market in the world based on logistics opportunities and business fundamentals. Second, the development of Chinese commercial logistics has shown new features, one of which is the continuous improvement of digitalisation and intelligence levels.

Study one moves affordance theory into the SCR research agenda. The thesis proposes a theoretical framework of digital affordances and SCR based on affordance theory. Results find that five digital affordances exist in logistics infrastructure, human capital, and collaboration networks, including flexibility, agility, visibility, and diversity. The results reveal three SCR goals: stability, continuity and opportunity creation. Digital affordances enhance and actualise SCR through service modularisation, information visibility, resource configuration, process optimisation and customer connection.

Study two first revealed that digital orientation (DO) and digital competency (DC)might

affect SCR and firm performance through thematic analysis. Study two further develops a conceptual framework and the associated hypotheses by combining the qualitative findings with those reported in the literature. The results show that DC can positively affect SCR and firm performance. DO can directly and positively affect firm performance and indirectly affect SCR through the mediation role of DC.

Based on the resource orchestration theory and ambidextrous innovation perspective, study three uncovered that human capital, logistics infrastructure and exploitative digital innovation have configuration effects on motivating SCR. In contrast, exploratory digital innovation can combine collaboration networks and human capital to develop SCR. The findings reveal distinct pathways through which combinations of digital innovations and resource orchestration contribute to SCR, underscoring these relationships' non-linear and conditional nature.

This thesis extends affordance theory into the domain of SCR, providing a new theoretical lens to SCR. It gives researchers and supply chain managers a new line of inquiry and strategic suggestions on perceiving and actualising digital affordance to enhance SCR. This thesis provides a reference for improved operations and resilience development under uncertain conditions such as extreme weather and climate change. Moreover, the thesis contributes to the literature by offering a nuanced understanding of SCR's multifaceted antecedents and provides actionable insights for logistics managers to optimise resource allocation and innovation strategies. The configurational approach of the thesis advances theoretical knowledge on SCR and holds practical value for crafting resilient supply chain strategies in the digital era.

Keywords: Supply Chain Resilience (SCR), Digital Techniques, Digital Affordance, Digital Orientation, Digital Competency, Digital Innovation, Logistics Firms

Acknowledgements

Completing this doctoral thesis would not have been possible without numerous individuals and institutions' unwavering support and guidance. It is with a heart full of gratitude that I acknowledge their contributions.

First and foremost, I extend my deepest gratitude to my supervisors for their invaluable mentorship, patience, and expertise. Their guidance has not only shaped my academic pursuits but also inspired me to strive for excellence in all endeavours.

To my principal advisor, Prof. Hing Kai Chan, I owe more than words can express. Prof. Chan has been a beacon of wisdom and a pillar of support throughout my doctoral journey. His keen insight into my research has been indispensable, and his unwavering belief in my abilities has been a constant source of motivation. Significantly, when my research direction initially shifted from urban emergency to supply chain management, it was challenging for me to handle both theoretical and practical supply chain issues. I am deeply grateful for the countless hours Prof. Chan spent discussing ideas, refining arguments, and providing a critical yet nurturing environment for the growth of my academic skills. He guided me to approach academic issues from the perspective of a reviewer and editor, which allowed me to scrutinise my research more critically. I also thank him for providing me with the opportunity to participate in international conferences and workshops to enhance my academic communication skills. The doors he opened to interdisciplinary perspectives have been a gift that has forever broadened my academic horizons.

I am also immensely grateful to Prof. Faith Chan, whose expertise in environment and flooding management greatly enriched my work. His enthusiasm for research is not just evident but palpable, creating an atmosphere of intellectual curiosity and excitement that is truly infectious. His passion for research is matched by his dedication to nurturing the next generation of scholars,

and I feel privileged to have been under his tutelage. His commitment to collaboration and networking has opened my eyes to the interconnectedness of knowledge and the value of diverse perspectives in solving complex challenges.

To Dr. Dimple R. Thadani, I extend my heartfelt thanks for her invaluable guidance, mentorship, and friendship. Her influence on my research and personal development is immeasurable, and I am profoundly grateful for the opportunity to have learned from and worked alongside such a kind and warm mentor. In the face of obstacles and moments of doubt, her unwavering support and encouragement have been a beacon of hope and a reminder of the importance of perseverance. Her belief in my abilities has bolstered my confidence and has been instrumental in propelling me forward in my academic pursuits.

In addition, I would also like to express my most profound appreciation to Prof. Yi Peng, who has been my academic gardener since my undergraduate studies. Among the many blessings in life, one of the most cherished is the encounter with a mentor who shapes not only my academic pursuits but also my approach to life. I am profoundly grateful to him for the continuous cultivation and tempering of my abilities. Under his tutelage, I have been fortunate to gain insights into the scholarly process, learning not just to conduct research but to appreciate the beauty and complexity inherent in pursuing knowledge. The resilience and adaptability he has instilled in me are invaluable assets that extend beyond the academic sphere. His patience and dedication to my development have been unwavering, providing a nurturing environment where curiosity and critical thinking are encouraged. The rigour of his academic standards has pushed me to strive for excellence, while his personal example of integrity and dedication has set a high bar for my own conduct. His guidance has equipped me with the skills and perspectives necessary to face life's challenges with grace and composure.

I am immensely thankful to my annual review committee members, Prof. David Phang, Prof. Min Zhang, Dr. Russa Yuan and Dr. Zhen Tan, for their insightful feedback, constructive criticism, and encouragement throughout the research process.

I owe a particular debt of gratitude to my colleagues and fellow researchers, Min Guo, Fan Liu, Xiaohui Lu, Tian Xiao, Xiaohe Wu, Ying Chen, Fangli Zeng, Jia Luo, Sicong Zhang, Jiayu Wang, with whom I have shared countless hours of discussion, debate, and collaboration. Their camaraderie and intellectual stimulation have been invaluable.

I offer my heartfelt thanks to my family, whose love and support have been a constant source of strength. Your unwavering belief in me has given me the courage to embark on this academic journey and persevere through its many challenges. I am deeply grateful to my parents for their endless encouragement and for the sacrifices they have made to provide me with the opportunities to pursue higher education. Their wisdom, guidance, and resilience have been a model for me to follow, and their love has always been a sanctuary in times of stress and uncertainty. I express my deep appreciation to my grandparents for their unselfish love.

Finally, I would like to acknowledge my study participants, without whom this research would not have been possible. Their willingness to share their experiences and insights has been instrumental to my work. My research would not have been as rich and comprehensive without the assistance of NUBS, Graduate school, and ZUFE. I am particularly grateful for the resources and facilities they provided, which greatly facilitated my work.

Thank you all for being part of this journey.

Papers Adapted from Thesis

Gu, X., Chan, H. K., Thadani, D. R., Chan, F. K. S., & Peng, Y. (2024). How digital affordances enhance supply chain resilience: case study of logistics companies. Journal of Supply Chain Management, being under third round review. (Adopted from Chapter 3)

Gu, X., Chan, H. K., Thadani, D. R., Chan, F. K. S., & Peng, Y. (2023). The role of digital techniques in organisational resilience and performance of logistics firms in response to disruptive events: Flooding as an example. International Journal of Production Economics, 266, 109033. (Adopted from Chapter 4)

Gu, X., Chan, H. K., Peng, Y., Thadani, D. R., Chan, F. K. S. (2024). Analysis of digital innovation configuration effect on supply chain resilience: the case of logistics firms, 33rd European Conference on Operational Research, Copenhagen, Demark. (Adopted from Chapter 5)

Gu, X., Chan, H. K., Peng, Y., Thadani, D. R., Chan, F. K. S. (2024). Analysis of digital innovation configuration effect on supply chain resilience: the case of logistics firms, 2024 Journal of Supply Chain Management Asia-Pacific Paper Development Workshop, Hangzhou, China. (Adopted from Chapter 5)

Gu, X., Chan, H. K., Thadani, D. R., Chan, F. K. S., & Peng, Y. (2023). The role of digital techniques in supply chain resilience and performance of logistics firms to disruptive events, Doctoral Workshop in 27th International Conference on Production Research, Cluj-Napoca, Romania. (Adopted from Chapter 4)

Gu, X., Chan, H. K., Thadani, D. R., Chan, F. K. S., & Peng, Y. (2023). Antecedents of supply chain resilience of logistics companies: an exploratory study, 27th International Conference on Production Research, Cluj-Napoca, Romania. (Adopted from Chapters 2 and 3)

Gu, X., Chan, H. K., Thadani, D. R., Chan, F. K. S., & Peng, Y. (2022). Antecedents of supply chain resilience of logistics companies during COVID-19: An exploratory study in China, The 16th International Conference on Operations and Supply Chain Management, Tianjin, China. (Adopted from Chapters 2 and 3)

Gu, X., Chan, H. K., Thadani, D. R., Chan, F. K. S., & Peng, Y. (2022). Antecedents of supply chain resilience during COVID-19: an exploratory study in China, the International Conference on National Spatial Planning and Advanced Urban Development, Hangzhou, China. (Adopted from Chapters 2 and 3)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

1.1 The Research Background and Motivation

Supply chains have become the backbone of the global economy, partly accounting for worldwide economic growth (Adobor, 2019). Today's supply chains are global, complex networks aiming to deliver products in the correct quantity and place. Logistics companies plan, implement, and control the movement and storage of goods, services, or information within a supply chain and between the points of origin and consumption (Robert, 2021). Coordinating the movement of supplies and materials is now a globalised process. The complex materials flow heavily relies on logistics firms' transportation and storage services (Herold et al., 2021; König & Spinler, 2016). Logistics companies connect supply chains and coordinate material flows by providing multimodal transportation, freight forwarding, warehousing and inventory management.

With the increasing need to transport quickly and efficiently, logistics companies have played a crucial role in overcoming the time and distance constraints in modern supply chains over the past years (Herold et al., 2021; Holl & Mariotti, 2018). According to Report Linker (2023), the global freight and logistics market increased to $16.52 billion in 2023 with a 5.5% compound annual growth rate. Furthermore, with the help of advanced logistics and optimisation, supply chain shippers achieve a competitive advantage. 89% of shippers reported that logistics companies contributed to improving service, and 80% said logistics companies helped reduce overall logistics costs (3PL Study, 2023).

However, unpredictable supply chain disruptive events such as economic crises, extreme weather and pandemics have caused unparalleled disruptions in the logistics industry (Gu et al., 2023; Herold et al., 2021; Singh & Singh, 2019). 11.5% of surveyed

companies suffered more than 10 Supply chain disruptions in 2022 (BCI Supply Chain Resilience Report, 2023). Disruptions force transportation delays and contribute to freight shutdowns that increase freight and passenger transportation costs and decrease carriers' capacity (Xu et al., 2020). These disruptions are difficult to predict in terms of time and scale, which causes logistics companies difficulty in delivering products and materials in the correct quantity, at the right place and time in unpredictable markets (Ozdemir et al., 2022). The dynamic demand and supply of the logistics market interfere with smooth material flows and block logistics business activities such as transportation and storage services (Straka, 2019).

Moreover, given the high level of socialised services and strong conductivity and linkage roles of logistics firms, the impact of any supply chain disruptive events on the logistics industry will be transmitted and significantly affect the production and operation of upstream and downstream enterprises such as manufacturing and retailer companies (König & Spinler, 2016), as well as the normal social life of residents. For instance, insurance company Euler Hermes reported that logistics bottlenecks impact 25% of global trade volume (2022 State of the Third-Party Logistics Industry Report, 2022). It is difficult for logistics companies to manage a product's forward and backward flows in a risky and uncertain environment (Modgil et al., 2022). The increase in supply chain disruption frequency and uncertainty has put forward new requirements for logistics companies, such as developing proactive risk management processes and building resilience (Scholten et al., 2014).

To address the insufficiency of traditional risk management practices, logistics companies build Supply chain resilience (SCR) strategies that identify, monitor and reduce

supply chain risks and disruptions and react and recover quickly and cost-effectively (Macdonald et al., 2018). In this thesis, SCR generally refers to the supply chain capability of a logistics company to absorb turbulence and recover from disruption (Lengnick-Hall et al., 2011; Duchek, 2020). For instance, Herold et al. (2021) define SCR as "The logistics service providers' capability during an external shock of high-impact and low-probability, to adapt, reallocate and introduce operational measures to protect their core operational capacity as well as to create business opportunities to return to its original or improved financial profitability to contribute to the resilience of the supply chain." Logistics companies substantially influence SCR by minimising or eliminating risks that may develop due to unpredictable demand or supply or in emergencies by coordinating and controlling material movements (Shen & Sun, 2021; Song et al., 2022). For example, Austrian logistics firms have built SCR reactions and actions to the COVID-19 pandemic by creating revenue streams, enhancing operational transport flexibility, enforcing digitalisation and data management, and optimising logistics infrastructure and personnel capacity (Herold et al., 2021).

However, most existing logistics companies cannot adjust and recover quickly to achieve the desired SCR (BCI Supply Chain Resilience Report, 2023). For example, after the outbreak of COVID-19, the global supply chain was hit unprecedentedly. Due to the blockade policies implemented by various countries, factories have been closed, and transportation restrictions and labour shortages have affected every link in the supply chain (2022 State of the Third-Party Logistics Industry Report, 2022). Logistics companies cannot quickly adapt to new transportation demands and safety regulations, and many enterprises are facing supply chain disruptions, order delays, and rising costs (Gu et al.,

2023a; Sternberg et al., 2022). Besides, Zhengzhou (the capital city of the Henan province) had an extreme rainfall event on 20 July 2021 (Guo et al., 2023). The logistics industry's running hours index and running mileage index fell to the lowest level of the year, accounting for only 68.3% and 69.3% of the national average, respectively (Henan Federation of Logistics and Purchasing, 2021). Moreover, in March 2021, the cargo ship "Changci" ran aground in the Suez Canal, blocking one of the world's most important shipping lanes and causing hundreds of boats to be stranded. Many logistics companies have failed to adjust their routes and resources quickly, resulting in supply chain delays and increased costs (Bloomberg, 2021). Maersk stated that the Suez Canal blockage incident resulted in billions of dollars in losses (Maersk Financial Report, 2021).

The digitisation of the supply chain has been one potential driver that can enable the development of SCR and mitigate the negative impacts of disruptions in the digital era (Gu et al., 2023). In many cases, logistics firms are trying to redesign their supply chain operations and adjust their scheme with digital techniques to maintain essential services in the face of the unavailability of materials and transportation restrictions due to unpredictable disruptions. Digital techniques such as artificial intelligence (AI) and machine learning open new business opportunities and service innovations (Peppel et al., 2022), potentially improving logistics firms' efficiency and customer experience.

Advanced digital techniques make it easier to track changes, implement responses and accurately monitor the business, which can be a valuable tool for enhancing SCR (Bag et al., 2022). Digital techniques refer to specific methods or procedures digital technologies use to accomplish certain tasks. These can include algorithms for data compression, encryption methods for secure communication, programming paradigms for software

development, and user interface design principles for creating effective digital experiences. Some studies have explored the role of AI, blockchain technology and big data analytics in SCR (Bayramova et al., 2021; Gu et al., 2021; Modgil et al., 2022). These technologies exert their influence through various mechanisms, including the strategic investment in and application of digital tools, the cultivation of digital capabilities, the construction of digital solutions, and the empowerment of process optimisation (AL-Khatib & Ramayah, 2023; Gu et al., 2023; Gupta et al., 2023). 94% of surveyed logistics firms agreed that adopting emerging digital technology is critical to improving process efficiency and productivity and achieving SCR (3PL Study, 2023). Increased logistics companies plan to invest in digital technology to enhance SCR and reduce interruption risks (3PL Study, 2023; Gu et al., 2023).

The integration of digital techniques serves to automate and streamline the workflow within the supply chain, thereby increasing operational efficiency. It also strengthens the flexibility of delivery and manufacturing processes, which is critical for adapting to and withstanding disruptions (He et al., 2023; Jain et al., 2024). By automating routine tasks, digital techniques free up resources and enable logistics firms to focus on strategic initiatives that can further fortify their resilience. Moreover, using AI and machine learning algorithms allows for predicting potential disruptions and developing pre-emptive strategies, thus reducing the likelihood and impact of such events (Modgil et al., 2021). Blockchain technology ensures transparency and traceability, improving trust and collaboration among supply chain partners (Bayramova et al., 2021). Big data analytics, on the other hand, provides deep insights into consumer behaviour, market trends, and operational performance, enabling data-driven decision-making that is crucial for SCR

(Spieske & Birkel, 2021; Choi et al., 2016). In essence, the strategic harnessing of digital technologies is not merely an option but a necessity for logistics firms seeking to build and sustain a resilient supply chain in an increasingly volatile and complex business environment.

However, the role of digital techniques in SCR remains unclear. For instance, DHL, one of the world's leading logistics companies, embarked on a comprehensive digital transformation strategy to enhance SCR. This initiative aimed at integrating advanced technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and blockchain into their logistics network. DHL encountered significant difficulties seamlessly integrating new digital technologies with legacy systems. The complexity of integration led to prolonged project timelines and higher-than-expected costs (DHL, 2021). Despite collecting vast amounts of data from various sources, inconsistencies and inaccuracies in data quality undermined the effectiveness of AI algorithms designed to optimize routes and predict demand (DHL Global Forwarding, 2021). The lack of interoperability between data sources further complicated analytics efforts (DHL, 2021). Therefore, applying digital techniques cannot guarantee the success of SCR.

The SCR actualisation process using digital techniques needs to be further explored. First, unlike industry-embedded technologies that are more specific, digital techniques are tightly integrated with usage scenarios, behavioural subjects, and goal orientation to achieve diverse goals for organisations and industries. (Belitski et al., 2023). When the same digital technique takes distinct actions in different sectors, it exhibits different digital affordance characteristics, resulting in different organisational outputs. (Anderson & Robey, 2017; McCarthy et al., 2022). There is still limited empirical evidence about the affordance

of SCR and digital techniques.

Second, few studies have highlighted how digital techniques can influence SCR and mitigate the disruption. The interplay of digital techniques (digital orientation and digital competency) and SCR in disruptive events is under-researched. Not many studies have discussed DTs in the logistics sector (Ali et al., 2018; Chung, 2021; Pettit et al., 2019). Third, to recover from supply chain disruptions, firms should excel at using digital techniques to exploit their current structured resources (exploitative digital innovation) or explore unstructured resources (exploratory digital innovation). The literature often treats digital innovation and resources as isolated variables, ignoring multiple conjunctive causation relationships. Therefore, this thesis explores how digital techniques afford SCR goals, help firms deal with disruptions, and combine resources with innovative strategies to achieve and develop SCR in logistics.

1.2 Research Aims, Objectives, and Research Questions

Against the backdrop of the gaps, this thesis intends to shed light on the role of digital techniques on SCR in the logistics sector. More specially, this thesis attempts to investigate how the affordance of digital techniques can be actualised to enhance SCR goals, the driving mechanism of digital techniques on SCR to disruptions, and how firms orchestrate resources with digital innovations for developing SCR. The thesis is structured around three interconnected studies that collectively explore the role of digital techniques in enhancing supply chain resilience (SCR) within the logistics sector. Each study builds upon the insights and findings of the previous one, providing a comprehensive and layered understanding of how digital technologies can support and strengthen SCR.

The following three research questions derived from the research problem *'What are*

the roles of digital techniques in SCR and how can digital techniques enhance SCR?' will be accessed in different chapters of this thesis. When the same digital technology adopts different actions in various fields, it will exhibit different digital affordance characteristics, leading to different organisational output results. However, there is a paucity of conclusive empirical evidence that supports explaining what digital affordances affect SCR and how these affordances enhance SCR of logistics companies. The first research question raised is to explore the role of digital affordance in SCR in the logistics sector:

RQ1: *How do digital affordances enhance supply chain resilience?*

This question was raised due to the lack of empirical studies investigating how digital techniques can influence SCR and mitigate the disruption. Although logistics firms can employ digital techniques to improve supply chain resilience (SCR), the interplay of DTs and SCR in disruptive events is under-researched. In SCR research, few studies have considered the roles of two critical components of digital techniques, namely digital orientation and digital competency. The second research question aims to explore the role of digital techniques in SCR to disruptive events:

RQ2: *What are the roles of digital techniques in supply chain resilience to disruptive events?*

The third research question is raised because the previous often treats digital innovation and resources as isolated variables. Regarding research methodology, current SCR studies have concentrated on assessing a single variable's net effect, which ignores multiple conjunctive causation relationships among multiple causal conditions. However, companies can achieve the same SCR outcome through different resource orchestration and diverse digital innovation strategies. The third research question adopts a

configurational perspective to explore the synergistic effects of digital innovation and resource orchestration on SCR:

RQ3: *What are the configuration effects of digital innovation and resources on supply chain resilience?*

To answer the above research questions, this thesis aims to understand the role of digital techniques in supply chain resilience in the logistics sector. This thesis first clarifies the digital techniques affordance in motivating SCR of logistics firms (Research objective 1). Following this, this thesis investigates the role of two critical components of digital techniques (digital orientation and competency) in SCR and the performance of logistics firms to disruptive events (Research objective 2). This thesis also clarifies the configuration effects of digital innovation and resources on SCR (Research objective 3).

The first study lays the theoretical groundwork by examining the concept of digital affordances and their potential to motivate supply chain resilience (SCR). Through a series of case studies within the logistics industry, this research identifies the digital affordances logistics firms can leverage to build SCR. It provides a foundational understanding of how digital technologies can be harnessed to achieve resilience goals, such as stability, continuity, and opportunity creation. The findings from this study inform the subsequent empirical investigations by offering a clear framework of the digital affordances that contribute to SCR.

The second study shifts from a theoretical exploration to an empirical examination of how digital orientation (DO) and digital competency (DC) within logistics firms influence SCR during disruptive events, such as floods. This study uses a multi-method approach, including qualitative interviews and a structural equation model (SEM), to test the

hypotheses developed from the initial study. The qualitative insights from the first study guide the operationalisation of DO and DC, allowing for a rigorous test of their impact on SCR and firm performance. This study extends the understanding of digital techniques' roles in SCR by examining their application during disruptive scenarios.

The third study adopts a configurational approach to explore how different combinations of digital innovation and resourcefulness contribute to SCR. Building on the insights from the first two studies, this research investigates the synergistic effects of ambidextrous digital innovation (exploratory and exploitative) and various resources (human capital, logistics infrastructure, and collaboration networks) on SCR. Using fuzzy-set Qualitative Comparative Analysis (fsQCA), this study uncovers the complex causal pathways that lead to SCR, highlighting these relationships' non-linear and conditional nature. The findings from the first study, which identify the critical components of resources, are instrumental in shaping the configurational analysis conducted in this study.

In summary, the first study sets the stage by establishing a theoretical link between digital affordances and SCR. The second study empirically validates the role of digital techniques in enhancing SCR during disruptions. The third study then explores the nuanced interplay between digital innovation and resource orchestration in SCR. By sequentially addressing the roles of digital affordances, digital orientation and competency, and ambidextrous digital innovations, the three studies form a cohesive narrative that comprehensively explores the multifaceted nature of digital techniques in enhancing supply chain resilience. The findings from each study inform and enrich the subsequent ones, culminating in a robust and practical framework for logistics firms to improve their resilience in the face of disruptive events. Together, these studies provide a holistic view

of how digital techniques can be strategically utilised to bolster supply chain resilience in the logistics sector.

1.3 Methodology

To address these three research gaps, this thesis applies multiple methods to investigate the role of digital techniques in supply chain resilience in the logistics sector. The research commences with an in-depth examination of multiple case studies of representative logistics firms engaged in supply chain digitisation. To acquire a representative sample of logistics firms, this thesis starts by approaching leading logistics firms in the case area and expanding the interview samples based on their recommendations. As a qualitative method, the case study method delves into the significance and interpretation within contexts, aligning with the research objective of elucidating the digital affordance for supply chain resilience (Denzin & Lincoln, 2011). This approach is characterised by its openness, adaptability, and flexibility, facilitating the exploration of emergent themes and elements. It is instrumental in discerning the digital affordances that logistics firms can leverage to cultivate SCR (Bastas & Garza-Reyes, 2021). Multiple case studies are deemed more compelling and robust than single case studies, as they yield more affluent and more substantial findings (Sternberg et al., 2022; Taylor & Rosca, 2023).

Subsequently, thematic analysis is deployed to discern and categorise interview transcripts and annual reports, thereby facilitating the acquisition of pertinent insights. This thesis followed a standard approach inspired by thematic analysis, which adopted three steps of open, axial, and selective coding to extract the themes (Modgil et al., 2022). The application of theory-driven thematic coding has been pivotal in revealing the digital affordances and their actualisation process, which are crucial for enhancing supply chain

resilience. This methodological triangulation ensures a comprehensive and nuanced understanding of digital techniques' role in bolstering the SCR in the logistics sector. Thematic analysis is also conducted for hypotheses and framework development of studies two and three, which help this thesis identify and confirm critical variables and components.

The structural equation model (SEM) is applied to examine the role of digital techniques in SCR to disruptive events. In this thesis, digital techniques and SCR are latent variables composed of multiple dimensions measured by various items. SEM is suitable to deal with both manifest and latent variables (Barrett, 2007). SEM encapsulates regression analysis and path modelling methodologies, offering a more comprehensive approach to understanding associations between digital techniques and SCR. A random sampling approach was applied to collect data, and questionnaires were distributed through online and offline surveys.

Fuzzy-Set Qualitative Comparative Analysis (fsQCA) is a configuration case analysis method based on Boolean logic and algebra (Ragin, 2009). It allows for examining complex causal relationships by considering the degree to which conditions are met rather than treating them as binary presence or absence, thus providing a more nuanced understanding of the causal mechanisms at play (Ragin, 2014). This thesis explores the configuration effects of digital innovation and resource orchestration on SCR. FsQCA does not demand special treatment for causal conditions across diverse levels, making it particularly suitable for exploring SCR’s multi-level conjunctive causal phenomena (Stroe et al., 2018). In conclusion, multiple methods help this thesis explore and clarify the role of digital techniques in SCR.

1.4 Summary of Results

By addressing the research questions, this thesis conducts three studies to explore the role of digital techniques in SCR. Study one aims to move affordance theory into the SCR research agenda. Study one proposes a theoretical framework for digital affordances and SCR based on affordance theory. Thematic analysis was used to investigate how digital affordance influences SCR. The findings reveal four digital affordances in logistics infrastructure, human capital, and collaboration networks: flexibility, agility, visibility, and diversity. The findings identify three SCR goals for affordance effects: stability, continuity, and opportunity creation. Digital affordances inspire and enable SCR through service modularisation, information visibility, resource configuration, process optimisation, and customer connection.

Study two further develops a conceptual framework and the associated hypotheses of digital techniques and SCR. Two distinct components of digital techniques are identified by interviews: digital orientation (DO) and digital competency (DC). Structural equation modelling was then conducted to test the conceptual model. The results show that DO plays a vital role in the development of DC. The results demonstrate that DC can improve SCR and company performance. DO can have a direct and beneficial impact on company performance and an indirect impact on SCR through DC's mediation role. Disruption has a positive effect on SCR. Hence, disruption might be an opportunity for logistics organisations to develop SCR. This study also discovered that while firm size does not affect SCR, it negatively impacts performance.

Study three employs a fuzzy-set Qualitative Comparative Analysis (fsQCA) to explore the configuration effects of digital innovation and resources on SCR. This study

finds that no single digital innovation or resource type is necessary to promote SCR. Logistics companies can attain a high SCR by leveraging human capital and infrastructure for exploitative digital innovation. Logistics enterprises can combine human capital and collaboration networks with exploratory digital innovation to achieve high SCR. In contrast, lacking human capital and exploitative digital innovation might fail to create SCR. Furthermore, their SCR will be poor if logistics businesses do not engage in exploratory digital innovation and have adequate human capital and logistics infrastructure resources.

1.5 Summary of Research Contributions

This thesis is expected to add to the present knowledge of supply chain digitalisation and resilience in supply chain management. First, this thesis explains the affordance theory concerning supply chain resilience (SCR), offering a new theoretical perspective on SCR. The thesis emphasises SCR as the main objective for logistics companies to enhance digitalisation and investigates the connection between digital affordances and SCR, thus contributing to the existing research on digital affordance and SCR. Moreover, it provides researchers and supply chain managers with fresh avenues for investigation and strategic recommendations for recognising and implementing digital affordance to drive SCR.

Second, this thesis examines the impact of digital techniques on supply chain resilience (SCR) during disruptive events. It identifies two factors, digital orientation and competency, which influence SCR. The research findings demonstrate that digital competency directly impacts SCR and improves firm performance. Additionally, digital orientation directly and positively affects overall firm performance and indirectly affects SCR through the mediation of digital competency. The study contributes to the advancement of SCR research and addresses the gap between theory and practice by

elucidating how digital techniques enhance SCR in the face of disruptions. This enriches the application of dynamic capability theory and evolutionary theory.

Third, this thesis involves the discovery that a combination of human capital, logistics infrastructure, and exploitative digital innovation can be configured to stimulate SCR. In contrast, exploratory digital innovation can facilitate the development of SCR by combining collaboration networks and human capital. This research uncovers the underlying driving mechanisms and substitution relationships that contribute to the enhancement of SCR and explores the distinct driving mechanisms that lead to lower levels of SCR from the perspective of causal asymmetry. This study significantly contributes to understanding causal complexity in the SCR context, drawing on resource orchestration theories and ambidextrous innovation. In summary, these three studies provide insights into supply chain management research and contribute to the practical application of theoretical knowledge.

1.6 Thesis Structure

This thesis consists of eight chapters that will be outlined to enhance understanding of the above research aims and objectives. Table 1.1 lists the thesis structure and research activities. The introduction chapter starts with the research background from which research questions arise. Following research questions, the Introduction chapter proposes the research aims and objectives. Methodology, results, and contributions are summarised in this chapter to offer a broad overview of the entire thesis. Chapter two reviews the related works on SCR, including SCR's definition and concept, SCR's theories and configurations, disruptive events and applied methodology in SCR research, the influencing factors of SCR,

and the relationship between digital technologies and SCR. Through the literature review, this thesis identifies the research gaps related to the research questions.

Table 1.1 Thesis structure and research activities

Thesis chapter	Major contexts	Research activities
Ch.1 Introduction	Research background Research questions, aims and objectives Methodology summary Results and contribution Summary Thesis structure	The motivation and rationale of the study.
Ch.2 Literature review	SCR concept and definition SCR-related theories and configuration Disruptive events in SCR SCR influencing factors SCR methodology Research gaps	Literature review
Ch.3 Research methodology	Research philosophy Research flow Data collection approaches Data analysis approaches Ethics consideration	Methodology design, literature review and data collection.
Ch.4 Digital affordances and SCR	Theoretical framework Case studies Thematical analysis Digital affordances actualisation strategy for SCR	Clarifies the digital techniques affordance in motivating SCR
Ch.5 Digital techniques and SCR to disruptions	Thematic analysis Hypotheses development	Investigates the role of two critical components of digital

	Structural equation model analysis Digital techniques implementation strategy for SCR	techniques (digital orientation and competency) in SCR
Ch. 6 Digital innovation and resources orchestration in SCR	Thematical analysis Theoretical framework Fuzzy-set qualitative comparison analysis Digital innovation and resource orchestration strategy for SCR	Clarifies the configuration effects of digital innovation and resources on SCR
Ch.7 Discussion	Theoretical implication Managerial implication	Discuss the overall findings of this research and the implications for recommendations.
Ch.8 Conclusions	Conclusion Limitation Future research opportunity	Conclude the results and limitations and propose future agendas.

Chapter three introduces the overview of the thesis's applied methodology. I first explain the philosophy of the thesis research, including ontology, epistemology, and axiology. The chapter then discusses the research design and flow, demonstrating the linkages between research questions and three studies. Then, I introduce the data collection and analysis methods applied in this thesis. Data collection contains interviews, case studies, questionnaires, and secondary data released by firms. Data analysis methods include content analysis, structural equation model, and fuzzy-set qualitative comparative analysis. I also explain the ethical issues in this chapter.

Chapters five, six, and seven present the research developments, chapter-related methods, and findings of three studies. Then, chapter eight details a discussion of the

studies' findings from theoretical and managerial perspectives. The last chapter addresses the conclusions to the research questions. The concluding chapter also proposes Thesis contributions, limitations, and future works.

CHAPTER 2 LITERATURE REVIEW

This chapter reviews the literature on supply chain resilience (SCR). This chapter first reviews the concept and definition of supply chain resilience. Then, this chapter summarises the configuration of SCR based on previously applied theories. This chapter also reviews SCR's influencing factors, including resources, capabilities, organisational strategies, digital technologies, and innovation. This chapter also summarises the methods applied in current SCR research, including data collection and analysis methods. Finally, this chapter identified research gaps and positioned our thesis studies.

2.1 Definition and Concept of Supply Chain Resilience

The term "resilience" has long been used in many disciplines, such as psychology, ecology, engineering, economics, and risk management. Previous studies conceptualise "resilience" from ecological, socio-ecological, community, organisational, and individual perspectives. Only a few of the previous studies presented were in the context of supply chain resilience (Ruiz-Martin et al., 2018), which leads to the lack of a consistent definition of "supply chain resilience (SCR)" and reduces the significance of the concept of "SCR" for practice and research (Hillmann and Guenther, 2020). Only recently has the SCR gained increasing attention in supply chain management research (Duchek et al., 2020). Even though the concept of resilience is still fuzzy, some perspectives still exist to conceptualise and define SCR.

SCR can be regarded as an emergent property of complex adaptive systems (Burnard and Bhamra, 2011; Hilton et al., 2012). In this view, an organisation or a supply chain is a comprehensive and complex system similar to the urban system (Folke, 2006). SCR is defined as an attribute or feature of a complex system (Limnios et al., 2014). SCR is both a function of

planning for and preparing for future crises (planned resilience) and adapting to chronic stresses and acute shocks (adaptive resilience) (Barasa et al., 2018; Kahn et al., 2018). SCR is approached as a positive and desirable concept of system characteristics (Erol et al., 2010; Linnenluecke, 2017). SCR is a fundamental quality of organisations that respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behaviours (Home III, 1997; Riolli and Savicki, 2003). Witmer and Mellinger (2016) proposed that SCR is a complex phenomenon that includes inter-and intra-system dynamics, exploring psychological and interpersonal processes, and structural components that contribute to system integrity. SCR refers to complex systems survival, system adaptation, the absorbance of disturbance, or robustness and ability to rebound and recover from adversity (Erol et al., 2010; Burnard et al., 2018).

Most studies understand SCR as a capability or ability to deal with internal and external crises, risks, changes, or jolts. It is the capability to absorb, effectively, the disruptive event, develop a response of the organisational structure to keep the system in operation and articulate a set of activities to resolve the threat (Lengnick-Hall and Beck, 2005; Linnenluecke and Griffiths, 2012; Morales et al., 2019). SCR is a critical factor for growth and success and is also considered capable of absorbing disruptions, maintaining the structure, and keeping the system functioning (Walker and Salt, 2012). From the perspective of strategy or operation, SCR means that a company can balance expansion strategies with governance issues (Carmeli and Markman, 2011).

Several studies define SCR with a focus on what a resilient firm does, while understanding resilience as a capability or ability pays more attention to what a resilient organisation has. For example, SCR is *"the maintenance of positive adjustment under challenging conditions such that the organisation emerges from those conditions strengthened and more resourceful"* (Conz and

Magnani, 2020, p404). A resilient firm can return to its performance level at any key performance metric. An organisation may be better placed to make decisions that not only overcome the impact of a disruption, regardless of its magnitude, but also potentially transcend them to development opportunities by improving the system's adaptive capacity (Burnard et al., 2018). It can achieve its objectives and realise opportunities in the face of predicted or unpredicted disruptive events (Ruiz-Martin et al., 2018; Sahebjamnia et al., 2018).

More recently, SCR has been understood to lead to resilient outcomes (Sutcliffe and Vogus, 2003; Linnenluecke and Griffiths, 2012). This process perspective points to the dynamic nature of resilience as an interaction between the supply chain and the environment (Williams, 2017). Duchek et al. (2020) proposed that SCR can be defined as *"the ability to anticipate potential threats, to cope effectively with unexpected events, and to learn from these events to produce a dynamic capability that is directed toward facilitating organisational change"*. It is a constant process that includes reconstructing supply chain values, processes, and behaviours and analysing vision, values, elasticity, empowerment, coping, and connections on both an individual and organisational level (Witmer and Mellinger, 2016). For instance, Teo et al. (2017) considered that SCR is a form of learning where a firm not only survives via positive adjustment to current adversity but strengthens its capability to overcome future challenges. Resilience can be activated and points to latent organisational resources that can be called upon or recombined in different circumstances. As for the strategic resilience of the supply chain, it is highly dedicated to supporting business planning under a long-term horizon, which studies the strategies under environmental changes, the anticipation and adaptation to long-term trends, and the development of the capability to change on time (Sahebjamnia et al., 2015). A firm's response to adversity results in growth and learning (Hillmann and Guenther, 2020).

Individuals and groups also conceptualise SCR in an organisation, which is reflected through the resilience of employees and teams. SCR can be generated by resilient employees who demonstrate their ability to recover from adversity and their capacity to utilise and proactively develop personal and workplace resources (King et al., 2016). Resilient employees can help organisations return to normal functioning following a crisis (Kim, 2020). An organisation can only be as resilient as its employees or teams (Shin et al., 2012). Therefore, individual resilience and SCR are linked and reciprocally influence each other (Riolli and Savicki, 2003).

Supply chain resilience can be conceptualised as a system characteristic, capacity, actions, process, individual or team, as shown in Table 2.1. Even at present, there is no clear conceptualisation of supply chain resilience. As for SCR in the logistics sector, SCR of logistics companies generally refers to the supply chain capability of logistics companies to absorb turbulence and recover from disruption (Lengnick-Hall et al., 2011; Duchek, 2020). For instance, Herold et al. (2021) define SCR as "The logistics service providers' capability during an external shock of high-impact and low-probability, to adapt, reallocate and introduce operational measures to protect their core operational capacity as well as to create business opportunities to return to its original or improved financial profitability to contribute to the resilience of the supply chain." In logistics, SCR also ensures that day-to-day operations can continue without significant disruption. This includes having contingency plans for various scenarios and ensuring that these plans are regularly updated and tested (Ju et al., 2021). SCR in the logistics sector can be defined as the ability of a logistics network to prepare for, withstand, and recover from disruptions while maintaining or quickly restoring operations to their desired state. It involves not just bouncing back from adversity but also the ability to adapt and thrive in the face of change (Gu et al., 2023).

By integrating existing concepts, supply chain resilience can be understood as “the combination of characteristics (Linnenluecke, 2017), abilities, capacities (Vogus and Sutcliffe, 2007) that allow an organisation to absorb disruptions, maintain the structure, and keep the system functioning facing known and unknown disturbances (Barasa et al., 2018), and grow and learn in the process (Teo et al., 2017) strengthens its capability to overcome future challenges (Wright et al., 2012)”.

Table 2.1 The concepts of supply chain resilience (SCR)

Perspectives	The concept of SCR	Citations
System characteristic	SCR is approached as a positive and desirable concept or system characteristic.	Limnios, et al., 2014; Erol, et al., 2010; Linnenluecke, 2017; Burnard, et al., 2018
Capability or ability	SCR is a capability or ability to deal with internal and external crises, risks, changes, or jolts.	Lengnick-Hall and Beck, 2005; Linnenluecke and Griffiths, 2012; Morales, et al., 2019
Actions	SCR is the maintenance of positive adjustment under challenging conditions such that the organisation emerges from strengthened conditions and is more resourceful.	Sutcliffe and Vogus, 2003; Vogus and Sutcliffe, 2007; Sheffi, 2007; Burnard, et al., 2018
Process	SCR has been understood as a process that leads to resilient outcomes, which means the result of an organisation's response to adversity is growth and learning.	Linnenluecke and Griffiths 2012; Teo, et al., 2017; Williams, 2017; Duchek, et al, 2020
Individual or team	SCR can be generated by resilient employees and teams.	Shin, et al. 2012; King, et al., 2016; Oeij, et al., 2018; Kim, 2020

2.2 Theories of Supply Chain Resilience

The configuration of supply chain resilience depends on the theory and perspectives researchers adopt. Previous studies have proposed different ways to configure SCR, but no unified division exists. Table 2.2 presents the major theories used to construct the dimensions of SCR,

such as dynamic capability theory, complex adaptive system theory, evolutionary theory, and resources-based theory. Resource-based theory, evolutionary theory and dynamic capability theory focus on the organisations' capability to respond and recover from crises and disruptions. Complex adaptive system theory highlights the interaction between an organisation's system and environment.

Table 2.2 The configuration of supply chain resilience

Theory	Dimension	References
Dynamic capability theory	Proactive dimension (flexibility, redundancy/reserve capacity, integration, efficiency, market strength, and financial strength) and reactive dimension (response and recovery abilities of organisations).	Eltantawy, 2016; Chowdhury & Quaddus, 2017; Morales, et al., 2019; Singh & Singh, 2019
Complex adaptive system theory	Self-organisation, hierarchy, emergence and learning.	Edson, 2012; Morales, et al., 2019; Yaroson, et al., 2021
Evolutionary theory	Routines (organisational genetics, acquired behaviours) and evolutionary processes (the principle of heredity, variation, and selection).	Nelson, 2009; McCarthy, Collard, & Johnson, 2017; Jiang, Ritchie, & Verreynne, 2019
Resources-based theory	Physical resources (productive resources, productive services, unused productive resources) and human resources (knowledge and experience, managerial services/capabilities, managerial process/routines).	Barney, 2001; Danes, et al., 2009; Jiang, Ritchie, & Verreynne, 2019
Institutional theory	Organisational practices, policies, organisational behaviour, and actions in response to environmental pressure.	Castellacci, 2005; Singh & Singh, 2019;

Organisational information processing theory	Structural practices and capabilities of an organisation for information processing in the face of increased uncertainty.	Galbraith, 1974; El Baz & Ruel, 2021
Production theory	Capital, labour, infrastructure, and materials.	Dormady, Roa-Henriquez, & Rose, 2019
Capital stock theory	Physical, financial, human, social, and natural capital	Mäler, Li, & Destouni, 2007; Baral & Stern, 2011

Many studies take the dynamic capability theory as the theoretical perspective and determine the dimensions of SCR. Dynamic capability is defined as the ability of an enterprise to solve problems systematically, perceive opportunities and threats, make timely and market-oriented decisions, and change its resource base (Barreto, 2010). Firms need the dynamic capability to be resilient against disruption. Based on dynamic capability theory, an organisation should include proactive and reactive capabilities (Chowdhury and Quaddus, 2017). Proactive capability includes flexibility, redundancy/reserve capacity, integration, efficiency, market strength, and financial strength, while reactive capability contains organisations' response and recovery abilities (Pal et al., 2014; Chowdhury & Quaddus, 2017). For example, Brusset and Teller (2016) regard resilience as an operational capability, which refers to the ability of an organisation to survive through product delivery and daily operation, while dynamic capability is a higher-level capability that can promote the performance of companies. In addition, operational capability can promote dynamic capability.

The evolutionary theory originated from biological analogies and applied in evolutionary economics. The evolutionary theory tries to explain the change in organisational patterns over time. The theory proposes that organisations' capabilities and rules can be modified over time (Metcalfe, 1998). Evolutionary theory highlights the SCR from routines and the evolutionary process.

Routines are composed of organisational genetics acquired behaviours, while the evolutionary process includes the principles of heredity, variation, and selection (Jiang et al., 2019). There are three stages in the evolutionary framework that challenge environmental conditions, the process of change, and configuration diversity (McCarthy, Collard and Johnson, 2017). Disturbance and environmental changes trigger the SCR. The evolutionary change explains how an organisation varies, selects, and retains to drive resilience-enhancing changes, and configuration diversity is a pattern produced by resilient adaptations (Reinmoeller and Van Baardwijk, 2005).

The resource-based theory argues that an organisation is a collection of resources, and having valuable, scarce, unique and non-replicable resources is the basis for an enterprise to achieve competitive advantage (Das and Teng, 2000). SCR is determined by the organisation's physical and human resources. Physical resources contain productive, productive, and unused productive resources, while human resources include knowledge and experience, managerial services/capabilities, and managerial processes/routines (Jiang, Ritchie, & Verreynne, 2019). For instance, material and human resources are critical for firms to recover from disruption and disasters. Brewton et al. (2010) proposed that family firm resilience comprises survivability capital, including human, social, and financial resources.

Complex adaptive system theory regards an organisation as an open system interacting with the internal and external environment (Erol, Sauser, and Mansouri, 2010). Systemic adaptation requires attention to environmental feedback and change incorporation into the system (Edson, 2012). Complex adaptive systems exhibit self-organisation, hierarchy, emergence, and learning (Holling and Gunderson, 2002). Self-organisation is internal evolution, hierarchy is created through system structure, emergence means dynamic innovation in the face of environmental disruption, and learning is the experience and mechanism of future crises (Edson, 2012). Nair and

Reed-Tscohas (2019) categorised the dimensions of the complex adaptive system into internal mechanisms, external mechanisms, and co-evolution. Internal mechanisms concern the interaction between system agents, and external mechanisms concern how system agents respond to environmental changes and disruptions. Co-evolution is the advanced characteristics or features of the system after interactions. Based on complex adaptive system theory at the organisational level, Morales et al. (2019) divided SCR into resilient leadership, resilient organisational culture, adaptation capacity, and organisational and managerial capabilities.

The above theories are the major theories applied in SCR studies. Besides, some scholars combined the research context (e.g., platforms/ firms/specific influencing factor) with SCR and categorised SCR dimensions from other theories, including institutional, organisational information processing, production, and capital stock theories. Institutional theory suggests the external environment influences the institution's behaviours (March and Olsen, 1983). Therefore, Singh and Singh (2019) thought that SCR was organisational practices, policies, behaviour, and actions that responded to environmental pressure. With the increasing information process, organisations need to develop capabilities to deal with information processes in an uncertain environment. Organisational information processing theory provides insight into how organisations deal with unpredictable disruptions. El Baz and Ruel (2021) suggested that SCR is an organisation's structural practice and capability to mitigate disruption impacts in the information society. As for optimal conditions for production, production theory provides an approach to developing SCR as capital, labour, infrastructure, and materials (Dormady, Roa-Henriquez, and Rose, 2019). Based on capital stock theory, physical, financial, human, social, and natural capital are essential SCR elements (Baral and Stern, 2011).

