University of Glasgow

Reframing Disruption: A Contingency and Resource Dependence Perspective on the New Disruption and Automotive Supply Chain Resilience

By

Weiyuan Li

Submitted in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

Adam Smith Business School

College of Social Sciences

University of Glasgow

December 2024

ABSTRACT

The global spread of the COVID-19 has had a profound impact on the global supply chain, prompting a rethink of the research agenda on supply chain resilience (SCRES). The current research on disruption and resilience-related topics has been revealed to be inadequate in defining and addressing this unprecedented disruption. Furthermore, its considerable impact has rendered preceding strategies for addressing SCRES ineffective, resulting in prolonged recovery periods for the supply chain. Nevertheless, there is a paucity of research that has identified specific and clear strategies for addressing similar scenarios in the future, particularly within the manufacturing sector. Consequently, this research aims to gain a comprehensive understanding of this New Disruption by extending the existing research on supply chain disruption (SCD), and seeks to identify appropriate recovery strategies to enhance SCRES in the event of potential risks in the future. This research has successfully established a framework combining contingency theory and resource dependency theory, conceptualising the disruptive event as the New Disruption, and developed a clear definition that extends the boundary of SCD.

In order to gain insight into the manufacturing supply chain, this research employed a qualitative approach, collecting data through focus groups and interviews with practitioners from organisations occupying various roles in China's automotive supply chain. Thematic analysis and Interpretive Structural Modelling revealed additional challenges unique to this New Disruption in the manufacturing sector, which were not identified in the literature on the effects of the COVID-19 pandemic. The empirical findings elucidated the manner in which this New Disruption impacted the automotive supply chain from the outset of the lockdown period, gradually permeating the supply chain and amplifying its destructive effects, thus exerting a long-term impact until the recovery stage. In terms of recovery, this research emphasised the importance of collaborative efforts among supply chain partners in facilitating the swift recuperation of the supply chain from disruptions. This may be achieved through the sharing of information, resources, and adjustments to enhance the SCRES in face of exogenous threats. Although the concept of information and resource sharing has been previously discussed in the literature, the results provided a detailed account of its practical application. Additionally, the collaborative approach to adjustments represents a more specific method of action following the sharing of information and resources. In this context, the results also offered practical recommendations for organisations to address comparable disruptions in the future.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENT

No words can express my gratitude for my parents Mr Jun Li and Ms Wenru Zhang, and my principal supervisor Prof. Ming Lim. Besides I would like to thank my second supervisor Dr James Wilson for his contribution to my work.

I extend my appreciation to all my friends who helped me establish connections with organisations and who volunteered to assume the moderator role. The data collection period could not be so smooth without their help.

I am indebted to Dr Scott Hurrell who provided invaluable support during the challenging period in my first year. It was because of his kind help as well as assistance from the administrative team that I was able to continue my PhD journey.

AUTHORS DECLARATION

"I declare that, except where explicit reference is made to the contribution of others, that this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution."

Printed Name: WEIYUAN LI

Signature: _____

1 INTRODUCTION

1.1 Introduction

The COVID-19 pandemic has made a significant impact on economies, societies and communities. According to a study conducted by UK Research and Innovation (2024), the pandemic has affected individuals, families and societies on health, social, economic and behavioural change, both in short and long term. It highlights the mental health issues following community-wide periods of social isolation. At the same time, The British Academy (2021) also emphasises the long-term social impacts of COVID-19. Problems like increasing levels of debt, risks of unemployment, failing business and significant shifts in the structure of economy may rise and worsen for the foreseeable future. And these may further lead to unstable level of trust in governance and social security issues.

From the perspective of research, this kind of disruption is new to the area of supply chain disruption (SCD) and has drawn attention to the topic of supply chain resilience (SCRES) in recent years. However, research so far has not systematically studied the mechanism of this disruption, and had limited focus on certain supply chains. As one of the most important pillars of economy, the manufacturing sector has faced many problems during and after the pandemic, while received less focus from academia compared with medical and food supply chains. Therefore, this thesis aims to extend the concept of SCD by investigating in detail the characteristics of this unprecedented disruption and its impact on the manufacturing supply chain. Meanwhile, it complements recovery strategies for organisations to improve SCRES efficiently, and get prepared for potential risks in the future.