These theories contribute to a deep understanding of the configuration of SCR and the robust development of its framework and dimensions. However, current studies have not adopted digital techniques or theories to explore SCR in the digital era. Therefore, this thesis tries to move affordance theory and ambidextrous innovation perspective into the SCR research agenda, providing an additional theoretical lens to SCR.

2.3 Disruptive Events in Supply Chain Resilience Research

The core issue of SCR research is how to predict, deal with, and recover from disruptions and crises when facing internal and external adverse factors. Organisations constantly face inevitable adverse factors (Boin, 2010), such as economic recession, climate change, natural disasters, industrial accidents, product recalls, information technology default, and information security incidents. The categorization of the disruptive events is shown in Table 2.3. These adverse factors have brought certain degrees of negative impact on the organisation, thus pushing the organisation to be prepared, responsive, and able to overcome different intensities and forms of adverse factors. Organisations need to maintain their essential functions in the face of crisis, quickly recover, and effectively control the deterioration of the situation to prevent the organisation from losing control (Meyer, 1982).

Table 2.3 Categorisation of the supply chain disruptive events

Category	Typical disruptive events	Citation
Natural disasters	· Earthquakes · Floods · Typhoons · Droughts	e.g. Bastug and Yercan, 2021; Harries et al., 2018;
Public health events	· Pandemic · Epidemics	e.g. Bastug and Yercan, 2021; Melián-Alzola et al., 2020

Human-induced accidents	· Factory fires · Explosions · Transportation accidents	e.g. Aslam et al., 2020; Kim et al., 2020
Technical changes	· Information system crashes · Cyber attacks · Equipment failures	e.g. Oh and Teo, 2006; Ignatiadis & Nandhakumar, 2007; Choi et al., 2023
Economic changes	· Market supply and demand fluctuations · Raw material price volatility · Exchange rate fluctuations	e.g. Pal and Mattila, 2014; Tsiapa and Batsiolas, 2019; Brewton. et al., 2010
Political and social factors	· Wars · Terrorist attacks · Strikes · Policy changes	e.g. Gao, et al., 2019;

The SCR empirical studies first need to identify the disruption events or organisational changes to explore the impacts on SCR and the role of SCR. Some studies integrated all disruptions to explore the SCR in a general context (Akgün and Keskin, 2014; Singh and Singh, 2019). For instance, Oh and Teo (2006) studied the impacts of information technology and managerial proactiveness in building net-enabled SCR in environmental turbulence. Morales et al. (2019) explored the predictors of SCR in the context of disruption events and uncertainty. Aslam et al. (2020) studied how the supply chain achieves SCR in the face of natural and human-caused disasters.

Other SCR studies focused on the impacts of specific events such as COVID-19 (Bastug and Yercan, 2021), the Thailand floods of 2011 (Andrew et al., 2016), the 2011 Canterbury earthquakes (Prayag et al., 2018), 1990–93 and end 2007–09 economic crisis (Pal and Mattila, 2014), financial

crisis during the period 2007–2011 (Tsiapa and Batsiolas, 2019). For example, Bastug and Yercan (2021) assessed logistics SCR after the COVID-19 outbreak. Teo et al. (2017) explored how leadership activates hospital resilience in SARS. Prayag et al. (2018) studied the relationship between SCR and tourism financial performance after the 2011 Canterbury earthquake. Kim et al. (2020) considered the resilience effect of the workforce when the firms were in the CEO turnover events.

Most studies did not measure the disruption events and only regarded the crisis events as a research background. To clear the relationship between disruption events and SCR, measuring them using a quantitative approach is essential. Some approaches to measuring the disruption events include Likert scales, the frequency or the number of events, and physical characteristics, as shown in Table 2.4. The Likert scale is a major approach to measuring events. For example, Melián-Alzola et al. (2020) applied 7-point scales to measure the impact, frequency, and predictability of the nine types of change through surveys. Senbeto and Hon (2020) adopted four items to assess the extent of market turbulence and uncertainty. Whether there is a crisis or disruption, the number of events is also used to measure crisis events. Levine et al. (2018) regarded crisis as a dummy variable that equals one if the firm is in a crisis period and zero during a non-crisis period. Nguyen et al. (2021) used the frequency index and the historical number of disasters to measure supply chain disruptive events. Moreover, the physical characteristics of disasters can be applied to measure disasters such as climate and extreme weather (Linnenluecke and Griffiths, 2012). Coates et al. (2020) used the hydrodynamic model to evaluate flooding when evaluating operational resilience.

Table 2.4 Disruption events measurement in supply chain resilience studies

Events	Events measurement	Organisations	Citations
The COVID-19 pandemic, the dynamism and complexity of the business environment, disruptive events, market turbulence	Likert scales (e.g., 5-point, 7-point scales ranging from "low level" to "high level")	Tourism, supply chain, manufacturing firms, family firms	Melián-Alzola, et al., 2020; Golgeci &Ponomarov, 2013; Aslam, et al., 2020; Brewton. et al., 2010
Systemic banking crises	Yes (1)/No (0)	Supply chain, bank	Levine, et al., 2018; Dixit, et al., 2020
2007 flood in Tewkesbury; climate and weather extremes	Physical characteristics, hydrodynamic mode	Small and medium-sized enterprises	Coates, et al., 2020; Linnenluecke & Griffiths, 2012
Floods, global large-scale disruptive events, CEO turnover	The number of disasters, frequency index	Small firms, general	Harries, et al., 2018; Nguyen, et al., 2021
2011 Canterbury earthquake, Thailand flood of 2011, market disruptions, turbulence…	Background	…	…

In summary, most studies did not measure the disruptive events and only regarded them as research backgrounds. Some studies aimed to apply quantitative data to establish the relationship between SCR and related factors. However, it is difficult to quantify the impacts of disruptive events and match the actual implications for SCR with objective data. Most previous SCR empirical studies adopted a combined approach to measuring disruptive events using subjective data, which has been beneficial for studying the widespread impacts of a specific disaster or

disruption on SCR. This thesis also applies the Likert scale to measure the impact of disruptive events and explore the role of digital techniques in SCR to disruptions.

2.4 Influencing Factors of Supply Chain Resilience

Disruptions directly cause turbulence in organisations, which influences supply chain resilience. SCR studies have explored the impacts of the different disruptions on SCR. The disruption severity and change dimensions considerably affect SCR (Melián-Alzola et al., 2020; Senbeto and Hon, 2020). First, natural hazards significantly influence SCR, such as floods (Coates et al., 2020) and earthquakes (Prayag et al., 2020). Whitman et al. (2014) found that organisations in central business districts were more likely to close after an earthquake. Andrew et al. (2016) found that private and non-governmental organisations and organisations in rural areas were more resilient than public organisations and organisations in urban areas in the face of floods. Second, pandemics have caused a severe impact on SCR. Melián-Alzola et al. (2020) established the significant negative effects of COVID-19 on tourism's SCR, especially in the hotel industry. Third, market turbulence and business climate negatively impact SCR (Hallak et al., 2018; Gölgeci and Kuivalainen, 2020). Senbeto and Hon (2010) found that market turbulence and uncertainty were negatively associated with hotel SCR. Yilmaz et al. (2020) proposed that a triadic buyer-supplier–supplier–supplier–supplier resilience is highest when co-opetition prevails in a competitive market. Besides, supply chain resilience is influenced by supply chain disruption orientation and can positively affect supply chain dynamism (Yu et al., 2019). Moreover, SCR is affected by the firm adaption strategy, such as CEO turnover (Kim et al., 2020), merger and acquisition (M&A), and demerger processes (Croucher et al., 2020).

In addition to external influencing factors like various disruptions, many internal organisational factors affect SCR, including organisational resources, capability, strategy, and

technology innovation, as shown in Figure 2.1. Resources, including physical, financial, social, human, and natural resources, confer value or benefit to the supply chain and are one determinant of SCR. For example, Gölgeci and Kuivalainen (2020) argued that social capital, cognitive structures, and partnerships can drive SCR. To highlight the role of resources, Queiroz et al. (2021) revealed that resource reconfiguration and supply chain disruption orientation positively affect SCR. Kähkönen et al. (2021) used data from surveys conducted in the medical devices industry to find that reconfiguring ability strongly influenced SCR during COVID-19. Ali et al. (2021) further identified fourteen capacity factors to improve the SCR against the disruption of the COVID-19 pandemic, which include flexibility in sourcing, flexibility in order fulfilment, capability, efficiency, visibility, adaptability, anticipation, recovery, dispersion, collaboration, organisation, market position, security, and financial strength.

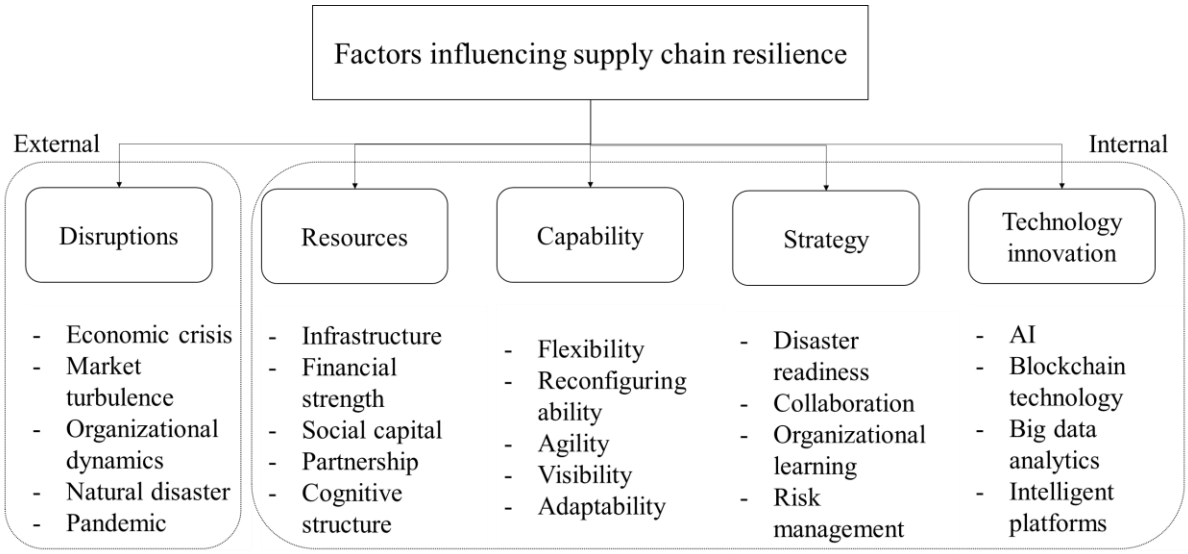

Figure 2.1 Factors influencing supply chain resilience (Source: author)

Investments in dynamic capabilities, such as adaptability and flexibility, can enhance SCR during abnormal times (Hobbs, 2021). Supply chain flexibility refers to the ability of firms to adapt to changing environments and stakeholder requirements with minimal interruption (Erol et al.,

2010). Flexibility can facilitate the redeployment of resources in supply chains in a dynamic environment (Pettit et al., 2013), improving supply chain adaptability to improve SCR (Christopher & Holweg, 2011). Herold et al. (2021) revealed that logistics service providers' resilience functions through five main themes: creating revenue streams, enhancing operational transport flexibility, enforcing digitalisation and data management, and optimising logistics infrastructure and personnel capacity. Supply chain agility generally refers to responding quickly to changes in demand and supply. Supply chain agility means that supply chains effectively detect supply chain crisis and disruption risks, improving SCR through rapid changes in business processes and systems (Sáenz & Revilla, 2014). Aslam et al. (2020) found that supply chain agility mediates the relationship between supply chain ambidexterity and SCR.

Specific resilience strategies also contribute to the supply chain's response and actions during disruption events (Scala & Lindsay, 2021). Ruel and El Baz (2021) demonstrated the role of supply chain disaster readiness in setting the stage for resilience. Collaboration can facilitate resource sharing and information exchange so supply chain firms can support each other in an emergency, reduce the cost of building resilience, and enhance SCR (Abeysekara et al., 2019; Scholten et al., 2019). Azadegan and Dooley (2021) further verified that Meso-level SCR develops when multiple supply networks cooperate on short to medium-term supply risks. Mandal and Saravanan (2019) took the tourism supply chain as an example and pointed out that organisational learning orientations positively impact the resilience of the tourism supply chain. El Baz and Ruel (2021) demonstrated that risk management practices are intermediaries in fostering SCR. To fit the dynamic supply-demand information processing requirement, supply chain risk management capabilities establish the information processing capacities in bolstering SCR by supply chain disruption orientation and visibility control mechanisms (Yang et al., 2021). Learning is essential

for organisations to achieve their goals. Organisational learning has a statistically significant impact on SCR (Mousa et al., 2020). Knowledge sharing can improve the utilisation of internal resources and knowledge. Knowledge-sharing capability has been shown to significantly influence improving SCR (Sabani and Parast, 2020).

Besides, leadership can be active resilience in organisational disruptions and crises (Williams et al., 2017). SCR depends mainly on the leader's abilities and capabilities to develop an effective response to disruptions (Morales et al., 2019). Leadership can develop SCR by creating social, emotional, and cognitive resources (Teo et al., 2017). Moreover, inter-organisational relationships (Bruller et al., 2019), networks, and collaboration can significantly contribute to SCR (Fang et al., 2020). Anderson et al. (2019) found that the preference for cooperation was critical for achieving SCR. Kim (2020) found that organisation-employee relationships were a positive and robust antecedent for SCR. The firms with lower density and centrality and the highest connectivity and network size exhibit higher resilience (Dixit et al., 2020). Levine et al. (2018) established that firms in high-trust economics were more resilient than those in low-trust economics. Furthermore, organisational culture focuses on activities for control and flexibility (Henri, 2006). Risk management culture plays a significant role in SCR (Li et al., 2019; Kumar and Anbanandam, 2020).

2.5 Digital Technologies and Supply Chain Resilience

Many organisations have been engaging in digital transformation and trying to adopt the digitalisation of their processes and services (Modgil et al., 2021). Digital transformation can affect SCR by applying the appropriate IT and information systems (Gu et al., 2021). It is broadly recognised that technology and advanced systems are associated with SCR (Tsiapa & Batsiolas, 2018). For instance, Gu et al. (2021) established that the investigative use of IT significantly affects

suppliers' and customers' resilience, whereas the ambidextrous use only enhanced the supply chain's customer-side resilience. However, Mandala and Saravanan (2019) found no significant relationship between technology orientations and SCR, even with positive path coefficients. Furthermore, enterprise systems were shown to increase control in the organisation but decrease organisational flexibility and resilience (Ignatiadis & Nandhakumar, 2007; Choi et al., 2023).

Even though the relationship between digital technologies and SCR has not been clarified, some specific emerging digital technologies have been associated with SCR. Big data analytics is suitable for improving the SCR of business operations and risk management (Spieske & Birkel, 2021; Choi, Chan, & Yue, 2016). Bag et al. (2022) examined the role of big data and predictive analytics (BDPA) in developing a resilient supply chain network in the South African mining industry. They found that BDPA can help improve supply chain visibility to establish community and resource resilience. Bayramova et al. (2021) found that blockchain technology solutions can positively impact SCR's visibility, collaboration, integration, risk management, and information sharing. Modgil et al. (2022) demonstrated that an AI-facilitated supply chain can contribute to developing resilience in the network. Ramanathan (2021) emphasised the role of digital supply chain technologies in encouraging firm resilience practices for emerging markets in the automotive sector. Ning et al. (2022) indicated that firms can achieve higher SCR if they employ digital technologies to increase supply chain traceability and agility.

Digital technology affects SCR through technological investment and application, digital capability cultivation, digital solution construction, and process optimisation empowerment (AL-Khatib & Ramayah, 2023; Gu et al., 2023; Gupta et al., 2023). The application of digital technologies helps to automate and optimise the task flow of the supply chain, strengthen delivery and manufacturing flexibility, and promote SCR (He et al., 2023; Jain et al., 2024).

As for technological investment and application, Gu et al. (2021) found that the exploratory use of information technology significantly impacts the SCR of suppliers and customers, while the two-way use of information technology will only enhance the resilience of the customer side of the supply chain. Bayramova et al. (2021) discussed measures to leverage blockchain technology to enhance SCR in the face of increased risk and uncertainty. Concerning digital capability cultivation, Singh and Singh (2019) found that IT infrastructure capabilities can positively impact SCR directly or through the intermediary of big data analytics capabilities. Nakandala et al. (2023) verified the positive role of Industry 4.0 technology capabilities in SCR. Regarding digital solutions, Modgil et al. (2022) found that AI facilitates the systematic development of resilient structures and networks in supply chains. Specifically, AI can enhance SCR by ensuring last-mile delivery, offering personalised solutions to upstream and downstream supply chain stakeholders, minimising the impact of disruption and facilitating an agile procurement strategy (Modgil et al., 2021). As for process optimisation, Burgos and Ivanov (2021) stressed the importance of the digital twin in a resilient supply chain, which includes demand, inventory, and capacity management. Shen and Sun (2021) found that an integrated supply chain structure and comprehensive intelligent platforms can promote SCR and handle supply chain risks through a case study of JD.com.

In summary, current studies have explored the specific role of a single digital technique from adoption, application, capability and strategy. However, few studies have highlighted how digital techniques can influence SCR and mitigate the disruption. Besides, current studies have failed to investigate the role of different affordances generated by digital technologies in SCR. There is still limited empirical evidence about SCR and digital affordance in logistics companies. Therefore, this thesis explores the role of digital techniques in SCR under disruptions and clarifies the digital affordance in motivating SCR.

2.6 Methodology in Supply Chain Resilience Research

Supply chain resilience methodology includes data collection, measurement, and analysis methods. According to the data source, data collection methods can be divided into primary and secondary data. The primary data collection methods include surveys, questionnaires, interviews and cases. The secondary data sources contain enterprise survey databases, business panel data, national statistical data, annual reports, policy documents and social media data. Data collection can be divided into qualitative and quantitative methods, depending on the classification of data types. Applying SCR data analysis methods relies on the data type and research aims. Table 2.5 presents the data sources and analysis methods of different SCR studies.

Table 2.5 Methods in supply chain resilience research

Firm types	Data sources	Analytic methods	Citations
Manufacturing companies, supply chains, food production firms, textile and clothing firms, material	Survey and questionnaire	SEM (Structural equation model), partial least squares (PLS), exploratory factor analysis (EFA), Confirmatory factor analysis (CFA), Harman's one-factor test, partial correlation technique, two-factor model, Pearson correlations	Morales, et al., 2019; Whitman, et al., 2014; Umoh, et al ., 2014; Golgeci & Ponomarov, 2013
Manufacturing firms, supply chain firms, production firms, private firms	Interview	Qualitative content analysis, inductive coding processes, cross-case analysis, simulation-based approach	Umoh, et al ., 2014; Dxit, et al., 2020; Witmer & Mellinger, 2016; Croucher, et al., 2016

Small and medium-sized enterprises (SMEs), textile firms	Cases	Simulation experiments, cross-case analysis, multiple-design case approach	Coates, et al., 2020; Pal and Mattila, 2014
Manufacturing firms, family firms	Enterprise surveys database, business panel data	DID (Difference in difference) methods, Spearman's Rank Correlation Statistical, hierarchical regression, Cluster approach, Bayesian Classification and Regression Tree models (BCART)	Levine, et al., 2018; Castellacci, 2015; Brewton, et al., 2010; Back, et al., 2017
Logistics organisations	Social media data (Tweets)	Sentiment analysis	Bastug & Yercan, 2021
Conservation area management committees, employee-owned businesses (EOBs) and non-employee-owned businesses	Annual reports, audit report	Thematic coding, descriptive statistical techniques, multiple regression analyses, correlation analysis.	Baral & Stern, 2011; Lampel, et al., 2014
Hospital emergency departments	Policy documents	Conceptual analysis, thematic analysis	Back, et al., 2017

Surveys and questionnaires are the critical data collection methods for SCR studies to collect primary quantitative data. Random sampling is widely applied to collect primary data in SCR empirical studies. Organisations were selected using simple or stratified random sampling techniques (El Baz and Ruel, 2020; Gölgeci and Kuivalainen, 2015) based on geographic location (Whitman et al., 2014; Yu et al., 2019), industry categorisations (Kim et al., 2020) and firm registration list (Umoh et al., 2014). Besides, Mousa et al. (2020) conducted comprehensive count

sampling to collect questionnaires. Doeksen and Symes (2015) collected survey data through theoretical sampling. An alternative method of snowballing sampling was also applied to collect survey data. Snowball sampling refers to randomly selecting some interviewees and conducting interviews with them, then asking them to provide some other survey objects that belong to the research target population and selecting subsequent survey objects based on the clues formed (Goodman, 1961). For instance, Aslam (2020) collects supply chain resilience data using snowballing sampling through electronic mail.

The questionnaire and survey data are almost composed of variable items, measured by Likert scales such as 4-point, 5-point, and 7-point scales. Common method bias refers to the artificial covariation between predictor and benchmark variables caused by the same data source, measurement situation, project context, and project characteristics (Conway and Lance, 2010). The SCR questionnaire data come from the same source or in the same measurement situation, which may cause common method bias. Harman one-factor test is a basic method to test the common method bias in SCR research, such as the studies of Mandal and Saravanan (2019), Abeysekara et al. (2019), and Dubey et al. (2021). Confirmatory factor analysis (CFA) is also a critical method to test common method bias in psychology, but almost all SCR studies only applied CFA to assess the scales. Besides, Aslam et al. (2020) used different Likert-type scales in different survey sections to avoid the common bias method, which controlled the bias from the source of deviation. Dubey et al. (2021) used a partial correlation technique to control method variance by a marker variable, which can explore the common method bias. Moreover, exploratory factor analysis (EFA) was applied to measure the validity of the SCR scales.

Enterprise panel data is also one of the major data sources for scholars to test the hypotheses of SCR. Due to the quantitative attribute, there are some common data analysis methods to analyse

questionnaire data, secondary panel data, and survey data, such as correlation technique, regression analysis and cluster approach. Pearson correlation (Garmestani et al., 2006; Gölgeci and Ponomarov, 2015) and Spearman's Rank Correlation Statistical (Umoh et al., 2014) are usually applied to establish the correlation relationship between SCR and other variables. Regression analysis was further used to clear the specific impacts of influencing factors on SCR (Brewton et al., 2010; Baral and Stern, 2011) and the influence of SCR (Li et al., 2017; Nkundabanyanga et al., 2019). For instance, Barel and Stern (2011) found that human and social capital positively influenced SCR through multiple regression analysis. Besides, the cluster approach was employed to classify the samples according to the resilience level and variable type (Borekci et al., 2014). Considering the roles of mediating and moderating variables in the SCR framework, many scholars employed various structural equation models to establish the SCR hypotheses. For example, a structural equation model (SEM) was applied to confirm the mediating role of absorptive capacity. Covariance-based structural equation modelling (CB-SEM) was used to verify the mediating role of big data analytics capability (Singh and Singh, 2019). The partial least squares structural equation modelling (PLS-SEM) revealed the mediating role of supply chain risk management practice (El Baz and Ruel, 2021). Moreover, panel data is a time series that can be observed in different periods. Therefore, DID (Difference in difference) methods are applied to compare SCR in different periods (Levine et al., 2018). Overall, compared with variable data of questionnaires and surveys, the measurement and variables of SCR are more limited due to the different purposes of the panel data.

Interviewing is another essential data collection method for exploring the relationship between SCR and other factors. In-depth, semi-structured and narrative interviews were conducted to collect qualitative data (Harries et al., 2018; Croucher et al., 2020). Policy documents and most

annual reports also are qualitative data. Therefore, qualitative content analysis, thematic analysis and conceptual analysis were applied to conceptualise, construct and assess SCR and explore the related relationship with other factors (Baral & Stern, 2011; Back et al., 2017; Dixit et al., 2020). Some quantitative annual reports and audit reports can be analysed by regression and correlation analyses (Lampel et al., 2014). Cases are also selected to clear SCR and are usually combined with the interview (Fang et al., 2020). Except for the cross-case and multiple-design case approaches, cases were chosen to simulate SCR results by defining SCR parameters and constructing a simulation model (Dixit et al., 2020). Moreover, tweets from the logistics organisation were used to analyse the logistics supply chain's resilience through sentiment analysis (Bastug and Yercan, 2021).

In summary, many research methods and data collection approaches could be applied in SCR research. Multiple methods can provide a more comprehensive view of a problem or situation, allowing for a more nuanced understanding. In some cases, using multiple methods can lead to more efficient solutions, as they might complement each other and cover different aspects of a problem more effectively. Therefore, this thesis applies multiple methods to investigate the role of digital techniques in supply chain resilience in the logistics sector.

2.7 Gaps in Current Research and Concluding Remarks

Although some studies have explored the role of AI, blockchain technology, and big data analytics technologies in SCR (e.g., Bayramova et al., 2021; Gu et al., 2021; Modgil et al., 2022), current studies failed to delve into the role of different affordances generated by digital techniques on SCR. Unlike industry-embedded technologies that are more specific, digital techniques are tightly integrated with usage scenarios, behavioural subjects, and goal orientation to achieve diverse goals for organisations and industries. (Belitski et al., 2023). Achieving organisational

goals through digital techniques is essentially digital affordance and its actualisation process (Autio et al., 2018). When the same digital technique takes distinct actions in different sectors, it exhibits different digital affordance characteristics, resulting in different organisational output outputs. (Anderson & Robey, 2017; McCarthy et al., 2022). Some studies have explored the potential roles of digital affordance in organisational innovation, performance, and dynamic survival of firms (e.g., Belitski et al., 2023; Henningsson et al., 2021; Liu et al., 2023). However, there is still limited empirical evidence about SCR and digital affordance in logistics companies.

Moreover, few studies have highlighted how DTs can influence SCR and mitigate the disruption. The role of DTs in managing disasters must be examined further (Bonn, 2019; Kaur et al., 2022; Bag et al., 2022), and not many studies have discussed DTs in the logistics sector (Ali et al., 2018; Chung, 2021; Pettit et al., 2019). Thus, DTs' role in improving logistics firms' SCR against disruptive events remains unclear. Study two focuses on flood events and analyses the critical components of DTs, namely digital orientation (DO) and digital competency (DC). In times of emergency, DO can be understood as a firm's emphasis on acquiring and incorporating emerging DTs for operation during a disaster (Masa'deh et al., 2018). In contrast, DC refers to basic technical skills and abilities that enable people to accomplish their work tasks efficiently in a disaster (Oberländer et al., 2020). The role of DO and DC in SCR and performance has not attracted much attention.

Furthermore, digital innovations facilitate a heightened level of visibility, allowing stakeholders to identify and respond to disruptions promptly, thereby enhancing supply chains' overall agility and responsiveness (Alvarenga et al., 2023; Tang, 2018; Sheffi, 2015). However, simply having digital tools is insufficient. The strategic orchestration of these resources alongside existing capabilities may catalyse the SCR (Hitt & Ireland, 2017). The configurational view offers

various benefits, including the capacity to account for the equifinality and causal asymmetry that define the pursuit of SCR, where multiple paths can lead to the same outcome, and the same result can be attained through diverse combinations of conditions (Schneider & Wagemann, 2012). However, in terms of research methodology, current studies have concentrated on assessing a single variable's "net effect" or the interaction effects of two factors, which ignore "multiple conjunctive causation" relationships among multiple causal conditions (Rihoux & Ragin, 2009).

To address the above gaps, this thesis intends to shed light on the role of digital techniques on SCR in the logistics sector. Three sub-research questions were derived from the overall research question: "What the roles of digital techniques in SCR are, and how to enhance SCR with digital techniques?". Sub-question 1, "How do digital affordances enhance supply chain resilience?" delves into the concept of digital affordances—the opportunities for action provided by digital technologies that can be leveraged to achieve specific goals. Sub-question 1 seeks to understand how these affordances can be actualized within logistics firms to enhance and strengthen SCR. Exploring digital affordances provides insights into how logistics companies can utilize digital technologies to identify, monitor, and reduce supply chain risks and disruptions, enhancing their resilience.

Sub-question 2, "What are the roles of digital techniques in supply chain resilience to disruptive events?" examines the specific components of digital techniques, such as digital orientation and digital competency, and their impact on SCR during disruptive events. Sub-question 2 aims to uncover how these digital techniques can be employed to prepare for, respond to, and recover from such events, thus improving the SCR of logistics firms. Understanding the roles of digital techniques in the context of disruptions provides practical strategies for logistics firms to maintain operations and performance during crises.

Sub-question 3, “What are the configuration effects of digital innovation and resources on supply chain resilience?” adopts a configurational approach to explore how different combinations of digital innovation (both exploratory and exploitative) and resources (including human capital, logistics infrastructure, and collaboration networks) can influence SCR. Sub-question 3 seeks to identify the synergistic effects and potential substitution relationships between these factors, offering a nuanced understanding of the multifaceted antecedents of SCR. This approach acknowledges that there may be multiple pathways to achieving SCR, each tailored to individual firms' unique context and capabilities.

The overall research question sets the stage for an in-depth investigation into the role of digital techniques in SCR, while the sub-questions provide a structured framework to explore specific aspects of this relationship. RQ1 focuses on the motivational aspects of digital affordances, RQ2 examines the practical application of digital techniques during disruptive events, and RQ3 explores the complex interplay between digital innovation, resources, and their combined effects on SCR. These questions provide a comprehensive understanding of how digital techniques can be harnessed to build and sustain supply chain resilience in the logistics sector. Therefore, this thesis developed three studies to answer the research questions. Study one tries to elaborate affordance theory into the SCR research agenda and explore how digital affordance enhances SCR. Study two adopts multiple methods to clarify the role of DTs in the SCR of logistics firms during disruptive events. Study three seeks to explore the interplay between ambidextrous digital innovation and resources via the lens of resource orchestration and provide a comprehensive framework for logistics firms to improve SCR.

CHAPTER 3 RESEARCH METHODOLOGY

This thesis aims to understand the roles of digital techniques in SCR by multi-methods exploration. This thesis tries to answer three research questions: (a) How do digital affordances enhance supply chain resilience? (b) What are the roles of digital techniques in supply chain resilience to disruptive events? (c) What are the configuration effects of digital innovation and resources on supply chain resilience? This chapter first presents the research philosophy and strategy. After adopting the research philosophy, this chapter discusses the research flow, data collection, and analysis methods used in this thesis. This chapter also discusses the ethical considerations and concludes with applied research methodologies.

3.1 Research Philosophy and Strategy

Post-positivism describes a single reality and perceives the phenomena through limited perception (Racher & Robinson, 2003; English & Ivory, 2014). Moreover, the value realist of post-positivism accepts that the researcher's values may influence findings and methodology and seeks to remedy bias (Weideman, 2012). Besides, the post-positivism prefers mixed methods. This thesis tries to figure out the role of digital techniques in SCR. Supply chain digitalisation is a single reality in the transformation process, while SCR is the actions and capabilities accessed through humans' perception. There are many measurement methods to measure SCR, such as systematic, process, resources, capabilities items, and scales. Because different researchers prefer different scales and analysis methods to achieve research aims, the measurement of digital techniques innovation and the definition of SCR can be distinctly different. The researchers' values may influence the findings and methodology. In this thesis, the findings of the relationship between digital techniques and SCR will be influenced by previous research values, but mixed methods can

eliminate the bias to the greatest extent. Therefore, the personalized research philosophy of this thesis is post-positivism. The following parts explain how ontology, epistemology and axiology exist in this thesis study.

Ontology is the systematic description of objective things concerning. From the perspective of ontology, post-positivism argues that ontology is a single reality investigated by researchers (Bisman, 2010). Today's supply chains are sophisticated networks worldwide that strive to deliver products in the proper amount, location, and time in volatile marketplaces. Economic crises, extreme weather, and pandemics are unpredictable, disruptive occurrences that have caused unprecedented disruptions in supply chains (Herold et al., 2021; Singh & Singh, 2019). These disruptions are challenging to predict regarding time and scale (Ozdemir et al., 2022). Practitioners concentrate on developing SCR strategies that identify, monitor, and eliminate supply chain risks and disruptions and respond and recover swiftly and cost-effectively (Macdonald et al., 2018). Digitisation of the supply chain has advanced considerably in recent years (Nayal et al., 2022). The impact of digital techniques on SCR is a single reality that mixed methods will explain. Case studies will be applied to explore the role of digital techniques in the affordance of SCR. A structural equation model and fuzzy-set qualitative comparison analysis will be used to clarify the effects of digital techniques on SCR. This relates to the ontology of post-positivism.

Epistemology is an individual’s belief in knowledge and knowledge acquisition, which is about how human beings understand the world and themselves and how to distinguish the objective world from the subjective world (Johnson & Duberley, 2002). Besides, an epistemology of post-positivism proposed that facts and values are distinct and scientific knowledge consists only of facts (Walsham, 1995). Researchers try to find and explain the reality through their transitive and intransitive knowledge (Bhaskar, 1975). A theoretical framework will be constructed to better

abstract the relationship between digital affordance and SCR. Besides, the theoretical model should consider other key control variables, which can be extracted from literature reviews and news reports. An empirical study will be applied to test the hypothesis of this study. Digital techniques and SCR are the empirical observations. This thesis observed digital techniques from different perspectives, including digital affordances (study 1), digital orientation and competency (study 2), and ambidextrous digital innovations (study 3). This thesis also uses multiple methods to identify SCR from the perspective of affordance goals and capabilities. Digital techniques and SCR are accessed through different perceptions of researchers, consisting of post-positivism epistemology.

Axiology investigates and evaluates the significance of various material and spiritual phenomena and the subject's behaviour to the individual, class, and society (Hart, 1971). Current research has investigated the role of AI, blockchain technology, and big data analytics in SCR (Bayramova et al., 2021; Gu et al., 2021; Modgil et al., 2022). Some research has investigated the potential effects of digital affordance on organizational innovation, performance, and company survival (Belitski et al., 2023; Henningsson et al., 2021; Liu et al., 2023). However, empirical data on SCR and digital affordance in logistics firms remains sparse. The extant literature has scarcely addressed the influence of digital techniques on SCR and their capacity to ameliorate disruptions. An in-depth investigation into the role of digital techniques in disaster management is imperative, as the current body of work is nascent in this domain (Bonn, 2019; Kaur et al., 2022; Bag et al., 2022).

Furthermore, the discourse on applying digital techniques within the logistics sector is notably sparse (Ali et al., 2018; Chung, 2021; Pettit et al., 2019). Regarding research methodology, the prevailing studies have often overlooked the intricate ‘conjunctive causation’ dynamics among

many causal factors, which is a significant oversight in the academic discourse (Rihoux & Ragin, 2009). This thesis can contribute to exploring the relationship and influence path between digital techniques and SCR. The proposed managerial strategy can provide practical and scientific suggestions for the firms to improve their SCR. Axiology in post-positivism can accept the findings and methodology and remedy bias (St John & Neesham, 2020). This thesis will propose findings and create social values consistent with post-positivism's axiology.

3.2 Research Flow

The research design is summarised in Figure 3.1, which shows the research flow of this thesis and the links among the three studies and research questions. Study one explores how digital affordances enhance the SCR of logistics firms. Study two explores the impacts of digital techniques (digital orientation and competency) on the SCR and performance of logistics firms in response to disruptive events. Study three clarifies the configuration effects of ambidextrous digital innovations and resources on SCR.

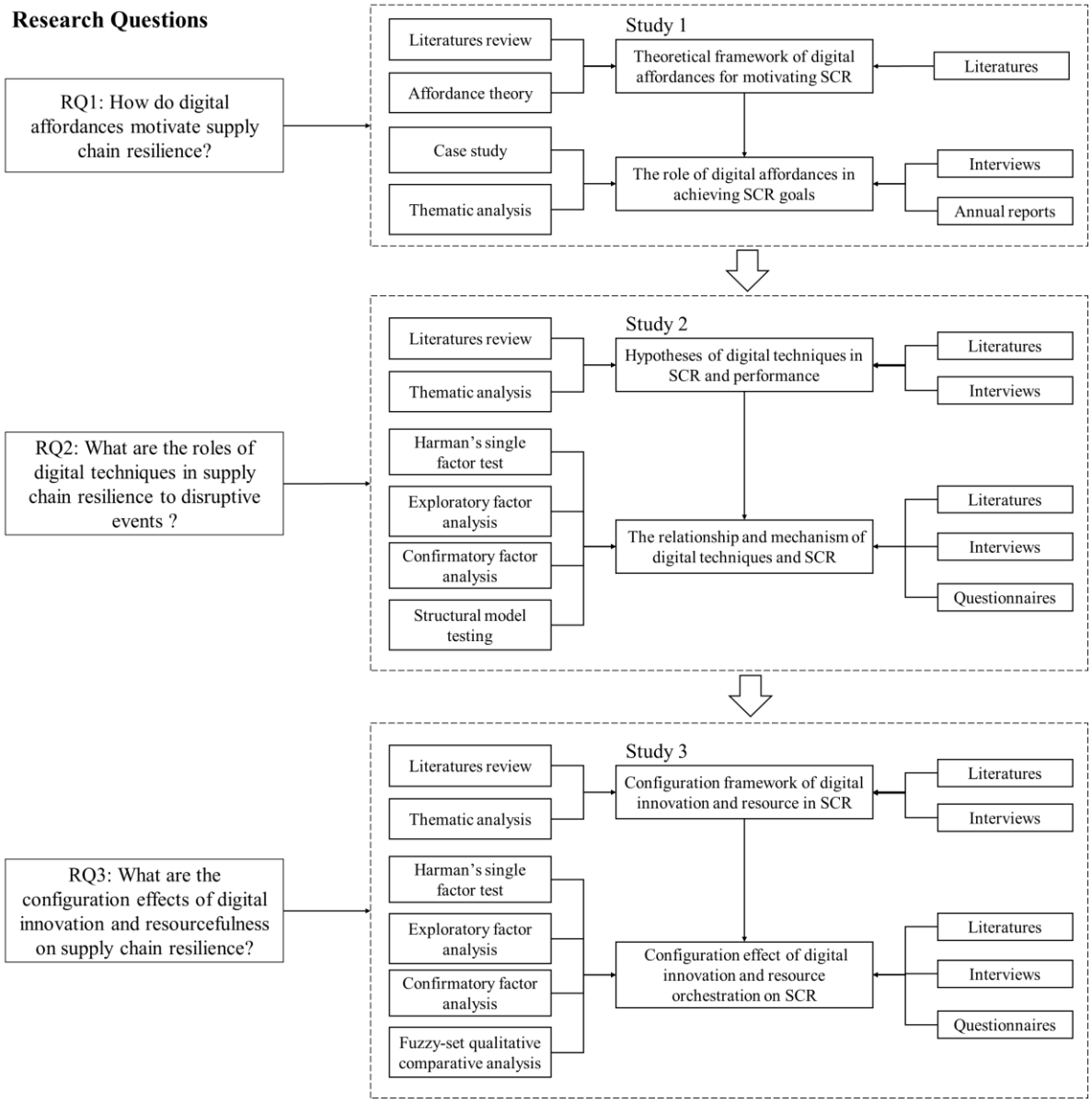

Figure 3.1 Flow chart of the research (Source: author)

The collective body of work presented in these three studies advances the discourse on the role of digital techniques in enhancing supply chain resilience (SCR) within the logistics sector. Study one establishes a theoretical foundation and provides empirical evidence for understanding the motivational role of digitalization in fostering SCR, laying a solid groundwork for subsequent research endeavours. It introduces a theoretical framework that elucidates how digital affordances can be actualized to enhance SCR, thereby setting the stage for a deeper exploration of this

phenomenon.

Building upon this foundation, study two delves into the specific components of digital technologies, namely digital orientation (DO) and digital competency (DC) and examines their direct and indirect influences on SCR and firm performance. Through a multi-method approach that includes semi-structured interviews and structural equation modelling, this research uncovers the interplay between DO and DC, revealing that while DC positively impacts SCR, DO enhances firm performance both directly and indirectly through the mediating role of DC.

Study three broadens the research perspective by integrating the concepts of digital innovation and resource orchestration. Employing fuzzy-set Qualitative Comparative Analysis (fsQCA), this study explores the configurational effects of digital innovation and resources on SCR, uncovering distinct pathways through which these elements contribute to SCR. The findings underscore the non-linear and conditional nature of the relationships between digital innovations and resource orchestration, offering a nuanced understanding of the multifaceted antecedents of SCR.

These three studies have a harmonious integration of theory and practice. Each study begins with a theoretical proposition, which is then empirically tested, providing actionable insights for supply chain managers and contributing to the practical application of theoretical knowledge. This dual focus advances the theoretical understanding of SCR and offers strategic suggestions for perceiving and actualizing digital affordances to enhance SCR in the logistics sector.

This thesis uses multiple-methods approach to explore the role of digital techniques in SCR as the following reasons. The multifaceted nature of SCR, influenced by technological, organizational, and environmental factors, necessitates a holistic and nuanced understanding that a single method alone may not provide. By combining multiple methods, the thesis aims to capture

the full complexity of these interactions and offer a more robust and credible analysis.

First, using multiple methods enhances the validity and reliability of the research through triangulation, which involves verifying findings through different sources and methods. This process reduces the risk of bias or errors associated with a single method and provides a more comprehensive and reliable basis for the findings. For instance, qualitative methods, such as case studies and thematic analysis, offer deep insights and context, while quantitative methods, such as structural equation modelling (SEM), provide statistical evidence and generalizability. This combination ensures that the research is rich in detail and supported by empirical data.

Second, each research question in this thesis is addressed using methods best suited to its specific requirements. The first research question, which focuses on how digital affordances motivate supply chain resilience, is explored through case studies and thematic analysis. These methods allow for an in-depth examination of how digital technologies are utilized and their impact on resilience. The second research question, which examines the practical application of digital techniques during disruptive events, is analysed using SEM. This method is appropriate for testing the relationships between digital orientation, competency, and SCR, providing empirical evidence to support the findings. The third research question, which explores the complex interplay between digital innovation and resourcefulness, is addressed using fuzzy-set qualitative comparative analysis (fsQCA). FSQCA is well-suited for handling multi-level and conjunctive causal relationships, offering a nuanced understanding of the configurations that lead to high and low levels of SCR.

The flexibility and adaptability of the multi-method approach are also crucial. Qualitative methods, such as case studies and interviews, are open and flexible, allowing researchers to explore emerging themes and elements that may not have been initially anticipated. This is particularly

important in a rapidly evolving digital supply chain management field. Case studies provide rich, contextual data that are essential for understanding the specific challenges and opportunities faced by logistics firms, thereby enhancing the practical relevance of the research.

In summary, the multi-method approach in this thesis is designed to leverage the complementary strengths of different research methods. By integrating qualitative and quantitative methods, the research can address the complexity of the topic, enhance the credibility of the findings, and offer practical insights for academics and practitioners in the logistics sector. Table 3.1 lists the applied methods and applied reasons. This approach ensures that the thesis provides a comprehensive, robust, and valid exploration of the role of digital techniques in supply chain resilience.

Table 3.1 Method selection and rationales

	Methods	**Rationales**
Data collection	Interviews	- Rich and Contextual Data: Interviews provide deep insights into how organizations perceive and utilize digital techniques. Interviews also offer detailed, contextual insights into specific configurations and their effects on SCR. - Justification: Interviews allow for exploring individual experiences and organizational strategies, providing nuanced insights that are difficult to capture through quantitative means.
	Questionnaire survey	- Empirical Evidence: Quantitative surveys provide statistical data to test hypotheses and identify patterns. - Justification: Surveys provide the ability to generalize findings from the qualitative phase and quantify the impact

		of digital techniques on SCR.
	Secondary data: annual reports	- Rich and Contextual Data: Annual reports provide comprehensive and officially documented information about a company's financial performance, strategic initiatives, and operational activities. They are meticulously prepared and audited, ensuring high accuracy and reliability. This makes them an excellent source for understanding how companies perceive and report using digital technologies and supply chain resilience strategies. - Cross-check: By integrating data from annual reports with the findings from interviews, the thesis can provide a more comprehensive and robust understanding of the role of digital techniques in supply chain resilience within the logistics sector.
Data analysis	Content analysis	- Flexibility: Allows for the exploration of emergent themes and nuanced understanding. - Validation of Themes: By coding and categorizing textual data, the research can identify common themes and sentiments that reflect organizational experiences and digital affordances related to SCR. Comparing the findings from content analysis with those from interviews and case studies strengthens the credibility of the research by corroborating patterns and themes across different datasets.
	Structural equation model	- Generalizability: SEM allows for analysing relationships between multiple variables, providing generalizable findings. - Hypothesis Testing: Suitable for testing the impact of digital orientation and competency on SCR.

	Fuzzy-set qualitative comparative analysis (fsQCA)	- Complex Causal Relationships: fsQCA is well-suited for examining multi-level and conjunctive causal relationships, providing a nuanced understanding of configurations. fsQCA allows for identifying multiple pathways to SCR, acknowledging the complexity and non-linearity of the relationships. - Configuration Effects: fsQCA helps identify the combinations of factors that lead to high and low levels of SCR.

3.3 Data Collection

3.3.1 Interview

The expert interview will be applied to develop logistics firms' SCR framework and gain insights. Interviews with logistics firm managers, employees and researchers will be conducted to understand the current supply chain digitalisation situation and the logistics firm's SCR. In-depth interviews with logistics company managers will be conducted to explore the respondents' experiences and insights regarding the SCR. The interview questions were semi-structured and short to create effective interaction between respondents and researchers, which helps the respondents present and make meaning based on their experiences and feelings. The interview guide was designed to capture the broad perspectives of the impact of emerging disruptive events and any reaction or countermeasures that logistics companies have deployed to develop SCR.

In study one, the interview guide was designed to capture what digital affordances can enhance SCR and how they actualise the SCR goals of logistics companies. In study two, interviews are applied to identify the critical components of digital techniques influencing the SCR of logistics firms against floods and gain insights into how logistics firms achieve SCR. In study

three, interviews and focus groups will also be conducted to identify critical components of digital innovations and resources affecting the SCR of logistics companies and gain insights into how digital innovation enhances SCR.

3.3.2 Questionnaire

In the prelude to constructing the questionnaires for Studies 2 and 3, a foundational system of primary digital techniques and supply chain resilience (SCR) indicators will be meticulously developed, drawing upon a comprehensive review of the pertinent literature on SCR and digitalization. This foundational system serves as the bedrock for the subsequent development of the questionnaires. The questionnaires will incorporate a seven-point Likert scale, a widely recognized measurement tool in survey research, designed to quantify the significance of each indicator within the realms of digital techniques—encompassing digital orientation and competency in Study 2—and ambidextrous digital innovation and SCR in Study 3. This scale will provide a nuanced spectrum for respondents to express their perceptions and attitudes towards the constructs under investigation.

Following the initial design, the questionnaires will be subjected to a rigorous review by a panel of experts to refine the items and enhance the overall quality of the measurement instrument. Subsequently, both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) will be conducted. These statistical techniques are instrumental in identifying the core indicators underpinning the constructs of interest and establishing the final measurement model for the variables. The target population for the thesis is an aggregation of top-tier executives, senior managers, junior managers, and other professional staff intimately involved in logistics firms' operational facets. For Study 2, the sampling frame is derived from companies in areas prone to flooding, as previously reported by news outlets (The People’s Government of Zhejiang Province,

2023), complemented by the logistics industry register (Zhejiang Logistics Association, 2023).

In contrast, Study 3 adopts a random sampling methodology to gather data suitable for fuzzy-set Qualitative Comparative Analysis (fsQCA). The distribution of questionnaires is facilitated through both online and offline channels, targeting executives and managers for completion. Participants must have a tenure of no less than three years within their respective companies and must have been actively engaged in innovation initiatives. It is also a prerequisite for their profound understanding of the subject matter. Moreover, the companies they represent must have introduced either a service or product innovation within the recent three-year period, underscoring the relevance of their experience to the study's thematic focus.

3.3.3 Secondary data collection approach

The utilization of secondary data is pivotal, encompassing the case study firms' annual reports and operational datasets. This secondary data is a critical resource, offering supplementary perspectives that corroborate and augment the narratives derived from firm interviews. To enrich the qualitative data obtained through interviews and to attain a more profound comprehension of the operational dynamics and strategic orientations of the logistics entities under scrutiny, the annual reports of these companies were meticulously collated.

The compilation of annual reports, representing a form of public financial communication issued by case firms, spans three years from 2019 to 2021. This temporal scope ensures a robust representation of the companies' financial health and strategic evolution over time. The practice of amassing such documents from the official web portals of the case firms is aligned with the methodologies advocated by Lajili and Zéghal (2009) and Tate et al. (2010).

Furthermore, incorporating diverse data sources is recognized for its capacity to mitigate the inherent subjectivity that may be present in interview-based data. This approach is instrumental in

substantiating the research findings and enhancing the credibility of the study (Ali et al., 2021; Herold et al., 2021). In congruence with this principle, the present thesis will extend its data collection efforts to encompass annual reports and foundational firm information from reputable open-access databases. This strategy broadens the data spectrum and ensures a more comprehensive and multifaceted analysis of the research phenomena.

3.4 Data Analysis

3.4.1 Content analysis

Content analysis is a systematic method employed to categorize and organize vast quantities of data or information, facilitating identifying and elucidating research issues (Weber, 1990). Mayring (2014) articulates content analysis as a research methodology that enables deriving context from text or other meaningful events through repeatable and valid inferences. These inferences are pivotal in addressing issues related to the information content, the sender, the recipient, or the broader impact of the information (Weber, 1990).

In parallel, thematic analysis will be deployed to dissect the qualitative data from interviews. The thematic analysis examines the interview content through a lens defined by specific analysis units. The overarching aim is to delve into the mechanisms by which digital affordances stimulate SCR in Study 1, to discern the pivotal elements of digital techniques and SCR in Study 2, and to uncover the critical facets of digital innovations, resources and SCR in Study 3. This method uses a theory-driven coding approach to pinpoint the specific antecedents within the dataset (Walsham, 2006). The assessment of thematic saturation is predicated on the thoroughness of theme development and the significance of themes within the data.

A content analysis of literature and annual reports will be conducted. This serves a dual purpose: firstly, it provides a critical cross-verification mechanism for the case study and interview

findings, and secondly, it reinforces the reliability and validity of the qualitative insights by corroborating them against the existing body of knowledge. This integrative approach ensures a comprehensive understanding of the research phenomena and enhances the robustness of the conclusions drawn from the data.

3.4.2 Structural equation model

Structural Equation Model (SEM) is a sophisticated analytical technique that validates relationships among variables. It encapsulates regression analysis and path modelling methodologies, offering a more comprehensive approach to understanding variable associations. SEM's integration of factor analysis with path modelling adeptly addresses the limitations of traditional path analysis, particularly in assessing the relationships between latent constructs. One of the critical strengths of SEM is its capacity to handle both manifest (observed) and latent (unobserved) variables, a feature that sets it apart from other statistical techniques (Barrett, 2007). SEM can perform regression analysis, path modelling, and covariance structure analysis, providing a multifaceted view of the data.

SEM's ability to elucidate the interplay and causal pathways between variables is particularly noteworthy. It offers a nuanced perspective on how individual variables influence others, especially latent variables, where it can effectively delineate the causal mechanisms and directional influences (Yao et al., 2021). Furthermore, SEM accounts for measurement error in variables, enhancing the precision of the analysis. SEM is deemed an appropriate analytical tool in Study 2, which seeks to investigate the impact of digital techniques on the supply chain resilience (SCR) of logistics firms in the face of disruptive events. As a latent variable, SCR comprises multiple dimensions measured by various items. SEM will be instrumental in examining the effects of digital techniques on logistics firms' SCR and other potential influencing pathways.

By applying SEM, study two will be able to rigorously test the hypothesized relationships, including the roles of digital orientation and digital competency and their direct and indirect effects on SCR. This methodological choice ensures that the study's findings are grounded in a robust statistical framework, allowing for the drawing of well-informed conclusions about the role of digital techniques in enhancing the SCR of logistics firms to disruptive events.

3.4.3 Fuzzy-set qualitative comparative analysis

Fuzzy-Set Qualitative Comparative Analysis (fsQCA) represents a significant departure from traditional linear regression analysis, offering a robust methodology for examining complex causality within case-based research. Rooted in Boolean logic and algebra, fsQCA, as introduced by Ragin (2009), transcends binary categorizations of conditions, allowing for a more refined assessment of causal relationships based on the degree to which conditions are satisfied. This nuanced approach provides a richer understanding of the causal mechanisms at work, capturing the complexity inherent in social phenomena.

Unlike linear regression, which is often constrained to analysing the "net effect" of a single variable or the interaction effects between two variables, fsQCA is adept at exploring the "multiple conjunctive causation" relationships among a multitude of causal conditions (Rihoux & Ragin, 2009). This methodological innovation addresses a fundamental limitation of traditional regression analysis: its focus on linear relationships and its inability to capture the complexity of causal interactions fully (Fainshmidt et al., 2019).

In Study 3, fsQCA is employed to investigate the pathways through which resources and digital innovation collectively influence logistics enterprises' supply chain resilience (SCR). The application of fsQCA in this study challenges the assumption of causal symmetry inherent in traditional statistical analysis methods, offering a more comprehensive and nuanced perspective

on causal mechanisms. The findings of study three, facilitated by fsQCA, contribute to the literature by highlighting the importance of considering the configurational nature of causality in understanding SCR. This approach moves beyond the mainstream quantitative research's focus on net effects, offering a more holistic and nuanced understanding of how multiple factors interact to influence SCR in logistics enterprises.

3.5 Ethical Considerations

In the realm of scholarly inquiry, research ethics encompass the foundational principles and benchmarks that dictate the conduct of research, with a particular emphasis on safeguarding the rights and well-being of research subjects (Saunders et al., 2012). These ethical considerations are indispensable not only for protecting the participants involved in the study but also for the researchers and the academic institutions they represent (Myers, 2020).

The integration of ethics should be a pervasive and continuous endeavour throughout the entire research lifecycle, including the research design, the planning phase, the data collection, the data analysis, and the reporting of findings. In this thesis, ethical considerations were meticulously woven into every aspect of the research process. Formal approval from the University of Nottingham Ningbo China's Ethics Review Committee was secured before data collection. This procedural step is crucial for obtaining the necessary clearance to conduct research that upholds ethical integrity. Participants in the study were made aware of their rights through comprehensive and transparent communication. During the interviews, they were informed about the assurance of anonymity and the confidentiality of their contributions, both in writing and verbally. This dual approach ensures that participants understand their rights and the ethical considerations guiding the research.

By taking these measures, the thesis demonstrates a commitment to ethical research practices,

which is essential for maintaining trust, ensuring the validity of the research, and contributing to the body of knowledge responsibly and respectfully.

CHAPTER 4 DIGITAL AFFORDANCES AND SUPPLY CHAIN RESILIENCE

4.1 Introduction

In supply chain management, unforeseen perturbations, such as economic downturns, climatic anomalies, and global health crises, have precipitated unprecedented disruptions within the logistics sector (Herold et al., 2021). Empirical data from a recent survey indicate that 11.5% of the organizations polled encountered more than ten incidents of supply chain disruption in the year 2022 (BCI Supply Chain Resilience Report, 2023). These disruptions have necessitated prolonged transportation intervals and have led to the cessation of freight operations, thereby augmenting the expenses associated with transporting goods and passengers and concurrently diminishing the operational capacity of carriers (Xu et al., 2020).

Considering the extensive provision of inherently social services and the pronounced roles of logistics firms as conduits and links within the supply chain ecosystem, the repercussions of disruptive incidents within the supply chain are not confined to the logistics sector alone. These effects are transmitted and can significantly influence the operational dynamics of both upstream and downstream entities, such as manufacturers and retail enterprises (König & Spinler, 2016), as well as the societal fabric of the populace at large. In response to the escalating demand for rapid and efficient transportation, logistics enterprises have assumed a pivotal function in surmounting the temporal and spatial limitations inherent in contemporary supply chain configurations throughout recent years (Herold et al., 2021; Holl & Mariotti, 2018). The volatility in the logistics market's demand and supply dynamics disrupts the seamless flow of materials and impedes the execution of logistical business operations, including transportation and storage services (Straka, 2019).

The escalating frequency and unpredictability of supply chain disruptions have engendered

new imperatives for logistics companies. These imperatives include constructing and enhancing resilience capabilities (Scholten et al., 2014). This underscores the necessity for logistics firms to adopt proactive strategies that fortify their operational frameworks against potential disruptions, thereby ensuring the continuity and stability of supply chain processes.

In response to the limitations inherent in conventional risk management, the logistics industry has increasingly directed its efforts towards cultivating SCR. Previous supply chain risk management has traditionally concentrated on how organizations confront a spectrum of disruptions and embrace strategies designed to attenuate associated risks (Dubey et al., 2021; Singh & Singh, 2019). Logistics firms exert a substantial influence on the enhancement of SCR by striving to diminish or altogether avert the emergence of risks that may arise from the unpredictability of demand or supply conditions or in the face of emergencies. This is achieved through the orchestrated control and direction of the flow of materials (Shen & Sun, 2021; Song et al., 2022). By doing so, these companies safeguard their operations and contribute to the overall robustness and reliability of the supply chains in which they participate. This proactive stance towards risk management is essential in an ever-increasing complexity and volatility environment.

Advanced digital techniques facilitate the real-time tracking of fluctuations within the supply chain, enabling swift and informed response mechanisms and precise oversight of business operations. Such capabilities are invaluable in bolstering SCR, as they allow for proactively identifying vulnerabilities and implementing robust countermeasures (Bag et al., 2022). By leveraging the power of data analytics and predictive modelling, logistics firms can anticipate and mitigate potential disruptions, thereby fortifying the resilience of their supply chain networks. This digital transformation not only enhances the agility and adaptability of these organizations in the face of uncertainty but also positions them at the forefront of the evolving logistics landscape.

Unlike industry-embedded technologies, which are more specific, digital technologies are deeply integrated with usage scenarios, behavioural subjects, and goal orientation to achieve diversified goals for organisations and industries (Belitski et al., 2023). For example, enterprises can use big data analytic technology to achieve customised services, reduce costs or develop SCR for different purposes (AL-Khatib & Ramayah, 2023; Bag et al., 2022). Achieving organisational goals through digital technologies is essentially digital affordance and its actualisation process (Autio et al., 2018). Digital affordances are the perceived and actual properties of digital technologies that determine how they can be used to achieve specific outcomes.

In the context of supply chain resilience (SCR), digital affordances refer to how digital technologies enable organizations to enhance their ability to anticipate, prepare for, respond to, and recover from disruptions. Digital affordance emerges from the technological architecture of digital infrastructure. Digital affordance is not a technical feature or a result of technological use but rather a possibility of goal-oriented actions and a relationship that constantly changes during the digital actualisation process (Autio et al., 2018; H. Wang et al., 2018). When the same digital technology adopts different actions in different fields, it will exhibit different digital affordance characteristics, leading to different organisational output results (Anderson & Robey, 2017; McCarthy et al., 2022).

However, the current literature fails to address how digital affordances enhance SCR. The literature has extensively discussed the implementation and impact of digital technologies in supply chains. Some studies have explored the role of AI, blockchain technology and big data analytics technologies in SCR (e.g., Bayramova et al., 2021; Gu et al., 2021; Modgil et al., 2022), current studies failed to delve into the role of different affordances generated by digital technologies on SCR. Some studies have explored the potential roles of digital affordance in

organisational innovation, performance, and dynamic survival of firms (e.g., Belitski et al., 2023; Henningsson et al., 2021; Liu et al., 2023). There is a notable gap in understanding how these technologies, through their affordances, contribute to the resilience of supply chains within the logistics sector. Additionally, there is a paucity of conclusive empirical evidence that supports explaining what digital affordances affect SCR and how these affordances enhance the SCR of logistics companies. This study aims to explore how digital affordances can enhance SCR. Specifically, the research question is considered:

RQ1. How do digital affordances enhance supply chain resilience?

Answers to the question are sought by investigating fourteen case studies of Chinese logistics companies, as China has the largest logistics market in the world and is making progress in digitising logistics based on logistics opportunities and business fundamentals (Statista Research Department, 2023). This study makes several contributions to SCR and digitalisation by providing insights into this topic. First, this study elaborates affordance theory to SCR, providing an additional theoretical lens to SCR. Second, this study clarifies the SCR goals of logistics companies, which are stability and continuity to opportunity creation. Next, this is one of the first papers to empirically explain digital affordances and their actualisation process for SCR in the logistics sector, with a new line of inquiry and strategy suggestions. Finally, this study verifies the role of digital affordance in SCR, which has not been deeply explored. The above helps advance the knowledge of digital affordances and SCR.

4.2 Theoretical Positioning

Affordance theory proposes the possibilities for action afforded to specified user groups by IT artefacts to achieve individual or collective goals (McCarthy et al., 2022). The concept of affordance was first introduced by ecological psychologist Gibson (1979), who pointed out that

affordance is the possibility that the environment provides behavioural objects. Subsequent research has transplanted the concept of affordances to the organisational level and even into the domain of human-technology interaction, extending the connotation of affordances beyond the intrinsic properties of technology (Strong et al., 2014). Affordance investigates the link between the planned system features and the user's perception of the system features, as indicated by the goal-oriented action options it offers (Wang et al., 2018). Affordance also encompasses the social elements of the organisation, the interconnection between organisational technologies and its social fabric, and the potential for new forms of action (Henningsson et al., 2021; Leonardi, 2011).

Digital affordance emerges from the technological architecture of digital infrastructure. Affordance theory provides a theoretical lens through which firms select and employ digital technologies and the subsequent changes in organisational processes and services (Anderson & Robey, 2017). Affordance theory emphasises human initiative as a potential for action, which means affordance focuses on usage scenarios rather than technical features (Pozzi et al., 2018; Volkoff & Strong, 2017). In its extension, affordance theory explores the actions taken by organisations to achieve various opportunities for digital technology.

Digital affordance presents a broader connotation in three aspects: technological resources, user groups, and interaction methods (Henningsson et al., 2021). Owing to the innate advantages of flexibility and uncertainty inherent in digital technologies, digital technologies facilitate the redesign of value creation, delivery, and acquisition processes within the practice of digital affordances (Autio et al., 2018; Belitski et al., 2023). Digital affordance contributes to the possibilities of resilient action caused by the interaction between digital technologies and organisations. Therefore, affordance theory provides a theoretical foundation for studying logistics companies to achieve SCR through digital affordance.

This study develops an initial theoretical framework based on affordance theory and a review of the affordance literature (Anderson & Robey, 2017; Bernhard et al., 2013; Murthy & Madhok, 2021; Wang et al., 2018), as shown in Figure 4.1. The theoretical framework of digital affordances in achieving SCR goals contains four steps. The first step is the cognition process of affordance existence, which means digital affordance exists in real-world application scenarios after the interplay between digital technologies and logistic firms. The second step is recognising digital affordances, which originate from digital technology features and firms' capabilities. To fully harness the potential of digital technologies towards achieving predetermined SCR objectives, logistics companies need to exhibit a profound perception and understanding of digital affordances. The third step is the behaviours for digital affordance actualisation. As a goal-oriented iterative process, the realisation of SCR necessitates active engagement behaviours from logistics companies in enacting digital affordances. The last step is the affordance effects of SCR goals—a collection of concrete results and ultimate goals achieved through digital affordances.

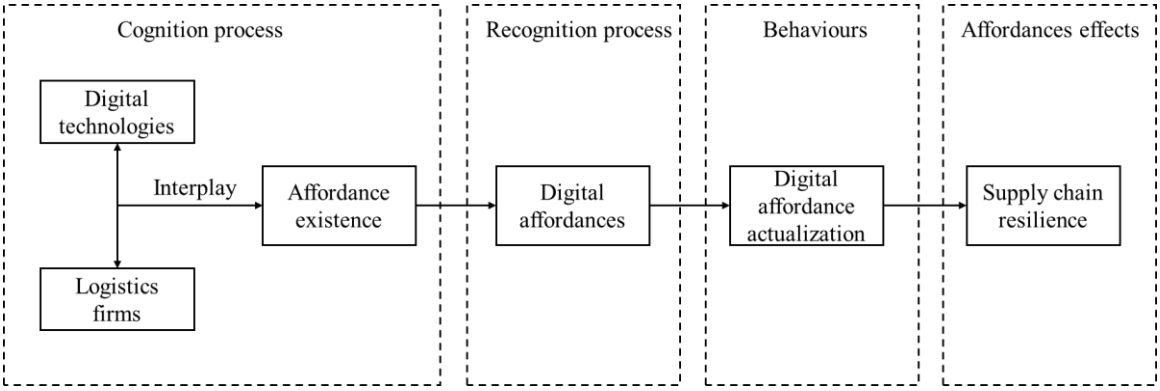

Figure 4.1 Theoretical framework of digital affordances for motivating SCR (Source: author)

4.3 Research Methods

The study aims to elaborate affordance theory into SCR study and clarify how digital

affordances enhance the SCR of logistics firms. Referring to DuHadway et al. (2022), this study adopted the theory elaboration methods, as shown in Figure 4.2.

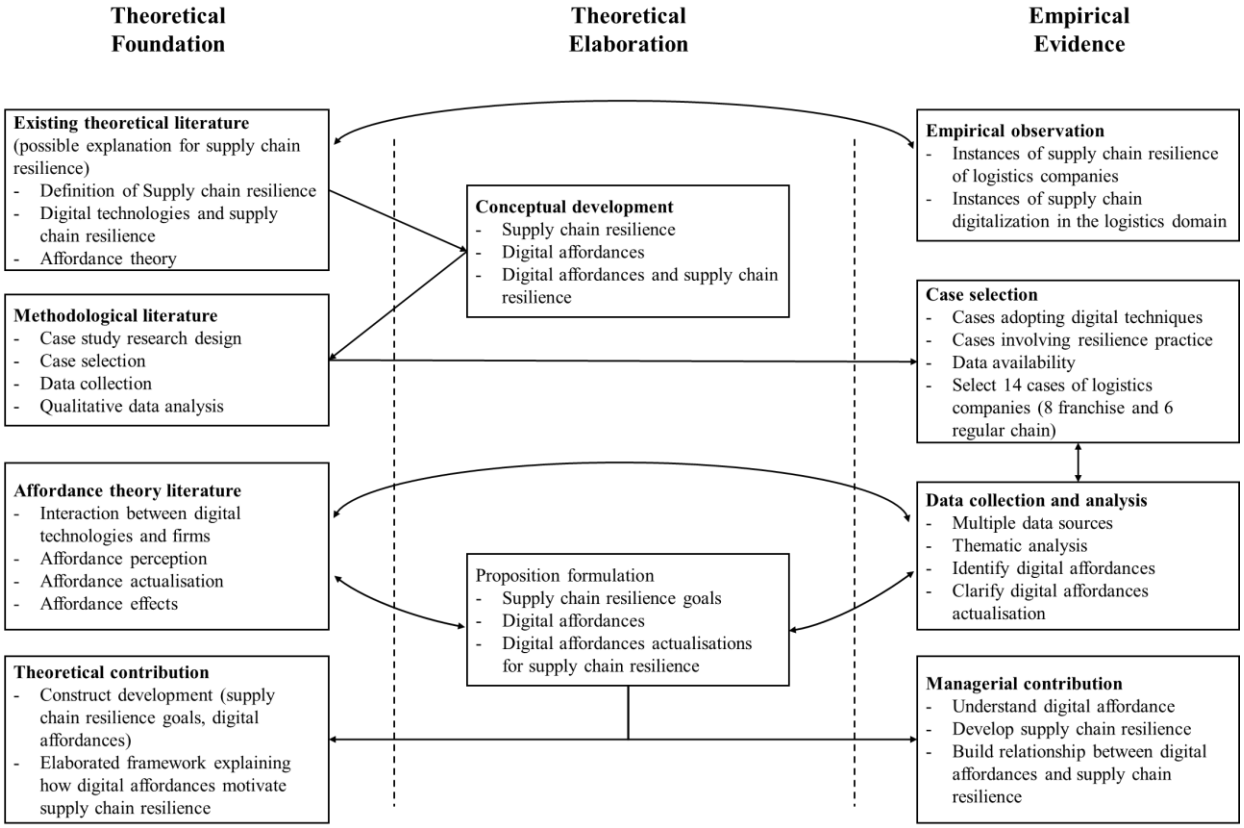

Figure 4.2 Theory elaboration method (Source: author)

Multiple case studies were used to inductively identify digital affordances and their actualisation process for logistics companies' SCR for the following reasons. First, as one of the qualitative approaches, the case approach explores the meaning and interpretation in specific contexts (Denzin & Lincoln, 2011), which matches our research aim of clarifying digital affordances for SCR. Second, case studies are used to elaborate theories (Ketokivi & Choi, 2014). Hence, the case study is suitable for this study to elaborate on affordance theory in SCR. Third, the case study approach allows for openness, flexibility and adaptation to investigate novel themes and elements (Bastas & Garza-Reyes, 2021), which can help us identify the digital affordances for logistics companies to develop SCR. Finally, multiple case studies are more appealing and robust

than single case studies since they produce more substantive results (Sternberg et al., 2022; Taylor & Rosca, 2023). This study drew on affordance theory during data collection and analysis.

4.3.1 Case selection

This study uses Chinese logistics companies to explore actual supply chain practices and management for developing SCR for the following reasons. First, according to the 2022 Agility Emerging Markets Logistics Index (Statista Research Department, 2023), China has the largest logistics market in the world based on logistics opportunities and business fundamentals. Second, the development of Chinese commercial logistics has shown new features, one of which is the continuous improvement of digitalisation and intelligence level (China Commercial Logistics Development Report, 2023). The e-commerce logistics industry has expanded swiftly, with 2021 revenue exceeding 850 billion yuan (Statista Research Department, 2023). Therefore, China is a suitable case area for exploring logistics companies' digital affordances and SCR, which can provide effective digitalisation and SCR experiences for other countries and regions. The case selection process is shown in Figure 4.3.

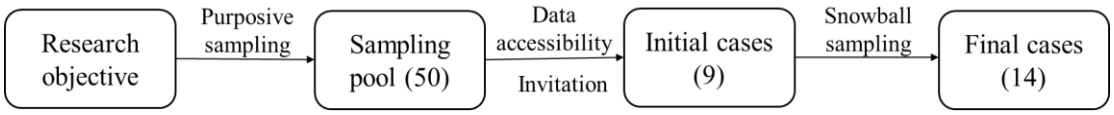

Figure 4.3 Case selection process (Source: author)

Logistics companies were first selected via purposive sampling to build a sampling pool (Scala & Lindsay, 2021). Chinese logistics companies operate in two commercial modes, either the franchise or the regular chain (self-owned) mode (Wang & Xiao, 2015). The core difference between regular chain mode and franchise mode is franchise rights. Franchise logistics companies divide the physical grid into units and transfer part of the property rights within the units to reduce organisational boundaries and introduce market transactions to solve internal management

problems (Wang & Xiao, 2015). Under the regular chain mode, the enterprise controls all logistics services to ensure that each link operates based on the same service standards and processes. Logistics firms operating in the regular chain mode can realise the superposition of multiple value-added services.

The case firms were selected according to their commercial mode (franchise or regular chain). Purposive sampling begins with representative logistics companies (Scala & Lindsay, 2021). The leading logistics firms were identified using the China smart logistics industry report (Gu et al., 2023). Fifty logistics companies were approached as the starting point at the firm level, and interviewees were selected per expert criteria. After invitations for participation, we accessed eight logistics companies as our initial cases up to April 2022.

Furthermore, the sample was extended using the snowball sampling technique (Parker & Scott, 2019), which can help strategically identify the target firms and research participants related to the phenomenon under investigation. We finally selected fourteen case companies after the recommendations of initial logistics cases in June 2022. Six of the fourteen case firms are in regular chain mode, while the other eight are in franchise mode. The case firms are engaged in both transportation and warehousing logistics services and can provide comprehensive insights into the SCR of the logistics sector.

4.3.2 Data collection

Compared to other data collection methods, such as surveys, in-depth interviews are particularly effective in investigating novel issues and allow for the collection of more comprehensive data (Boyce and Neale, 2006). In-depth interviews with logistics company managers were conducted to explore the respondents' experiences and insights regarding SCR and digital affordances. The interview guide was designed to capture what digital affordances can

enhance SCR and how they actualise the SCR goals of logistics companies, as shown in Appendix A.

The interview questions were semi-structured to create effective interaction between respondents and researchers, which helps the respondents present and make meaning based on their experiences and feelings (Sá et al., 2019; Sternberg et al., 2022). The managers of logistics firms who had been at a prominent level of involvement in logistics operations for more than five years were selected as respondents of the case firms. An invitation letter, including a research introduction and outline, was sent to the interviewees a week before the formal interviews in July 2022. Two researchers of this study served as interviewers to conduct formal interviews.

The number of interviews was determined by when saturation was reached (Engeset, 2020). Saturation is the most critical determinant of sample size in qualitative research. Saturation was assessed based on the extent of theme development and theme importance in these data. The interview saturation justification process is shown in Figure 4.4.

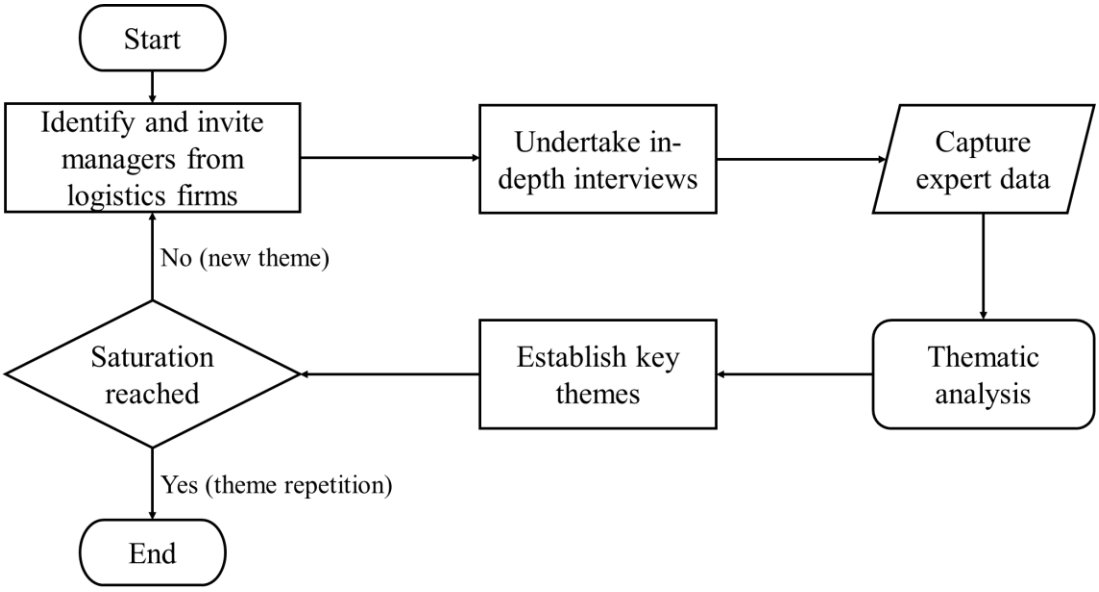

Figure 4.4 Saturation justification process (Source: author)

According to Galvin (2015), a sample of 11 interviewees, selected according to expert criteria

from diverse manufacturing industries, will be sufficient to give a researcher 95% confidence in finding themes. This probability is much higher for themes that occur at higher percentages across the population (Bastas & Garza-Reyes, 2021). This was also validated by Guest et al. (2006), who concluded that 12 interviews achieved saturation of themes but that the essential elements for themes were already present in six interviews. Hennink et al. (2017) further proposed,

As such, 88% of all emergent themes had been developed by twelve interviews, and 97% of all central themes were developed; therefore, the codebook structure had stabilised by twelve interviews with few changes or additions after that.

This was further validated by the interviews reaching a saturation point at the end of eleven interviews when no additional understanding of such themes was added. Three more interviews were conducted to cross-check the results and reduce the qualitative sampling bias. Fourteen interviews were conducted with open-ended questions to explore other logistics issues that interviewees had experienced from July to September 2022. Each interview lasted between 60 to 120 min. Interviewees were assured of confidentiality and were permitted to record. Table 4.1 displays more detailed information about the participants and interviews. After the interview, I had follow-up communication with some information sources to verify and supplement the initial data.

Table 4.1 Interview information

	Organisational Role	Ownership Structure	Commercial Mode	Working Experience	Interview Length
A	Operation Manager	Non-state-owned	Franchise	9 years	70 min
B	Sorting Director	Non-state-owned	Franchise	6 years	65 min
C	Services Manager	State-owned	Regular chain	9 years	60 min
D	Business Manager	Non-state-owned	Franchise	7 years	75 min
E	Operation Manager	Non-state-owned	Franchise	5 years	60 min

F	Regional Manager	Non-state-owned	Franchise	22 years	85 min
G	Operation Manager	State-owned	Regular chain	8 years	70 min
H	Warehouse Director	Non-state-owned	Regular chain	13 years	65 min
I	Business Manager	Non-state-owned	Franchise	12 years	65 min
J	Public Affairs Manager	Non-state-owned	Regular chain	16 years	75 min
K	Business Manager	Non-state-owned	Franchise	8 years	65 min
L	Business Manager	Non-state-owned	Regular chain	11 years	120 min
M	Regional Manager	Non-state-owned	Franchise	12 years	80 min
N	Services Manager	State-owned	Regular chain	10 years	70 min

Considering multiple sources of evidence can reduce the subject bias of interviews and validate the data (Ali et al., 2021; Yin, 2018). The annual reports of the above logistics companies were collected to expand the information from the interviews (Lajili & Zéghal, 2009; Tate et al., 2010). Using secondary data has the advantages of less subjective bias and higher internal validity (Herold et al., 2021). The annual reports, a public data disclosure from case firms' official websites, were gathered from 2019 to 2021. These annual reports were analysed to cross-check the interview answers on the logistics operations and strategies to see if logistics companies conduct actual digital actualisation behaviours to build SCR. Table 4.2 details the methods of this study we took to guarantee validity and reliability (Bals & Tate, 2018; Sternberg et al., 2022).

Table 4.2 Methods to ensure validity and reliability

Criterion	Method
Construct validity: identifying correct operational measures for the concepts being studied.	· The digital affordances and SCR goals were identified and categorised based on affordance theory and literature. · The interview records were transcribed. · Multiple data sources were evaluated (interviews, annual

	reports).
Internal validity: seeking to establish a causal relationship whereby certain conditions are believed to lead to other conditions, as distinguished from spurious relationships.	· Patterns were matched across multiple cases. · A thematic analysis was conducted to link digital affordances and SCR.
External validity: defining the domain to which a study's findings can be generalised.	· Explicit sampling criteria by commercial modes · Representative cases for SCR practice of logistics companies. · Description of actors and situations
Reliability: demonstrating that the study can be repeated with similar results.	· Interview protocol · Case study database · Coding checks with two researchers

Source: Adopted from Sternberg et al. (2022) and Bals & Tate (2018)

4.3.2 Data analysis

Thematic analysis was applied to identify and categorise the interview transcripts and annual reports, which can help gain relevant insights (Modgil et al., 2022). This study followed the guide of six phases of thematic analysis put forward by Braun and Clarke (2006). The thematic analysis process is shown in Figure 4.5.

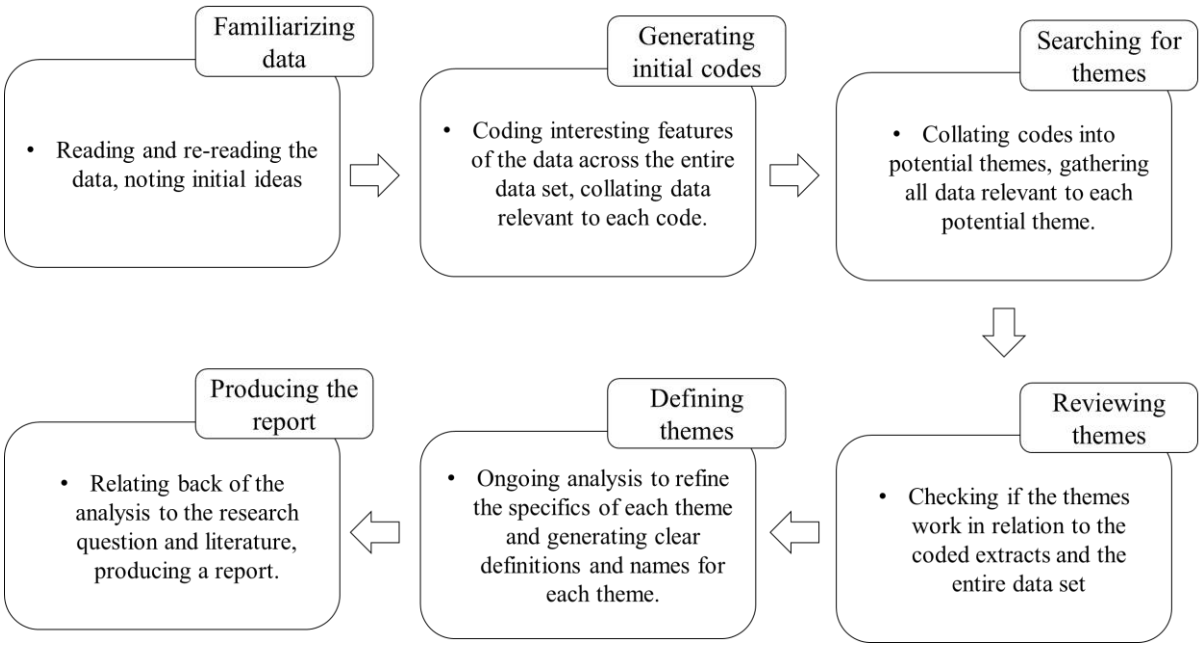

Figure 4.5 Thematic analysis process (Source: author)

Theory-driven coding is applied to identify the specific antecedents of the data set (Walsham, 2006). This study identified and matched themes based on the theoretical framework of digital affordances and SCR. The transcription was structured based on the structured interview questions and produced 137 pages of single-spaced text. NVivo 12 was applied to code the initial order by tagging and naming the text selection. Then, we clustered the codes into potential themes and extracted the code that corresponds to the items that have been identified. Two researchers processed the interview code and cross-checked it after coding. To ensure data accuracy, we refined the specifics of each theme and generated clear definitions after reviewing them. This step allowed us to produce a coding structure. Referring to Taylor & Rosca (2023), the coding structure of this study is shown in Appendix B.

4.4 Case Results

The theory-driven thematic coding helped us to uncover the digital affordances and their actualisation process for motivating SCR. Figure 4.6 illustrates vital observations of the case

results. As digital affordances are goal-orientated, this study first identified three SCR goals of logistics firms through thematic coding. Based on SCR goals, this study found three resources through which digital affordances can be generated and exist. Then, we clarified four digital affordances and five actualisation behaviours to enhance SCR.

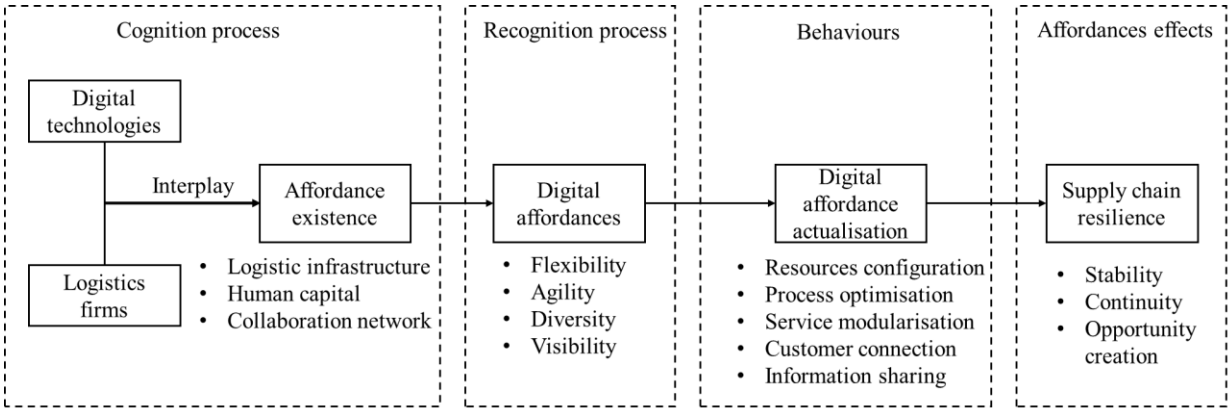

Figure 4.6 Digital affordances for motivating SCR (Source: author)

4.4.1 SCR goals

From thematic analysis, SCR has three goals: stability, continuity, and opportunity creation. We define SCR as proactive, positive processes and outcomes that help logistics firms maintain operation stability and service continuity and create opportunity in the face of supply chain disruptions. Compared with previous studies, this study emphasises proactive outcomes (Aigbedo, 2021; Falasca, 2008; Kamalahmadi & Parast, 2016). Facing disruptive events, resilient logistics companies can maintain operational stability for survival, continue business and services for recovery, and create growth opportunities. Interviewees C and F both stated that

A logistics company with SCR means that its work and business will not be interrupted by disruptions, and logistics activities are continuous and stable. The chain will not break and will not affect our regular operation.

Stability and continuity can be viewed as the fundamental goals of SCR. Stability is a firm's

goal to maintain its functionality and structure unchanged or with minimal changes after being disturbed. A stable logistics firm can withstand external shocks and retain its original operational state, ensuring its reliability and sustainability in the face of pressure and disruptions. Continuity is related to the goal of a resilient company, which is to continue providing services and functions after being disrupted. A resilient logistics company with good continuity can ensure that its core business and operation are not disturbed or return to normal quickly. For SCR, continuity emphasises the importance of maintaining uninterrupted critical processes and activities in adversity. Stability and continuity provide a foundation for logistics companies to create opportunities. Interviewee G pointed out,

The SCR is like flying a kite. We actively lead the line rather than passively respond to the crisis. Interviewee J further emphasised that *SCR for logistics companies means we can find or create business opportunities in the crisis, transform the negative impact of the disruption, and not only solve the crises*.

The interviewees showed that opportunity creation is an advanced goal of SCR for logistics firms to respond to disruptive events and create additional revenues for growth. Opportunity creation emphasises the goal of enterprises to seize new opportunities when facing market changes, economic fluctuations, technological innovation, or other potential disruptions. A highly resilient company can recover from disruptions and learn and adapt to these disturbances, enhancing its SCR through opportunity creation. Logistics companies can identify potential market opportunities and develop action plans through strategic management. This forward-looking planning helps logistics enterprises make quick decisions and take action when facing disruptions. For instance, Interviewee A mentioned,

Although our transportation capacity was limited during the epidemic, we developed a cold

chain and intra-city distribution business, which helped us achieve SCR and improve operation performance.

4.4.2 Affordance existence

In this study, digital affordances are orientated by SCR goals, meaning those existing resources that are opposite to SCR or meaningless for SCR are ignored. Logistic companies adopt digital technologies and develop digital systems or platforms to perceive the existence of digital affordance. The thematic analysis revealed that digital affordances exist in three logistics companies' resources to enhance SCR after interaction between digital technologies and logistics firms, including logistics infrastructure, human capital, and collaboration networks.

Logistics infrastructure provides a foundation for a firm to respond to disruptions for SCR (Herold et al., 2021), which includes fleets, warehouses, sorting hubs, service stations, self-lifting cabinets, packaging materials and equipment. Logistics infrastructure empowers digital affordances with multiple digital technologies such as the Internet of Things (IoT), AI, 5G and big data analytics. For example, 5G communication technology provides high-speed, low-latency connectivity to support real-time data transmission and remote operations, enhancing the responsiveness of logistics vehicle networks. The Internet of Things (IoT) achieves real-time tracking and monitoring of goods by installing sensors on goods and transportation equipment, improving the security and traceability of goods. As interviewee J stated that

Our company utilises the Internet of Things and 5G technology to enable real-time communication between devices, jointly improving the resilience and reliability of logistics infrastructure.

Automation and robotics improve efficiency and solve labour shortages in warehouse transportation scenarios, with more than ten respondents indicating the application of related

equipment. As Interviewee F mentioned that

Unmanned devices can operate in harsh weather or unsafe environments, ensuring the continuity of our logistics operations. Our company can quickly reconfigure unmanned equipment to adapt to market demand changes and improve logistics transportation networks' flexibility and resilience.

Collaboration networks build and develop SCR by maintaining numerous secure relationships with suppliers and customers, including logistics partner networks, fleet carrier cooperation, e-commerce platforms and franchisee cooperation. Franchise-mode logistics companies have many franchisees to help with delivery and express. For instance, Interviewee A stated,

Our company has directly signed agreements with more than 5350 network partners. When a crisis event occurs, such as an epidemic outbreak, vehicles are restricted, and business is challenging to develop. We cannot find a fleet to help us establish regional business quickly. We will find long-term partners to help us maintain business stability and continue our transportation services.

Networked organisational structures with digital affordances provide greater resilience by maintaining secure relationships with suppliers and customers. Electronic data interchange allows the exchange of business documents, such as orders and invoices, between different computer systems, increasing the efficiency of transactions between partners. Mobile applications are used in collaborative networks to provide real-time information updates and interactions between drivers and customers, enhancing the flexibility and responsiveness of logistics networks. Blockchain technology is used to improve the transparency and security of the supply chain, which helps prevent goods fraud and enhance trust among partners. As interview D mentioned,

We have developed smart contracts using blockchain technology. The automatic execution of

intelligent contracts reduces human errors and trust costs, providing a fair and efficient cooperation platform for all parties involved in our cooperation. This enhances the resilience and risk resistance of our collaboration network.

As for perceiving digital affordance in human capital, logistics companies adopt machine learning analytics, Augmented Reality (AR), Virtual Reality (VR) and big data analytic technologies for talent management, human resources information management, digital training and development. For instance, AR and VR technologies are used to train and simulate complex logistics operations and improve employee operational skills and the ability to respond to unexpected situations, which enhance the SCR of logistics companies (Companie A, C, D, H). Logistics companies utilise online learning and simulation software to provide flexible training programs for employees, which improve adaptability and SCR by enhancing employees' skills and knowledge (Company C, F, N). Logistics companies utilise machine learning algorithms to predict employee turnover and performance issues, thereby enabling pre-emptive measures to mitigate potential human capital risks (Company B).

4.4.3 Digital affordances

This study found that flexibility, agility, diversity, and visibility are the heterogeneous and unique digital affordances for logistics companies that enhance SCR. Flexibility and agility appear to take the form of quick decision-making, the possibility to learn quickly, and the possibility to flexibly adapt routines and strategies with digital empowerment. Logistics companies have rapidly adjusted their operation strategy and labour management with big data and machine learning analytics to develop SCR during disruptive events.

Flexibility and agility improve the logistics network's stability, continuity, and management efficiency, as well as maintain the SCR and economics of transportation. In addition, flexible

logistics routine optimisation and operation adjustment were considered solid enablers of SCR. Whether there is sufficient and flexible transportation capacity and whether the transportation capacity can be arranged reasonably and efficiently is related to the service quality and profitability of express enterprises and the breadth and depth of services provided. Interviewees M and J both mentioned,

Flexible capability can build SCR. For instance, through the big data routing and electronic face-to-face list system, we can flexibly design, optimise and adjust the routing and transportation capacity to meet the stable growth and temporary fluctuation needs of express business, which helps effectively solve the mismatch between point-to-point transportation volume and transportation capacity between cities.

Interviewees also highlighted diversity that can develop SCR. Diversity boosts SCR and competitive advantage through differentiated services. Logistics companies use big data analytics to analyse a large amount of logistics data to better understand market trends and customer needs, thereby providing diversified services. AI optimises route planning, inventory management, and customer service, improving supply chain diversity and resilience. IoT devices monitor the status of goods and transportation environments, providing personalised and customised logistics solutions. The strategic deployment of digital technologies in logistics companies leads to more versatile service portfolios and supply chains that are more resilient and better equipped to manage disruptions and risks. For instance, Interviewee N stated,

We gradually improved the digital matching system of large express delivery, which makes it achieve a continuous decline in cargo damage rate and the leading transportation quality in the logistics industry.

Visibility was considered an essential digital affordance in fostering SCR. By leveraging

digital technologies to achieve end-to-end visibility and control over the entire logistics process, logistics companies enhance internal management's efficiency and elevate SCR. Logistics companies utilise digital technology to erect a logistics control tower, a central hub for planning logistics and warehousing networks. The logistics control tower is instrumental in monitoring the fulfilment status of orders and tracking shipments in real-time. Consequently, the logistics control tower enables enterprises to access end-to-end supply chain visibility services, enhancing operational transparency and efficiency.

Visibility facilitates a more transparent and traceable tracking of goods and information, which is crucial for efficient operations. By leveraging real-time data and predictive analytics, companies can make informed decisions that allow them to pivot swiftly to changing consumer demands and economic conditions. As interviewee I mentioned,

We have implemented a technology known as the Logistics Control Tower, which acts as the commander of the logistics domain. It oversees the entire supply chain operation, from when the goods leave the factory until they safely reach the customer. The Control Tower can monitor all information in real-time, and if it detects any anomalies, such as a delay in goods or a change in the transportation route, it promptly alerts the company to take appropriate actions, thereby enhancing our resilience to supply chain disruptions.