This chapter begins with an introduction to the background relevant to this study in Section 1.2. Subsequently, Section 1.3 introduces the motivation for this study, i.e. gaps found in current literature. Section 1.4 accordingly presents the research objectives and research questions of this research. The chapter concludes with a discussion of how this research contributes to the existing body of knowledge and the practical industry in section 1.4 and the structure of the thesis in section 1.5.

1.2 Research Background

1.2.1 The New Disruption raised by COVID-19

Considering the recent disruptive events to the supply chains, the impact of the COVID-19 pandemic on supply chains is notably distinct from other disruptions. Global supply chains

are disrupted by delays and terminations in international logistics and labour shortages (Trautrims et al., 2020; Xu et al., 2020). The global spread of coronaviruses has caused disruptions in the production of materials and products (e.g. China was forced to stop production and the global supply of items declined), logistical delays and barriers resulting in market demand not being met, increased risk of organisational bankruptcy, and unstable demand, among other effects (Cai and Luo, 2020). Worryingly, automotive and medical manufacturers have also been affected by the closure of production facilities in COVID-19-affected areas (e.g., travel restrictions and a lack of supply of parts forced Volkswagen to shut down its car production facility in China). In addition, when the virus spread globally in earlier months, many supply chains were harmed, people were blocked and quarantined, and most important sectors of the economy were partially or completely shut down (Xu et al., 2020). Production and logistics activities have been halted or delayed as a result of the strict embargoes and restrictions imposed on producers and retailers, which has affected the demand and supply of a wide range of commodities (Singh et al., 2021).

At the demand level, the issue raised is the viability of supply chains due to the severe skewing of supply and demand, and the threat of bankruptcy (Ivanov, 2020). For example, demand for products related to the prevention of coronaviruses (e.g. PPE and respirators) has risen sharply, while demand for some high-tech products has declined. As global pandemics hit communities, the challenges faced by producers in facing high demand for the most important items (e.g., toilet paper, masks, disinfectant sprays, hand sanitisers, etc.) were significantly disrupted (Paul and Chowdhury, 2020; Ivanov, 2020). Similarly, food processing organisations have been affected by the surge in demand for food (Luckstead et al., 2020). On the other hand, the impact has been extended due to the closure of borders, which has led to a significant disruption in the demand for air travel. In addition, the demand for smartphones and petroleum-fuelled cars also declined (Cai and Luo, 2020).

Conversely, the supply side has also been affected, with a significant drop in raw materials and limitations on production capacity. Considering the health concerns posed by COVID-19, the government has called for limits on the social distance of populations and the collection of medical supplies (e.g., ventilators), selecting the right suppliers to provide the missing supplies has been a challenge, mainly in global supply chains where these alliances have shown vulnerability and lack of resilience (Fonseca and Azevedo, 2020).The COVID-19 mitigation policies have exposed supply chains to suboptimal supply (Trautrims et al., 2020).

All the phenomena point to the conclusion that this disruption induced by COVID-19 is an unparalleled instance of SCD. The extensive and enduring negative impact on global supply chains, compounded by varying regional response policies, has created significant challenges that current literature has not fully addressed. On the one hand, the most recent global pandemic dates back to SARS in 2002. At that time, global supply chains were still in their nascent stage, and many supply chains had not yet expanded their scope globally and suffered limited impacts (Tan and Enderwick, 2006). According to WTO Statistics, before the COVID-19 outbreak, total global merchandise exports in 2019 exceeded 19 trillion US dollars, three times the level before SARS emerged in 2002 (WTO, 2022). Moreover, medical treatment has been found in a relatively short period of time, effectively controlling the spread of the virus (Liu et al., 2020). Therefore, research on the challenges faced by supply chains in this regard cannot be applied to the current situation. On the other hand, many existing studies on SCD use the 2011 Japan earthquake and subsequent tsunami as a case study (Park et al., 2013). While this natural disaster also created some challenges for supply chains, especially in the automotive and semiconductor industries, it was a regional event with limited global impact (Kumar and Havey, 2013). More interestingly, some of the conclusions drawn in those studies, such as global sourcing and production, were widely discussed in the study of disruptions caused by the pandemic. Compared with those in the literature, this disruption is unique in that it affected global supply chains for a protracted period, and in the process engendered new situations that directly or indirectly impeded the recovery of supply chains (Guan et al., 2020). Therefore, it is necessary to conceptualise this type of disruption as the New Disruption, for extending the research on SCD and lying a foundation for future research.