4.4.4 Digital affordance actualisation

The digital affordance actualisation behaviours contained service modularisation, information sharing, resource configuration, process optimisation and customer connection. The digital actualisation behaviours and related digital technologies are shown in Figure 4.7.

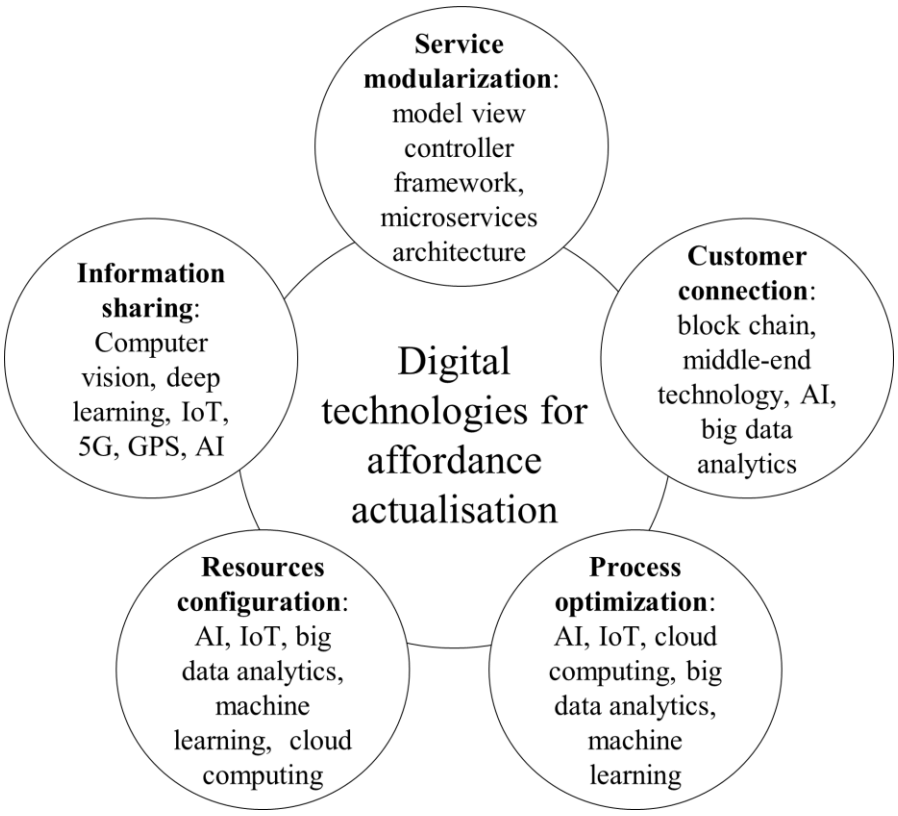

Figure 4.7 Digital affordances actualisation for SCR and related techniques (Source: author)

As some supply chain disruptions are due to spatial heterogeneity, logistics firms rely on online services to reduce the negative impacts on offline business. Logistics firms innovated and modularised the logistics services on the digital platform to create opportunities. Firstly, logistics companies design each supply chain link as independent modules, such as inventory management, transportation, and order processing, so that each module can be independently upgraded and optimised without affecting the stability of the entire logistics system. Application programming interface and microservice architectures were applied to achieve seamless integration between different digital service modules, which improved system flexibility and enhanced SCR. For example, the 2021 annual report of the company stated that Company D's Research and Development (R&D) expenses were RMB 2.8 billion, with a year-on-year increase of 36.9%,

accounting for 2.7% of the total revenue. Additionally, Interviewee D stated,

Our company has promoted comprehensive digital transformation by integrating emerging technologies such as big data, cloud computing and artificial intelligence on the logistics platform. Services modularisation improves the reuse rate of the digital platform and effectively helps us organise and coordinate complementary products and services through appropriate platform operation modes and governance structure, thus creating new business growth and achieving SCR.

The logistics industry, as an information-intensive industry, has always been data-driven. Breaking down the data silos across various supply chain segments and achieving seamless connectivity and flow of information is crucial for enhancing the supply chain's agility, reliability, and predictability. However, the traditional logistics operation has a low degree of informatisation, poor connection between various modes of transportation and scattered information resources, resulting in much long-distance and cross-regional road transportation, which makes it more vulnerable. Digital technologies have helped logistics enterprises realise information visibility for developing SCR. By establishing or utilising existing digital platforms, logistics companies can achieve real-time information sharing with upstream and downstream partners in the supply chain, which improves the transparency and responsiveness of the entire supply chain. Interviewee G mentioned,

Our company's digital platform X can check the information trends of customers promptly, which helps us build SCR by visualising information. The digital platform H monitors all data personnel, product quantity and warehousing. Digital platform Z refines the data visualisation of receiving and dispatching/service quality based on the Angle of Arrival (AOA) map.

Logistics workers exchange and share logistics information on the platform. Logistic operators visually analyse the data and information in logistics services and effectively use the

information to improve SCR and efficiency. Digital information sharing enhances logistics companies' ability to perceive market changes, enabling them to quickly adjust their strategies to cope with demand fluctuations, thereby enhancing supply chain agility and flexibility. By sharing information, logistics companies can better identify, evaluate, and respond to risks in the supply chain, which improves the resilience and responsiveness of the supply chain.

Moreover, digital logistic technologies generate robust forecasting and analysis capabilities through algorithmic drive and data mining, effectively configuring supply-demand and transportation capacity resources and optimising logistics, transportation, and procurement business processes for SCR. In other words, digital actualisation behaviours can generate digital affordance in SCR through reconfiguring resources and optimising processes. Logistics companies implement more flexible inventory management strategies, including safety stock and dynamic inventory control, to cope with market fluctuations. AI and machine learning algorithms are used to optimise inventory management, demand forecasting, and resource allocation, which enhances the intelligence level of logistics resource reconfiguration. Additionally, the digital freight platform intelligently matches goods and transportation capacity, which improves transportation efficiency, reduces empty driving rates, and optimises resource allocation. With the help of a dynamic routing platform, the express delivery on-time rate of company I increased by 5%. Interviewee H said,

Our company optimises and adjusts the route and transport capacity through the big route and electronic bill platform to meet express business's stable growth and temporary fluctuation demand.

As for process optimisation for SCR, logistics companies used advanced supply chain simulation tools to simulate potential supply chain scenarios and optimise supply chain structure and processes. Automation technology and intelligent algorithms are applied to optimise processes

such as order processing, inventory management, and transportation scheduling, which reduces human errors and improves service continuity. For example, interviewee B and D both mentioned,

We used digital technology to achieve device interconnection and automatic data collection. By analysing the data, we can promptly identify potential problems to address, such as reducing vehicle congestion and changing route planning, thereby improving the transportation process and achieving SCR under limited conditions.

In addition, digital technologies have a more robust connection capability and a more expansive connection range to create a network effect. Logistics companies use big data analytics and artificial intelligence technology to analyse customer behaviours and predict market trends, which allows them to prepare response strategies in advance. In addition, logistics companies develop or adopt supply chain visualisation tools to enable customers to see the flow of their goods in the supply chain, which increases customer engagement and transparency in the supply chain.

Moreover, logistics firms better understand customers' risk preferences and emergency needs by closely connecting with customers so that they develop more accurate risk management plans and emergency response strategies. The logistics platform provides data analysis and corresponding digital solutions to upstream and downstream or ecosystem partners through a digital feedback mechanism, enhancing business continuity in crisis and obtaining new business growth. Interviewee G said,

Through a digital logistics platform integrated with intelligent logistics technologies, our company creates end-to-end logistics solutions with a high-added value that meets industry characteristics. We tapped the needs of existing customers and developed high-quality potential customers so that the volume of contract logistics business and operating revenue increased by 15.80% and 22.64%, respectively, year on year.

In summary, digital actualisation behaviours allow firms to transform digital affordances to enhance SCR and add value. Digital affordances provide a flexible, agile, visible, and diverse way to generate new revenue and business value so logistics firms can be more resilient in responding to disruptions.

4.5 Discussion

4.5.1 Theoretical implications

Based on digital affordance theory, study 1 identifies four digital affordances and five digital affordances actualisation behaviours, which clarify the procedural mechanisms of logistics companies leveraging digital affordances to develop SCR. Firstly, previous studies have explored the relationship between digital affordances and specific organisational goals such as pandemic control (Mora et al., 2021), social support (Carr et al., 2016) and organisational innovation (Chatterjee et al., 2020; Liu et al., 2023), but have not included SCR as an organisational goal in this analytical framework. Study one takes SCR as the organisational goal for logistics companies to develop digitalisation and explores the relationship between digital affordances and SCR, which expands the research on digital affordance.

Study one clarifies SCR goals in the logistics sector by taking digital affordances and the SCR framework as a theoretical foundation. SCR goals include stability, continuity and opportunity creation, which have not been proposed in previous studies. When facing disruptive events, firms first consider the stability of services and organisational structure for survival. Firms need to continue to deliver services for recovery throughout the resilience process. Stability and continuity construct the fundamental goals of SCR, while opportunity creation presents an advanced goal. Companies perceive and generate digital affordances and create business opportunities during disruption, which change and even form new operations and service methods. Due to a company's

limited resilience or digitalisation investment, companies need to prioritise stability and continuity goals when working toward SCR, then try to create opportunity, which contributes to the theoretical development of SCR.

Study one also elaborates affordance theory into the SCR field, providing an additional theoretical lens to SCR, as shown in Figure 7.1. Previous studies examined the role of specific emerging technology in SCR, including AI, digital twin, blockchain and big data technology (Bayramova et al., 2021; Modgil et al., 2021; Shen & Sun, 2021). However, it is difficult for these studies to explain why some companies or organisations with digital technology adoption and applications still struggle to achieve and enhance SCR through their efforts. Study one explored and clarified the role of digital affordances in enhancing SCR.

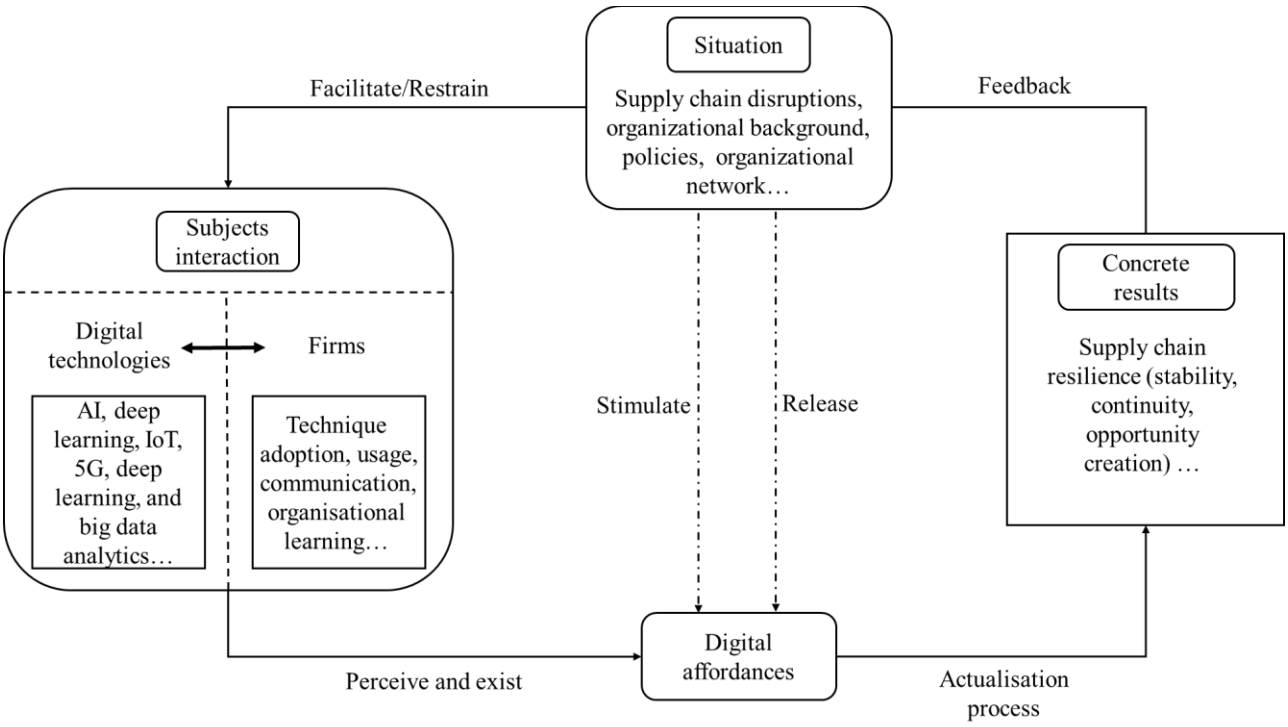

Figure 4.8 Elaborated theoretical framework (Source: author)

Applying affordance theory explains the possibility of digital affordance for SCR. Digital affordance represents an actionable potentiality or possibility (Belitski et al., 2023). The

manifestation of specific digital actualisation actions undertaken is contingent upon the situation. The situations stimulate and release potential digital affordances. The affordance situations encompass the technological and organisational background, external disruptions, societal backdrop and relational networks. The interaction between digital technologies and firms helps organisations perceive and produce digital affordances, which achieve specific SCR goals, including stability, continuity and opportunity creation. The concrete results of SCR provide feedback on the affordance situation, which further promotes or constrains the interaction between firms and digital technologies to form a cycle. Several interaction modalities include digital technology adoption, usage, digital training and communication. Different situations and interaction modalities engender distinct mechanisms, producing diverse digital affordances.

Firms may harness a singular or multiplicity of digital affordances to actualise their SCR goals. Study 1 identifies flexibility, agility, diversity and visibility as digital affordances for motivating SCR. Current studies consider flexibility and agility dynamic capabilities for developing SCR (Aslam et al., 2020; Chunsheng et al., 2019; Mandal & Saravanan, 2019). However, previous studies did not consider them as digital affordances generated by the interplay between firms and digital technologies (Aslam et al., 2020; Chunsheng et al., 2019; Mandal & Saravanan, 2019), which means flexibility and agility rely on non-digitalisation shaping mechanism. Study one explored how logistics companies can leverage digital agility and flexibility to drive SCR from the perspective of digital affordances. Digital agility and flexibility are pivotal in enhancing SCR, enabling companies to respond more swiftly, intelligently, and effectively to dynamic market and environment changes.

Study one also found that digital visibility and diversity play vital roles in supporting SCR. Digital visibility provides the clarity needed to navigate and optimise supply chain operations,

while diversity introduces robustness and adaptability, ensuring that the supply chain can withstand and recover from various types of disruptions. Above digital affordances deepened affordance theory and expanded the research on the relationship between digital affordances and specific SCR goals.

The digital actualisation behaviours of service modularisation, information sharing, resource configuration, process optimisation and customer connection explain how digital affordances prompt logistics firms to achieve SCR. Previous studies focused more on the perceived technology affordances and affordances potentials, which ignored the affordance actualisation process (Liu et al., 2023; Mora et al., 2021; Wang et al., 2018). However, perceiving and recognising is the first step to understanding the goal-orientated digital affordance effect. Various companies may still encounter difficulties in achieving digital affordance goals. It is essential to clarify the digital affordance actualisation process to achieve organisational goals.

The finding of these five digital affordance actualisation behaviours advances the creation of functional affordances of digital technologies to achieve resilient goals and enhance SCR. This finding deepens the "digital affordance – actualisation – outcome" theoretical framework, which can provide new theoretical references for supply chain digitalisation and resilience development research. In summary, study one revealed the connection between affordance theory and SCR and found that actualising digital affordances with specialised digital technologies can promote SCR.

4.5.2 Managerial implications

Study one offers valuable implications for practising managers in supply chain management. First, firms need to integrate digitalisation and SCR strategy as more unpredictable disruptive events will cause unparalleled disruptions. Companies need to consider SCR goals strategically and create a risk prevention strategy combining cost and service to enhance SCR. Given limited

resources and costs, supply chain companies prioritise ensuring the stability and continuity of business and services. Firms may pay attention to maintaining stability and continuity and create new business opportunities during disruptions. For instance, in the post-epidemic stage, changes in lifestyle and purchase methods have led to changes in business. People now purchase daily necessities, such as fresh fruits and vegetables, through an online home platform. Logistics companies developed cold-chain and intra-city distribution businesses to create opportunities for SCR. Companies may improve consumer and market insights to generate opportunities during disruptions, focus on current competitive advantages and provide distinctive goods and services.

Our findings validated that digital affordances of flexibility, agility, diversity and visibility can enhance SCR. Enterprises can strengthen the construction of digital infrastructure and maximise digital affordance actualisation. In the digital transformation process, digital affordances can drive traditional supply chain enterprises to achieve organisational goals such as SCR and competitive advantages. Digital flexibility, agility, diversity, and visibility catalyse organisational transformation and innovation, enabling the construction of SCR adaptable to digital contexts. Enterprises should explore the potential of digital technology to achieve new organisational goals.

The latent possibilities offered by digital technology can prompt supply chain enterprises to make corresponding internal adjustments, thereby establishing organisational inertia compatible with the digital environment. When constructing an innovative digital strategy, enterprises may focus on product design and digital technology research and development around situations to attract networked partners to join the supply chain system by attracting digital affordances. Subsequently, based on their own needs, enterprises may opt to develop in-house or collaborate with technology service providers and ecosystem partners to leverage the functionalities inherent in digital technology. This collaboration is directed towards constructing and creating an internal

digital architecture system, which is instrumental in underpinning subsequent digital operations to ensure rapid and stable growth for the enterprise.

The digital actualisation processes include service modularisation, information sharing, resource configuration, process optimisation, and customer connection. Supply chain firms can build and enhance SCR through digital actualisation behaviours. Most supply chain enterprises have recognised the importance of digital technology in developing SCR. However, many enterprises, constrained by a limited understanding of digital technology, focus blindly on digital investment to advance resilient strategy. These companies neglect integrating and optimising existing resources, leading to a development process that deviates from expectations. To address this issue, enterprises may adopt a holistic and systematic approach to their digital transformation based on their actual circumstances. Digital transformation enhances enterprise resource configuration efficiency and optimises organisational structure and processes, increasing flexibility. As a result, companies can respond more effectively to external shocks and disruptions.

Companies need to strengthen the coordination and integration of existing internal resources with digital technologies. For example, study one found that digital affordances exist in logistics infrastructure, human capital and collaboration networks. When integrating digital technology, enterprises should undertake a comprehensive evaluation to ensure that the digital technologies can effectively integrate with internal resources. Firms should first confirm what specific resources are needed for digital affordances to develop SCR. This would allow the supply chain firms to fully use and reconfigure resources for digitalisation.

4.6 Concluding Remarks

Supply chain disruptions have profoundly impacted the global economy and many supply chains, requiring them to be more resilient. Based on affordance theory, this study proposes a

theoretical framework of digital affordances and SCR and takes logistics firms as cases to explore how digital affordances enhance SCR. This study clarifies three goals of SCR: stability for survival, continuity for recovery, and opportunity creation for growth. This study also found four digital affordances in logistics infrastructure, human capital, and collaboration networks: flexibility, agility, redundancy, visibility, and diversity. Moreover, digital affordances enhance and actualise SCR through service modularisation, information visibility, resource configuration, process optimisation and customer connection.

CHAPTER 5 DIGITAL TECHNIQUES AND SUPPLY CHAIN RESILIENCE TO FLOODING

5.1 Introduction

Over the past year, flooding has been one of the world's most common hazards, significantly threatening global supply chains (BCI, 2022; Haraguchi & Lall, 2015). A flood is "*an overflowing of water onto land that is normally dry, causing more damage than any other severe weather-related event*" (United States Environmental Protection Agency, 2014). Floods can occur due to extreme precipitation, ocean waves coming onshore, quickly melting snow, or damage to dams or levees (National Severe Storms Laboratory, 2020). More than 874 flood events occurred from 2017 to 2021, which caused direct economic losses of more than 210 million USD worldwide (Global Disaster Data Platform, 2022). The United Nations Office for Disaster Risk Reduction (2020) revealed that floods are the most frequent human-cost disaster type, accounting for 44% of all disasters, with an average of 163 events annually from 2000 to 2019. More than 1.65 billion people have been affected by floods worldwide, and the total recorded economic losses from floods have been approximately 651 billion USD over the last two decades (Emergency Events Database, 2020).

Furthermore, flooding has been one of the significant supply chain disruptions in the past year and adversely affects the firm business performance (BCI, 2022). From the supply chain perspective, the aftermath of the rains and extensive flooding strongly impacts industrial activities (Vishnu & Sridharan, 2016). Flooding leads to the accumulation of water on roads and the destruction of subgrades and pavements, forcing railway delays and stopping freight lines. Flooding increases the cost of freight and passenger transportation and decreases carriage capacity, significantly impacting transportation and logistics. Many companies stop work and production

during flooding and suffer property losses. For instance, the 2011 Thailand Chao Phraya Flood seriously disrupted and damaged the supply chain, forcing logistics and manufacturing firms to shut down or relocate (Andrew et al., 2016). Moreover, the labour force is affected by floods and becomes vulnerable to physical and psychological diseases (Daniel & Michaela, 2021). Some employees even lose their positions owing to business adaptation and economic losses of disaster-stricken firms (Andrew et al., 2016).

Logistics firms are essential in connecting production and consumption (Hofmann & Rüsch, 2017), but they rely heavily on transportation using the roads and railways, making them more vulnerable to urban floods (Jason, 2022). Logistics firms' operating costs and economic losses significantly increase during floods because of transportation disruptions. In particular, floods can affect logistics inventory, forcing logistics companies to transfer inventory. Sudden, inevitable, and unpredictable floods have also forced logistics enterprises' internal and external environments to change accordingly, making it challenging to transport materials and resupply inventories on time. For instance, Zhengzhou (the capital city of the Henan province) had an extreme rainfall event on 20 July 2021 (Guo et al., 2023). Floods caused traffic disruption and damaged the logistics infrastructure. Urban distribution, trunk transportation, transit distribution, and other logistics activities have stagnated in some regions, which has seriously impacted the development of the province's logistics industry and caused significant economic growth losses.

The logistics vehicle online index refers to the proportional relationship between the number of vehicles running online daily during the survey period and the number of vehicles in the overall monitoring sample (Henan Federation of Logistics and Purchasing, 2021). On 21 July 2021, the Henan province logistics vehicle online index was 76.9%, 23.1% less than the benchmark data (100%) of normal logistics operations in previous years. The running hours index and running

mileage index fell to the lowest level of the year and accounted for only 68.3% and 69.3% of the national average, respectively (Henan Federation of Logistics and Purchasing, 2021). Furthermore, there are extreme cases where floods have damaged firms and never recovered (Haraguchi & Lall, 2015).

The potential role of digital techniques (DTs) in mitigating the negative impacts of floods has been gaining more attention. Advanced DTs make tracking changes, implementing responses, and accurately monitoring them easier (Choi & Chan, 2023), which can be valuable for managing flood-related operational risks (Bag et al., 2022). To cope with the possible supply chain disruption caused by severe weather events like extreme precipitation, some logistics firms tried to connect the weather forecast data to the transportation management system to provide early warnings and prompt forecasting. For example, the DHL Resilience360 team used weather tracking data to help companies avert supply chain disruptions against hurricanes through alarm functions and early warning of the possible impact on the supply chain so that logistics companies can respond in advance and reduce supply disruptions caused by extreme weather events (Bonn, 2019). DTs can also be helpful in the flood recovery stage by reducing deployment time, assisting with communications, and providing enhanced access to data from past experiences (Sodhi & Tang, 2013; Kabra & Ramesh, 2015).

Current flood events have highlighted the importance of supply chain resilience (SCR) and the ability of logistics firms to prepare for, respond to, and recover from floods. SCR generally refers to the capability of an organisation to absorb turbulence and recover from disruption (Lengnick-Hall et al., 2011; Duchek, 2020). Previous research suggests that resilience is necessary for organisations to respond and recover from disruption events, which may be improved with DTs (Ambulkar, Blackhurst, & Grawe, 2015; Pettit, Croxton, & Fiksel, 2019). For example, Chewning

et al. (2013) found that organisations enhanced various aspects of resilience related to their recovery after Hurricane Katrina through adaptive information technology (IT), including information sharing, (re)connection, and resource acquisition. Firdhous and Karuratane (2018) found that DTs can be leveraged to enhance the disaster resilience of rural communities. Compared with other sudden natural hazards, such as earthquakes, floods can be predicted with relative accuracy in terms of time and location by monitoring the conditions of extreme precipitation, continuous rainfall, and high water, which provides an opportunity for logistics firms to establish adaptation strategies (De Leeuw, Vis, & Jonkman, 2012). Overall, logistics firms should acquire resilience to mitigate the disruption caused by floods. This study aims to explore the role of digital techniques in SCR. Specifically, the research question is considered:

RQ2. What are the roles of digital techniques in supply chain resilience to disruptive events?

However, the role of DTs in managing disasters must be examined further (Bonn, 2019; Kaur et al., 2022; Bag et al., 2022), and not many studies have discussed DTs in the logistics sector (Ali et al., 2018; Chung, 2021; Pettit et al., 2019), especially for flood management. Thus, DTs' role in improving logistics firms' SCR against disruptive events remains unclear. The present study investigates how DTs can improve SCR toward flooding to address this gap.

5.2 Disruption Positioning

The significant impact of floods on logistics is mainly attributed to the disruption of transport routes (Wisetjindawat et al., 2017). Logistics run through all enterprise activities, and only efficient logistics can ensure the regular operations of an enterprise. Floods can seriously disrupt the road network and infrastructure, causing road inundation, traffic delays, and accessibility losses (Lu et al., 2022), and transport infrastructure can be directly or indirectly damaged, posing more long-term threats to the logistics activities of firms (Pregnolato et al., 2017). During a flood, logistics

companies may also be operating at a reduced capacity, motivating firms to consider emergency logistics support and optimisation strategies to ensure business continuity (Kundu et al., 2022), which require additional transportation time and cost for firms. In extreme floods, logistics recovery heavily relies on the public infrastructure and the ability of transportation services to recover to the pre-flood levels (Lin, 2020).

Floods and logistics disruptions make it particularly difficult to import raw materials and export products, challenging all delivery, receiving, and shipping aspects. The lack of parts supply can also be responsible for stopping or adjusting production (Haraguchi & Lall, 2015). Daily Express had to transport freight more expensively and inefficiently to ensure successful transportation (First Financial Daily, 2010). Moreover, warehousing becomes a common issue in floods (Wang et al., 2019), which can damage warehouse structures in multiple ways. Rainfall alone can ruin the roof, possibly partially or collapse in rare situations.

Internal water damage also occurs, and product deterioration follows. In addition, floods may damage the warehouse administrative facility (AKSP, 2020). Hence, logistics companies must pay more attention to warehouse location, space, and distribution planning. The logistics costs can increase considerably with the increase in warehousing time and the labour costs associated with distribution (Ramaa et al., 2012).

Some studies employed qualitative data to evaluate the effects of digital transformation on SCR by constructing the SCR framework and analysing the content. Most studies aimed to apply quantitative data to establish the relationship between SCR and related factors. However, it is difficult to quantify the impacts of disruptive events and match the actual implications for SCR with objective data. Most previous SCR empirical studies adopted a combined approach to measuring disruptive events using subjective data, which has been beneficial for studying the

widespread impacts of a specific disaster or disruption on SCR. The present study uses interviews to gain insights into the effects of flood disruption in Phase 1 and adopts the Likert scale in Phase 2 to quantify the flood disruptive impacts (FDI) on SCR.

5.3 Research Methods

5.3.1 Research design

Our study design comprises two consecutive phases with multiple methods, as shown in Figure 5.1. In Phase 1, qualitative semi-structured interviews of logistics managers are employed to understand the role of DTs in SCR against floods. The in-depth interviews are used to collect data on how logistics firms can achieve SCR through DTs and how the firms develop DTs to minimise flood risks. Considering there is no established theory on the relationships between all our study constructs under floods, our investigation and research design are in the preliminary stage. This study proposes the research model and hypothesis based on the results of the qualitative interview data. In Phase 2, the questionnaire is designed to collect survey data and multivariate analysis to test the research model and hypotheses.

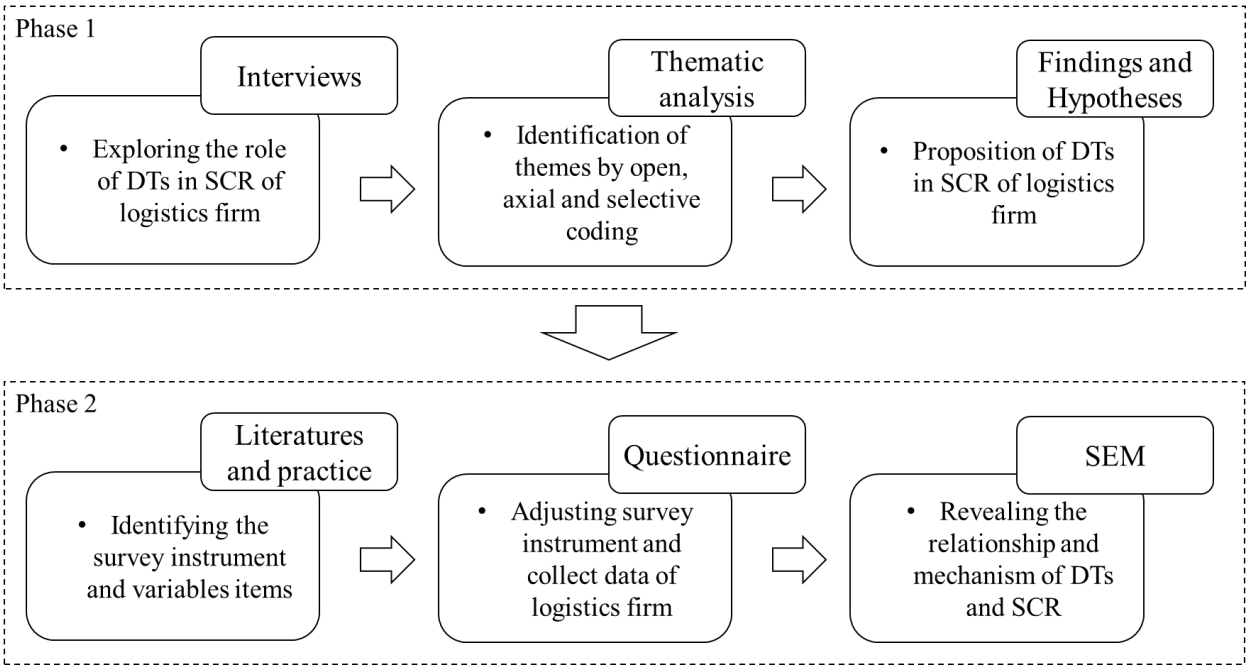

Figure 5.1 Research design (Source: author)

5.3.2 Study area

This study uses the logistics firms in Zhejiang province as the study objects. Zhejiang province is located along the southeast coast of China, with a total area of 105,500 km^2, as shown in Figure 5.2. As a coastal province, more than 6,600 km of coastline is affected by storm surges. Zhejiang faces a flood season of up to six months each year, with a high risk of flooding. Zhejiang's flooding is divided into the plum and typhoon seasons, challenging flood emergency management, causing significant economic losses, and threatening human safety. For instance, under the joint influence of typhoon Lekima and nearshore waves in 2019, the direct financial loss caused by floods was approximately 7.622 billion yuan, which affected more than 5.748 million people. Additionally, thirty-nine people died, and nine went missing because of the flood in Zhejiang (Jin, 2019). A total of 6.314 million people were affected by the flood caused by typhoon Fitow in 2013, where six people were killed, four people went missing, and the direct economic loss amounted to

275.58 billion yuan (CCTV, 2013).

Figure 5.2 Location of case area (Source: author)

As for the logistics industry, Zhejiang is also a practical study area for examining the role of DTs on the SCR of logistics firms against floods. First, the total volume of logistics business in Zhejiang ranks second in China, with the maximum daily processing capacity reaching 160 million pieces (Zhejiang Provincial Development and Reform Commission, 2021). Second, innovation of the logistics mode represented by the digital economy and technologies in Zhejiang province is at the forefront (Zhejiang Provincial Development and Reform Commission, 2021). Third, the express service network of Zhejiang has been fully developed, with 100% coverage of the direct postal service in both the villages and towns (Zhejiang Provincial Development and Reform Commission, 2021). In other words, the logistics firms in Zhejiang province are more likely to be exposed to floods. Therefore, Zhejiang province is a reasonable sample to help generalise the results.

5.3.3 Phase 1 study: a qualitative investigation

This first phase aims to identify the critical components of DTs influencing the SCR of logistics firms against floods and gain insights into how logistics firms achieve SCR. Semi-structured interviews were conducted in Zhejiang logistics industries.

5.3.3.1 Sampling approach and participants

Our sampling strategy is the snowball sampling approach, one of the most popular methods in qualitative research (Parker et al., 2019; Zeng et al., 2021). Snowball sampling starts with a small number of initial seeds that fit the research criteria and are invited to participate in the study. Then, the initial participant recommends other potential participants (Noy, 2008). One important criterion for our study was that the logistics firms had developed DTs to reduce flood risks.

To acquire a representative sample of logistics firms, we started by approaching leading logistics firms in the case area and expanding the interview samples based on their recommendations. The leading logistics firms were identified using the China Smart Logistics Industry report (Entrepreneurial State Research Centre, 2021) and China's top 50 digital smart logistics enterprises (China Federation of Logistics and Purchasing, 2022). The listed logistics firms in Zhejiang province were approached as the starting cases. The interview protocol comprises four steps, as shown in Figure 5.3. Semi-structured interviews were conducted from March to June 2022 with nine managers and directors from different logistics firms who were familiar with DTs and had previously experienced flood management. Each interview lasted 45 to 60 min.

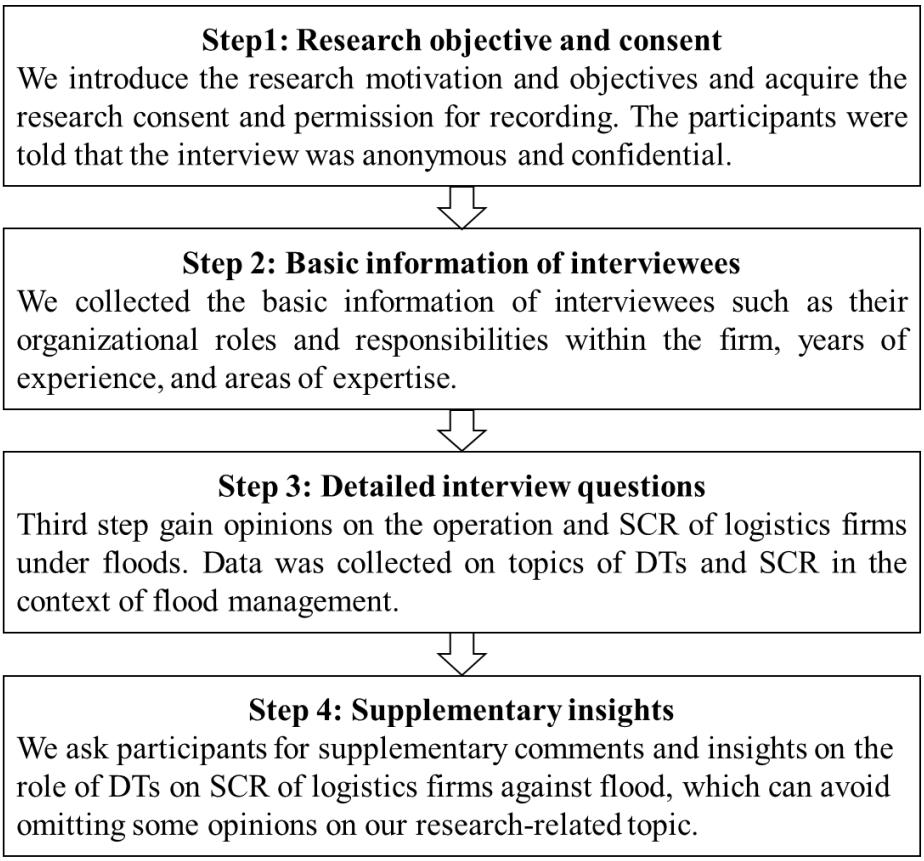

Figure 5.3 Interview protocol (Source: author)

The number of interviews was determined by reaching saturation, the most crucial determinant of sample size in qualitative research (Engeset, 2020). These data's theme development and importance level were used to measure saturation, meaning the interviews end after no new themes emerge (Galvin, 2015; Hennink et al., 2017). Hennink et al. (2017) found that 84% of codes were identified after six interviews, and 91% of all new codes had been developed after nine interviews. Guest et al. (2006) found that the essential elements of themes were already present in 6 interviews. Bag et al. (2022) evaluated the role of big data prediction analytics in developing a resilient supply chain network and found that theoretical saturation had been reached after ten interviews. This study achieved code saturation at nine interviews as no more emerging themes could be identified after thematic analysis (Galvin, 2015). Notably, nine interviewees have

all worked in the logistics industry for over eight years, as shown in Table 5.1, which further ensures the representation of qualitative cases and data saturation.

Table 5.1 Interviewees information

Number	Organisational Role	Ownership Structure	Working Experience	Interview Length
1	Operation Manager	Non-state-owned	9 years	45 min
2	Services Manager	State-owned	9 years	50 min
3	Regional Manager	Non-state-owned	22 years	50 min
4	Operation Manager	State-owned	8 years	55 min
5	Warehouse Director	Non-state-owned	13 years	50 min
6	Business Manager	Non-state-owned	12 years	55 min
7	Public Affairs Manager	Non-state-owned	16 years	45 min
8	Business Manager	Non-state-owned	8 years	50 min
9	Business Manager	Non-state-owned	11 years	60 min

5.3.3.2 Thematic analysis

In Phase 1, we followed a standard approach inspired by thematic analysis, which adopted three steps of open, axial, and selective coding to extract the themes (Modgil et al., 2022). The thematic analysis allowed us to study DTs' role in improving logistics firms' SCR against floods. First, the raw interview content of “the role of DTs in improving SCR and logistics FP in the context of floods” was coded as open coding. Second, we systematically went through the open coding and applied axial coding to related data to identify critical themes. Finally, we employed selective coding to display the observed phenomenon and develop relationships between the variables by returning to the literature and theory. The coding system of thematic analysis is shown in Figure 5.4.

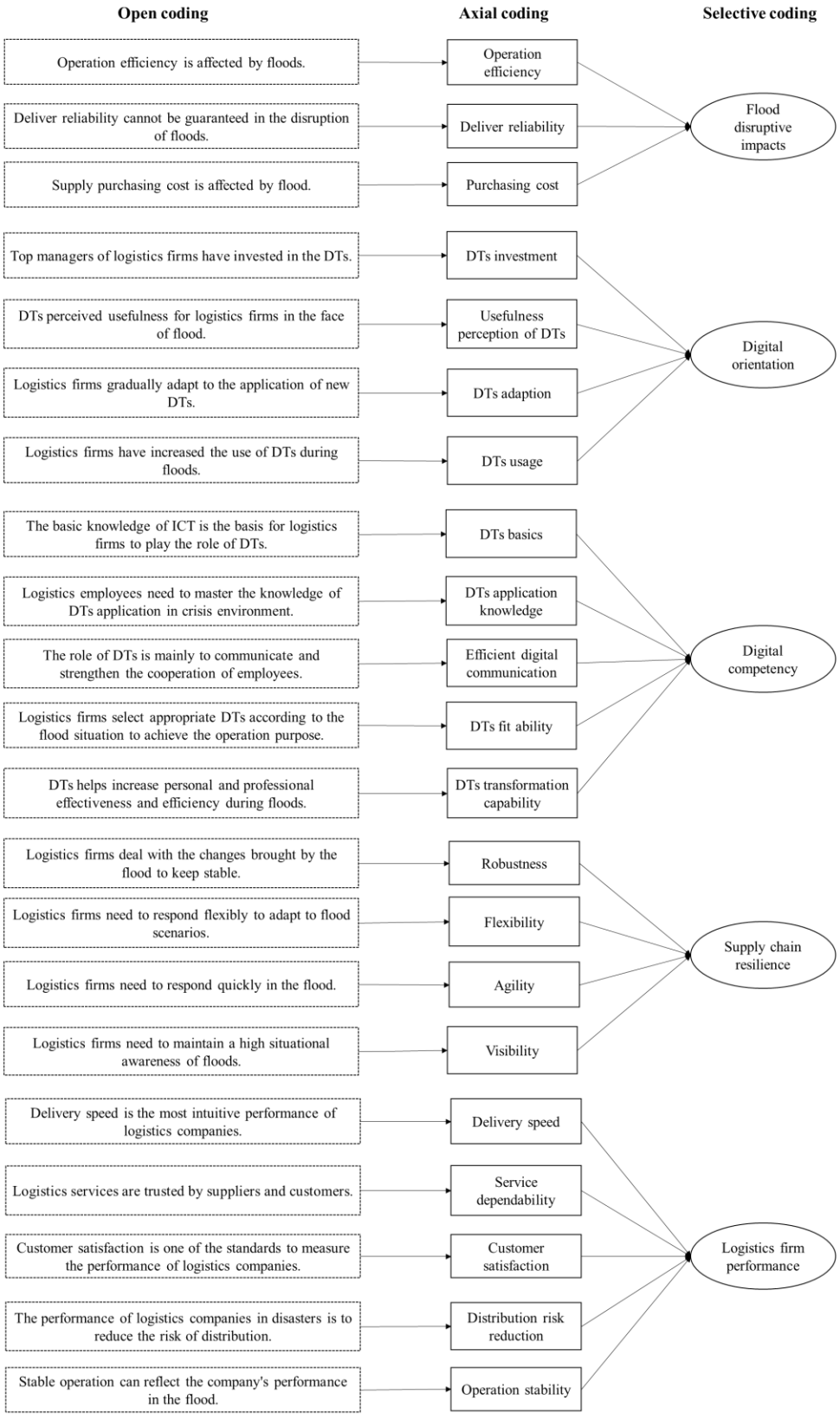

Figure 5.4 The coding scheme of the thematic analysis (Source: author)

5.4 Findings of Phase 1 and Hypotheses Development

5.4.1 Effect of FDI on SCR

In the study area, most of the floods were caused by typhoons, which brought extreme precipitation in a short time. The interviewees demonstrated that instantaneous heavy rainfall led to severe floods because the urban road drainage capacity was exceeded. For instance, the rainfall of Yuyao City exceeded 1000 mm during Typhoon In-fa (National Meteorological Centre of China, 2021). The flood caused traffic disruption and logistics infrastructure damage in some cities (Chan et al., 2022). In some regions, logistics activities have stalled, including urban distribution, trunk line transportation, and transit distribution, reducing the efficiency of logistics firms (Lu et al., 2022; Interviewee A, detailed excerpts in Appendices). Table 5.2 presents the typical interview excerpts of propositions.

Table 5.2 Qualitative results and typical interview excerpts

Qualitative results	Typical interview excerpts
Effect of flood disruptive impacts on SCR	*In the flood of 2013, one of the firm's logistics warehouses was directly flooded; the deepest water was nearly 1 metre, and almost tens of thousands of packages were destroyed. Although the staff spontaneously carried out rescues and the local people also helped, the flood came too fast to save many losses* (Interviewee A). *The previous floods greatly impacted the company's operation, making us carry out response and adaptation plans to reduce losses in the later period, which we think is resilient* (Interviewee B).
Effect of DO on DC	*Although our firm has emergency plans to deal with floods and applies DTs to our business, there is currently no clear DO and strategy to apply these technologies and develop these DT capabilities during floods* (Interviewee D).
Effects of DTs (DO and	*At this stage, we have different digital strategies and unique emergency plans to*

DC) on SCR	*deal with floods, but they are not combined with their orientation. However, our firm has a unique tail-end platform and information mass delivery platform to improve information communication and exchange during the flood period. We can adjust the delivery and transportation plan in a timely manner according to the information released above* (Interviewee F).
Effects of DTs on logistics firm performance	*During the flood period, the distribution efficiency will decline. We will use the targeting gun to scan the temporarily undeliverable objects through information communication technology and send messages to customers to let them understand our situation. In addition, DTs have also helped us reduce operational risks in early warning. After the event, with the change in flood conditions, we can also quickly select the transportation road to distribute the objects according to the information on the system platform* (Interviewee G).
Effect of SCR on logistics firm performance	*Our company previously emphasised flexibility in dealing with disruptive crises like floods. However, compared with resilience, flexible response lacks initiative, agility, and redundant resources, sometimes leading to our failure to promptly adjust operations. Nevertheless, through strengthening resilience, we can adjust the express storage, prepare more emergency resources in advance, and transfer some equipment. At the same time, rapid and agile response enables us to resume distribution for the first time, improving the company's operating efficiency and performance during the flood* (Interviewee E).

Based on the dynamic capability, SCR is the ability to maintain and restore firm function using response and adaptation plans (Chowdhury & Quaddus, 2017; Jiang et al., 2019). Floods have dramatically influenced logistics firms in the past, which required them to enhance their efforts in flood management (Andrew et al., 2016; Pathak & Ahmad, 2016). Interviewee B pointed out,

"*The previous floods had a great impact on the company's operation, making us carry out*

response and adaptation plans to reduce losses in the later period, which we think is resilient."

As discussed in the literature review above, there is a relationship between disruptive impacts and SCR. Hallak et al. (2018), Melián-Alzola et al. (2020), and Senbeto and Hon (2020) found that disruptive events have adverse effects on SCR, whereas Yu et al. (2019) revealed that dynamism of disruption can positively affect SCR. In this study, we hypothesise that FDIs trigger the SCR of logistics firms:

H1: The FDIs will positively be related to triggering and expanding the SCR of logistics firms.

5.4.2 Effect of digital orientation on digital competency

In recent years, the logistics industry has become deeply integrated with emerging DTs such as the Internet of Things (IoT), 5G communication technology, remote sensing, and artificial intelligence. Logistics firms apply DTs to collect and process information in real-time and make optimal decisions for obtaining optimal layouts, which helps to achieve higher quality, efficiency, low-cost division of labour, and collaboration for each component unit in the logistics system (Chung, 2021). Emerging DTs also provide an intelligent solution to flooding management for logistics firms in flood-prone areas (Kaur et al., 2022). Collaborative sensing has been integrated into the logistics management system to respond to emergencies. As interviewee C noted,

"*We integrate the meteorological information and early warning of the meteorological bureau into our logistics management system to timely adjust the storage and transportation routes*."

Furthermore, the IoT provides a distributed framework and information to handle flood situations. Thus, remote sensing is essential for logistics firms' flood management. As interviewee D addressed,

"*We have equipped warehouses and logistics vehicles with IoT technologies to better prepare*

for and respond to floods. Meanwhile, remote sensing technology allows us to better analyse the logistics operation environment when floods occur."

Combined with organisational information processing theory, interviews identified two distinct components of DTs in floods: digital orientation (DO) and digital competency (DC). DC allows logistics firms to use DTs effectively in flooding events and engage in swift decision-making. The lack of DO is the common feature of the lack of DC, indicating the immaturity of an enterprise. Once the IT orientation is determined, DC can be effectively developed (Interviewee D). However, some logistics firms lack the DO to develop DC in floods.

Above all, DO has a vital role in developing DC in the context of floods. Researchers have not previously considered the relationship between DO and DC, but some studies verified the significant relationship between firm orientation and competency. For instance, Racela (2014) proposed that customer orientation plays a role in developing innovation competencies. Al Mamun and Fazal (2018) revealed that firm orientation of innovativeness, proactiveness, and autonomy positively influenced entrepreneurial competencies. Thus, we propose the second research hypothesis:

H2: DO will positively be related to active the DC of logistics firms.

5.4.3 Effects of DTs on SCR

DO can improve the SCR of logistics firms by suggesting the proper adaptation and mitigation strategy using DTs (Taghizadeh & Taghizadeh, 2021). DO provides an approach for logistics firms to establish efficient strategies to improve resilience and overcome the adverse effects of floods by bringing more combinations of DTs and assisting firms in operation innovation. Employees can share their understanding of the operation, and disaster data can flow across their mobile digital platforms to aid the development of response plans (Ramanathan, 2021; Chan et al.,

2023).

DC allows logistics firms to identify and evaluate flood risk by enhancing visibility. The development and utilisation of DC may improve the SCR because DC ensures the continuity of operations when a flood is expected to occur. Logistics workers can learn the most relevant or familiar DTs and decide upon the most appropriate technology according to the resilience practices adopted during floods. Furthermore, they can effectively connect, share, communicate, and collaborate with others in digital environments (Oberländer et al., 2020) to transition from an unforeseen flood situation to a known action by sharing accurate real-time data and making appropriate decisions. DC helps logistics firms creatively apply DTs to increase effectiveness and efficiency and maintain operation functions (Interviewee F).

Although previous studies have not directly discussed the effects of DO and competency on SCR, a few studies have explored the relationships among technology usage, capability, and resilience. Rajesh (2016) proposed that firms' technological capabilities can influence their SCR capabilities. Mandal (2019) found that outside-in IT capability can affect resilience, but inside-out IT capability did not significantly influence tourism resilience. The thematic analysis (Figure 5) shows that DO includes DT usage and adoption. Previous studies have verified that major technologies can affect resilience (Gu et al., 2021; Singh & Singh, 2019). Overall, DO and DC may influence logistics firms' SCR in the context of floods. Hence, we propose third and fourth hypotheses:

H3: DO will positively relate to enhancing the SCR of logistics firms.

H4: DC will positively relate to enhancing the SCR of logistics firms.

5.4.4 Effects of DTs on FP

DTs have helped to optimise and improve supply chain operations, procurement, production,

logistics, and services (Llach & Alonso-Almeida, 2015). Our investigation indicated that DO increases the investment of logistics firms in DTs. DO accelerates logistics firms' process optimisation and resource integration, which help form a competitive advantage and provide consumers with stable products and services (Interviewees D and F). In the context of floods, DO can help logistics firms adjust their procurement and delivery plans, thus guaranteeing sustainable operation and high-level performance.

DC allows logistics firms to exchange information with customers quickly and understand uncertain situations more clearly using DTs (Zhou et al., 2022), which is particularly valuable during an unexpected flood. Early warning mechanisms in logistics firm platforms can also reduce the cost of facilities and equipment. By using DTs for flood management, logistics firms effectively reduce the delivery and warehouse risk. DC improves connectivity among inter-firm members to help them work on integrating the digital and physical worlds. Moreover, communication enabled by DTs can help promote mutual understanding between the firm and its customers, reducing conflicts and improving satisfaction (Interviewee G).

Hence, DO and DC lead to the improvement of FP in flood conditions. There are some similar findings in the previous studies. Hunter and Perreault (2006) indicated that the technology orientation of salespeople directly impacts internal role performance. Masa'deh et al. (2018) and Rezazadeh (2016) found that technology orientation was positively related to organisational performance. Al Mamun and Fazal (2018) verified that entrepreneurial competencies positively affected micro-enterprise performance. Chakravarty et al. (2013) revealed that IT competencies enhanced FP by supporting the implementation of requisite entrepreneurial and adaptive actions. Thus, we propose the fifth and sixth hypotheses:

H5: DO will positively relate to improving FP in logistics.

H6: DC will positively relate to improving FP in logistics.

5.4.5 Effect of SCR on FP

SCR may help logistics firms operate more efficiently (Abeysekara et al., 2019; Akgün & Keskin, 2014) in the context of floods. SCR helps logistics firms manage changes effectively and adjust quickly, maintaining the operation and restoring it to a stable performance level in floods. Logistics firms often adapt their resource mix to secure or maintain a competitive advantage. In this way, SCR enables logistics firms to manage flooding disruption, deal with unexpected situations, and continue to deliver services, allowing them to optimise operation plans and maintain a high performance level during a flood period (Interview E).

Indeed, logistics firms can achieve a high performance level by enhancing their SCR, which has been verified in studies of other sectors. Prayag et al. (2018) found that SCR is a significant predictor of financial performance for tourism. Liu et al. (2018) addressed the positive effects of the three types of SCR on FP in the liner shipping industry. However, Hallak et al. (2018) found that the impact of resilience on FP was unsupported in the upscale restaurant sector. Thus, we propose the seventh research hypothesis:

H7: The stronger the SCR, the higher the logistics firm's performance.

By incorporating the findings from the qualitative investigation and related literature, we developed our conceptual framework for the quantitative study, as shown in Figure 5.5. Moreover, firm size was used as a control variable to determine the impacts of DO and DC on SCR and FP.

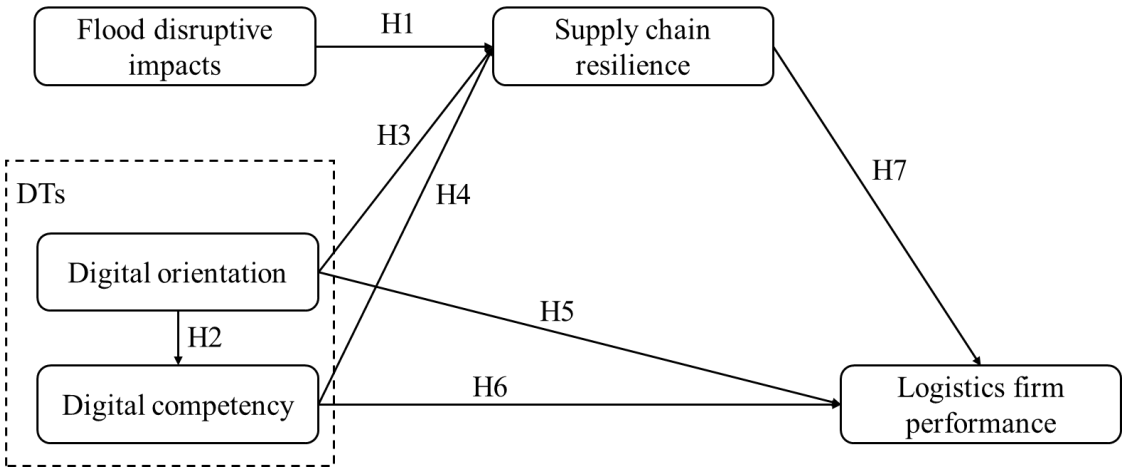

Figure 5.5 Conceptual framework and hypotheses (Source: author)

5.5 Phase 2 Study: A Quantitative Investigation

To gain further insights and verify the findings of the Phase 1 study, we designed a structured questionnaire based on the previous results and literature to implement in Phase 2. In Phase 1, we established the link between DTs and SCR under flood management. The quantitative analysis in Phase 2 can assess the relationships and hypotheses proposed in Phase 1.

5.5.1 Measurement

Starting from the conceptual research model, the initial survey items were extracted from the interviews and existing literature and adapted based on practice. Four items of the SCR construction were adopted from Jia et al. (2020) and El Baz & Ruel (2021). Three items of FDIs were adopted from El Baz & Ruel (2021) and Yu et al. (2019). Thirteen items of DC were adopted from Janssen et al. (2013), and Oberländer et al. (2020), and six items of DO were adopted from Ramanathan (2021), which involve two major components identified from the data coding and analysis in Phase 1. Six items of logistics FP were adopted from Ramanathan (2021) and Ahmed et al. (2014). Apart from the control variable of firm size, all variables were assessed using Likert 7-point scales from 1 (strongly disagree) to 7 (Strongly agree), as shown in the Appendices.

Table 5.3 Variables measurement

Variables		Measurement items
Supply chain resilience (Jia et al., 2020; El Baz & Ruel, 2021)	To what extent do these statements apply to your firm in the context of floods? (1–7, strongly disagree to strongly agree)	
	SCR1	We can cope with changes brought by floods
	SCR2	We can adapt to floods flexibly
	SCR3	We can provide a quick response to the floods
	SCR4	We can always maintain high situational awareness of floods
Flood disruptive impacts (El Baz & Ruel, 2021; Yu et al., 2019; interviews)	How do floods affect your firm? (1–7, no influential to very influential)	
	FDI1	The overall efficiency of operations
	FDI2	Lead time for delivery (delivery reliability)
	FDI3	Purchasing costs for supply
Digital orientation (Ramanathan, 2021; interviews)	To what extent do these statements apply to your firm in the context of floods? (1–7, strongly disagree to strongly agree)	
	DO1	In my firm, top management is committed to investing in the DTs
	DO2	In my firm, DTs perceived usefulness
	DO3	We can adapt the DTs in a shorter period
	DO4	In my organisation, DTs are used higher extent to enable a shared understanding of operations
Digital competency (Janssen et al., 2013; Oberländer et al., 2020)	To what extent do these statements apply to your firm in the context of floods? (1–7, strongly disagree to strongly agree)	
	DC1	We know the basics (terminology, navigation, functionality) of digital devices and can use them for elementary purposes, especially during floods
	DC2	We can connect, share, communicate, and collaborate with others effectively in digital environments during floods

	DC3	We understand the broader context of the use and development of DTs against floods
	DC4	We are aware of the most relevant or common DTs and can decide upon the most appropriate technology according to the purpose or need at hand during floods
	DC5	We can confidently and creatively apply DTs to increase personal and professional effectiveness and efficiency during floods
Firm performance (Ramanathan, 2021; Ahmed et al., 2014; interviews)	To what extent does your firm perform in the context of floods? （1–7, extremely worse to extremely good)	
	FP1	Speed of delivery
	FP2	Dependability of our service
	FP3	Risk reduction on distribution
	FP4	Stability of operations
	FP5	End customer satisfaction

5.5.2 Sampling and data collection

This study's target population comprises top managers, senior managers, junior managers, and other professionals responsible for the operations of logistics firms. We selected the samples from the companies in flood-prone areas identified by previous news reports (The People's Government of Zhejiang Province, 2023) and the logistics industry list (Zhejiang Logistics Association, 2023). A random sampling approach was applied to collect data, and questionnaires were distributed through online and offline surveys. After a two-round survey in August (first round) and September (second round) 2022, we approached 359 respondents from different logistics firms and received 323 questionnaire responses. Among these, fifteen responses were removed from the analysis owing to missing information, resulting in 308 usable questionnaires.

Considering the target population, we removed the responses received from the general staff and finally collected 150 valid samples. The final effective response rate was 41.7%, comparable to other similar survey studies (Jia et al., 2020). The demographic profile of respondents is shown in Table 5.4.

Table 5.4 Demographic profile of the respondents

Survey questions	Division/range	Numbers	Percentage (%)
Firm size	< 20	12	8.00
	20–49	27	18.00
	50–99	25	16.67
	100–199	22	14.67
	200–499	20	13.33
	500–999	13	8.67
	1000–4999	20	13.33
	> 5000	11	7.33
Ownership Structure	State-owned	36	24.00
	Private-owned	70	46.67
	Foreign capital-owned	30	20.00
	Joint venture owned	14	9.33
Working experience	< 6	55	36.67
	6–10	52	34.67
	11–15	21	14.00
	> 15	22	14.67
Organisational position	Top manager	23	15.33
	Senior manager	56	37.33
	Junior manager	71	47.33
Age group	< 25	12	8.00

	25–35	62	41.33
	36–50	55	36.67
	51–65	19	12.67
	> 65	2	1.33
Gender	Male	82	54.67
	Female	68	45.33
Educational Qualifications	Below senior high school	13	8.67
	Senior high school	18	12.00
	College	48	32.00
	Undergraduate	57	38.00
	Master and above	14	9.33

5.5.3 Non-response bias test

We tested the non-response bias to check the data validity by comparing the differences between the first-round and second-round respondents (Bag et al., 2022; Jia et al., 2020). The results of the T-test yielded no significant difference in any indicator items ($P > 0.05$) between the first-round and second-round respondents. Therefore, non-response bias is not a concern in this study.

5.5.4 Common-method bias test

This study adopted procedural and statistical measurements to assess the common-method bias (Jiang et al., 2019; Podsakoff et al., 2003). A variety of strategies have been employed to address the procedures. First, we obtained and adapted variable items from diverse sources. Second, a pilot survey and exploratory factor analysis (EFA) were conducted to revise and adjust survey instruments, whose variables were measured separately. Third, we collected survey data from

different flood-prone areas via online and offline surveys, which ensured respondents' anonymity. Notably, we developed the survey questionnaire questions to be simple, concise, and clear through the feedback and comments of respondents and survey investigators.

For statistical measurement control, Harman's single factor test was conducted on the variable items (Harman & Harman, 1976). The test results revealed that a single factor explained 38.51% of the variance, indicating that common methods bias was unlikely to be an issue in this study because most of the variance was not explained by a single factor. Second, the latent factor test was applied (Podsakoff et al., 2003). No significant difference was observed in the factor loadings in this test after introducing a latent factor into the measurement model. Hence, minimal common methods bias was involved in the survey data.

5.6. Results of Phase 2

5.6.1 EFA of survey instruments

Considering that the original items of previous studies are not related to flood management of logistics firms and may not be suitable to investigate the role of DTs on SCR against floods, we conducted a pilot survey in July 2022 and applied EFA to revise the initial survey instruments. Fifty-one participants finished the pilot survey and commented on the questionnaire design. Data appropriateness was checked using KMO statistics (all > 0.8), and Bartlett's test of sphericity showed that it was significant ($p < 0.001$). Based on the EFA results, as shown in Table 5.5, the items with a factor loading over 0.7 were selected as formal survey instruments (Alksasbeh et al., 2019; Maskey et al., 2018). Finally, we obtained four items of SCR, three items of flood disruption, four items of DO, five items of DC of DTs, and five items of FP for the updated survey. We also revised the item description and questionnaire details based on the comments and feedback from

the pilot survey. Detailed items of the variables are provided in the Appendix, and all item labels are explained.

Table 5.5 EFA of the initial survey instruments

	Item labels	Factor loading of variables		
Supply chain resilience	SCR1	0.840		
	SCR2	0.720		
	SCR3	0.834		
	SCR4	0.790		
Flood disruptive impacts	FDI1	0.830		
	FDI2	0.792		
	FDI3	0.915		
Digital orientation	DO1	0.760		
	DO2	0.839		
	DO3	0.811		
	DO4	0.660		
	DO5	0.627		
	DO6	0.722		
Digital competency	DC1	0.764	−0.023	−0.523
	DC2	0.630	0.443	−0.132
	DC3	0.681	−0.288	−0.353
	DC4	0.765	0.097	−0.177
	DC5	0.643	−0.094	0.586
	DC6	0.664	0.455	−0.180
	DC7	0.554	0.557	0.178
	DC8	0.647	0.061	0.128
	DC9	0.685	0.142	0.171
	DC10	0.767	−0.439	−0.065

	DC11	0.654	−0.336	−0.068
	DC12	0.828	−0.161	0.230
	DC13	0.774	−0.177	0.268
Firm performance	FP1	0.678		
	FP2	0.830		
	FP3	0.861		
	FP4	0.715		
	FP5	0.789		
	FP6	0.818		

5.6.2 Reliability and validity analysis

The measurement model was assessed by examining the reliability and validity of the final survey instruments. The Cronbach's alpha coefficient estimation method was applied to test reliability using SPSS 28. The reliability results are shown in Table 5.6. Regarding latent variables of SCR, DO, DC, FDI, and FP, the values are all greater than 0.8, indicating that the reliability of questionnaire data reached a high level (Nunnally, 1994).

Table 5.6 Reliability and validity results

Variables/items	Factor loading	CR	AVE	Cronbach's Alpha (α)
Supply chain resilience		0.921	0.709	0.917
SCR1	0.873			
SCR2	0.870			
SCR3	0.778			
SCR4	0.844			
Digital orientation		0.933	0.776	0.931
DO1	0.848			

DO2	0.881			
DO3	0.878			
DO4	0.915			
Digital competency		0.936	0.743	0.935
DC1	0.861			
DC2	0.865			
DC3	0.849			
DC4	0.869			
DC5	0.867			
Firm performance		0.932	0.735	0.932
FP1	0.841			
FP2	0.878			
FP3	0.808			
FP4	0.896			
FP5	0.860			
Flood disruptive impacts		0.871	0.694	0.869
FDI1	0.861			
FDI2	0.776			
FDI3	0.859			

Confirmatory factor analysis was first applied to test the measurement model using Amos 28. The common validity indicators that need to be used in the analysis include the standardised factor loading, average variance extracted (AVE), and composite reliability (CR). Table 6 indicates the validity results. All factor loadings were higher than 0.7 and significant ($p < 0.001$), revealing high convergence. The AVE values for each variable were greater than 0.5, indicating convergent validity.

Furthermore, the CR values of the construct variables were higher than 0.7, which further

confirms the convergent validity (Everitt & Dunn, 2001). To test discriminant validity, we compared the square root of AVE with the correlation value. If the square root of AVE is greater than the value of the correlation coefficient, the discriminant validity is considered high (Cable & DeRue, 2002). From the calculation, we found that all square roots of the construct AVE values were much larger than the correlation coefficient values, as shown in Table 5.7. Therefore, the measurement model satisfies the test of reliability and validity.

Table 5.7 Discriminant validity coefficients

	FDI	**SCR**	**DC**	**DO**	**FP**
FDI	**0.833**				
SCR	0.739**	**0.842**			
DC	0.669**	0.699**	**0.862**		
DO	0.584**	0.575**	0.588**	**0.881**	
FP	0.606**	0.622**	0.641**	0.540**	**0.857**

(Bold numbers are the square roots of construct AVE values, and other numbers are the correlation coefficients. ** denotes that correlation is significant at the 0.01 level).

5.6.3 Structural model testing

The conceptual model was tested using the structural equation model (SEM) and AMOS 28. As shown in Table 5.8, the SEM has good fitness. The ratio of the chi-squared value and degrees of freedom ($\chi 2$/DF) is less than 3. The root mean square error of approximation (RMSEA) is below 0.08, and the standardised root mean square residual (SRMR) is less than 0.1. The values of the goodness of fit index (GFI), adjusted goodness of fit index (AGFI), comparative fit index (CFI), incremental fit index (IFI), normed fit index (NFI), and Tucker Lewis index (TLI) are all larger than 0.9, implying that the model fit is acceptable (Barrett, 2007; Yao et al., 2021).

Table 5.8 Calculation results of commonly used fitting indices

Fitting index	χ2/DF	SRMR	RMSEA	GFI	AGFI	IFI	CFI	NFI	TLI
Result	2.026	0.059	0.073	0.914	0.908	0.923	0.922	0.958	0.912
Judgement value	< 3	< 0.1	< 0.08	> 0.9	> 0.9	> 0.9	> 0.9	> 0.9	> 0.9

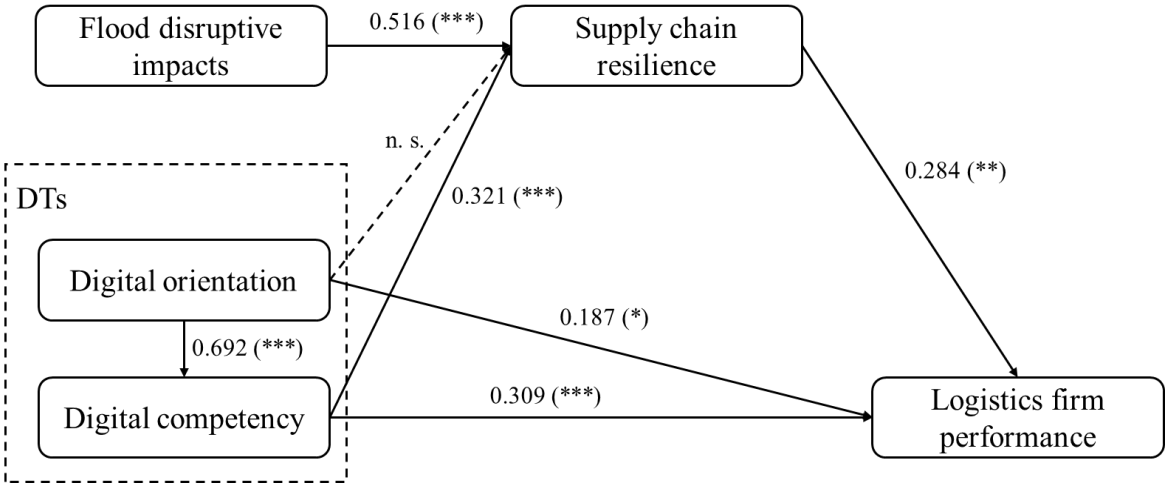

Figure 5.6 The model estimates results (Source: author)

(p < 0.05 is significant, p<0.05*, p<0.01**, 0<0.001***)

The estimated path analysis results are presented in Figure 5.6 and Table 5.9. The path coefficient of flood disruption on SCR is 0.516 (p = 0.000), and thus H1 is supported. FDI positively affects SCR, which means flood disruption can be an opportunity for logistics firms to develop SCR. The results showed that DO positively influences DC (p = 0.000), which supports H2. However, DO does not significantly affect SCR (p = 0.098 > 0.05), lacking support for H3. The path coefficient between DC and SCR is 0.321 (p = 0.000), which supports H4. Hence, we find that DO has an indirect mediation effect on SCR through DC.

Table 5.9 The results of the hypotheses test using SEM

Hypotheses	Structural paths	Estimate	S.E.	CR	p
H1	FDI→SCR	0.516	0.090	5.767	***
H2	DO→DC	0.692	0.090	7.707	***
H3	DO→ SCR	0.124	0.075	1.656	0.098
H4	DC→SCR	0.321	0.076	4.227	***
H5	DO→FP	0.187	0.084	2.219	0.026
H6	DC→FP	0.309	0.092	3.376	***
H7	SCR→FP	0.284	0.097	2.927	0.003
/	Firm size→SCR	−0.022	0.034	−0.635	0.526
/	Firm size→FP	−0.092	0.038	−2.406	0.016

($p < 0.05$ is significant, $p<0.05$*, $p<0.01$**, $0<0.001$***)

In addition, there is a positive relationship between DO and FP ($p = 0.026$) and DC and FP ($p < 0.001$). The findings indicate that DTs can enhance the logistics firm's performance in floods. Moreover, SCR positively affects FP ($p = 0.003$). Therefore, the SEM results support H5–H7. As for the control variable, firm size does not affect SCR but negatively affects FP during a flood. This may be because large-scale companies are more likely to be exposed to floods, so the FP is relatively affected.

5.7 Discussion

5.7.1 Theoretical implications

Study 2 provides several original theoretical implications for the interpretations and relationships among DO, DC, SCR, and FP. Organisational information processing theory proposes that organisations may develop processing information capabilities to deal with uncertain supply chain disruption (El Baz & Ruel, 2021). The test of the conceptual framework in Figure 7 provides empirical evidence for the importance of strengthening SCR through DTs. We found two

components of DTs that impact SCR in response to disruptive events: DO and DC. The findings confirmed that DC can directly affect SCR and improve logistics performance. A firm with high DC understands various basic skills associated with DTs and their application scopes (Oberländer et al., 2020) in disaster management and operation. As for the employees, they know the basics of DTs, especially how to apply them in abnormal working environments like floods. During disruptive events, firms need to scan and analyse the environmental conditions and disruption characteristics quickly (Kaur et al., 2022) to respond effectively.

Strong DC also implies that companies can choose the most relevant and effective technologies to apply to disruptive crises. For instance, collecting logistics vehicle data via the IoT, big data, and cloud computing technologies helps mitigate crises by expediting response actions (Bag et al., 2022; Kaur et al., 2021). One important aspect is that the DC can help in emergency information sharing and collaborative communication (Llach & Alonso-Almeida, 2015), which is critical for developing SCR with high crisis situational awareness and quick response to supply chain disruptions. As predicted, DC directly affects FP because it can help firms maintain the continuity of their operations and increase customer satisfaction through crisis communication. The findings of Phase I also support this.

Notably, DO cannot directly lead to SCR, even though it can contribute to FP. DO includes DT investment, usefulness perception of DT, quickness of DT adoption, and the extent of DT usage in operations. Previous research revealed that IT usage and infrastructure significantly affect firms' resilience (Castellacci, 2015; Gu et al., 2021). However, the results indicate that DO did not significantly influence the SCR of logistics firms, which is similar to the finding of Mandal and Saravanan (2019). Some logistics firms have perceived the usefulness of DTs and adopted emerging DTs in a shorter time. Logistics firms only use DTs to develop SCR operations, which

may lead to failure because the employees and managers of logistics firms lack sufficiently high DC to transform DO into SCR against disruptions effectively. Still, the findings found that DO can significantly improve the DC of logistics firms in the disruption management process.

Moreover, the findings suggest that DC mediates the effect of DO on SCR during floods. It is necessary to improve the personal and professional proficiency related to the appropriate DTs and their application during disruptive events, which can facilitate DO in SCR. Furthermore, DO and DC can directly improve FP during flooding situations. As for other disruptive events, the disruption impacts may be different from floods. Firms can strengthen DO and DC and monitor DT disruptions to prepare, respond, and recover more effectively based on the specific attributes and impacts of the disruptions.

SCR has also been shown to positively influence logistics firms' performance during floods, which previous studies have observed in other disruptive events (Ahmed et al., 2014; Akgün & Keskin, 2014; Gu et al., 2021). These findings provide empirical evidence of the vital role of SCR on FP for disaster management research and dynamic capability theory. Firms can develop SCR with robust, agile, visible, and flexible capabilities to improve FP, even though supply chain disruptions may harm firms to some extent. Therefore, exposure to supply chain disruption is not necessarily a threat. It can even be an opportunity for firms to optimise risk management and develop SCR (Yu et al., 2019). In the analysis, we found that FDI positively affects the SCR of logistics firms. Due to disruptive impacts, firms must respond and restore operations in the risk or disruption management process. Evolutionary theory states that the evolutionary process can modify and improve organisational capability (Jiang et al., 2019). The disruptive effects of various supply chain disruptions trigger the development of SCR. Firms need to perceive risks and configure their agility, adaptation, and flexibility in response to an uncertain disruptive event. This

finding leads to novel insight into how firms turn disruption into opportunity by enhancing resilience. While some firms are slow to respond and recover, the firms with high SCR levels can increase FP in a turbulent disaster environment.

5.7.2 Managerial implications

Some challenges are associated with applying DTs to enhance SCR and FP. First, some firms lack efficient SCR development or digital transformation strategies and mindlessly deploy DTs, making it difficult to realise value from the investment. Second, many firms still lack digital talent, and most digital deployment programmes remain in the pilot stage. Pilot DT projects and experiences are difficult to replicate and promote quickly, so they cannot significantly affect SCR and FP across the entire enterprise or scenario. Third, some firms have not yet established a digital talent training and resilience empowerment system.

The findings of Study 2 may contribute to several practical implications for developing SCR and improving FP using DTs. Figure 7.2 shows a framework for applying DTs in firms to empower SCR and enhance FP, as determined from the above findings. First, disruptive events are becoming frequent owing to climate change and the turbulent global economic environment. Firms need to adjust their strategies and consider disruptions as development opportunities for securing competitive advantages, not only regarded as dynamism or threats. Firms can vary, select, and retain their strategies to drive resilience-enhancing changes and configuration diversity in the disaster or risk management process, which may become a pattern for improving resilient adaptation (McCarthy et al., 2017). SCR can be developed by enhancing the overall robustness, agility, flexibility, and visibility, which are generally the goals of most firms. For instance, logistics companies can quickly transfer objects from high-risk warehouses to safe warehouses after flood risk judgement when receiving rainfall and flood warnings. Logistics firms can improve logistics

and operation visibility by establishing information-sharing platforms with the IoT and big data analytics approaches (Chan et al., 2022). Another vital aspect for the firm is establishing effective emergency response processes and flexible emergency plans. As for logistics firms, it is crucial to establish an inventory buffer zone for robustness and optimise multiple transportation routes for flexibility.

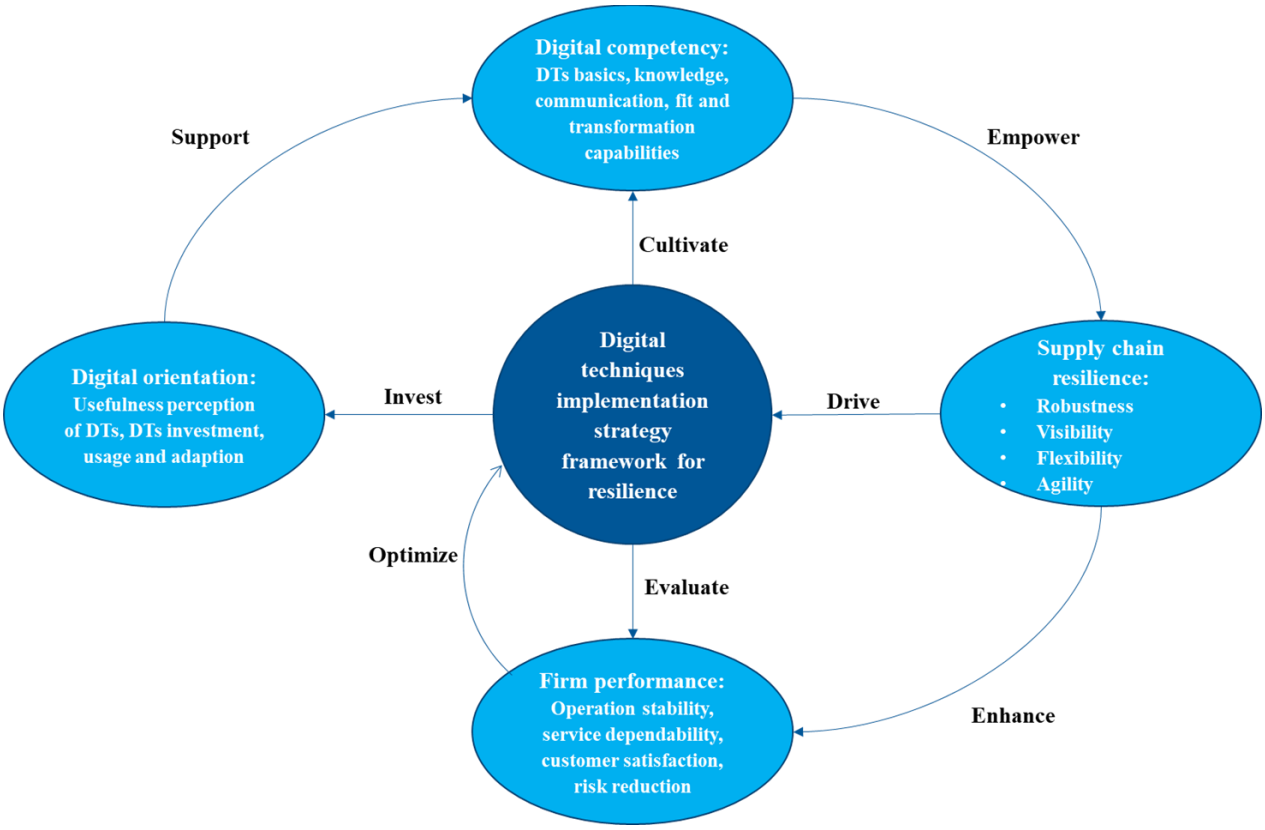

Figure 5.7 DTs implementation strategy framework for SCR (Source: author)

The findings of Study 2 demonstrated the critical role of DC in empowering SCR and enhancing FP. To support the positive effect of DC on SCR, it is necessary to consider that DO also plays a vital role. Therefore, a firm must cultivate DC and invest in DO. For instance, logistics companies can establish DTs and data-driven dynamic routing planning and operation visibility to ensure efficient performance. The linkage of logistical components (e.g., location, weight, quantity, task, object, and identity) can be formed through DTs, enabling the practical application of

perception technology, data collection, and network transmission technology. Intelligent scheduling and dynamic route planning can be implemented through data analysis and applied algorithms, as well as dynamic adjustment, early warning systems, and optimisation. Moreover, logistics companies can establish an end-to-end visible process and active early warning mechanism with DTs to strengthen SCR and improve customer satisfaction. For example, logistics firms may use a digital strategy to address customers' expectations for the visibility and early warning of disruptions by establishing a system based on visible, manageable, controllable, and traceable processes.

In disaster management, DTs provide a practical approach to decreasing risk and damage by providing forecasting, prediction, risk assessment, and risk management. Since logistic employees at different levels may not perceive and communicate disruptive information well, logistics firms need to organise lectures or training based on DTs. Furthermore, the logistics company can strengthen the front-, middle-, and back-end architectures and flexibly arrange the business capabilities by digitising their processes. The evaluation of FP can also help optimise the DT implementation strategy.

5.8 Concluding Remarks

This chapter investigated the role of DTs as driving factors that strengthen the SCR of logistics firms towards disruptive events, using flooding as an example. Two critical aspects of DTs can help logistics firms improve SCR and performance. The DC of DTs can positively affect SCR and FP. DO can directly and positively affect FP. However, DO requires the mediation of DC to affect SCR. Moreover, we found that FDIs can positively impact the SCR of logistics firms. We highlight the importance of combining DTs in disruption management and logistics operations. This study provides a reference for improved operations and resilience development under

uncertain conditions such as extreme weather and climate change.

CHAPTER 6 DIGITAL INNOVATION AND RESOURCE ORCHESTRATION IN SUPPLY CHAIN RESILIENCE

6.1 Introduction

In the ever-evolving global logistics, the intricate network of supply chains is continually tested by a plethora of disruptions. These include geopolitical tensions that can alter trade routes and tariffs, environmental uncertainties that threaten resource availability, and public health crises such as the COVID-19 pandemic, which have disrupted traditional operational models (Williams et al., 2017). In this context, the supply chain resilience (SCR) construct has become imperative for logistics entities. It is not merely a defensive mechanism to withstand external shocks but a dynamic capability that enables firms to rebound and recalibrate their operations in response to emergent demands (Pettit et al., 2013). The cultivation of SCR is thus pivotal for logistics firms to navigate turbulent global commerce with agility and foresight, ensuring continuity and stability in the face of unpredictable challenges.

In the contemporary business landscape, logistics companies stand as vital arteries in the global economy, facilitating the seamless exchange of commodities and data on an unprecedented scale. Their ability to integrate and manage diverse resources and technologies is paramount to enhancing supply chain operations' overall agility and robustness (Teece, 2007). The unique positioning of logistics firms enables them to exert considerable influence over the velocity and directionality of goods movement, thereby shaping the resilience and efficiency of international trade networks.

Digital innovation has emerged as a game-changer in this sector, revolutionizing conventional supply chain management paradigms and ushering in a new era of intelligent logistics (Christopher & Peck, 2014). Digital innovation within the logistics sector refers to introducing new or improved

digital technologies, processes, or applications that create value within the supply chain. It encompasses the strategic use of digital tools such as Artificial Intelligence (AI), the Internet of Things (IoT), and blockchain to enhance operational efficiency, transparency, and adaptability (Tsai, 2016; Tang, 2018). Digital innovation is crucial for logistics firms developing SCR in the face of disruptions. Digital innovation is not merely about the presence of technology but also about how these technologies are leveraged to achieve strategic goals.

In this context, digital innovation has become a cornerstone for logistics firms, offering advanced tools and methodologies to transform traditional supply chain management into a more responsive, transparent, and adaptive system. Digital innovations facilitate a heightened level of visibility, allowing stakeholders to promptly identify and respond to disruptions, thereby enhancing supply chains' overall agility and responsiveness. For instance, Sheffi (2015) underscores the multifaceted nature of supply chain disruptions and the imperative of building resilience as a strategic response. Similarly, Tang (2018) emphasizes the role of digital technologies in enhancing supply chain visibility and responsiveness, thereby contributing to overall resilience. These digital innovations enable real-time monitoring, predictive analytics, and automated decision-making processes, which are crucial for pre-empting disruptions and optimizing resource allocation (Tsai, 2016). However, the mere presence of digital tools is insufficient; the strategic orchestration of these resources alongside existing capabilities can genuinely catalyse the resilience of supply chains (Hitt & Ireland, 2017).

Exploratory innovation delves into new knowledge and technologies to create breakthrough products or services, while exploitative innovation enhances the efficiency and performance of existing offerings (Berraies & Zine El Abidine, 2019; Harmancioglu et al., 2020). Explorative innovation represents the pursuit of new opportunities by introducing novel digital technologies

and methodologies. It is vital for long-term growth and competitiveness, as it can lead to breakthrough solutions and new market spaces. In the context of SCR, explorative innovation enables logistics firms to anticipate and adapt to emerging trends and disruptions (Zhang et al., 2015). Exploitative innovation enhances existing operations and processes by optimising current digital assets. It ensures that firms can efficiently leverage their existing technologies to improve customer service, reduce costs, and increase operational stability (Berraies & Zine El Abidine, 2019). For SCR, exploitative innovation is crucial for maintaining ongoing operations' effectiveness and quickly recovering from disruptions.

This study adopts a configurational perspective to explore the synergistic effects of ambidextrous digital innovation—encompassing both exploratory and exploitative facets—and resource orchestration on SCR. A configurational perspective is essential for investigating the effects of digital innovation on SCR because it acknowledges that there is no one-size-fits-all approach to achieving resilience. Instead, different combinations of resources, capabilities, and strategies can lead to similar outcomes. This perspective allows a more nuanced understanding of the complex causal relationships contributing to SCR. It recognizes these relationships' non-linear and conditional nature, which is often overlooked in traditional linear analyses. By employing a configurational approach, this study can uncover the specific combinations of digital innovation and resource orchestration conducive to SCR.

The configurational approach allows for a more nuanced understanding of how different combinations of resources and digital innovation can lead to the desired outcome of SCR, revealing the complex causal pathways often obscured in traditional linear analyses (Ragin, 2009). By considering these elements combined and mutually reinforcing roles, we aim to address the gap in the literature that often treats digital innovation and resource management as isolated variables.

This research aims to uncover the specific conditions and combinations under which digital innovation can effectively contribute to SCR. By examining the interplay between exploratory and exploitative digital innovation through the lens of resource orchestration, this study seeks to provide a comprehensive framework that logistics firms can utilize to enhance SCR. The configurational view offers several advantages, including the ability to account for the equifinality and causal asymmetry that characterizes the pursuit of SCR, where multiple paths can lead to the same outcome, and the same result can be achieved through different combinations of conditions (Schneider & Wagemann, 2012). The research question of this chapter addresses:

RQ3. What are the configuration effects of digital innovation and resources on supply chain resilience?

By answering this question, the paper aims to offer theoretical insights that can guide managerial practices and inform strategic decision-making in supply chain management, ultimately contributing to developing more resilient supply chains in an unpredictable and challenging business environment.

6.2 Theoretical Background and Framework

6.2.1 Resource orchestration theory

Resource Orchestration Theory (ROT) has emerged as a cutting-edge framework within the strategic management domain, elucidating how firms can achieve and sustain competitive advantages through the effective management and configuration of resources (Hitt & Ireland, 2017). ROT posits that resources alone do not directly lead to competitive advantages; instead, orchestrating these resources—encompassing identification, acquisition, integration, and application facilitates value creation (Sirmon, Hitt, & Ireland, 2007). ROT underscores managers' proactive and creative role in resource management and continuously adjusting and optimising

resource combinations in dynamic environments (Eisenhardt & Martin, 2000; Asiaei et al., 2021).

In digital innovation, ROT offers a theoretical foundation for understanding how enterprises leverage digital technologies and data assets to drive innovation processes (Teece, Pisano, & Shuen, 1997; Liu et al., 2016). Digital innovation necessitates that firms possess advanced technological resources and the capability to orchestrate these resources to develop novel business models and services (Barney, 1991; Hughes et al., 2018). ROT highlights the fluidity and reconfigurability of resources in digital contexts, as well as the pivotal role of managers in fostering the integration of knowledge across departments and organizational boundaries (Grant, 2016; Asiaei et al., 2021).

The configuration effect of resources is particularly significant in supply chain management. ROT suggests that a supply chain's resilience is not solely dependent on the internal resource allocation of individual firms but also on the interaction and orchestration of resources within the entire supply chain network (Collis & Montgomery, 2005). Effective resource orchestration enables supply chains to better cope with market fluctuations and potential disruptions (Teece, 2007).

As a strategic management tool, ROT provides profound insights for understanding and analysing digital innovation and supply chain resilience. By emphasizing the dynamic management and allocation of resources, this theory enriches our understanding of the sources of competitive advantage and offers supply chain managers strategies for optimizing resource allocation and enhancing supply chain resilience (Hitt & Ireland, 2017). In the face of digital transformation and globalization trends, applying ROT in supply chain management has become increasingly important and extensive (Li & Jia, 2018; Liu et al., 2016).

Therefore, ROT offers new perspectives and methodologies for studying SCR in the context of digital innovation. By focusing on the dynamic management and configuration of resources,

ROT not only enriches our understanding of the sources of SCR but also provides practical strategies for supply chain managers to optimize resource allocation and enhance the resilience of supply chains. With the continuous advancement of digital technology and the deepening trend of globalization, the application of ROT in the field of SCR can help us explore the configuration roles of digital innovation and resources in SCR.

6.2.2 Ambidextrous innovation perspective

Ambidextrous innovation is a strategic approach that allows organizations to sustain long-term growth by balancing pursuing new opportunities with exploiting existing resources (Robb et al., 2022). This concept emphasizes the need for organizations to maintain a dual focus on exploratory and exploitative innovation (Saleh et al., 2023). Exploratory innovation delves into new knowledge and technologies to create breakthrough products or services, while exploitative innovation enhances the efficiency and performance of existing offerings (Berraies & Zine El Abidine, 2019; Harmancioglu et al., 2020). This dual capability enables companies to remain competitive in rapidly changing market environments (Buccieri et al., 2020).

Exploitative innovation typically deepens a firm’s core knowledge base longitudinally, while exploration innovation extends its existing knowledge base horizontally (Robb et al., 2022; Saleh et al., 2023). Exploitative innovation is often seen as optimising existing processes and technologies, building upon a firm's current expertise (Li et al., 2024). This approach ensures the reinforcement of existing market positions and improved product quality and efficiency, solidifying customer relationships and loyalty. Exploitative innovation is characterized as the refinement and expansion of inherent capabilities and skills, whereas exploration innovation is described as attempts at new methods, representing a firm’s efforts to explore, discover, and develop new knowledge (Berraies & Zine El Abidine, 2019; Tsai, 2016). Besides, exploration

innovation is akin to venturing into the unknown, seeking breakthroughs that can potentially transform industries and create new markets (Zhang et al., 2015). Exploratory innovation involves risk-taking and the willingness to invest in uncharted territories of knowledge, which can lead to significant advancements and long-term growth (Gong et al., 2021; Tsai, 2016).

In the digital era, ambidextrous innovation can be extended further to ambidextrous digital innovation (Li et al., 2024; Liu et al., 2023). Ambidextrous digital innovation encompasses traditional product or service innovations and innovations in digital tools, platforms, and processes (Scuotto et al., 2019). Ambidextrous digital innovation highlights how companies can balance the optimization of existing digital assets with the exploration of emerging digital technologies during digital transformation (Li et al., 2024). This strategic approach helps businesses maintain operational efficiency while seizing new opportunities by digitalization (Lu et al., 2023).

Therefore, the ambidextrous innovation perspective offers a novel perspective for supply chain management, emphasizing the importance of balancing innovation during digital transformation. By integrating exploratory and exploitative digital innovations, logistics companies can enhance the current performance of their supply chains and prepare for future challenges. This innovative strategy is crucial for building highly resilient supply chains and helping businesses of logistics companies maintain a competitive edge in the ever-evolving global marketplace.

6.2.3 Configuration framework

6.2.3.1 Ambidextrous digital innovation and SCR

Ambidextrous digital innovation may influence supply chain resilience. Through exploratory digital innovation, companies can develop new supply chain solutions, such as those based on the Internet of Things (IoT), Artificial Intelligence (AI), and blockchain technologies, which enhance

transparency, responsiveness, and adaptability of supply chains (Alvarenga et al., 2023; Belhadi et al., 2024; Cui et al., 2023; Gu et al., 2023; Ye et al., 2024). Meanwhile, exploitative digital innovation can help companies optimize current supply chain processes, improving efficiency and reducing costs (Saleh et al., 2023). This balanced innovation strategy contributes to constructing a stable yet agile supply chain capable of withstanding market fluctuations and uncertainties (Ahmed et al., 2022; Ye et al., 2024).

Utilizing exploitative digital innovation plays a pivotal role in logistics companies, enhancing the SCR by improving the efficiency and effectiveness of existing processes. Table 6.1 presents a detailed structure coding of content analysis. Firstly, exploitative digital innovation fortifies the stability and reliability of supply chains by optimizing current technologies. For instance, applying automation and robotic technologies can reduce human error and enhance the speed and accuracy of operations. Automated warehouse management systems ensure real-time updates and precise inventory allocation, reducing inventory costs and improving response times. Additionally, exploitative digital innovation enhances the supply chain's responsiveness by improving communication efficiency. Using mobile applications, real-time tracking systems, and cloud-based communication platforms, logistics companies can access information more rapidly and respond more swiftly to market changes and customer demands. This instantaneous communication capability is crucial for quickly resolving supply chain disruptions.