1.2.2 The global operation of automotive supply chains

The global operation of the automotive supply chain (ASC) is a multifaceted and dynamic process that has evolved significantly over the years due to globalisation, technological advancements, and changing market demands. The automotive industry, being a crucial pillar of the global economy, relies heavily on an intricate network of suppliers and manufacturers spread across various regions, making it deeply integrated into the global industrial supply chain. The effective operational management of the automotive industry involves complex demand forecasting, lean manufacturing techniques such as just-in-time production, and robust supplier relationship management to maintain low inventory levels and ensure high product quality (Ivanov et al., 2021). The automotive industry also serves

as a pioneer in adopting modern technologies and management strategies, utilising information and communication technology to establish efficient logistics systems characterised by modular production, thereby facilitating the effective flow of information (Vasiliki and Apostolos, 2022). Strategic objectives within the ASC include international procurement and leveraging cross-docking platforms to connect assembly plants with suppliers (Serrano et al., 2021). This optimisation aims to minimise costs and enhance efficiency in distribution.

The global operation of the automotive supply chain has been significantly impacted by the New Disruption. Manufacturing has been particularly affected, with the resultant production bottlenecks having a ripple effect on other industries and countries, leading to a decline in demand for intermediate inputs and a reduction in the supply of intermediate products (Okuyama and Sahin, 2009). The pandemic has exposed the vulnerability of supply chains, especially in the automotive industry, due to shortages of raw materials, transportation problems, labour availability and demand fluctuations, leading to severe disruptions (Eldem et al., 2022). This highlights the necessity of adopting flexible and sustainable supply chain management practices, including developing recovery plans and best practices to mitigate such disruptions. Globalisation and outsourcing have further complicated supply chains, as manufacturers often rely on overseas suppliers, whose capabilities may be adversely affected by events such as the pandemic and geopolitical tensions (Arto et al., 2015).

This requires strategic decisions to be made on whether to continue working with these suppliers or to shift to localised procurement. Empirical analysis and computational experiments have shown that regionalisation of supplier selection practices can significantly enhance the robustness of the supply chain network (Jin et al., 2023). The increasing globalisation and specialisation of supply chains have led to competition between global supply chains rather than individual companies, highlighting the importance of efficient supply chain management in mitigating disruptions and other issues (Ullrich, 2014). Therefore, the global operation of the automotive supply chain requires a combination of resilience, technological progress, strategic procurement, sustainability, and efficient management practices to address the complexity of the modern global economy.

1.3 Research Motivation

With the worldwide spread of COVID-19, the supply chains are massively impacted at both local and global levels, putting pressure on most countries' critical infrastructures (Ahlqvist

et al., 2020). Not only the global movement of goods is affected but also the local production and the demand are affected. This has led to massive disturbances at various stages of the supply chain. A large number of works have already been published in the area of SCD and SCRES in the last two decades. But the question is, are the theories, principles, and strategies to mitigate supply chain disruptions still valid to tackle the current massive disruptions? Is there something different that supply chain players need to develop to deal with the current disruptions?