Table 6.1 Categories and codes

Categories	Sub-themes	Codes
Digital innovation	Exploratory digital innovation	· Introduce innovative technologies and methodologies such as Artificial Intelligence (AI), Machine Learning (ML), Blockchain and the Internet of Things (IoT)

		·Utilizing electronic waybill technology to improve efficiency in tracking shipments and processing data increases service transparency and security. · Digital twins improve efficiency and reduce costs by creating virtual copies of physical entities that can be used to test and optimize logistics processes in a virtual environment. · Using digital technology to offer personalized services and customized logistics solutions
	Exploitative digital innovation	· Use digital technologies to improve the quality of existing products or services. · IoT devices can provide real-time data on inventory levels, asset conditions, and transportation status, enabling proactive decision-making. · Use digital technologies to reduce the cost of production of existing products or services. · Use data analytics to gain insights into customer behaviour and market trends to better meet the needs of the existing customer base.
Resources	Infrastructure	· Improve logistics warehouses · Optimize sorting hubs · Expand transport fleet · Service stations and self-pickup cabinets · Packaging materials and equipment
	Human capital	· Reasonable organisational structure · Multiple employee training programs · Optimize staffing needs · Improve human efficiency

	Collaboration network	· Reliable franchisee · E-commerce platform cooperation ·Third-party vehicle partnership · Manufacturers network
Supply chain resilience	Flexibility	· Flexible arrangement of our truck scheduling and management · Setting up new direct and indirect services · Simplify the company's management structure · Collaboratively expand the supply chain
	Agility	· Adjust logistics capacity to pandemic conditions · Quickly change logistics process to needs of disruptions · Rapidly adjust labour management based on governmental regulation · Quickly adjust the operation plan to the pandemic environment
	Robustness	· Try to maintain business stability · Keep core work team · Provide stable service quality · Balanced and stable service network advantages · Build stable cooperation with partner companies
	Visibility	· Monitor all operation information in real-time · Check customers' information trends by visual technologies · Data visualisation of receiving and dispatching service quality

Furthermore, exploitative digital innovation strengthens the exploitation of internal and

external processes by integrating supply chain management systems. Implementing Enterprise Resource Planning (ERP) systems and Supply Chain Management (SCM) software enables logistics companies to manage orders, inventory, transportation, and supplier relationships more effectively. This integrated approach not only enhances the transparency of the supply chain but also strengthens the coordination between various supply chain segments. Lastly, exploitative digital innovation improves supply chain efficiency through continuous improvement and lean management. Logistics companies can continuously evaluate and optimise processes to identify and eliminate waste, improving resource utilization. Applying methodologies such as Lean Six Sigma helps logistics companies achieve higher quality and lower costs within the supply chain.

Exploratory digital innovation offers a range of tools and methodologies for logistics companies to enhance the resilience of their supply chains. Exploratory digital innovation introduces new technologies and methods, such as Artificial Intelligence (AI), Machine Learning (ML), Blockchain, and the Internet of Things (IoT), providing logistics companies with novel avenues to enhance the adaptability and flexibility of their supply chains. These technologies enable real-time monitoring of supply chain activities, the prediction of potential disruptions, and the swift adjustment of operational strategies in response to market fluctuations.

Subsequently, exploratory digital innovation fosters transparency and data sharing within the supply chain. The application of blockchain technology ensures the immutability and integrity of data, thereby elevating trust among various supply chain stakeholders. This transparency assists logistics companies in better understanding potential risks within the supply chain and devising corresponding mitigation measures. Moreover, exploratory digital innovation supports the customization and personalization of supply chain services. Utilizing big data analytics and AI algorithms, logistics companies can more accurately forecast market demands, optimize inventory

management, and provide more flexible delivery options, increasing customer satisfaction and loyalty.

6.2.3.2 Resources and SCR

Resources are essential for logistics companies to develop their SCR. The supply chain is disrupted and vulnerable when resources are limited (Pettit et al., 2013). Regarding disruptive events like COVID-19 in the supply chain, properly managing various resources can help organizations improve their business processes, gain efficiency, and achieve resilience (Dubey et al., 2021; Queiroz et al., 2021). Firms with valuable, inimitable, and non-substitutable resources can gain competitive advantages (El Baz & Ruel, 2021). Logistics companies have relocated assets and reconfigured resources to develop SCR, including logistics infrastructure, human capital, and collaboration networks.

As for logistics infrastructure, logistics companies have continued to increase the construction of transfer centres, layout automatic sorting equipment, and improve and optimize the transport capacity system. Logistics infrastructure, such as modern warehouses and efficient sorting centres, forms the backbone of a logistics company's operations. Optimization of these facilities can significantly increase the speed and accuracy of cargo handling, reducing delays and losses. Applying advanced automation and information technology further enhances logistics operations' efficiency and the supply chain's transparency. Maintaining and upgrading logistics infrastructure, including warehouses, sorting centres, and fleets, ensures operational reliability and efficiency. Up-to-date infrastructure can accommodate new technologies and processes, allowing the company to withstand disruptions better and maintain service quality.

Employee training and development are crucial for enhancing a logistics company's resilience. Well-trained staff can adapt to new technologies and processes, improving operational efficiency.

Training also fosters a culture of continuous improvement, which is essential for staying competitive in a rapidly evolving industry. Logistics companies fortify their supply chain resilience by establishing a rational organizational structure that ensures coordinated and effective communication among various departments. This structure facilitates swift responses to market changes and enhances decision-making efficiency, bolstering the company's ability to tackle various challenges flexibly. Besides, employee training and development are essential for bolstering a logistics company's resilience. A well-trained workforce can adapt to new technologies and processes, improving operational efficiency. Training also nurtures a culture of continuous improvement, which is vital for maintaining competitiveness in a fast-paced industry.

Logistics companies can expand their service reach and market penetration by establishing close cooperative relationships with franchisees and manufacturers. Such a cooperative network offers more flexible resource allocation and broader market coverage, enabling the company to quickly find alternative solutions to supply chain disruptions, thereby enhancing overall supply chain resilience. Partnering with e-commerce platforms is a strategic move for logistics companies to integrate their services seamlessly into the online shopping experience. This collaboration can lead to increased visibility, customer base expansion, and opportunities to adopt innovative technologies and practices from the e-commerce sector. Moreover, Collaboration with e-commerce platforms is a strategic move for logistics companies to integrate their services seamlessly into the online shopping experience. This partnership can lead to increased visibility, customer base expansion, and the opportunity to adopt innovative technologies and practices from the e-commerce sector.

By incorporating the findings from the qualitative investigation and related literature, we construct a conceptual model illustrating the configuration effects of digital innovation and

resources on SCR, as shown in Figure 6.1.

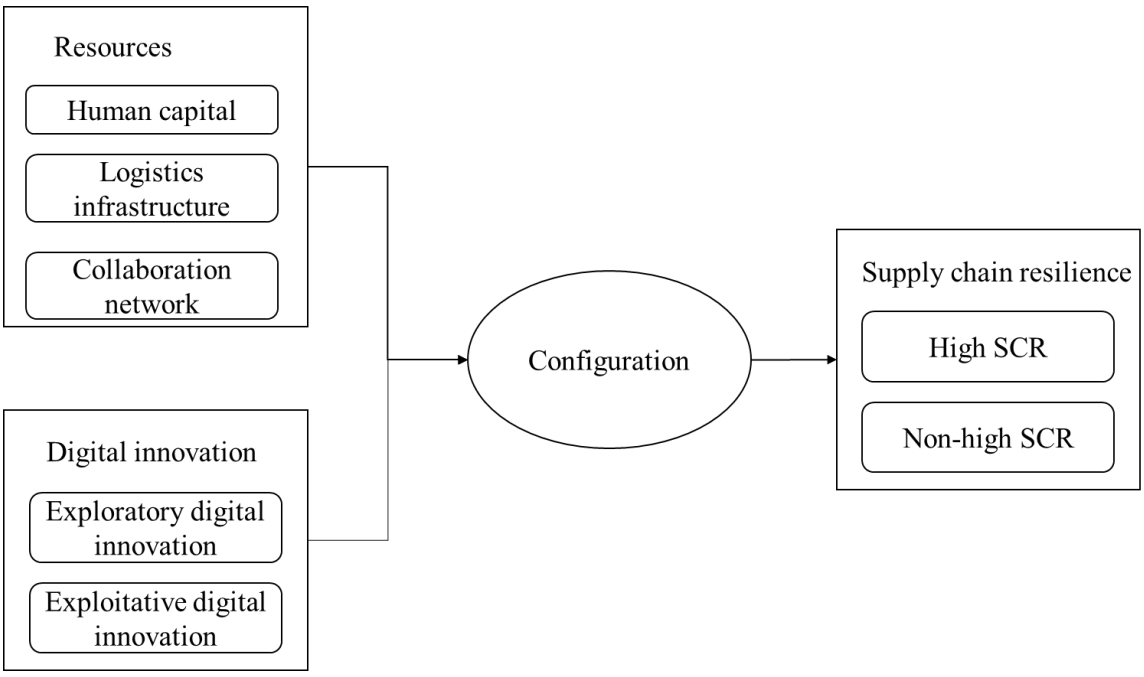

Figure 6.1 Conceptual framework (Source: author)

6.3 Research Methods

6.3.1 Research design

This chapter contains two consecutive phases with multiple methods, as shown in Figure 6.2. In Phase 1, we invite logistics operators and managers from different departments to conduct semi-structured interviews and focus groups. Thematic analysis is employed to understand the effects of resources and digital innovation on SCR. Based on resource orchestration theory and an ambidextrous innovation perspective, this study identifies and confirms logistics companies' specific resources and ways of digital innovation. This study further proposes the configuration framework of digital innovation and resources in SCR. In Phase 2, we identify variable instruments and items from literature and interview results. The questionnaire is designed to collect fsQCA data from logistics companies in China. FsQCA was applied to analyse and reveal the confirmation

effect of digital innovation and resources on SCR.

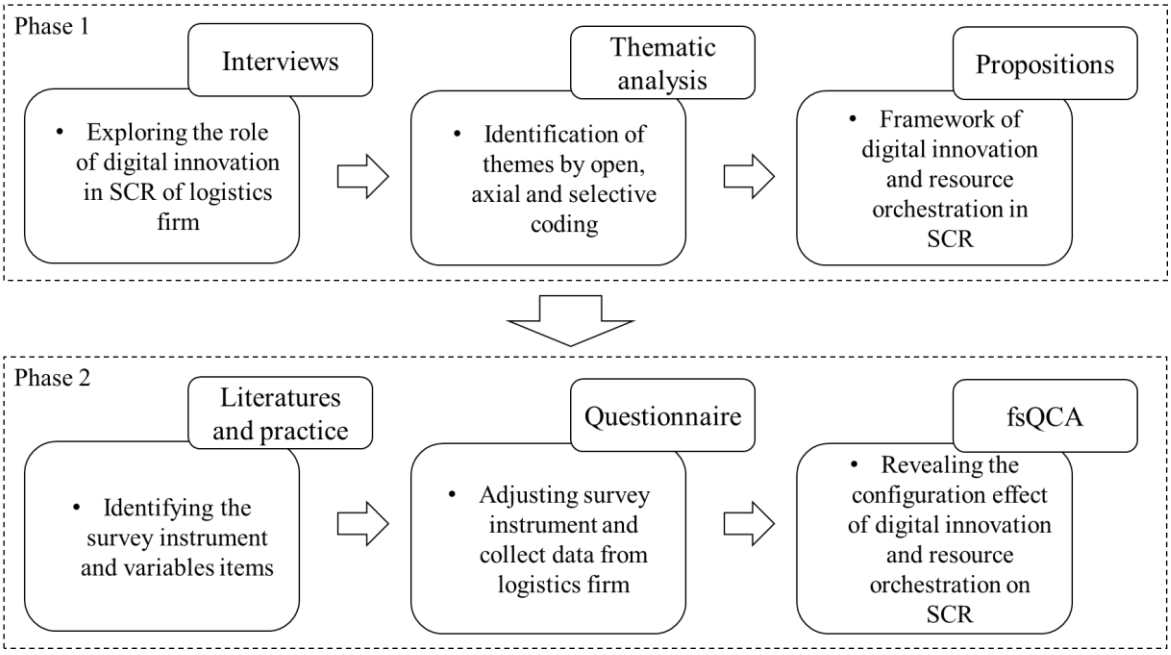

Figure 6.2 Research design (Source: author)

6.3.2 Fuzzy-set qualitative comparative analysis

This study explores the pathways through which the combination of multiple elements constituted by resources and digital innovation jointly affect the SCR of logistics enterprises. Different conditions form different causal configurations, and each can enhance SCR in a "different paths to the same destination" manner, which means different combinations of digital innovation and resource orchestration can impact the SCR of logistics companies. FsQCA can precisely identify the subtle impacts brought about by varying degrees of change in each condition (Pappas & Woodside, 2021). This method allows for a nuanced understanding of how different levels of an antecedent condition contribute to the outcome, capturing the complexity and gradation of causal effects that might be overlooked by traditional binary or linear approaches (J. Liu & Fan, 2023). Boolean operations employed in fsQCA do not lead to omitted variable bias. The method's advantage of not requiring control variables allows this study to identify practical

configurations of SCR within a well-established theoretical framework. FsQCA does not demand special treatment for causal conditions across different levels, making it particularly suitable for exploring SCR's multi-level conjunctive causal phenomena (Stroe et al., 2018). Therefore, fsQCA is ideal for this study to examine the configuration effects of digital innovation and resources on SCR. The steps of the fsQCA process are shown in Figure 6.3.

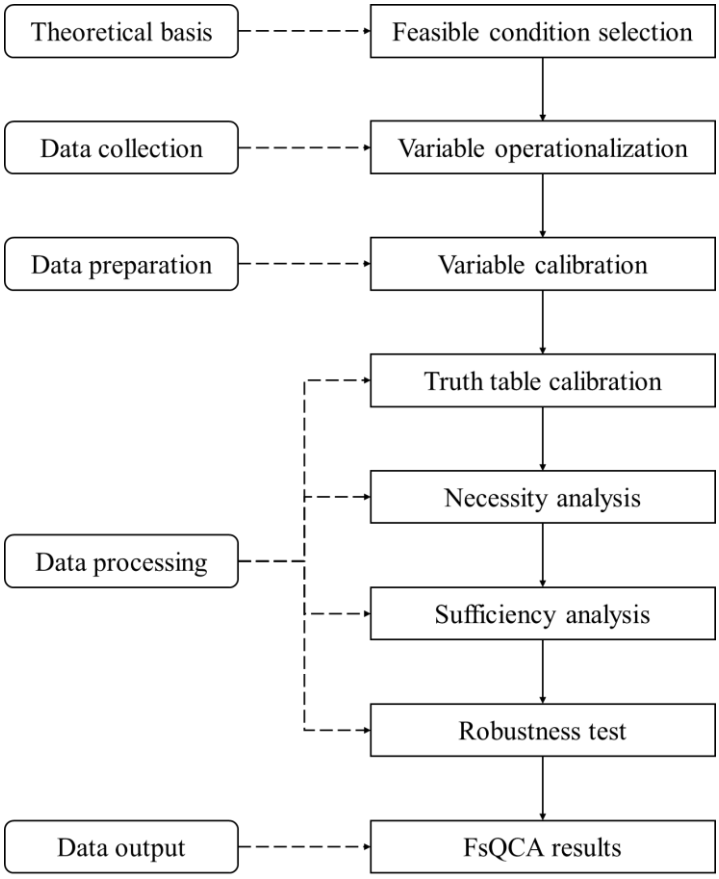

Figure 6.3 Steps of fsQCA process (Source: author)

Starting with our theoretical framework, we select feasible resources and digital innovation conditions for SCR based on interview results. We further operationalise variables and collect survey data based on the variable measurement. Variable calibration is conducted before formal data analysis. FsQCA processing includes truth table calibration, necessity analysis, sufficiency

analysis, and robustness tests.

6.3.3 Data collection

This study takes China as the study area and collects data from Chinese logistics companies. Selecting Chinese logistics companies as case data sources for studying the impact of digital ambidextrous innovation and resource configuration on SCR is justified for several reasons.

First, China boasts one of the largest logistics markets globally, with substantial domestic demand and export needs (Wang, 2021). The rapid development of e-commerce has led to significant growth in the logistics sector in China, providing a rich array of data and case studies for research. Second, China has made swift advancements in digital technology, particularly in mobile payments, cloud computing, big data, and artificial intelligence (Zhang & Li, 2020). Logistics companies widely adopt these technologies to enhance efficiency and responsiveness, offering practical scenarios for studying digital innovation. Besides, the Chinese government actively promotes digital transformation and innovation in the logistics industry, offering policy support and incentive measures (State Council Office of the People's Republic of China, 2022). Such policies create a favourable external environment for logistics companies to engage in digital dual innovation. Third, the supply chain networks in China are highly complex, involving various modes of transportation and a broad geographical spread (Chen et al., 2019). This complexity provides diverse cases for studying how resource configurations affect supply chain resilience. Fourth, Chinese logistics companies play a significant role in global supply chains and have experienced multiple natural disasters and public health events, such as the COVID-19 pandemic, in recent years. These events have tested the supply chain resilience of logistics companies (Liu, 2023). Studying the supply chain resilience of Chinese logistics companies can provide valuable perspectives for international comparisons.

We conducted interviews and focus groups to identify critical components of digital innovations and resources affecting the SCR of logistics companies and gain insights into how digital innovation enhances SCR. To acquire representative samples, we first collected annual reports from the official websites of logistics companies to identify if these companies have invested in digital innovations and applied digital technologies to improve their operations. We tried to contact targeted logistics companies by phone and email during June and July 2023. Finally, we successfully approached five typical logistics companies to conduct interviews, including one focus group interview. Identified interviewees were familiar with their companies' digital innovation development strategies and involved in logistics practices.

The key informants are shown in Table 6.2. Each interview lasted 40 to 60 minutes, and focus group interviews lasted almost 95 minutes. This study only applied interviews to identify key elements of digital innovation and resources for SCR, which helped gain primary insights and prepare for fsQCA in the next step. Therefore, this study did not conduct too many interviews and only satisfied saturation benchmarks when no new theme occurred.

Table 6.2 Basic information of Interviewees

Company number	Organisational Role	Ownership Structure	Firm size	Interview type	Interview Length
1	Operation Manager	State-owned	>1000	Semi-structured interview	45 mins
2	Technology Department Operator	Non-state-owned	500-999	Semi-structured interview	60 mins
2	Service managers	State-owned	>1000	Semi-structured interview	40 mins
3	Warehouse Director	Non-state-	200-499	Semi-structured	40 mins

		owned		interview	
4	Business Manager	Non-State-owned	500-999	Semi-structured interview	50 mins
5	Public Affairs Manager	Non-state-owned	>1000	Semi-structured interview	40 mins
6	Technology Department Operator	Non-state-owned	>1000	Semi-structured interview	55 mins
7	Business Operator	Non-state-owned	>1000	Focus group	95 mins
7	Operations Manager	Non-state-owned	>1000	Focus group	95 mins
7	Technology Department Operator	Non-state-owned	>1000	Focus group	95 mins
7	Service Operator	Non-state-owned	>1000	Focus group	95 mins

A random sampling approach is applied to collect fsQCA data, and questionnaires are distributed through online and offline surveys. The survey targets executives and managers for completion. Eligible participants must have been employed within their respective companies for at least three years. Additionally, they should have engaged in innovative activities and demonstrated a deep understanding of the associated content. It is also required that the company they represent has introduced service or product innovation within the last three years. To avoid the issue of homoscedasticity, the survey requires that respondents fill it out anonymously, and only one sample is collected from each enterprise.

We employed two distinct methods for distributing the questionnaire. First, leveraging the research team's established connections with corporate management, the questionnaires were

distributed through our network of contacts. Questionnaire distribution involved on-site completion and digital distribution methods, such as emailing links to the online survey and sharing QR codes for easy access. Second, we distributed paper questionnaires directly to logistics corporate managers. Finally, we approached 477 respondents from different logistics firms and received 167 questionnaire responses in September and October 2023. After deleting the responses with missing information and untargeted respondents, we collected 125 valid samples for further analysis. The final effective response rate was 26.2%. The sample characteristics are shown in Table 6.3.

Table 6.3 Sample characteristics

	Division/range	**Numbers**	**Percentage (%)**
Firm size	<50	7	5.60
	50-99	17	13.60
	100-199	39	31.20
	200-499	33	26.40
	500-999	17	13.60
	1000-4999	8	6.40
	>5000	4	3.20
Ownership Structure	State-owned	12	9.60
	Private-owned	103	82.40
	Joint venture owned	10	8.00
Work experience	3-6	57	45.60
	6-10	54	43.20
	11-15	7	5.60
	>15	7	5.60
Organisational	Top manager	87	69.60

position	Senior manager	34	27.20
	Junior manager	4	3.20
Age group	25-35	87	69.60
	36-50	34	27.20
	51-65	4	3.20
Gender	Male	75	60.00
	Female	50	40.00
Education	Below senior high school	1	0.80
	Senior high school	3	2.40
	College	20	16.00
	Undergraduate	92	73.60
	Master and above	9	7.20

6.3.4 Variable measurement and calibration

Our measures were based on interviews and previous literature and employed a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). We measured digital innovation using two variables called exploratory and exploitative digital innovation. The items of exploratory and exploitative digital innovation were taken from He and Wong (2004), Chang et al. (2011) and Kang et al. (2022) and revised based on interviews with logistics managers. The items of supply chain resilience were adopted by Gu et al. (2023) and revised based on interview feedback. We identified three typical resources from the thematic analysis of qualitative results: human capital, logistics infrastructure, and collaboration networks. Human capital contains staffing requirements match, organisational human structure, human efficiency, and training programs for different operating situations. Logistic infrastructure includes warehouse infrastructure, vehicles, sorting hubs, service stations, self-lifting cabinets, packaging materials, and equipment. Collaboration networks involve franchisee networks, fleet carrier cooperation,

logistics partner networks, and e-commerce platform cooperation. The detailed instruments and items are shown in Table 6.4.

Table 6.4 Variables measurement

Variables	Measurement items
Human capital (Interviews)	To what extent do these statements apply to your firm? (1-7, strongly disagree to agree strongly)
	HC1: The functional needs of our employees are matched.
	HC2: Our company's organizational structure is reasonable.
	HC3: Our company has a high workforce efficiency.
	HC4: Our company will train employees according to different operating situations.
Logistics infrastructure (Interviews)	To what extent does your firm perform in this logistics infrastructure? (1–7, extremely worse to extremely good)
	LI1: Storage facilities
	LI2: Logistics vehicles
	LI3: Service stations and self-pickup cabinets
	LI4: Packaging materials and equipment
	LI5: Sorting hubs
Collaboration network (Interviews)	To what extent do these statements apply to your firm? (1-7, strongly disagree to agree strongly)
	CN1: We have a lot of reliable franchisees.
	CN2: We work closely with tripartite vehicle companies.
	CN3: We have established integrated cooperation with manufacturers.
	CN4: We have established cooperation with e-commerce platforms.
Exploratory digital innovation (He and Wong, 2004; Kang et al., 2022;	To what extent do these statements apply to your firm? (1-7, strongly disagree to agree strongly)
	ErI1: We focus on leveraging digital technologies to launch the next generation

Interviews)	of products or services. ErI2: We focus on increasing the variety of products or services through digital technologies. ErI3: We focus on finding new and promising digital technology fields. ErI4: We use digital technology to open new markets.
Exploitative digital innovation (Chang et al., 2011; Kang et al., 2022; interviews)	To what extent do these statements apply to your firm? (1-7, strongly disagree to agree strongly) EiI1: We focus on using digital technologies to improve the quality of existing products or services. EiI2: We focus on leveraging digital technologies to increase the flexibility of current products or services. EiI3: We focus on using digital technologies to reduce the cost of production of existing products or services. EiI4: We favour the use of digital technologies to strengthen existing markets.
SCR (Gu et al., 2023; Interviews)	To what extent do these statements apply to your firm under supply chain disruptions? (1-7, strongly disagree to agree strongly) SCR1: We can cope with changes brought about by supply chain disruptions. SCR2: We can adapt to the supply chain disruptions quickly. SCR3: We can provide a quick response to the supply chain disruptions. SCR4: We can always maintain high situational awareness of supply chain disruptions.

Variable calibration refers to assigning membership degrees to a specific set of conditions in a case. Only after calibrating the raw case data to the set membership score can further subset relationship analysis of necessity and sufficiency be conducted (Xiang et al., 2022). Variable calibration includes direct calibration and indirect calibration. Direct calibration in fsQCA is predominantly employed, relying on three qualitative anchors—full membership threshold, non-

membership threshold, and the crossover point—to structure the calibration process (Murthy & Madhok, 2021). Common calibration criteria involve percentiles such as 95%, 50%, and 5%, or 75%, 50%, and 25%, ensuring the calibration accurately reflects theoretical insights and empirical data (Ragin, 2009).

However, it is not uncommon for the theoretical extremes of a scale to be unrepresentative in empirical data. In addition, in cases where the data heavily leans towards one pole of the scale, using the midpoint of the Likert scale for calibration may not be ideal (Fainshmidt et al., 2019). Due to several factors, the calibration of survey responses on the Likert scale may be complex, including asymmetric data distribution, measurement inaccuracies, inherent meanings of calibration conditions, and the types of responses the scale aims to elicit (Alwin, 2007; Norman, 2010; Fainshmidt et al., 2019). Therefore, directly applying such scales' "natural" reference points is not always feasible or appropriate in practice (Fiss, 2011; Ho et al., 2016).

Indirect calibration in fsQCA necessitates a reassessment of measurement outcomes grounded in qualitative evaluation. Initially, cases are categorized into distinct membership levels with presumed degrees of membership (Muñoz et al., 2020). Subsequently, preliminary membership scores are assigned to these levels and informed by theoretical and substantive knowledge through qualitative classification. After that, interval-scale data are utilized to refine these membership scores. This calibration approach emphasizes the integration of theoretical insights with empirical data, optimizing the accuracy and reliability of the calibration process, particularly in scenarios with rich qualitative information but limited direct quantitative measurements for the conditions in question (Ragin, 2008).

We established the thresholds for full membership, crossover, and full non-membership for each condition at the 75th percentile, mean, and 25th percentile, respectively, following the method

outlined by (Fainshmidt et al., 2019; Ho et al., 2016). This calibration technique mitigates the impact of higher-value skewness observed across various data variables, calibrating cases concerning their distribution within the dataset. Table 6.5 presents the variables and their anchors for calibration.

Table 6.5 Variable calibration

Variables	Full exclusion	Crossover point	Full inclusion
Human capital	5.000	5.612	6.250
Logistics infrastructure	5.400	5.765	6.200
Collaboration network	5.000	5.598	6.250
Exploratory digital innovation	5.000	5.613	6.250
Exploitative digital innovation	5.250	5.630	6.000
Supply chain resilience	5.333	5.700	6.111

6.3.5 Non-response bias test

The study categorizes the collected questionnaires into two groups based on the sequence of receipt: those received in the initial phase (early questionnaires) and those received towards the end (later questionnaires). An independent samples t-test was utilized to statistically analyse the data across several dimensions, including the firm size and ownership structure, to ensure comparability and identify potential disparities between the two groups. Upon thorough examination and statistical testing, it was revealed that the early and later respondents do not exhibit significant variances ($P > 0.05$) in the variables under consideration (e.g., HC1=0.37). The absence of significant differences across the board implies that the sample is representative and that the timing of response collection has not introduced any bias, thereby upholding the validity of the study's findings. Consequently, there is no evidence of response bias in the data collection

process, ensuring the reliability and generalizability of the research outcomes.

6.3.6 Common-method bias test

Clear and concise questionnaire items were randomly arranged before the formal survey to prevent common method bias. This study obtained and revised the variable items from different sources, including literature and interviews. Respondents were allowed to complete the survey anonymously through various methods, such as paper-based and electronic formats, to avoid motivational biases that could stem from psychological factors. After data collection, the Harman single-factor method was employed to test for common method bias. An unrotated principal component factor analysis was conducted on all measurement items. The results showed that the first factor explained a variance of only 28.785%, below the 40% threshold (Hair et al., 2010). Consequently, this finding suggests that no significant common method bias is present in the study.

6.3.7 Reliability and validity analysis

This study utilized SPSS 28.0 to test the reliability and validity of the questionnaire, with results detailed in Table 6.6. Firstly, the scale's internal consistency was evaluated using Cronbach's alpha and Composite Reliability (CR). The results indicated that all variables' Cronbach's alpha and CR values were above 0.7, demonstrating the scale's good reliability (Wright & Stone, 1979; Hair et al., 2010). Secondly, exploratory factor analysis (EFA) was performed using SPSS 28.0. The KMO values for all variables ranged from 0.719 to 0.851, with significance levels at 0.000***, indicating satisfactory sampling adequacy for factor analysis (Hair et al., 2010). Furthermore, all item standard factor loadings were above 0.6. The Average Variance Extracted (AVE) values for the variables ranged from 0.504 to 0.538, indicating that more than 50% of the variance in each variable is captured by its respective constructs (Fornell & Larcker, 1981). These results suggest adequate convergent validity of the scale.

Table 6.6 Reliability and validity results

Variables	Items	Factor load	CR	AVE	Cronbach's Alpha
Human capital (HC)	HC1	0.756	0.819	0.531	0.772
	HC2	0.674			
	HC3	0.729			
	HC4	0.753			
Logistics infrastructure (LI)	LI1	0.733	0.835	0.504	0.802
	LI2	0.727			
	LI3	0.675			
	LI4	0.694			
	LI5	0.719			
Collaboration network (CN)	CN1	0.651	0.826	0.544	0.720
	CN2	0.753			
	CN3	0.725			
	CN4	0.812			
Exploratory digital innovation (ErI)	ErI1	0.770	0.804	0.507	0.772
	ErI2	0.649			
	ErI3	0.725			
	ErI4	0.698			
Exploitative digital innovation (EiI)	EiI1	0.711	0.823	0.538	0.810
	EiI2	0.681			
	EiI3	0.756			
	EiI4	0.783			
Supply chain resilience (SCR)	SCR1	0.735	0.819	0.531	0.754
	SCR2	0.722			

SCR3	0.736
SCR4	0.721

To assess discriminant validity, we compared the square root of the Average Variance Extracted (AVE) and the correlation values of the constructs. The criterion for strong discriminant validity is that the square root of AVE should exceed the correlation coefficients (Cable and DeRue, 2002). Our calculations revealed that the square roots of the AVE for all constructs were significantly greater than their respective correlation coefficients, as illustrated in Table 6.7. The result confirms that the measurement model meets the criteria for both reliability and validity.

Table 6.7 Discriminant validity coefficients

	HC	LI	CN	ErI	EiI	SCR
HC	**0.729**					
LI	0.662**	**0.710**				
CN	0.696**	0.697**	**0.738**			
ErI	0.557**	0.526**	0.558**	**0.712**		
EiI	0.567**	0.484**	0.545**	0.536**	**0.734**	
SCR	0.460**	0.423**	0.473**	0.456**	0.440**	**0.729**

(Bold numbers are the square roots of construct AVE values, and other numbers are the correlation coefficients. ** denotes that correlation is significant at the 0.01 level).

6.4 Results and Findings

6.4.1 Truth table calibration

FsQCA version 4.0 software was applied to analyse the configuration effects of digital innovation and resources on SCR. We ascertain the minimum case frequency in our initial phase to preclude trivial empirical configurations. For studies with small sample sizes (< 50), the minimum case frequency can be set as 1 or 2. Larger samples (> 50) would contemplate a higher

frequency cutoff of cases while preserving approximately 80% of the original case count. An elevated frequency threshold implies that each configuration encompasses most cases, but this results in a reduced percentage of the sample being covered (i.e., coverage) (Ragin, 2009). Conversely, a lower frequency threshold increases the sample's coverage but includes some trivial configurations. This study has 125 samples (> 50), so we set 2 as the original frequency cutoff.

Subsequently, we determine the threshold for consistency to ensure the interpretive power of the configurations. The first criterion for selecting the consistency threshold is identifying the natural breakpoints within the achieved consistency, typically set at 0.8, with a minimum standard of 0.75 (Verbeke et al., 2019). This study also set 0.8 as the original consistency cutoff. Lastly, the Proportional Reduction in Inconsistency (PRI) value is established. This study sets the PRI value at 0.7 to circumvent the "subset relations" (Pappas & Woodside, 2021).

6.4.2 Necessity analysis

Before conducting path analysis, it is necessary to test whether a single antecedent factor is necessary for improving logistics companies' SCR. When a specific result is generated, if a particular factor persists, that factor is necessary for generating this result (Ragin, 2009). The measurement standard is the level of consistency, which reflects the degree to which cases with the same configuration of conditions belong to the same result. The consistency threshold is generally set to 0.9. If the consistency threshold of one condition is higher than 0.9, the condition is considered necessary for forming the outcome variable (White et al., 2021).

We used fsQCA 4.0 to analyse the necessary conditions for high and non-high SCR. As shown in Table 6.8, the consistency values of all antecedent conditions that lead to SCR in logistics companies are below 0.9. The results show that no antecedent variable can be used as a necessary and sufficient condition for the construction of supply chain resilience of logistics firms. We can

find that exploratory digital innovation, exploitative digital innovation, human capital, logistics infrastructure, and collaboration networks are not necessary conditions for forming SCR. Therefore, we need to explore further the configuration effects of multiple factors of resources and digital innovation on SCR.

Table 6.8 Necessity analysis results of high and low SCR

	High SCR		Low SCR	
	Consistency	**Coverage**	**Consistency**	**Coverage**
Human capital	0.802427	0.799823	0.341982	0.289718
~Human capital	0.287406	0.339451	0.763712	0.766649
Logistics infrastructure	0.732722	0.749810	0.371583	0.323186
~Logistics infrastructure	0.338612	0.387994	0.712345	0.693743
Collaboration network	0.721770	0.738604	0.410935	0.357413
~Collaboration network	0.372059	0.426319	0.69946	0.681194
Exploratory digital innovation	0.754625	0.759910	0.389692	0.333532
~Exploratory digital innovation	0.338168	0.394646	0.719485	0.713644
Exploitative digital innovation	0.784223	0.754091	0.391433	0.319909
~Exploitative digital innovation	0.292734	0.361411	0.699112	0.733601

Note: "~" means "none"

6.4.3 Sufficiency analysis

In the qualitative comparative analysis facilitated by fuzzy-set truth tables, three distinct solution types emerge: complex, parsimonious, and intermediate solutions (Ragin, 2009). Complex solutions are characterized by the absence of "logical remainders," whereas parsimonious solutions incorporate "logical remainders" without assessing their logical validity. Intermediate solutions exclusively include "logical remainders" congruent with empirical evidence and theoretical frameworks, and they preclude the dismissal of necessary conditions.

Consequently, intermediate solutions are often regarded as preferable to both complex and parsimonious solutions, given their fidelity to theoretical and empirical substantiation (Ragin, 2009).

Given the lack of a unified conclusion in existing research regarding the individual relationships between the five conditions and SCR, this paper cannot conduct a definitive counterfactual analysis. Consequently, the status of the six conditions is set as "present or absent" during the fsQCA analysis. This paper primarily reports intermediate solutions and distinguishes core conditions from auxiliary conditions by combining parsimonious solutions (Fiss, 2011). Table 6.9 illustrates the configurational pathways through which the five antecedent conditions lead to high SCR. The study categorizes the three configurations (A, B1, B2) into two major classes based on the dimensions of the antecedent conditions. The first configuration path is human capital * logistics infrastructure * exploitative digital innovation for achieving high SCR, while the second configuration path is human capital * collaboration network * exploratory digital innovation for developing high SCR. Human capital exists in two configuration paths as the core conditions. Logistics companies can utilize human capital and infrastructure for exploitative digital innovation to achieve high SCR. Logistics companies can also orchestrate human capital and collaboration networks with exploratory digital innovation to accomplish high SCR. Logistics infrastructure or exploitative digital innovation can be auxiliary conditions for motivating SCR in this configuration path.

Table 6.9 Sufficiency analysis results for the high SCR

Causal Condition	**Configuration**		
	A	**B1**	**B2**
Resources			
Human capital	●	●	●

Logistics infrastructure	●	•	
Collaboration network		●	●
Digital innovation			
Exploratory digital innovation		●	●
Exploitative digital innovation	●		•
Raw coverage	0.583395	0.532781	0.512801
Unique coverage	0.106704	0.056090	0.036111
Consistency	0.893270	0.895968	0.891663
Solution coverage		0.675596	
Solution consistency		0.880085	

Note: Black circles "●" indicate the presence of a condition, and circles with "⊗" indicate its absence. Large circle: core condition, small circle: peripheral condition, Blank space: "do not care" condition.

The consistency levels of the three configurations presented in Table 9 and the overall solution exceed the minimum standard of 0.75 (Schneider and Wagemann, 2012). The overall solution result means that all three configurations can fully explain the existence of results, which can be seen as a combination of sufficient conditions to help logistics companies achieve SCR. Additionally, the overall solution's coverage is 0.6756, indicating that all configurations account for 67.56% of the cases, which is higher than the QCA research levels in the field of organization and management (e.g. Fainshmidt et al., 2019; Ho et al., 2016; Jiang et al., 2021; White et al., 2021).

To explore the multifaceted driving mechanisms of supply chain resilience and the causal asymmetry within a logistics company, we also consider non-high SCR as the outcome variable and conduct a configurational analysis of the antecedent conditions. Table 6.10 illustrates the configurational pathways through which the five antecedent conditions lead to non-high SCR. The consistency levels of the four configurations and the overall solution are higher than the minimum

standard of 0.75. Besides, the overall solution's coverage is 0.6085, indicating that all configurations account for 60.85% of the cases.

Table 6.10 Sufficiency analysis results for the non-high SCR

Causal Condition	**Configuration**			
	C	**D1**	**D2**	**D3**
Resources				
Human capital	⊗	⊗	⊗	⊗
Logistics infrastructure	⊗	•		•
Collaboration network	⊗	•	⊗	
Digital innovation				
Exploratory digital innovation	⊗		⊗	⊗
Exploitative digital innovation		⊗	⊗	⊗
Raw coverage	0.490336	0.136688	0.453073	0.150966
Unique coverage	0.081317	0.046143	0.010099	0.004527
Consistency	0.873720	0.847732	0.907886	0.891975
Solution coverage	0.608567			
Solution consistency	0.872877			

We categorize the four configurations (C, D1, D2, D3, D4) into two significant classes for non-high SCR based on the core conditions of each configuration path. The first configuration category is ~Human capital * ~Logistics infrastructure * ~Exploratory digital innovation for appearing low SCR. The other configuration category is ~Human capital * ~ Exploitative digital innovation, leading to low SCR. Low human capital is the core condition in two configuration categories for non-high SCR. Lacking human capital and exploitative digital innovation can lead to the failure of developing SCR. Besides, if logistics companies do not conduct exploratory digital innovation and have enough human capital and logistics infrastructure resources, they will have

low SCR.

6.4.4 Robustness test

Robustness tests were performed to examine the stability of the configurations. This study further tests the robustness of the research results through the following two methods: adjust the frequency cut-off value and change the consistency threshold (Schneider & Wagemann, 2012). In this study, the frequency threshold is adjusted from 2 to 3. The setting of the frequency threshold still needs to meet the condition of including at least 75% of the observed cases. From the perspective of the set relationships among the configurations, the antecedent conditions of high SCR and non-high SCR configurations are entirely consistent, as shown in Tables 6.11 and 6.12. Therefore, after increasing the frequency threshold, the research conclusions of this paper remain robust.

Table 6.11 Robustness test of high SCR configuration for adjusting the frequency

Causal Condition	**Configuration**		
	A	**B1**	**B2**
Resources			
Human capital	●	●	●
Logistics infrastructure	●	•	
Collaboration network		●	●
Digital innovation			
Exploratory digital innovation		●	●
Exploitative digital innovation	●		•
Raw coverage	0.583395	0.532781	0.512801
Unique coverage	0.106704	0.056090	0.036111
Consistency	0.893270	0.895968	0.891663
Solution coverage		0.675596	

Solution consistency	0.880085

Table 6.12 Robustness test of low SCR configuration for adjusting the frequency

Causal Condition	**Configuration**			
	C	**D1**	**D2**	**D3**
Resources				
Human capital	⊗	⊗	⊗	⊗
Logistics infrastructure	⊗	•		•
Collaboration network	⊗	•	⊗	
Digital innovation				
Exploratory digital innovation	⊗		⊗	⊗
Exploitative digital innovation		⊗	⊗	⊗
Raw coverage	0.490336	0.136688	0.453073	0.150966
Unique coverage	0.081317	0.046143	0.010099	0.004527
Consistency	0.873720	0.847732	0.907886	0.891975
Solution coverage	0.608567			
Solution consistency	0.872877			

Moreover, we have increased the consistency level from 0.819 to 0.831. The overall solution's consistency level of high SCR has been raised from 0.8808 to 0.8879, while the overall solution's consistency level of non-high SCR has been raised from 0.8728 to 0.8769. However, the solution coverage of high SCR outcome has been decreased from 0.6759 to 0.6395. The solution coverage of low SCR has been reduced from 0.6086 to 0.5523. In terms of the set relationships among the configurations, the antecedent conditions of the other configurations are entirely identical, as shown in Tables 6.13 and 6.14. Consequently, after enhancing the consistency level, the research findings of this paper remain robust.

Table 6.13 Robustness test of high SCR configuration for adjusting consistency

Causal Condition	Configuration		
	A	B1	B2
Resources			
Human capital	●	●	●
Logistics infrastructure	●	•	
Collaboration network		●	●
Digital innovation			
Exploratory digital innovation		●	●
Exploitative digital innovation	●		•
Raw coverage	0.583395	0.106704	0.893270
Unique coverage	0.130235	0.009028	0.806600
Consistency	0.532781	0.004736	0.895968
Solution coverage		0.639485	
Solution consistency		0.887998	

Table 6.14 Robustness test of low SCR configuration for adjusting consistency

Causal Condition	Configuration			
	C	D1	D2	D3
Resources				
Human capital	⊗	⊗	⊗	⊗
Logistics infrastructure	⊗	•		•
Collaboration network	⊗	•	⊗	
Digital innovation				
Exploratory digital innovation	⊗		⊗	⊗
Exploitative digital innovation		⊗	⊗	⊗
Raw coverage	0.496082	0.520982	0.490336	0.150966

Unique coverage	0.069128	0.094028	0.401358	0.061988
Consistency	0.890869	0.856570	0.873720	0.891975
Solution coverage		0.552324		
Solution consistency		0.876970		

Therefore, we can find that the first configuration path of high SCR is human capital * logistics infrastructure * exploitative digital innovation for achieving high SCR. In contrast, the second configuration path is human capital * collaboration network * exploratory digital innovation for developing high SCR. Besides, the first configuration category of low SCR is ~Human capital * ~Logistics infrastructure * ~Exploratory digital innovation, while the other configuration category is ~Human capital * ~ Exploitative digital innovation leading to low SCR.

6.5 Discussion

6.5.1 Theoretical implications

Study three has several theoretical implications for supply chain resilience and digital innovation research. First, study three applied a configuration perspective to propose an integrated framework based on resource orchestration theory and ambidextrous innovation perspectives. Previous studies have mainly approached from a single perspective to explore the relationship between SCR and its drivers (e.g. Alvarenga et al., 2023; Bianco et al., 2023; Brandon-Jones et al., 2014; Ghobakhloo et al., 2023; Srinivasan & Swink, 2018), which ignore the interaction between these drivers of SCR and its combination effects for SCR. The analytic framework includes human capital, logistics infrastructure, collaboration network, and exploitative and exploratory digital innovation, which changes the limitation of traditional regression analysis that treats the antecedent variable as an independent variable acting on the dependent variable. We further revealed the

synergistic mechanism of digital innovation and resources on the SCR from different levels, which is beneficial for improving the theory of the impact of digital innovation on SCR.

Based on the conceptual framework for developing SCR, study three identified the critical conditions for motivating SCR. We found that no single digital innovation or resource type is necessary to promote SCR. The conditioning effects for high and low SCR are conjectural, meaning that outcomes are determined by the interdependence of several factors (Ragin, 2008). However, configurations differ between the two taxonomic groupings for high or low SCR. SCR is the equivalent result of the joint action of multiple enterprise resources and digital innovation. Two digital innovation ways and different resource arrangements present a company's specific level of supply chain performance, combined to form SCR with varying ways of configuration. There is a substitution/complementarity relationship between exploratory and exploitative digital innovation. Combining digital innovation with other types of organizational resources can promote SCR. Under the condition of having high human capital, exploratory innovation-collaboration networks and exploitative innovation-logistics infrastructure have a substitution relationship, which responds to the call to expand the research perspective on SCR (Iftikhar et al., 2021; Katsaliaki et al., 2021; Williams et al., 2017).

Besides, study three empirically explored the synergistic effects of digital innovation and resources on the SCR of logistics companies, which expanded the resource orchestration theory and ambidextrous innovation perspective in explaining causal complexity for SCR. The dynamic adjustment of resource orchestration based on internal and external environment bridges resources and sustained competitive advantage (Hughes et al., 2018). In the context of digital innovation for SCR, we found the importance of human capital and logistics infrastructure for exploitative digital

innovation to enhance SCR. In contrast, human capital and collaboration networks play an important role in combining exploratory digital innovation to develop SCR.

Resource orchestration theory emphasises that excellent performance stems from managers' and organisations' effective management of resources (Asiaei et al., 2021). Study three also approved the critical role of human capital in improving SCR. In the two configuration groups for high SCR, human capital is the core condition of all configuration paths for motivating SCR. We also found that insufficient human capital led to the failure to achieve SCR. During digital innovation, human capital endowed with high skills and specialized knowledge propels the development and application of cutting-edge technologies such as big data analytics, AI, IoT, and blockchain. These technologies enhance supply chain transparency, efficiency, and responsiveness by enabling real-time monitoring, intelligent forecasting, and automated decision-making (AL-Khatib & Ramayah, 2023; Belhadi et al., 2021; Chen et al., 2023; Datta et al., 2023), thereby reinforcing SCR. This insight offers empirical substantiation for resource orchestration theory, highlighting the strategic significance of human resources in the logistics and supply chain domain.

Apart from the vital orchestration role of human capital with digital innovation for SCR, study three clarified the configuration effects of logistics infrastructure and exploitative digital innovation on SCR, which enriches ambidextrous innovation perspective by confirming the combination of resource types and specific innovative approaches. Exploitative innovation generally involves optimising and refining existing processes, products, or services rather than creating entirely new entities (Li et al., 2024). The findings of study 3 revealed that exploitative digital innovation can combine logistics infrastructure and human capital to develop SCR. Logistics infrastructure refers to the physical and organizational structure that supports logistics activities, such as transportation networks, warehouses, distribution centres, and information

systems (Castillo et al., 2018). Infrastructure provides logistics companies with the necessary material foundation and is a prerequisite for achieving the flow and storage of goods. High-quality logistics infrastructure can reduce transportation costs, improve efficiency, and support complex logistics operations. From a resource perspective, infrastructure represents “hard” resources, the physical foundation and supporting conditions for realising logistics services. It is an indispensable capital-intensive investment in logistics activities. Exploitative innovation focuses on enhancing efficiency, reducing costs, improving product performance, or enhancing user experience (Scuotto et al., 2019; Ye et al., 2024). Exploitative digital innovation can lead to the success of SCR by utilising hardware facilities and systems.

Study 3 confirmed that exploratory digital innovation can combine collaboration networks and human capital to develop SCR. Exploratory innovation emphases focus on the development of entirely new products, services, or technologies, which may involve higher risks and uncertainties but may also yield greater returns (Cui et al., 2023; Kang et al., 2022; Scuotto et al., 2019). Collaboration network refers to the network of cooperative relationships established between logistics companies and other logistics service providers, suppliers, customers, and other related enterprises, which emphasizes information exchange, resource sharing, business collaboration, and complementary services (Alikhani et al., 2021; Bag et al., 2022). Collaborative networks are often seen as social capital encompassing relationships and interactions between organizations. Collaborative networks focus on integrating “soft” resources, such as information resources, customer resources, technical resources, and management experience. It efficiently coordinates logistics activities and expands service scope through strategic alliances, contract logistics, third-party logistics, and other forms.

Exploratory digital innovation synergizes with collaboration networks to augment the SCR by bolstering logistics systems' velocity, adaptability, and overall efficacy. From a resource-based vantage point, these networks amalgamate “soft” assets, encompassing informational, customer, and technological resources and managerial acumen (Brandon-Jones et al., 2014; Do et al., 2022). Through strategic alliances, contractual logistics arrangements, and third-party logistics engagements, collaboration networks facilitate the efficient orchestration of logistics operations and broaden service horizons. Within the logistics sector, such networks foster the dissemination of information, the mutualization of risks, and the consolidation of resources. They enhance the agility and swiftness of logistics enterprises, particularly in the context of market vicissitudes and fluctuating demand patterns. By engaging in collaborative efforts, logistics firms are empowered to more adeptly administer and refine supply chain mechanisms, optimizing their operational prowess and market adaptability.

The collaboration network within the logistics industry is primarily concerned with amalgamation and cooperative efforts regarding the intangible assets of various logistics enterprises (Aktas et al., 2021; De Souza et al., 2014). Conversely, the focus of infrastructure lies in the tangible aspects, such as the development and upkeep of physical resources (Hartwig & Nguyen, 2023). Collaboration networks are more related to relational and knowledge capital, while infrastructure is related to material and financial capital. These dual components are mutually reinforcing, jointly establishing the foundational bedrock upon which the logistics system operates efficiently. Companies can balance these two resources in the development process to achieve SCR and competitive advantage.

Human capital is essential for developing SCR, while collaboration networks – exploratory digital innovation and logistics infrastructure – exploitative digital innovation are complementary

conditions for motivating SCR. Balancing the focus on exploitative and exploratory innovation is essential for an enterprise. Exploitative innovation ensures short-term stability and profitability, and exploration innovation fuels a firm's long-term viability and competitiveness (Zhang et al., 2022). This balance is crucial in dynamic industries such as logistics, where technological advancements can rapidly shift the competitive landscape (Chang & Hughes, 2012). Therefore, a strategic approach integrating both types of innovation is vital for firms aiming to achieve resilience and success in an ever-evolving market (Harmancioglu et al., 2020). In practical application, distinguished firms prioritize establishing robust collaborative networks and enhancing infrastructure resources to attain optimal SCR.

Moreover, using fsQCA methods, we revealed the equivalent driving mechanisms and antecedent substitution relationships for improving SCR and explored the different driving mechanisms for low SCR from the perspective of causal asymmetry. Our investigation uncovered that the conditional configuration centred on exploratory digital innovation—human capital—collaboration networks and exploitative digital innovation—human capital—logistics infrastructure can promote logistics companies to produce high or low SCR in achieving the same goal through different paths. The driving path of high SCR is not the opposite of the simple non-high SCR driving path. Low human capital, low logistics infrastructure, low exploratory digital innovation, and low human capital and exploitative digital innovation lead to the failure of motivating SCR. The applied fsQCA and findings of the study break through the assumption of causal symmetry in traditional statistical analysis methods, which supplements the net effect thinking in mainstream quantitative research. Study three can provide references for exploring the complex mechanisms of SCR in the future.

6.5.2 Managerial implications

Study three provides several practical implications for managers in allocating resources and balancing ambidextrous digital innovations to develop SCR. First, resource orchestration and digital innovation are vital for enterprises to establish SCR. When building SCR, organizations can arrange various organizational resources, such as human capital, infrastructure, and collaboration networks, based on their characteristics, development needs, or external environment rather than relying on one resource type. Enterprises can select exploratory or exploitative digital innovation to develop SCR. A company with abundant infrastructure resources without human capital constraints can promote SCR through exploitative innovation. If an enterprise relies more on collaborative networks with various partners, SCR can be developed by combining exploratory digital innovation, collaboration networks, and human capital.

Considering empirical findings, integrating exploratory digital innovation with human capital and collaborative networks is a pivotal strategy for organizations seeking to bolster their supply chain resilience. Organizations can prioritize ongoing education and training programs that equip employees with the necessary competencies to navigate and leverage emerging digital tools and platforms. Digital training fosters a culture of digital literacy, where personnel across various tiers understand how to apply data analytics, AI, and IoT technologies to enhance supply chain visibility and responsiveness. Organisations can actively seek partnerships with technology providers, academic institutions, and industry peers to co-create digital solutions tailored to the unique needs of the supply chain. Such alliances can expedite the adoption of exploratory innovations and provide access to resources and expertise otherwise unavailable. Besides, enterprises can leverage digital tools to monitor supplier performance and dynamically adjust the network based on resilience metrics, ensuring a more adaptable and shock-resistant supply chain ecosystem.

Organizations can significantly enhance their supply chain resilience by strategically aligning exploratory digital innovation with human capital development and fostering robust collaborative networks. This approach necessitates a holistic view of digital transformation, where technology is seen not just as a tool but as a catalyst for embedding adaptability, agility, and innovation into the very fabric of supply chain operations. Through these practices, businesses can effectively navigate the complexities and uncertainties of the digital economy, safeguarding their competitive advantage and ensuring sustainable growth.

Building upon the findings of study three, it is evident that effectively leveraging exploitative digital innovation necessitates a synergistic approach, integrating human capital and organisational infrastructure to fortify the SCR. To fully harness exploitative digital innovations, organizations can invest in targeted upskilling initiatives tailored to the unique demands of their digital transformation. The digital upskilling investment includes cultivating deep expertise in data analytics, automation, and cybersecurity, ensuring the workforce can exploit new technologies for process optimization and risk mitigation. Besides, enterprises can enhance organizational infrastructure with advanced analytics capabilities to predict and mitigate risks, enabling proactive supply chain management. By exploiting big data and machine learning algorithms, businesses can identify patterns, simulate scenarios, and make data-driven decisions that strengthen SCR. Moreover, organisations can design organizational infrastructure to be flexible and scalable, capable of rapidly adapting to changes in demand or supply chain shocks. Infrastructure redesign includes cloud-based systems, modular designs, and agile methodologies, all of which expedite the exploitation of digital solutions during times of stress or growth.

The strategic fusion of human capital development and organizational infrastructure optimization is paramount for enterprises seeking to exploit digital innovations to bolster SCR

effectively. By embracing a comprehensive approach that integrates skill enhancement, cultural adaptation, and advanced technological infrastructures, businesses can transform digital exploitations into tangible improvements in operational robustness and SCR. Such practices safeguard against disruptions and position organizations at the forefront of competitive advantage in the digital era.

Furthermore, our research has identified the indispensable role of human capital in shaping the configurational effects on both high and low SCR. It is imperative for enterprises to consistently dedicate resources to the nurturing and advancement of their human capital. This investment is crucial for ensuring supply chains' seamless and vigorous functioning within modern markets' intricate and ever-changing landscape. Human capital encompasses the professionals directly involved in digital innovation, educators, and leaders critical in disseminating knowledge and nurturing the next generation of digital experts. By fostering a learning organization culture that actively encourages the adoption of innovative technologies and methodologies, the digital proficiency and SCR of the entire supply chain are progressively enhanced.

Human capital is pivotal in constructing and reinforcing SCR in the digital era. Its multifaceted influence drives technological innovation, refining decision-making processes, catalysing organizational transformation, nurturing specialized talent pools, and pioneering innovative services. Integrating human capital into the strategic fabric of supply chain management is thus essential for building SCR and maintaining a competitive edge in the face of market complexities and dynamics.

6.6 Concluding remarks

This study comprehensively examines the intricate relationship between digital innovation and supply chain resilience (SCR) within the logistics industry, highlighting the pivotal role of

resource orchestration. Through a fsQCA method, we have unveiled the complex causal pathways that lead to the enhancement of SCR, underscoring the impact of digital innovation's non-linear and conditional nature. This study uncovered that human capital, logistics infrastructure and exploitative digital innovation have configuration effects on motivating SCR, while exploratory digital innovation can combine collaboration networks and human capital to develop SCR. Besides, the configuration of low human capital, low logistics infrastructure, low exploratory digital innovation, and the configuration of low human capital and low exploitative digital innovation lead to the failure of achieving SCR. The study reveals that while digital innovation alone is not a panacea, its strategic integration with resource orchestration practices can significantly bolster a firm’s SCR to anticipate, respond to, and recover from disruptions. The identified configurational pathways provide a nuanced understanding that transcends the one-size-fits-all approach, recognizing individual firms' unique contexts and capabilities.

CHAPTER 7 DISCUSSION

The infusion of digital techniques such as Artificial Intelligence (AI), the Internet of Things (IoT), and blockchain into supply chain operations has demonstrated a significant potential to enhance SCR. Moreover, few studies have highlighted how digital techniques can influence SCR and mitigate the disruption. In SCR research, few studies have considered the roles of two critical digital technique components: digital orientation and digital competency. However, there is still limited empirical evidence about SCR and digital affordance in logistics companies. Besides, the current literature often treats digital innovation and resources as isolated variables with SCR, which ignores their joint effect. This thesis addresses these gaps by applying multiple theories and multi-methods in the logistics sector. The succeeding section discusses findings derived from Chapters Four, Five and Six.

7.1 Theoretical implications

Contributions are made to the body of knowledge on supply chain digitalisation and SCR by promoting an understanding of the actualisation of digital affordances for SCR against disruptive events. Study one elaborated the affordance theory to SCR, providing an additional theoretical lens to SCR. Based on digital affordance theory, this study identifies four digital affordances and five digital affordances actualisation behaviours, which clarify the procedural mechanisms of logistics companies leveraging digital affordances to develop SCR.

Study one takes SCR as the organisational goal for logistics companies to develop digitalisation and explores the relationship between digital affordances and SCR, which expands the research on digital affordance. SCR goals include stability, continuity and opportunity creation, which have not been proposed in previous studies. Due to a company's limited resilience or

digitalisation investment, companies need to prioritise stability and continuity goals when working toward SCR, then try to create opportunity, which contributes to the theoretical development of SCR. Digital affordances of flexibility, agility, redundancy, visibility and diversity deepened affordance theory and expanded the research on the relationship between digital affordances and specific SCR goals.

Study two advances the knowledge of SCR theory and bridges the theory-practice gap between digital orientation, digital competency, and SCR in supply chain disaster management. The test of the conceptual framework provides empirical evidence for the importance of strengthening SCR through digital techniques. Study two contributes to SCR research by clarifying the role of digital techniques in developing SCR, which enriches the application of dynamic capability theory and evolutionary theory.

Organisational information processing theory proposes that organisations may develop processing information capabilities to deal with uncertain supply chain disruption (El Baz & Ruel, 2021). In contrast to previous studies investigating technology usage and adoption in the supply chain, study two applied multiple methods to investigate the roles of digital orientation and digital competency in disruptions, contributing to digital technique-based disaster management and organisational information processing theory. SCR has also been shown to positively influence logistics firms' performance during floods, which previous studies have observed in other disruptive events (Ahmed et al., 2014; Akgün & Keskin, 2014; Gu et al., 2021). Moreover, existing studies have primarily focused on the resilience of manufacturing firms (Yu et al., 2019). The present study addresses the lack of theoretical consideration regarding the logistics industry and provides empirical support.

Study three contributes to the theoretical landscape by extending the resource orchestration theory and ambidextrous innovation perspective to the domain of SCR. The adaptive reconfiguration of resource management, contingent upon intrinsic and extrinsic environmental factors, serves as a conduit between resource allocation and perpetuating a competitive advantage (Hughes et al., 2018). Study three found the importance of human capital and logistics infrastructure for exploitative digital innovation to enhance SCR. In contrast, human capital and collaboration networks play an important role in combining exploratory digital innovation to develop SCR. Resource orchestration theory emphasises that excellent performance stems from managers' and organisations' effective management of resources (Asiaei et al., 2021). This study also approved the critical role of human capital in improving SCR.

Study three also offers a configurational view that appreciates the multiplicity of strategies and the importance of aligning digital initiatives with resource management for resilience. Previous studies have mainly approached the relationship between SCR and its drivers from a single perspective, which ignores the interaction between these drivers of SCR and their combined effects on SCR. Study three revealed the synergistic mechanism of digital innovation and resources on the SCR from different levels, which is beneficial for improving the theory of the impact of digital innovation on SCR. The applied fsQCA and findings of the study break through the assumption of causal symmetry in traditional statistical analysis methods, which supplements the net effect thinking in mainstream quantitative research.

7.2 Managerial implications

Practical contributions are presented as insights for companies to build SCR through digital affordances and transfer digital operation solutions under disruptive events. Study one explained the digital affordances actualisation process of service modularisation, information sharing,

resource configuration, process optimisation and customer connection for SCR. It provides supply chain managers with a new line of inquiry and strategic suggestions on perceiving and actualising digital affordance to enhance SCR. First, firms must integrate digitalisation and SCR strategies as more unpredictable disruptive events will cause unparalleled disruptions. Second, digital affordances can drive traditional supply chain enterprises to achieve organisational goals such as SCR and competitive advantages in digital transformation. When constructing an innovative digital strategy, enterprises may focus on product design and digital technology research and development around situations to attract networked partners to join the supply chain system by attracting digital affordances. Moreover, supply chain firms can build and enhance SCR through digital actualisation behaviours.

The findings of study two may contribute to several practical implications for developing SCR and improving firm performance using digital techniques. First, firms need to adjust their strategies and consider disruptions as development opportunities for securing competitive advantages, not only regarded as dynamism or threats. Second, a firm must cultivate digital competency and invest in digital orientation. This involves equipping employees with the necessary skills to navigate and utilize digital tools effectively and fostering a culture that embraces innovation and adapts to technological advancements. Investing in digital orientation means allocating resources to training programs that enhance digital literacy, enabling staff to understand and apply digital solutions to their work processes. Firms should establish a continuous learning culture where employees are encouraged to stay updated with the latest digital trends and have opportunities to upskill and reskill.

Moreover, digital techniques offer a pragmatic strategy for mitigating potential risks and damages in disaster management. This is achieved through forecasting models, predictive analytics,

risk assessment tools, and comprehensive risk management frameworks. Given the potential variance in the perception and communication of disruptive information among personnel at various hierarchical levels within an organization, it becomes imperative for firms to implement educational seminars or training programs that leverage digital technologies. These initiatives are designed to enhance the understanding and effectively disseminate critical disaster preparedness and response information.

Study three provides actionable insights, advocating a balanced focus on exploratory and exploitative digital innovations. It emphasizes the need for firms to cultivate an environment that supports the synergistic combination of human capital, infrastructure, and collaborative networks. Enterprises can select exploratory or exploitative digital innovation to develop SCR. A company with abundant infrastructure resources without human capital constraints can promote SCR through exploitative digital innovation. If an enterprise relies more on collaborative networks with various partners, SCR can be developed by combining exploratory digital innovation, collaboration networks, and human capital. Study three also has identified the indispensable role of human capital in shaping the configurational effects on both high and low SCR. It is imperative for enterprises to consistently dedicate resources to the nurturing and advancement of their human capital. This investment is crucial for ensuring supply chains' seamless and vigorous functioning within modern markets' intricate and ever-changing landscape. By doing so, firms can forge a resilient supply chain capable of withstanding and thriving amidst the uncertainties of the contemporary business landscape.

CHAPTER 8 CONCLUSIONS

Based on the discussion, this concluding chapter re-evaluates the research questions proposed in the literature review to address research gaps and three overarching questions: *(a) How do digital affordances enhance supply chain resilience? (b) What are the roles of digital techniques in supply chain resilience to disruptive events? (c) What are the configuration effects of digital innovation and resources on supply chain resilience?* In this concluding section, the research outcomes of the present dissertation are encapsulated, elucidating the extent to which they have fulfilled the research objectives. Subsequently, this chapter addresses the limitations of this thesis and proposes avenues for future research.

8.1 Conclusions

The gap in the literature regarding the empirical evidence of how digital affordances affect SCR and the lack of understanding of the motivational role of digitalization in SCR is addressed by exploring the digital affordances and their actualisation process. The first research question clarifies the digital techniques affordance in motivating SCR of logistics firms. Study one first moves affordance theory into the SCR research agenda. Then, study one proposes a theoretical framework of digital affordances and SCR based on affordance theory. The theoretical framework of digital affordances in achieving SCR goals contains four steps. The first step is the cognition process of affordance existence. The second step is recognising digital affordances, which originate from digital technology features and firms' capabilities. The third step is the behaviours for digital affordance actualisation. The last step is the affordance effects of SCR goals—a collection of concrete results and ultimate goals achieved through digital affordances.

Case studies were conducted in logistics companies to clarify the digital affordances and their actualisation process to enhance SCR. Thematic analysis was applied to analyse how digital affordance enhances SCR. The results reveal the three SCR goals of affordance effects: stability, continuity and opportunity creation. Based on SCR goals, this study found that digital affordances exist in three logistics companies' resources to enhance SCR after interaction between digital techniques and logistics firms, including logistics infrastructure, human capital, and collaboration networks. This study found that flexibility, agility, diversity, and visibility are the heterogeneous and unique digital affordances for logistics companies that enhance SCR. Digital affordances enhance and actualise SCR through service modularisation, information visibility, resource configuration, process optimisation and customer connection.

The second research question investigates the role of two critical components of digital techniques in SCR and the performance of logistics firms in disruptive events. This research question tackles how digital techniques, precisely digital orientation and competency, can influence SCR during disruptive events. It addresses the gap by providing insights into the interplay between digital techniques and SCR in the context of floods. Study two uses multiple research methods to examine the role of DTs, including digital orientation and digital competency, in logistics firms' SCR during floods. In Phase 1, managers in logistics firms shared their views on the role of DTs for SCR during floods through semi-structured interviews, which revealed that digital orientation and digital competency might affect SCR and firm performance through thematic analysis. This study further develops a conceptual framework and the associated hypotheses by combining the findings of Phase 1 with those reported in the literature.

In Phase 2, survey data was collected via a self-administrated questionnaire survey, and structural equation modelling was then conducted to assess the conceptual model. The results show

that digital orientation is vital in developing digital competency. The results demonstrate that digital competency can improve SCR and company performance. Strong digital competency also implies that companies can choose the most relevant and effective technologies to apply to disruptive crises. Digital orientation cannot directly lead to SCR. Digital orientation can have a direct and beneficial impact on company performance and an indirect impact on SCR through digital competency's mediation role. The effect of supply chain disruption has a positive influence on SCR. Hence, disruption might be an opportunity for logistics organizations to develop SCR. This study also discovered that firm size does not affect SCR but negatively impacts firm performance.

The third research question investigates the configuration effects of ambidextrous digital innovation and resources on SCR. This question aims to fill the gap in the literature that often treats digital innovation and resources as isolated variables, ignoring the multiple conjunctive causation relationships. Based on the resource orchestration theory and ambidextrous innovation perspective, study three first identifies the specific digital innovation and related resources that may affect SCR. This study clarified ambidextrous digital innovations, which are called exploratory digital innovation and exploitative digital innovation. Three critical resources for logistics firms are human capital, logistics infrastructure, and collaboration networks. By incorporating the findings from the qualitative investigation and related literature, study three constructs a conceptual model illustrating the configuration effects of ambidextrous digital innovation and three resources on SCR.

Study three employs a fuzzy-set Qualitative Comparative Analysis (fsQCA) to explore the configuration effects of digital innovation and resources on SCR. A random sampling approach is applied to collect fsQCA data, and questionnaires are distributed through online and offline surveys.

Study three uncovered that human capital, logistics infrastructure and exploitative digital innovation have configuration effects on motivating SCR, while exploratory digital innovation can combine collaboration networks and human capital to develop SCR. Study three also revealed that a lack of human capital and exploitative digital innovation can lead to the failure of the development of SCR. Besides, if logistics companies do not conduct exploratory digital innovation and have enough human capital and logistics infrastructure resources, they will have low SCR. The study demonstrated that while digital innovation alone is not enough driver for SCR, its strategic integration with resource orchestration practices can significantly bolster a firm's SCR.

In summary, three studies within the thesis address specific sub-questions that collectively contribute to answering the overarching research questions: "What the roles of digital techniques in SCR are and how to enhance SCR by digital techniques?". These sub-questions are derived from the identified gaps in the literature, ensuring that the research focuses on providing new insights and advancing the understanding of the role of digital techniques in SCR within the logistics sector.

8.2 Limitations and Future Research Opportunities

Despite the potential contributions, this research was not without certain limitations that can be improved in future studies. First, this thesis takes China as a study area because of the human and physical limitations. Even though China is a suitable case area of this thesis to explore the role of digital techniques in the SCR of logistics firms, the research is based on a specific sample of logistics companies, which may not fully represent the broader global logistics industry, potentially affecting the generalisability of the results. In future research, it is necessary to expand the empirical study and collect data from different countries. More cross-country studies can be conducted to extend the findings. Then, a comparison could be made between different contexts

regarding supply chain digitalisation and resilience practice. Future studies can encapsulate the impact of cultural and geographical differences on the adoption and effectiveness of digital techniques in SCR.

Second, this thesis collects cross-sectional data from interviews and questionnaire surveys, capturing the situation simultaneously. Considering the exploratory approach in unclear situations, study one adopted in-depth interviews and annual reports to explore the role of digital affordances on SCR. Study two conducted interviews and questionnaires to examine the role of digital orientation and competency in SCR. Study three also applied interviews and questionnaires to explore the configuration effect of ambidextrous digital innovation and multiple resources in SCR. Cross-sectional data limits the ability to infer causality and observe the evolution of SCR over time. Therefore, future studies can consider time series or panel data to explore the role of digital techniques in SCR. It is worth noting that attention should be paid to the connotation of variables and measurement accuracy when using panel data. Big data and simulation methods can also be applied in future studies to test the findings further.

Third, this thesis focuses on the logistics sector, which, as the connecting point of the supply chain, coordinates all parties involved, including suppliers, manufacturers, distributors, and retailers, to ensure the smooth operation of the overall supply chain. However, some thesis issues require further clarification and exploration of the influence of these digital techniques on the SCR of other types of companies. Other types of firms can further clarify and verify the relationship between digital affordances, affordances actualisation behaviours and SCR goals. Future studies can also explore diverse resource orchestration and digital innovation strategies in other sectors. In addition, study two takes flooding as a disruption example. Future studies may consider other disruptive events to investigate the role of digital techniques in SCR and expand on these insights.

References:

3PL Study, (2023), 2024 third-party logistics study. https://www.penskelogistics.com/insights/industry-reports/3pl-study (Accessed 5 November 2023).

Abeysekara, N., Wang, H., & Kuruppuarachchi, D. (2019). Effect of supply-chain resilience on firm performance and competitive advantage: a study of the Sri Lankan apparel industry. Business Process Management Journal, 25(7), 1673–1695.

Ahmed, A., Bhatti, S. H., Gölgeci, I., & Arslan, A. (2022). Digital platform capability and organizational agility of emerging market manufacturing SMEs: The mediating role of intellectual capital and the moderating role of environmental dynamism. Technological Forecasting and Social Change, 177, 121513.

Ahmed, M. U., Kristal, M. M., & Pagell, M. (2014). Impact of operational and marketing capabilities on firm performance: Evidence from economic growth and downturns. International Journal of Production Economics, 154, 59–71.

Aigbedo, H. (2021). Impact of COVID-19 on the hospitality industry: A supply chain resilience perspective. International Journal of Hospitality Management, 98, 103012.

Akgün, A. E., & Keskin, H. (2014). Organisational resilience capacity and firm product innovativeness and performance. International Journal of Production Research, 52(23), 6918–6937.

AKSP, (2020). Warehouse Flood Prevention – Preventing Water Damage in your Warehouse. https://www.akcp.com/blog/warehouse-flood-prevention/. Accessed on December 23, 2022.

Aktas, E., Bourlakis, M., & Zissis, D. (2021). Collaboration in the last mile: Evidence from grocery deliveries. International Journal of Logistics Research and Applications, 24(3), 227–241.

Al Mamun, A., & Fazal, S. A. (2018). Effect of entrepreneurial orientation on competency and micro-enterprise performance. Asia Pacific Journal of Innovation and Entrepreneurship, 12(3), 379–398.

Ali, M., Rahman, S. M., & Frederico, G. F. (2021). Capability components of supply chain resilience for readymade garments (RMG) sector in Bangladesh during COVID-19. Modern Supply Chain Research and Applications, 3(2), 127–144.

Alikhani, R., Torabi, S. A., & Altay, N. (2021). Retail supply chain network design with concurrent resilience capabilities. International Journal of Production Economics, 234, 108042.

AL-Khatib, A. W., & Ramayah, T. (2023). Big data analytics capabilities and supply chain performance: Testing a moderated mediation model using partial least squares approach. Business Process Management Journal, 29(2), 393–412.

Alksasbeh, M., Abuhelaleh, M., Almaiah, M. A., AL-jaafreh, M., & Abu karaka, A. (2019). Towards a Model of Quality Features for Mobile Social Networks Apps in Learning Environments: An Extended Information System Success Model. International Journal of Interactive Mobile Technologies, 13(05), 75.

Alvarenga, M. Z., Oliveira, M. P. V. D., & Oliveira, T. A. G. F. D. (2023). The impact of using digital technologies on supply chain resilience and robustness: The role of memory under the covid-19 outbreak. Supply Chain Management: An International Journal, 28(5), 825–842.

Alwin, D. F. (2007). Margins of error: A study of reliability in survey measurement. John Wiley & Sons.

Ambulkar, S., Blackhurst, J., & Grawe, S. (2015). Firm's resilience to supply chain disruptions: scale development and empirical examination. Journal of Operations Management, 33-34(Jan.), 111-122.

Anderson, C., & Robey, D. (2017). Affordance potency: Explaining the actualisation of technology affordances. Information and Organization, 27(2), 100–115.

Andersson, T., Cäker, M., Tengblad, S., & Wickelgren, M. (2019). Building traits for organizational resilience through balancing organizational structures. Scandinavian Journal of Management, 35(1), 36-45.

Andrew, S., Arlikatti, S., Siebeneck, L., Pongponrat, K., & Jaikampan, K. (2016). Sources of organisational resiliency during the Thailand floods of 2011: A test of the bonding and bridging hypotheses. Disasters, 40(1), 65–84.

Asiaei, K., Rezaee, Z., Bontis, N., Barani, O., & Sapiei, N. S. (2021). Knowledge assets, capabilities and performance measurement systems: A resource orchestration theory approach. Journal of Knowledge Management, 25(8), 1947–1976.

Aslam, H., Khan, A. Q., Rashid, K., & Rehman, S. U. (2020). Achieving supply chain resilience: the role of supply chain ambidexterity and supply chain agility. Journal of Manufacturing Technology Management, 31(6), 1185-1204.

Autio, E., Nambisan, S., Thomas, L. D. W., & Wright, M. (2018). Digital affordances, spatial affordances, and the genesis of entrepreneurial ecosystems. Strategic Entrepreneurship Journal, 12(1), 72–95.

Bag, S., Rahman, M. S., Srivastava, G., Chan, H.-L., & 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, 108541.

Bals, L., & Tate, W. L. (2018). Sustainable Supply Chain Design in Social Businesses: Advancing the Theory of Supply Chain. Journal of Business Logistics, 39(1), 57–79.

Baral, N., & Stern, M. J. (2011). Capital stocks and organizational resilience in the Annapurna Conservation Area, Nepal. Society & Natural Resources, 24(10), 1011-1026.

Barasa, E., Mbau, R., & Gilson, L. (2018). What is resilience and how can it be nurtured? A systematic review of empirical literature on organizational resilience. International journal of health policy and management, 7(6), 491.

Barney, J. B. (1991). Firm resources and sustained competitive advantage. Journal of Management, 17(1), 99-120.

Barreto, I. (2010). Dynamic capabilities: A review of past research and an agenda for the future. Journal of management, 36(1), 256-280.

Barrett, P. (2007). Structural equation modelling: Adjudging model fit. Personality and Individual Differences, 42(5), 815–824.

Bastas, A., & Garza-Reyes, J. A. (2021). Impact of the COVID-19 pandemic on manufacturing operations and supply chain resilience: Effects and response strategies. 24.

Bayramova, A., Edwards, D. J., & Roberts, C. (2021). The Role of Blockchain Technology in Augmenting Supply Chain Resilience to Cybercrime. Buildings, 11(7), 283.

BCI Supply Chain Resilience Report, (2023), BCI supply chain resilience report 2023. https://www.thebci.org/news/bci-launches-supply-chain-resilience-report-2023.html (Accessed 5 November 2023).

BCI, (2022). BCI Horizon Scan Report 2021. https://www.bsigroup.com/globalassets/localfiles/en-th/iso-22301/bci-horizon-scan-report/bci-horizon-scan-report-2021-th.pdf. Accessed on December 23, 2022.

Belhadi, A., Kamble, S., Jabbour, C. J. C., Gunasekaran, A., Ndubisi, N. O., & Venkatesh, M. (2021). Manufacturing and service supply chain resilience to the COVID-19 outbreak:

Lessons learned from the automobile and airline industries. Technological Forecasting and Social Change, 163, 120447.

Belhadi, A., Kamble, S., Subramanian, N., Singh, R. K., & Venkatesh, M. (2024). Digital capabilities to manage agri-food supply chain uncertainties and build supply chain resilience during compounding geopolitical disruptions. International Journal of Operations & Production Management.

Belhadi, A., Mani, V., Kamble, S. S., Khan, S. A. R., & Verma, S. (2021). Artificial intelligence-driven innovation for enhancing supply chain resilience and performance under the effect of supply chain dynamism: An empirical investigation. Annals of Operations Research.

Belitski, M., Korosteleva, J., & Piscitello, L. (2023). Digital affordances and entrepreneurial dynamics: New evidence from European regions. Technovation, 119, 102442.

Bernhard, E., Recker, J., & Burton-Jones, A. (2013). Understanding the actualisation of affordances: a study in the process modeling context. Business Process Management.

Berraies, S., & Zine El Abidine, S. (2019). Do leadership styles promote ambidextrous innovation? Case of knowledge-intensive firms. Journal of Knowledge Management, 23(5), 836–859.

Bhaskar, R. (1975). A Realist Theory of Science, Hassocks, England: Harvester Press.

Bianco, D., Bueno, A., Godinho Filho, M., Latan, H., Miller Devós Ganga, G., Frank, A. G., & Chiappetta Jabbour, C. J. (2023). The role of Industry 4.0 in developing resilience for manufacturing companies during COVID-19. International Journal of Production Economics, 256, 108728.

Bisman, J. (2010). Postpositivism and accounting research: a (personal) primer on critical realism. Australasian Accounting Business & Finance Journal, 4(4).

Boin, A. (2010). The new world of crises and crisis management: implications for policymaking

and research. Review of Policy Research, 26(4), 367-377.

Bonn, (2019). DHL Resilience360 uses improved weather shape tracking data to help companies avert supply chain disruptions from hurricanes. https://www.dhl.com/global-en/home/press/press-archive/2019/dhl-resilience360-uses-improved-weather-shape-tracking-data-to-help-companies-avert-supply-chain-disruptions-from-hurricanes.html. Accessed on December 23, 2022.

Brandon-Jones, E., Squire, B., Autry, C. W., & Petersen, K. J. (2014). A Contingent Resource-Based Perspective of Supply Chain Resilience and Robustness. Journal of Supply Chain Management, 50(3), 55–73.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101.

Brewton, K. E., Danes, S. M., Stafford, K., & Haynes, G. W. (2010). Determinants of rural and urban family firm resilience. Journal of Family Business Strategy, 1(3), 155-166.

Brueller, D., Brueller, N. N., Brueller, R., & Carmeli, A. (2019). Interorganisational relationships in times of decline: Implications for organizational resilience. Applied Psychology, 68(4), 719-758.

Brusset, X., & Teller, C. (2016). Supply chain capabilities, risks, and resilience. International Journal of Production Economics, 184(Feb.), 59-68.

Buccieri, D., Javalgi, R. G., & Cavusgil, E. (2020). International new venture performance: Role of international entrepreneurial culture, ambidextrous innovation, and dynamic marketing capabilities. International Business Review, 29(2).

Buliga, O., Scheiner, C. W., & Voigt, K. I. (2016). Business model innovation and organizational resilience: towards an integrated conceptual framework. Journal of Business Economics,

86(6), 647-670.

Burgos, D., & Ivanov, D. (2021). Food retail supply chain resilience and the COVID-19 pandemic: A digital twin-based impact analysis and improvement directions. Transportation Research Part E: Logistics and Transportation Review, 152, 102412.

Cable, D. M., & DeRue, D. S. (2002). The convergent and discriminant validity of subjective fit perceptions. Journal of Applied Psychology, 87(5), 875.

Carmeli, A., & Markman, G. D. (2011). Capture, governance, and resilience: Strategy implications from the history of Rome. Strategic Management Journal, 32(3), 322-341.

Carr, C. T., Wohn, D. Y., & Hayes, R. A. (2016). as social support: Relational closeness, automaticity, and interpreting social support from paralinguistic digital affordances in social media. Computers in Human Behavior, 62, 385–393.

Castellacci, F. (2015). Institutional voids or organizational resilience? business groups, innovation, and market development in Latin America. World Development, 70, 43–58.

Castillo, V. E., Bell, J. E., Rose, W. J., & Rodrigues, A. M. (2018). Crowdsourcing Last Mile Delivery: Strategic Implications and Future Research Directions. Journal of Business Logistics, 39(1), 7–25.

CCTV, (2013). Zhejiang Province announced the disaster of typhoon "Fitow" a total of 8,742,500 people were affected. https://www.dnfire.cn/article-1323484405979.html. Accessed on December 23, 2022.

Chakravarty, A., Grewal, R., & Sambamurthy, V. (2013). Information technology competencies, organizational agility, and firm performance: enabling and facilitating roles. Information Systems Research, 24(4), 976–997.

Chan, F. K. S., Gu, X., Qi, Y., Thadani, D., Chen, Y. D., Lu, X., ... & Chen, W. Y. (2022). Lessons

learnt from Typhoons Fitow and In-Fa: implications for improving urban flood resilience in Asian Coastal Cities. Natural Hazards, 110(3), 2397-2404.

Chan, H. K., Guo, M., Zeng, F., Chen, Y., Xiao, T., & Griffin, J. (2023). Blockchain-enabled authentication platform for the protection of 3D printing intellectual property: a conceptual framework study. Enterprise Information Systems, 2180776.

Chatterjee, S., Moody, G. D., Lowry, P. B., Chakraborty, S., & Hardin, A. (2020). The Nonlinear Influence of Harmonious Information Technology Affordance on Organizational Innovation. SSRN Electronic Journal.

Chen, J., Wang, H., & Li, S. (2019). Complexity of supply chain networks in China. Journal of Supply Chain Management, 45(3), 65-78.

Chen, X., He, C., Chen, Y., & Xie, Z. (2023). Internet of Things (IoT)—Blockchain-enabled pharmaceutical supply chain resilience in the post-pandemic era. Frontiers of Engineering Management, 10(1), 82–95.

Chewning, L. V., Lai, C. H., & Doerfel, M. L. (2013). Organizational resilience and using information and communication technologies to rebuild communication structures. Management Communication Quarterly, 27(2), 237-263.

China Federation of Logistics and Purchasing, (2022). Digitalization of logistics companies is an inevitable trend (with a list of the top 50 digital logistics companies in the first half of 2022). https://baijiahao.baidu.com/s?id=1741012595029287054&wfr=spider&for=pc. Accessed on April 9, 2023.

Choi, T. M., & Chan, H. K. (2023). Editorial Impacts of Technology Management on the Apparel Retailing and Manufacturing Industry. IEEE Transactions on Engineering Management, 70(4), 1255-1257.

Choi, T. M., Chan, H. K., & Yue, X. (2016). Recent development in big data analytics for business operations and risk management. IEEE Transactions on Cybernetics, 47(1), 81-92.

Choi, T. M., Chen, J., Li, G., & Yue, X. (2023). Platform supply chain innovations in the blockchain era: the ABCDE framework. International Journal of Production Research, 61(11), 3505-3511.

Chowdhury, M. M. H., & Quaddus, M. (2017). Supply chain resilience: Conceptualization and scale development using dynamic capability theory. International Journal of Production Economics, 188, 185–204.

Christopher, M., & Peck, H. (2014). Building the Resilient Supply Chain. International Journal of Logistics Management, 25(1), 1-14.

Chung, S.-H. (2021). Applications of smart technologies in logistics and transport: A review. Transportation Research Part E: Logistics and Transportation Review, 153, 102455.

Chunsheng, L., Wong, C. W. Y., Yang, C.-C., Shang, K.-C., & Lirn, T. (2019). Value of supply chain resilience: Roles of culture, flexibility, and integration. International Journal of Physical Distribution & Logistics Management, 50(1), 80–100.

Coates, G., Alharbi, M., Li, C., Ahilan, S., & Wright, N. (2020). Evaluating the operational resilience of small and medium-sized enterprises to flooding using a computational modelling and simulation approach: a case study of the 2007 flood in Tewkesbury. Philosophical Transactions of the Royal Society A, 378(2168), 20190210.

Collis, D. J., & Montgomery, C. A. (2005). Corporate strategy: A resource-based approach. Harvard Business Review, 83(7/8), 86-96.

Conz, E., & Magnani, G. (2020). A dynamic perspective on the resilience of firms: A systematic literature review and a framework for future research. European Management Journal, 38(3), 400-412.

Croucher, R., Glaister, K. W., Rizov, M., Rofcanin, Y., & Wood, G. (2020). Challenges and resilience: managers' perceptions of firm performance following M&As. Applied Psychology, 69(4), 1470-1505.

Cui, L., Wu, H., Wu, L., Kumar, A., & Tan, K. H. (2023). Investigating the relationship between digital technologies, supply chain integration and firm resilience in the context of COVID-19. Annals of Operations Research, 327(2), 825–853.

Danes, S. M., Lee, J., Amarapurkar, S., Stafford, K., Haynes, G., & Brewton, K. E. (2009). Determinants of family business resilience after a natural disaster by gender of business owner. Journal of Developmental Entrepreneurship, 14(04), 333-354.

Daniel, A., & Michaela, C. (2021). Mental Health and Health-Related Quality of Life in Victims of the 2013 Flood Disaster in Germany–A Longitudinal Study of Health-Related Flood Consequences and Evaluation of Institutionalized Low-Threshold Psycho-Social Support. International Journal of Disaster Risk Reduction, 102179.

Das, T. K., & Teng, B. S. (2000). A resource-based theory of strategic alliances. Journal of Management, 26(1), 31-61.

Datta, S., Jauhar, S. K., & Paul, S. K. (2023). Leveraging blockchain to improve nutraceutical supply chain resilience under post-pandemic disruptions. Computers & Industrial Engineering, 183, 109475.

De Leeuw, S., Vis, I. F., & Jonkman, S. N. (2012). Exploring logistics aspects of flood emergency measures. Journal of Contingencies and Crisis Management, 20(3), 166-179.

De Souza, R., Goh, M., Lau, H.-C., Ng, W.-S., & Tan, P.-S. (2014). Collaborative Urban Logistics – Synchronizing the Last Mile a Singapore Research Perspective. Procedia - Social and Behavioral Sciences, 125, 422–431.

DHL. (2021). DHL Reshaping Logistics with Digitalization," DHL Customer Solutions & Innovation, https://www.logistics.dhl/content/dam/downloads/global/en/company/about-dhl/innovation/whitepapers/DHL-Reshaping-Logistics-with-Digitalization.pdf. accessed July 2024.

DHL Global Forwarding. (2021). DHL warns of global supply chain disruption. DHL Newsroom. Retrieved from https://www.dpdhl.com/en/media_relations/press_releases/2021/03/dhl-warns-of-global-supply-chain-disruption.html

Dixit, V., Verma, P., & Tiwari, M. K. (2020). Assessment of pre and post-disaster supply chain resilience based on network structural parameters with CVaR as a risk measure. International Journal of Production Economics, 227, 107655

Do, H., Budhwar, P., Shipton, H., Nguyen, H.-D., & Nguyen, B. (2022). Building organizational resilience, innovation through resource-based management initiatives, organizational learning and environmental dynamism. Journal of Business Research, 141, 808–821.

Doeksen, A., & Symes, D. (2015). Business Strategies for Resilience: The Case of Zeeland's Oyster Industry. Sociologia Ruralis, 55(3), 325-342.

Dormady, N., Roa-Henriquez, A., & Rose, A. (2019). Economic resilience of the firm: A production theory approach. International Journal of Production Economics, 208, 446-460.

Dubey, R., Bryde, D. J., Blome, C., Roubaud, D., & Giannakis, M. (2021). Facilitating artificial intelligence powered supply chain analytics through alliance management during the pandemic crises in the B2B context. Industrial Marketing Management, 96, 135–146.

Duchek, S. (2020). Organizational resilience: a capability-based conceptualization. Business Research, 13(1), 215-246.

Duchek, S., Raetze, S., & Scheuch, I. (2020). The role of diversity in organizational resilience: a

theoretical framework. Business Research, 13(2), 387-423.

DuHadway, S., Mena, C., & Ellram, L. M. (2022). Let the buyer beware: How network structure can enable (and prevent) supply chain fraud. International Journal of Operations & Production Management, 42(2), 125–150.

Edson, M. C. (2012). A complex adaptive systems view of resilience in a project team. Systems Research and Behavioural Science, 29(5), 499-516.

Eisenhardt, K. M. (1989). Making fast strategic decisions in high-velocity environments. Academy of Management journal, 32(3), 543-576.

Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic capabilities: What are they? Strategic Management Journal, 21(10-11), 1105-1121.

El Baz, J., & Ruel, S. (2021). Can supply chain risk management practices mitigate the disruption impacts on supply chains' resilience and robustness? Evidence from an empirical survey in a COVID-19 outbreak era. International Journal of Production Economics, 233, 107972.

Eltantawy, R. A. (2016). The role of supply management resilience in attaining ambidexterity: a dynamic capabilities approach. Journal of Business & Industrial Marketing.

Emergency Events Database. (2020). https://public.emdat.be/data. Accessed on December 23, 2022.

Engeset, A. B. (2020). "For better or for worse"–the role of family ownership in the resilience of rural hospitality firms. Scandinavian Journal of Hospitality and Tourism, 20(1), 68-84.

English, F., & Ivory, G. (2014). Positivism, Postpositivism. In Encyclopedia of Educational Leadership and Administration. SAGE Publications, Inc.

Entrepreneurial State Research Centre, (2021). The 2020 China smart logistics industry report. https://www.sohu.com/a/445280439_120855974. Accessed on April 9, 2023.

Erol, O., Sauser, B. J., & Mansouri, M. (2010). A framework for investigation into extended enterprise resilience. Enterprise Information Systems, 4(2), 111-136

Everitt, B. S., & Dunn, G. (2001). Applied multivariate data analysis (Vol. 2). London: Arnold.

Fainshmidt, S., Wenger, L., Pezeshkan, A., & Mallon, M. R. (2019). When do Dynamic Capabilities Lead to Competitive Advantage? The Importance of Strategic Fit. Journal of Management Studies, 56(4), 758–787.

Falasca, M., Zobel, C. W., & Cook, D. (2008, May). A decision support framework to assess supply chain resilience. In Proceedings of the 5th International ISCRAM Conference (pp. 596-605).

Fang, S., Prayag, G., Ozanne, L. K., & Dde Vries, H. (2020). Psychological capital, coping mechanisms and organizational resilience: Insights from the 2016 Kaikoura earthquake, New Zealand. Tourism Management Perspectives, 34, 100637.

Firdhous, M. F. M., & Karuratane, P. M. (2018). A model for enhancing the role of information and communication technologies for improving the resilience of rural communities to disasters. Procedia Engineering, 212, 707-714.

First Financial Daily. (2020). Floods test express logistics companies digest costs without raising prices. https://www.yicai.com/news/366177.html. Accessed on December 23, 2022.

Fiss, P. C. (2011). Building better causal theories: a fuzzy set approach to typologies in organization research. Academy of Management Journal, 54(2).

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. Global environmental change, 16(3), 253-267.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18(1), 39-50.

Galvin, R. (2015). How many interviews are enough? Do qualitative interviews in building energy

consumption research produce reliable knowledge? Journal of Building Engineering, 1, 2–12.

Gao, Q., Xia, D., Shi, Y., & Quan, J. (2019). Policies adoption for supply disruption mitigation based on customer segmentation. IEEE Access, 7, 47329-47338.

Garmestani, A. S., Allen, C. R., Mittelstaedt, J. D., Stow, C. A., & Ward, W. A. (2006). Firm size diversity, functional richness, and resilience. Environment and Development Economics, 533-551.

Ghobakhloo, M., Iranmanesh, M., Foroughi, B., Tseng, M.-L., Nikbin, D., & Khanfar, A. A. A. (2023). Industry 4.0 digital transformation and opportunities for supply chain resilience: A comprehensive review and a strategic roadmap. Production Planning & Control, 1–31.

Gibson, J. J. (1986). The ecological approach to visual perception: classic edition. Psychology press.

Global disaster data platform, (2022). https://www.gddat.cn/newGlobalWeb/#/FeatureAnalysis. Accessed on December 23, 2022.

Gölgeci, I., & Kuivalainen, O. (2020). Does social capital matter for supply chain resilience? The role of absorptive capacity and marketing-supply chain management alignment. Industrial Marketing Management, 84, 63-74.

Golgeci, I., & Ponomarov, S. Y. (2013). Does firm innovativeness enable effective responses to supply chain disruptions? An empirical study. Supply Chain Management: An International Journal, 18 (6), 604-617.

Gong, L., Liu, Z., Rong, Y., & Fu, L. (2021). Inclusive leadership, ambidextrous innovation and organizational performance: The moderating role of environment uncertainty. Leadership & Organization Development Journal, 42(5), 783–801.

Goodman, L. A. (1961). Snowball sampling. The annals of mathematical statistics, 148-170.

Grant, R. M. (2016). Contemporary strategy analysis: Text and cases edition. Wiley.

Gu, M., Yang, L., & Huo, B. (2021). The impact of information technology usage on supply chain resilience and performance: An ambidextrous view. International Journal of Production Economics, 232, 107956.

Gu, X., Chan, H. K., Thadani, D. R., Chan, F. K. S., & Peng, Y. (2023). The role of digital techniques in organisational resilience and performance of logistics firms in response to disruptive events: Flooding as an example. International Journal of Production Economics, 266, 109033.

Guest, G., Bunce, A., & Johnson, L. (2006). How Many Interviews Are Enough?: An Experiment with Data Saturation and Variability. Field Methods, 18(1), 59–82.

Guo, X., Cheng, J., Yin, C., Li, Q., Chen, R., & Fang, J. (2023). The extraordinary Zhengzhou flood of 7/20, 2021: How extreme weather and human response compounding to the disaster. Cities, 134, 104168.

Gupta, S., Modgil, S., Choi, T.-M., Kumar, A., & Antony, J. (2023). Influences of artificial intelligence and blockchain technology on financial resilience of supply chains. International Journal of Production Economics, 261, 108868.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). Multivariate data analysis (7th ed.). Pearson.

Hallak, R., Assaker, G., O'Connor, P., & Lee, C. (2018). Firm performance in the upscale restaurant sector: The effects of resilience, creative self-efficacy, innovation and industry experience. Journal of Retailing and Consumer Services, 40, 229–240

Haraguchi, M., & Lall, U. (2015). Flood risks and impacts: A case study of Thailand's floods in 2011 and research questions for supply chain decision making. International Journal of

Disaster Risk Reduction, 14, 256-272.

Harman, H. H., & Harman, H. H. (1976). Modern factor analysis. University of Chicago Press.

Harmancioglu, N., Sääksjärvi, M., & Hultink, E. J. (2020). Cannibalize and combine? The impact of ambidextrous innovation on organizational outcomes under market competition. Industrial Marketing Management, 85, 44–57.

Harries, T., McEwen, L., & Wragg, A. (2018). Why it takes an 'ontological shock' to prompt increases in small firm resilience: Sensemaking, emotions and flood risk. International Small Business Journal, 36(6), 712-733.

Hart, S. L. (1971). Axiology-theory of values. Philosophy and Phenomenological Research, 32(1), 29-41.

Hartwig, T., & Nguyen, T. T. (2023). Local infrastructure, rural households' resilience capacity and poverty: Evidence from panel data for Southeast Asia. Journal of Economics and Development, 25(1), 2–21.

He, X., Hu, W., Li, W., & Hu, R. (2023). Digital transformation, technological innovation, and operational resilience of port firms in case of supply chain disruption. Marine Pollution Bulletin, 190, 114811.

Henan Federation of Logistics and Purchasing, (2021). Henan Province released the "Analysis Report on the Impact of the 7.20 Flood on Henan Province's Logistics Operation". https://new.qq.com/rain/a/20210802A0AF1F00. Accessed on December 23, 2022.

Henningsson, S., Kettinger, W. J., Zhang, C., & Vaidyanathan, N. (2021). Transformative rare events: Leveraging digital affordance actualisation. European Journal of Information Systems, 30(2), 137–156.

Hennink, M. M., Kaiser, B. N., & Marconi, V. C. (2017). Code Saturation Versus Meaning

Saturation: How Many Interviews Are Enough? Qualitative Health Research, 27(4), 591–608.

Henri, J. F. (2006). Organizational culture and performance measurement systems. Accounting, organizations and Society, 31(1), 77-103.

Herold, D. M., Nowicka, K., Pluta-Zaremba, A., & Kummer, S. (2021). COVID-19 and the pursuit of supply chain resilience: Reactions and "lessons learned" from logistics service providers (LSPs). Supply Chain Management: An International Journal, 26(6), 702–714.

Hillmann, J., & Guenther, E. (2020). Organizational resilience: a valuable construct for management research?. International Journal of Management Reviews.

Hitt, M. A., & Ireland, R. D. (2017). Resource orchestration theory: A new perspective on strategic management. Strategic Management Journal, 38(10), 2145-2162.

Ho, J., Plewa, C., & Lu, V. N. (2016). Examining strategic orientation complementarity using multiple regression analysis and fuzzy set QCA. Journal of Business Research, 69(6), 2199–2205.

Hofmann, E., & Rüsch, M. (2017). Industry 4.0 and the current status as well as future prospects on logistics. Computers in industry, 89, 23-34.

Hohenstein, N.-O., Feisel, E., Hartmann, E., & Giunipero, L. (2015). Research on the phenomenon of supply chain resilience: A systematic review and paths for further investigation. International Journal of Physical Distribution & Logistics Management, 45(1/2), 90–117.

Holl, A., & Mariotti, I. (2018). The Geography of Logistics Firm Location: The Role of Accessibility. Networks and Spatial Economics, 18(2), 337–361.

Holling, C. S., & Gunderson, L. H. (2002). Resilience and adaptive cycles. In: Panarchy: Understanding Transformations in Human and Natural Systems, 25-62.

Hughes, P., Hodgkinson, I. R., Elliott, K., & Hughes, M. (2018). Strategy, operations, and

profitability: The role of resource orchestration. International Journal of Operations & Production Management, 38(4), 1125–1143.

Hunter, G. K., & Perreault, W. D. (2006). Sales Technology Orientation, Information Effectiveness, and Sales Performance. Journal of Personal Selling & Sales Management, 26(2), 95–113.

Iftikhar, A., Purvis, L., & Giannoccaro, I. (2021). A meta-analytical review of antecedents and outcomes of firm resilience. Journal of Business Research, 135, 408–425.

Ignatiadis, I., & Nandhakumar, J. (2007). The impact of enterprise systems on organizational resilience. Journal of Information Technology, 22(1), 36-43.

Jain, N. K., Chakraborty, K., & Choudhury, P. (2024). Building supply chain resilience through industry 4.0 base technologies: Role of supply chain visibility and environmental dynamism. Journal of Business & Industrial Marketing.

Janssen, J., Stoyanov, S., Ferrari, A., Punie, Y., Pannekeet, K., & Sloep, P. (2013). Experts' views on digital competence: Commonalities and differences. Computers & Education, 68, 473–481.

Jason, M. (2022). Flooding impacts transport and logistics sector. https://mhdsupplychain.com.au/2022/04/19/flooding-impacts-transport-and-logistics-sector/. Accessed on December 23, 2022.

Jia, X., Chowdhury, M., Prayag, G., & Hossan Chowdhury, M. M. (2020). The role of social capital on proactive and reactive resilience of organizations post-disaster. International Journal of Disaster Risk Reduction, 48, 101614.

Jiang, F., Zheng, X., Fan, D., Zhang, P., & Li, S. (2021). The Sharing Economy and Business Model Design: A Configurational Approach. Journal of Management Studies, 58(4), 949–976.

Jiang, Y., Ritchie, B. W., & Verreynne, M. (2019). Building tourism organizational resilience to

crises and disasters: A dynamic capabilities view. International Journal of Tourism Research, 21(6), 882–900.

Jin, L. (2019). Typhoon "Lekima" has caused 39 deaths in Zhejiang 9 people lost. https://zj.zjol.com.cn/news.html?id=1263474&from_channel=52e5f902cf81d754a434fb50. Accessed on December 23, 2022.

Johnson, Phil, & Duberley, Joanne. (2002). Understanding management research: an introduction to epistemology. Organization Studies (May-June).

Kabra, G., & Ramesh, A. (2015). Analysing ICT issues in humanitarian supply chain management: a SAP-LAP linkages framework. Global Journal of Flexible Systems Management, 16(2), 157-171.

Kähkönen, A.-K., Evangelista, P., Hallikas, J., Immonen, M., & Lintukangas, K. (2021). COVID-19 as a trigger for dynamic capability development and supply chain resilience improvement. International Journal of Production Research, 1–20.

Kamalahmadi, M., & Parast, M. M. (2016). A review of the literature on the principles of enterprise and supply chain resilience: Major findings and directions for future research. International Journal of Production Economics, 171, 116–133.

Kang, M., Robb, C., & Stephens, A. (2022). A Comparative Analysis of South Korean and U.S. Firms: Ambidextrous Innovation, Supply Chain Resilience, and Market Performance. Operations and Supply Chain Management: An International Journal, 565–581.

Katsaliaki, K., Galetsi, P., & Kumar, S. (2021). Supply chain disruptions and resilience: A major review and future research agenda. Annals of Operations Research.

Kaur, M., Kaur, P. D., & Sood, S. K. (2021). Energy efficient IoT-based cloud framework for early flood prediction. Natural Hazards, 109(3), 2053–2076.

Kaur, M., Kaur, P. D., & Sood, S. K. (2022). ICT in disaster management context: A descriptive and critical review. Environmental Science and Pollution Research, 29(57), 86796–86814.

Kim, Y., Jeong, S. S., Yiu, D. W., & Moon, J. (2020). Frequent CEO turnover and firm performance: The resilience effect of workforce diversity. Journal of Business Ethics, 1-19.

Kim, Y., Jeong, S. S., Yiu, D. W., & Moon, J. (2020). Frequent CEO turnover and firm performance: The resilience effect of workforce diversity. Journal of Business Ethics, 1-19.

King, D.D., Newman, A., & Luthans, F. (2016). Not if, but when we need resilience in the workplace. Journal of Organizational Behavior, 37(5), 782-786.

König, A., & Spinler, S. (2016). The effect of logistics outsourcing on the supply chain vulnerability of shippers: Development of a conceptual risk management framework. The International Journal of Logistics Management, 27(1), 122–141. https://doi.org/10.1108/IJLM-03-2014-0043

Kundu, T., Sheu, J.-B., & Kuo, H.-T. (2022). Emergency logistics management—Review and propositions for future research. Transportation Research Part E: Logistics and Transportation Review, 164, 102789.

Lajili, K., & Zéghal, D. (2009). A Content Analysis of Risk Management Disclosures in Canadian Annual Reports. Canadian Journal of Administrative Sciences / Revue Canadienne Des Sciences de l'Administration, 22(2), 125–142. https://doi.org/10.1111/j.1936-4490.2005.tb00714.x

Lampel, J., Bhalla, A., & Jha, P. P. (2014). Does governance confer organizational resilience? Evidence from UK employee owned businesses. European Management Journal, 32(1), 66-72.

Lengnick-Hall, C. A., & Beck, T. E. (2005). Adaptive fit versus robust transformation: How

organizations respond to environmental change. Journal of Management, 31(5), 738-757.

Lengnick-Hall, C. A., Beck, T. E., & Lengnick-Hall, M. L. (2011). Developing a capacity for organizational resilience through strategic human resource management. Human resource management review, 21(3), 243-255.

Leonardi. (2011). When Flexible Routines Meet Flexible Technologies: Affordance, Constraint, and the Imbrication of Human and Material Agencies. MIS Quarterly, 35(1), 147.

Levine, R., Lin, C., & Xie, W. (2018). Corporate resilience to banking crises: The roles of trust and trade credit. Journal of Financial and Quantitative Analysis, 53(4), 1441-1477.

Li, C., Wong, C. W., Yang, C. C., Shang, K. C., & Lirn, T. C. (2019). Value of supply chain resilience: roles of culture, flexibility, and integration. International Journal of Physical Distribution & Logistics Management, 50(1), 80-100.

Li, M., & Jia, S. (2018). Resource orchestration for innovation: The dual role of information technology. Technology Analysis & Strategic Management, 30(10), 1136–1147.

Li, X., Li, X., & Ding, S. (2024). Digital transformation and innovation ambidexterity: Perspectives on accumulation and resilience effects. European Journal of Innovation Management.

Li, Z., Wang, N., Wang, Z., & Ge, S. (2024). Empirical Research on the Relationship Between Ambidextrous Innovation Value of Cloud Computing and Environmental Characteristics. Journal of the Knowledge Economy.

Limnios, E. A. M., Mazzarol, T., Ghadouani, A., & Schilizzi, S. G. (2014). The resilience architecture framework: four organizational archetypes. European Management Journal, 32(1), 104-116.

Lin, F. (2020). Flood prevention and disaster relief, brothers from China Post, SF Express, Suning

and Tongda Baibang are all in battle. https://view.inews.qq.com/k/20200729A0O49S00?web_channel=wap&openApp=false. Accessed on December 23, 2022.

Linnenluecke, M. K., & Griffiths, A. (2012). Assessing organizational resilience to climate and weather extremes: complexities and methodological pathways. Climatic change, 113(3), 933-947.

Liu, C.-L., Shang, K.-C., Lirn, T.-C., Lai, K.-H., & Lun, Y. H. V. (2018). Supply chain resilience, firm performance, and management policies in the liner shipping industry. Transportation Research Part A: Policy and Practice, 110, 202–219.

Liu, D., Jiang, Y., Zhou, Q., & Yao, S. (2023). R&D investment management and ambidextrous technological innovation: Evidence from Chinese listed firms. International Review of Economics & Finance, 88, 843–860.

Liu, H., Wei, S., Ke, W., Wei, K. K., & Hua, Z. (2016). The configuration between supply chain integration and information technology competency: A resource orchestration perspective. Journal of Operations Management, 44(1), 13–29.

Liu, J., & Fan, B. (2023). What contributes to local-level institutional adaptation under climate change? A configurational approach based on evidence from China's Sponge City Program. Journal of Environmental Management, 342, 118292.

Liu, Q. (2023). Resilience in Chinese logistics: A post-COVID-19 analysis. Global Supply Chain Review, 12(2), 99-112.

Liu, Y., Dong, J., Mei, L., & Shen, R. (2023). Digital innovation and performance of manufacturing firms: An affordance perspective. Technovation, 119, 102458.

Llach, J., & Alonso-Almeida, M. del M. (2015). Integrating ICTs and Supply Chain Management:

The Case of Micro-Sized Firms: Integrating ICTs and Supply Chain Management. Human Factors and Ergonomics in Manufacturing & Service Industries, 25(4), 385–397.

Lu, H. T., Li, X., & Yuen, K. F. (2023). Digital transformation as an enabler of sustainability innovation and performance – Information processing and innovation ambidexterity perspectives. Technological Forecasting and Social Change, 196, 122860.

Lu, X., Shun Chan, F. K. S., Chen, W.-Q., Chan, H. K., & Gu, X. (2022). An overview of flood-induced transport disruptions on urban streets and roads in Chinese megacities: Lessons and future agendas. Journal of Environmental Management, 321, 115991.

Macdonald, J. R., Zobel, C. W., Melnyk, S. A., & Griffis, S. E. (2018). Supply chain risk and resilience: Theory building through structured experiments and simulation. International Journal of Production Research, 56(12), 4337–4355.

Maersk Financial Report, (2021). Maersk Q1 2021 Financial Report. https://investor.maersk.com/financials/financial-reports

Mandal, S. (2019). Exploring the influence of IT capabilities on agility and resilience in tourism: Moderating role of technology orientation. Journal of Hospitality and Tourism Technology, JHTT-01-2018-0001.

Mandal, S., & Saravanan, D. (2019). Exploring the influence of strategic orientations on tourism supply chain agility and resilience: an empirical investigation. Tourism Planning & Development, 16(6), 612–636.

Manuj, I., & Mentzer, J. T. (2008). Global supply chain risk management strategies. International Journal of Physical Distribution & Logistics Management, 38(3), 192–223.

March, J. G., & Olsen, J. P. (1983). The new institutionalism: Organizational factors in political life. American political science review, 78(3), 734-749.

Masa'deh, R., Al-Henzab, J., Tarhini, A., & Obeidat, B. Y. (2018). The associations among market orientation, technology orientation, entrepreneurial orientation and organizational performance. Benchmarking: An International Journal, 25(8), 3117–3142.

Maskey, R., Fei, J., & Nguyen, H.-O. (2018). Use of exploratory factor analysis in maritime research. The Asian Journal of Shipping and Logistics, 34(2), 91–111.

Mayring, P. (2014). Qualitative content analysis: theoretical foundation, basic procedures and software solution.

McCarthy, I. P., Collard, M., & Johnson, M. (2017). Adaptive organizational resilience: an evolutionary perspective. Current opinion in environmental sustainability, 28, 33-40.

McCarthy, S., Rowan, W., Kahma, N., Lynch, L., & Ertiö, T. P. (2022). Open e-learning platforms and the design–reality gap: An affordance theory perspective. Information Technology & People, 35(8), 74–98.

Melián-Alzola, L., Fernández-Monroy, M., & Hidalgo-Peñate, M. (2020). Hotels in contexts of uncertainty: Measuring organisational resilience. Tourism Management Perspectives, 36, 100747.

Metcalfe, J. S. (1998). Evolutionary economics and creative destruction (Vol. 1). Psychology Press.

Meyer, A. D. (1982). Adapting to environmental jolts. Administrative Science Quarterly, 27(4), 515-537.

Modgil, S., Gupta, S., Stekelorum, R., & Laguir, I. (2022). AI technologies and their impact on supply chain resilience during COVID-19. International Journal of Physical Distribution & Logistics Management, 52(2), 130–149.

Modgil, S., Singh, R. K., & Hannibal, C. (2021). Artificial intelligence for supply chain resilience: Learning from Covid-19. The International Journal of Logistics Management.

Moosmayer, O. Laasch, C. Parkes, & K. G. Brown (Eds.), The SAGE handbook of responsible management learning and education. London: SAGE.

Mora, L., Kummitha, R. K. R., & Esposito, G. (2021). Not everything is as it seems: Digital technology affordance, pandemic control, and the mediating role of sociomaterial arrangements. Government Information Quarterly, 38(4), 101599.

Morales, S. N., Martínez, L. R., Gómez, J. A. H., López, R. R., & Torres-Argüelles, V. (2019). Predictors of organizational resilience by factorial analysis. International Journal of Engineering Business Management, 11, 1847979019837046.

Mousa, M., Abdelgaffar, H. A., Chaouali, W., & Aboramadan, M. (2020). Organizational learning, organizational resilience and the mediating role of multi-stakeholder networks. Journal of Workplace Learning, 32 (3), 161-181.

Muñoz, P., Kimmitt, J., & Dimov, D. (2020). Packs, Troops and Herds: Prosocial Cooperatives and Innovation in the New Normal. Journal of Management Studies, 57(3), 470–504.

Murthy, R. K., & Madhok, A. (2021). Overcoming the Early-stage Conundrum of Digital Platform Ecosystem Emergence: A Problem-Solving Perspective. Journal of Management Studies, 58(7), 1899–1932.

Myers, M.D., 2020. Qualitative research in business and management. Sage Publications.

Nair, A., & Reed-Tsochas, F. (2019). Revisiting the complex adaptive systems paradigm: Leading perspectives for researching operations and supply chain management issues. (2019), 80-92

Nakandala, D., Yang, R., Lau, H., & Weerabahu, S. (2023). Industry 4.0 technology capabilities, resilience and incremental innovation in Australian manufacturing firms: A serial mediation model. Supply Chain Management: An International Journal, 28(4), 760–772.

National Meteorological Centre of China, (2021). Central Meteorological Observatory: The worst

typhoon “Fireworks” in the history of weather inventory. https://china.huanqiu.com/article/44B1GutAM1r. Accessed on April 9, 2023.

Ning, Y., Li, L., Xu, S. X., & Yang, S. (2022). How do digital technologies improve supply chain resilience in the COVID-19 pandemic? Evidence from Chinese manufacturing firms. Frontiers of Engineering Management.

Norman, G. (2010). Likert scales, levels of measurement and the “laws” of statistics. Advances in Health Sciences Education, 15(5), 625–632.

Noy, C. (2008). Sampling knowledge: The hermeneutics of snowball sampling in qualitative research. International Journal of social research methodology, 11(4), 327-344.

Nunnally, J. C. (1994). Psychometric theory 3E. Tata McGraw-hill education.

Oberländer, M., Beinicke, A., & Bipp, T. (2020). Digital competencies: A review of the literature and applications in the workplace. Computers & Education, 146, 103752.

Oh, L. B., & Teo, H. H. (2006). The impacts of information technology and managerial proactiveness in building net-enabled organizational resilience. In IFIP International Working Conference on the Transfer and Diffusion of Information Technology for OR (pp. 33-50). Springer, Boston, MA.

Pal, R., Torstensson, H., & Mattila, H. (2014). Antecedents of organizational resilience in economic crises—an empirical study of Swedish textile and clothing SMEs. International Journal of Production Economics, 147, 410-428.

Pappas, I. O., & Woodside, A. G. (2021). Fuzzy-set Qualitative Comparative Analysis (fsQCA): Guidelines for research practice in Information Systems and marketing. International Journal of Information Management, 58, 102310.

Parker, C., Scott, S., & Geddes, A. (2019). Snowball sampling. SAGE research methods

foundations.

Pathak, S., & Ahmad, M. M. (2016). Flood recovery capacities of the manufacturing SMEs from floods: A case study in Pathumthani province, Thailand. International Journal of Disaster Risk Reduction, 18, 197–205.

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

Pettit, T. J., Croxton, K. L., & 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

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903.

Ponomarov, S. Y., & Holcomb, M. C. (2009). Understanding the concept of supply chain resilience. The International Journal of Logistics Management, 20(1), 124–143. https://doi.org/10.1108/09574090910954873

Pozzi, G., Pigni, F., & Vitari, C. (2014). Affordance theory in the IS discipline: A review and synthesis of the literature. In AMCIS 2014 Proceedings.

Prayag, G., Chowdhury, M., Spector, S., & Orchiston, C. (2018). Organizational resilience and financial performance. Annals of Tourism Research, 73, 193–196.

Pregnolato, M., Ford, A., Wilkinson, S. M., & Dawson, R. J. (2017). The impact of flooding on road transport: A depth-disruption function. Transportation Research Part D: Transport and Environment, 55, 67–81.

Queiroz, M. M., Fosso Wamba, S., & Branski, R. M. (2021). Supply chain resilience during the

COVID-19: Empirical evidence from an emerging economy. Benchmarking: An International Journal.

Racela, O. C. (2014). Customer Orientation, Innovation Competencies, and Firm Performance: A Proposed Conceptual Model. Procedia - Social and Behavioral Sciences, 148, 16–23.

Racher, F. E., & Robinson, S. . (2003). Are phenomenology and post-positivism strange bedfellows?. Western Journal of Nursing Research, 25(5), 464-81; discussion 482-91.

Ragin, C. C. (2009). Redesigning social inquiry: Fuzzy sets and beyond. University of Chicago Press.

Ragin, C. C. (2014). The comparative method: Moving beyond qualitative and quantitative strategies. University of California Press.

Rajesh, R. (2016). Forecasting supply chain resilience performance using grey prediction. Electronic Commerce Research and Applications, 20, 42–58.

Ramanathan, U. (2021). The role of digital technologies in supply chain resilience for emerging markets' automotive sector. Supply Chain Management, 26(6), 18.

Rao, Y., Li, Q., Mao, X., & Wenyin, L. (2014). Sentiment topic models for social emotion mining. Information Sciences, 266, 90-100.

Rezazadeh, B., Karami, H., & Karami, A. (2016). Technology orientation, dynamic capabilities and SMEs performance. Strategic Management Quarterly, 4(1), 41-60.

Rihoux, B., & Ragin, C. C. (Eds.). (2009). Configurational comparative methods: Qualitative comparative analysis (QCA) and related techniques (Vol. 51). Sage.

Riolli, L., & Savicki, V. (2003). Information system organizational resilience. Omega, 31(3), 227-233.

Robb, C., Kang, M., & Stephens, A. (2022). The effects of dynamism, relational capital, and

ambidextrous innovation on the supply chain resilience of U.S. firms amid COVID-19. Operations and Supply Chain Management: An International Journal, 1–16.

Ruel, S., & El Baz, J. (2021). Disaster readiness' influence on the impact of supply chain resilience and robustness on firms' financial performance: A COVID-19 empirical investigation. International Journal of Production Research, 1–19.

Ruiz-Martin, C., López-Paredes, A., & Wainer, G. (2018). What we know and do not know about organizational resilience. International Journal of Production Management and Engineering, 6(1), 11-28.

Sá, M. M. de, Miguel, P. L. de S., Brito, R. P. de, & Pereira, S. C. F. (2019). Supply chain resilience: The whole is not the sum of the parts. International Journal of Operations & Production Management, 40(1), 92–115.

Sabahi, S., & Parast, M. M. (2020). Firm innovation and supply chain resilience: a dynamic capability perspective. International Journal of Logistics Research and Applications, 23(3), 254-269.

Sahebjamnia, N., Torabi, S. A., & Mansouri, S. A. (2015). Integrated business continuity and disaster recovery planning: Towards SCR. European Journal of Operational Research, 242(1), 261-273.

Saleh, R. H., Durugbo, C. M., & Almahamid, S. M. (2023). What makes innovation ambidexterity manageable: A systematic review, multi-level model and future challenges. Review of Managerial Science, 17(8), 3013–3056.

Saunders, M.N.K., Philip, L., Adrian, T., 2012. Research methods for business students. Pearson Education

Scala, B., & Lindsay, C. F. (2021). Supply chain resilience during pandemic disruption: Evidence

from healthcare. Supply Chain Management: An International Journal, 26(6), 672–688.

Schneider, C. Q., & Wagemann, C. (2012). Set-theoretic methods for the social sciences: A guide to qualitative comparative analysis. Cambridge University Press.

Scholten, K., Sharkey Scott, P., & Fynes, B. (2014). Mitigation processes – antecedents for building supply chain resilience. Supply Chain Management: An International Journal, 19(2), 211–228.

Schriber, S., Bauer, F., & King, D. R. (2019). Organizational resilience in acquisition integration—Organisational antecedents and contingency effects of flexibility and redundancy. Applied Psychology, 68(4), 759-796.

Scuotto, V., Arrigo, E., Candelo, E., & Nicotra, M. (2019). Ambidextrous innovation orientation effected by the digital transformation: A quantitative research on fashion SMEs. Business Process Management Journal, 26(5), 1121–1140.

Senbeto, D. L., & Hon, A. H. Y. (2020). Market turbulence and service innovation in hospitality: Examining the underlying mechanisms of employee and organizational resilience. The Service Industries Journal, 40(15–16), 1119–1139.

Sheffi, Y. (2015). The Power of Resilience: How the Best Companies Manage the Unexpected. MIT Press.

Shen, Z. M., & Sun, Y. (2021). Strengthening supply chain resilience during COVID-19: A case study of JD .com. Journal of Operations Management, joom.1161.

Shin, S. J., Kim, T. Y., Lee, J. Y., & Bian, L. (2012). Cognitive team diversity and individual team member creativity: A cross-level interaction. Academy of Management Journal, 55(1), 197-212.

Singh, N. P., & Singh, S. (2019). Building supply chain risk resilience: Role of big data analytics

in supply chain disruption mitigation. Benchmarking: An International Journal, 26(7), 2318–2342.

Sirmon, D. G., Hitt, M. A., & Ireland, R. D. (2007). Managing firm resources in dynamic environments to create value: Looking inside the black box. Academy of Management Review, 32(1), 273-292.

Sodhi, M. S., & Tang, C. S. (2014). Buttressing supply chains against floods in Asia for humanitarian relief and economic recovery. Production and operations management, 23(6), 938-950.

Song, M., Ma, X., Zhao, X., & Zhang, L. (2022). How to enhance supply chain resilience: A logistics approach. The International Journal of Logistics Management, 33(4), 1408–1436.

Spieske, A., & Birkel, H. (2021). Improving supply chain resilience through industry 4.0: A systematic literature review under the impressions of the COVID-19 pandemic. Computers & Industrial Engineering, 158, 107452.

Srinivasan, R., & Swink, M. (2018). An Investigation of Visibility and Flexibility as Complements to Supply Chain Analytics: An Organizational Information Processing Theory Perspective. Production and Operations Management, 27(10), 1849–1867.

St John, J., & Neesham, C. (2020). Paradigms in responsible management learning and education research. In D. C.

State Council Office of the People's Republic of China. (2022). Modern logistics development plan of the 14th five-year plan. https://www.gov.cn/zhengce/content/2022-12/15/content_5732092.htm Accessed on December 14, 2022.

Sternberg, H., Linan, I., Prockl, G., & Norrman, A. (2022). Tragedy of the facilitated commons: A multiple-case study of failure in systematic horizontal logistics collaboration. Journal of

Supply Chain Management, 58(4), 30–57.

Stroe, S., Parida, V., & Wincent, J. (2018). Effectuation or causation: An fsQCA analysis of entrepreneurial passion, risk perception, and self-efficacy. Journal of Business Research, 89, 265-272.

Strong, D., Volkoff, O., Simon Fraser University, Johnson, S. (2014). A Theory of Organization-EHR Affordance Actualization. Journal of the Association for Information Systems, 15(2), 53–85.

Studer, R, Benjamins, V. R., Fensel, D. (1998). Knowledge engineering: principles and methods. Data & Knowledge Engineering, 25(1-2):161-197.

Sutcliffe K and Vogus J. (2003). Organizing for resilience. In: Cameron JDKS(ed) Positive organizational scholarship: foundations of a new discipline. San Francisco: Island Press, 2003, pp.94-110.

Taghizadeh, E., & Taghizadeh, E. (2021). The impact of digital technology and industry 4.0 on enhancing supply chain resilience. In Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management Singapore (pp. 2021-2029).

Tang, C. S. (2018). Perspectives in supply chain risk management. International Journal of Production Economics, 201, 38-50.

Tate, W. L., Ellram, L. M., & Kirchoff, J. F. (2010). Corporate social responsibility reports: a thematic analysis related to supply chain management: Corporate Social Responsibility Reports. Journal of Supply Chain Management, 46(1), 19–44.

Taylor, K. M., & Rosca, E. (2023). Sink, swim, or drift: How social enterprises use supply chain social capital to balance tensions between impact and viability. Journal of Supply Chain

Management, 59(2), 62–86.

Teece, D. J. (2007). Explicating dynamic capabilities: The nature and micro foundations of (sustainable) enterprise performance. Strategic Management Journal, 28(13), 1319-1350.

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

Teo, W. L., Lee, M., & Lim, W. S. (2017). The relational activation of resilience model: How leadership activates resilience in an organizational crisis. Journal of Contingencies and Crisis Management, 25(3), 136-147.

The National Severe Storms Laboratory of USA. (2020). https://www.nssl.noaa.gov/education/svrwx101/floods/. Accessed on December 14, 2022.

The People's Government of Zhejiang Province, (2023). Flood prevention and typhoon prevention. https://www.zj.gov.cn/col/col1229415712/. Accessed on April 9, 2023.

The United Nations Office for Disaster Risk Reduction. (2020). Human cost of disasters: An overview of the last 20 years 2000-2019. Page 7-16.

The United States Environmental Protection Agency. (2014). https://www.nssl.noaa.gov/education/svrwx101/floods/. Accessed on December 14, 2022.

Tohidi, H., & Jabbari, M. M. (2012). Innovation as a success key for organizations. Procedia Technology, 1, 560-564.

Trkman, P., & McCormack, K. (2009). Supply chain risk in turbulent environments—A conceptual model for managing supply chain network risk. International Journal of Production Economics, 119(2), 247–258.

Tsai, F.-S. (2016). Knowing what we know differently: Knowledge heterogeneity and dynamically ambidextrous innovation. Journal of Organizational Change Management, 29(7), 1162-1188.

Tsiapa, M., & Batsiolas, I. (2019). Firm resilience in regions of Eastern Europe during the period 2007–2011. Post-Communist Economies, 31(1), 19-35.

Umoh, G. I., Amah, E., & Wokocha, H. I. (2014). Management development and organizational resilience: A case study of some selected manufacturing firms in Rivers State, Nigeria. IOSR Journal of Business and Management (IOSR-JBM), 16(2), 7-16.

Verbeke, A., Ciravegna, L., Lopez, L. E., & Kundu, S. K. (2019). Five Configurations of Opportunism in International Market Entry. Journal of Management Studies, 56(7), 1287–1313.

Vishnu, C. R., & Sridharan, R. (2016). A case study on impact of Chennai floods: supply chain perspective. Industrial Engineering Journal, 9(8), 12-16.

Vogus, T. J., & Sutcliffe, K. M. (2007, October). Organizational resilience: towards a theory and research agenda. In 2007 IEEE International Conference on Systems, Man and Cybernetics (pp. 3418-3422). IEEE.

Volkoff, O., & Strong, D. M. (2017). Affordance theory and how to use it in IS research. In R. D. Galliers & M.-K. Stein (Eds.), The Routledge Companion to Management Information Systems (1st ed., pp. 232–245). Routledge.

Walker, B., & Salt, D. (2012). Resilience thinking: sustaining ecosystems and people in a changing world. Island press.

Walsham, G. (1995). The emergence of interpretivism in IS research. Information Systems Research, 6(4), 376-394.

Walsham, G. (2006). Doing interpretive research. European Journal of Information Systems, 15(3), 320–330. https://doi.org/10.1057/palgrave.ejis.3000589

Wang, F. (2021). The burgeoning logistics market in China: Drivers and implications. International

Journal of Logistics Research, 34(1), 12-29.

Wang, H., Wang, J., & Tang, Q. (2018). A Review of Application of Affordance Theory in Information Systems. Journal of Service Science and Management, 11(01), 56–70. https://doi.org/10.4236/jssm.2018.111006

Wang, J. J., & Xiao, Z. (2015). Co-evolution between etailing and parcel express industry and its geographical imprints: The case of China. Journal of Transport Geography, 46, 20–34. https://doi.org/10.1016/j.jtrangeo.2015.05.005

Wang, W., Yang, J., Huang, L., Proverbs, D., & Wei, J. (2019). Intelligent Storage Location Allocation with Multiple Objectives for Flood Control Materials. Water, 11(8), 1537.

Weber, R. P. (1990). Basic content analysis (No. 49). Sage.

Weideman, A. . (2012). Positivism and Postpositivism. The Encyclopedia of Applied Linguistics. Blackwell Publishing Ltd.

White, L., Lockett, A., Currie, G., & Hayton, J. (2021). Hybrid Context, Management Practices and Organizational Performance: A Configurational Approach. Journal of Management Studies, 58(3), 718–748.

Whitman, Z., Stevenson, J., Kachali, H., Seville, E., Vargo, J., & Wilson, T. (2014). Organizational resilience following the Darfield earthquake of 2010. Disasters, 38(1), 148-177.

Williams, T. A., Gruber, D. A., Sutcliffe, K. M., Shepherd, D. A., & Zhao, E. Y. (2017). Organizational response to adversity: Fusing crisis management and resilience research streams. Academy of Management Annals, 11(2), 733-769.

Wisetjindawat, W., Burke, M. I., & Fujita, M. (2017). Analysing impacts of natural disasters on logistics activities: Flood risks and petroleum fuels in Queensland, Australia. Transportation Research Procedia, 25, 1198–1212.

Wright, B. D., & Stone, M. H. (1979). Best test design as a multistage process. Journal of Educational Measurement, 16(1), 3-11.

Wright, C., Kiparoglou, V., Williams, M., & Hilton, J. (2012). A framework for resilience thinking. Procedia Computer Science, 8, 45-52.

Xia, Y., Chan, H. K., Zhong, L., & Xu, S. (2022). Enhancing hotel knowledge management: the influencing factors of online hotel reviews on travellers' booking intention. Knowledge Management Research & Practice, 20(1), 34-45.

Xiang, K., Zhang, H., & Qiao, G. (2022). How to create interactive rituals: Key factors and strategic configurations for host-guest interaction in boutique hotels. Journal of Hospitality and Tourism Management, 52, 428–438.

Xu, Z., Elomri, A., Kerbache, L., & El Omri, A. (2020). Impacts of COVID-19 on Global Supply Chains: Facts and Perspectives. IEEE Engineering Management Review, 48(3), 153–166.

Yao, L., Shen, J., Zhang, F., Gu, X., & Jiang, S. (2021). Influence of Environmental Values on the Typhoon Risk Perceptions of High School Students: A Case Study in Ningbo, China. Sustainability, 13(8), 4145.

Yaroson, E. V., Breen, L., Hou, J., & Sowter, J. (2021). Advancing the understanding of pharmaceutical supply chain resilience using complex adaptive system (CAS) theory. Supply Chain Management: An International Journal, 26(3), 323-340.

Ye, D., Liu, M. J., Luo, J., & Yannopoulou, N. (2024). How to Achieve Swift Resilience: The Role of Digital Innovation Enabled Mindfulness. Information Systems Frontiers, 26(2), 551–573.

Yu, W., Jacobs, M. A., Chavez, R., & Yang, J. (2019). Dynamism, disruption orientation, and resilience in the supply chain and the impacts on financial performance: A dynamic capabilities perspective. International Journal of Production Economics, 218, 352–362.

Zeng, F., Chan, H. K., & Pawar, K. (2021). The effects of inter-and intraorganizational factors on the adoption of electronic booking systems in the maritime supply chain. International Journal of Production Economics, 236, 108119.

Zhang, H., Wu, F., & Cui, A. S. (2015). Balancing market exploration and market exploitation in product innovation: A contingency perspective. International Journal of Research in Marketing, 32(3), 297–308.

Zhang, Y., & Li, J. (2020). Technological advancements in Chinese logistics: Trends and impacts. Asian Journal of Technology and Innovation, 5(4), 211-230.

Zhejiang Logistics Association, (2023). Enterprise list of logistics industry. https://www.zjwlcg.org/EvaluationCriteria1/index.jhtml. Accessed on April 9, 2023.

Zhejiang Provincial Development and Reform Commission, (2021). Notice of the Provincial Development and Reform Commission on Printing and Distributing the "14th Five-Year Plan for the Development of Modern Logistics Industry in Zhejiang Province". https://www.zj.gov.cn/art/2021/6/24/art_1229540815_4671278.html. Accessed on April 9, 2023.

Zhou, J., Hu, L., Yu, Y., Zhang, J. Z., & Zheng, L. J. (2022). Impacts of IT capability and supply chain collaboration on supply chain resilience: Empirical evidence from China in COVID-19 pandemic. Journal of Enterprise Information Management.

Appendix A: Interview guide of study one

1. Introduction
   1.1 Research motivation and objectives

   1.2 Confidentiality, research consent, and permission for recording

2. General background information

Interviewee's role and responsibility within the firm, years of experience, areas of expertise, position, education level

3. Company information

Firm size, years in existence, critical services provided, organisational structure and operation mode.

4. Interview questions

4.1 Broad impact of the disruptive events on logistics firms

- What are the significant challenges your company has faced over the past few years?

- How did your firm cope with these disruptions and challenges?

4.2 Supply chain resilience

- What is the supply chain resilience of a logistics firm?

- What are your firm's supply chain resilience goals?

4.3 Digital affordance and supply chain resilience

- What kind of digital techniques does your firm adopt or apply? Do these techniques help your firm develop supply chain resilience? Why? And how do they help?

- What resources have allowed you to accomplish and develop supply chain resilience when you apply digital techniques?

- What digital techniques and potential possibilities have driven you to accomplish and develop supply chain resilience?

- What digital actions have been taken by your firm to strengthen supply chain resilience to disruptive events?

- How do these actions help your firm build or develop resilience? Have you been successful?

- What challenges do you think exist when your firm develops supply chain resilience in the current situation?

5. End of interview

- Is there anything else you would like to tell me?

- Could you recommend other suitable logistics firms for us to interview?

Thanks for your interview and for providing insights for us.

Appendix B. Code structure of study one

Code	Subdimension	Representative quotes (firm numbers)
Supply chain resilience goals	Stability	· A logistics company with SCR means that its work and business will not be interrupted by disruptions, and logistics activities are stable (C and F).
	Continuity	· SCR means that our company can continue to operate in a crisis event (A, C, G, J, and M). · Our company's SCR goal is to continue to meet customer needs in the face of supply chain disruptions (E and K).
	Opportunity creation	· SCR's goal for our logistics companies is to find business opportunities in the crisis, transform the negative impact of the disruption, and not only solve the crisis (H and J). · Although our transportation capacity was limited during the epidemic, we further developed a cold chain and intra-city distribution business, which helped us improve our resilience and performance (A and I).
Digital affordances	Flexibility	· Through the big data routing and electronic face-to-face list system, we can flexibly design, optimise and adjust the routing and transportation capacity to meet the stable growth and temporary fluctuation needs of express business, which helps effectively solve the mismatch between point-to-point transportation volume and transportation capacity between cities (J and M). · We can quickly change the original organisational structure to cope with supply chain disruptions and build

	SCR (C, G, and K). · We also used a technology called “cloud warehouse.” This is like having an infinitely expanded virtual warehouse, and the storage space can be automatically adjusted according to the amount of goods. Cloud warehouses can quickly develop and provide sufficient space when a large amount of goods need to be stored. The cloud warehouse can automatically shrink after the goods are transported away, saving costs. This flexibility allows us to meet various needs and enhances our resilience (K).
Agility	· Our company also uses “cloud computing” technology. Through cloud computing, we can view the location of goods in real time, track transportation status, and even predict potential issues. In this way, even in the event of traffic congestion or extreme weather, the company can quickly adjust transportation plans to ensure that goods arrive at their destination on time, which enhances our adaptability and resilience (E and L). · We develop emergency plans and management teams to ensure business continuity, enabling us to respond to supply chain disruptions with SCR (B, C, G, K, and N). · We used big data analysis to help make decisions. By analysing historical data, future transportation trends can be predicted, such as which routes may be busier and which periods may have more goods to transport. In this way, we can prepare in advance, optimise resource

		allocation, and improve transportation efficiency (C).
	Diversity	· Our company conducts differentiated business to help us have SCR and enhance competitiveness during the pandemic (D, F, and N). · We gradually improved the digital matching system of large express delivery, which makes it achieve a continuous decline in cargo damage rate and the leading transportation quality in the logistics industry (N). · We have explored personalised needs in multiple scenarios and enhanced service diversity, which helps us meet customer needs even if traditional business is hindered. This is immensely helpful for improving SCR (L and J).
	Visibility	· Our digital platform refined the data visualisation of receiving and dispatching service quality for SCR (A, G, H, K and N). · We can promptly check customers' information trends using visual technologies (A, I, K, M). · The control tower can monitor all information in real time, and if it detects any anomalies, such as a delay in goods or a change in the transportation route, it promptly alerts the company to take appropriate actions, thereby enhancing our resilience to supply chain disruptions (I).
Affordance existence	Logistic infrastructure	· Our company utilises the Internet of Things and 5G technology to enable real-time communication between devices, jointly improving the resilience and reliability of logistics infrastructure (J). · Unmanned devices can operate in harsh weather or

		unsafe environments, ensuring the continuity of our logistics operations. Our company can quickly reconfigure unmanned equipment to adapt to market demand changes and improve logistics transportation networks' flexibility and resilience (F).
	Human capital	· We optimised staffing needs with machine learning and big data analytics to develop SCR (A-D, G, J and K). · We improved human efficiency to develop SCR (A-F, H-K, and N). · AR and VR technologies are used to train and simulate complex logistics operations and improve our employee operational skills, which enhance our SCR (A, C, D, H)
	Collaboration network	· We have developed smart contracts using blockchain technology. The automatic execution of intelligent contracts reduces human errors and trust costs, providing a fair and efficient cooperation platform for all parties involved in our cooperation. This enhances our collaboration network's resilience and risk resistance (D). · Our company has directly signed agreements with more than 5350 network partners. When a crisis event occurs, such as an epidemic outbreak, vehicles are restricted, and business is challenging to develop. We will find long-term partners to help us maintain business stability and continue our transportation services (A).
Affordance actualisation	Resources configuration	· Our company optimises and adjusts the route and transport capacity through the big route and electronic bill platform to meet express business's stable growth and

	temporary fluctuation demand (E, H, and J). · We have reduced drivers 'pick up' time from three to four days to a few hours or even minutes by matching vehicles and goods online with big data analytics (C and I).
Process optimisation	· We utilised digital technologies to optimise and upgrade business processes and achieve SCR. This dramatically ensures our company's SCR by improving efficiency and reducing costs (D and G). · We used digital technology to achieve device interconnection and automatic data collection. By analysing the data, we can promptly identify potential problems, such as reducing vehicle congestion and changing route planning, thereby improving transportation process efficiency and achieving SCR under limited conditions (A, B, D and I).
Service modularisation	· Services modularisation improves the reuse rate of the digital platform and effectively helps us organise and coordinate complementary products and services through appropriate platform operation modes and governance structure, thus creating new business growth and developing SCR (D and L). · Through digital twins, our company can simulate actual logistics scenarios in a virtual environment, test different combinations of service modules, and see which is most effective. In this way, when problems arise in the real world, we have prepared solutions in advance, greatly enhancing resilience (K).

Information sharing	· Our employees exchange and share logistics information on the platform. Then, we visually analyse the data and information in logistics services and effectively use the information to improve SCR and efficiency (B, C, D and H). · Digital platform Z refines the data visualisation of receiving and dispatching/service quality based on the Angle of Arrival (AOA) map (C, E, G and H).
Customer connection	· We tapped the needs of existing customers and developed high-quality potential customers by applying digital platforms and AI to increase the volume of contract logistics business and operating revenue (D, G, and N). · We have developed a Customer Relationship Management (CRM) system to remember the preferences and needs of each customer. When customers use our logistics services again, we can provide personalised services, such as recommending additional services that customers may be interested in or prioritising orders based on urgency. This personalised experience has improved customer satisfaction, allowing us to continue our business well during crises (A, B, and G).