Research on SCD has focused on several aspects, such as proactive approaches to SCD (Li and Barnes, 2008; Knemeyer et al., 2009; Trkman and McCormack, 2009; Wakolbinger and Cruz, 2011) and mitigation strategies for supply chain disruptions (Zsidisin et al., 2005; Tang, 2006; Tomlin, 2006; Craighead et al., 2007; Yang and Yang, 2010). However, to date, research to identify or investigate supply chain network-wide disruptions (i.e. assessing all disruptions in various regions of the supply chain simultaneously) has been limited (Greening and Rutherford, 2011; Baryannis et al., 2019). Structural dynamics caused by disruptions similar to the New Disruption can lead to ripple effect in supply chains (Ivanov et al., 2017; Bier et al., 2020; Duong and Chong, 2020; Xu et al., 2020), and this ripple effect is exacerbated by supply chain complexity (Birkie and Trucco, 2020), such as the bullwhip effect that never occurred in manufacturing sector due to the response to the New Disruption (Handfield et al., 2020). Given that most studies in this area have investigated disruptions in each area/function of the supply chain in isolation (Ho et al., 2015; Snyder et al., 2016), it remains unclear how the New Disruption has propagated within the system, and how the ripple effect impacts or disrupts the overall supply chain structure, such as the constraints on production capacity, labour and logistics due to the uncertainty of regional anti-epidemic policies. Similarly, disruption strategies are developed by considering disruptions in only one area of the supply chain (Paul et al., 2015; Duong and Chong, 2020). As a result, companies use different strategies to manage supply, demand, and production during major disruptions (Tang, 2006; Tang and Nurmaya Musa, 2011). From a practical perspective, existing strategies are insufficient to help businesses through this crisis, and some established plans do not fully apply in the face of the New Disruptions (Van Hoek, 2020).

It is also worth mentioning that, a common observation in literature review articles is that quantitative modelling approaches have been more popular among research on SCD

(Baryannis et al., 2019； Birkie and Trucco, 2020； Duong and Chong, 2020； Chowdhury et al., 2021). These models are used for a wide variety of purposes, such as assessing disruptions, making strategic decisions under outages, and evaluating various disruption management strategies including recovery strategies. However, most of these studies consider single disruptions, i.e. they only focus problems on supply, demand, production or transportation when designing recovery models, rather than multiple disruptions like the New Disruption (Paul et al., 2021). The remaining qualitative research mainly provides some frameworks and concepts to assist the implementation of SCRES strategies (Bier et al., 2020). Studies including proposing drivers of vulnerability (Peck, 2005； Keow Cheng and Hon Kam, 2008) and presenting risk management approaches (Hallikas et al., 2004； Faisal et al., 2006； Greening and Rutherford, 2011； Hittle and Moustafa Leonard, 2011) are aimed at a certain node in the supply chain, and there is a gap on effective response methods when the entire supply chain is at risk or disrupted. Although some papers mention that risks are shared in supply chain collaboration, it is still at the conceptual level, lacking a complete framework and specific solutions for supply networks.

As for research published since the pandemic outbreak, most authors presented conceptual works, for example ‘lean resilience’ proposed by Ivanov and Dolgui (2021) where assets deployed to mitigate disruptions are actively used to generate values. A reason for that not much modelling and empirical research has been reported could be the issue is still in the early stage (Pujawan and Bah, 2021). That is to say, although several articles have been published since the start of the COVID-19 pandemic, systematic, methodologically sound, and theoretically grounded research remains scarce (Chowdhury et al., 2021).

So, what could be learned from current literature is that suggestions for dealing with the New Disruption are very limited (Sombultawee et al., 2022). Thus, an opportunity exists for further research into the investigation of the New Disruption and development of better strategies for improving SCRES against pandemic risks or other systemic risks that have not yet been anticipated. This research is going to find an optimal strategy for each specific challenge brought by the New Disruption at different stages of the pandemic. In other words, it tries to explore new tools, strategies, and approaches to promote SCRES for organisations both in the short term and in the long term. And, compared to earlier general and conceptual research on SCRES, this research could influence ongoing supply chain decisions and redesigns more specifically. Therefore, another potential contribution of this study lies in bridging the gap between research findings and industrial practice, which would not only

reduce the need for supply chain managers to learn the lessons from literature, but also contribute to reducing structural risks of the supply chain.

1.4 Research Aim and Research Questions

This study aims to take a holistic view of the challenges posed by the New Disruption to supply chain recovery. Current literature focuses primarily on identifying and investigating the impacts of pandemics (Chowdhury et al., 2021), but few studies aim to explore recovery issues and assess potential difficulties. Recovery challenges are likely to be common across a range of possible global crises, and many of the challenges posed by pandemics such as COVID-19 have clear risks. In addition, the crisis is likely to be a very long-term issue requiring effective post-crisis recovery strategies (Brandon-Jones et al., 2014; Cheng and Lu, 2017).

To fulfil the aim, this research is going to answer the following questions:

Research Question 1 *What is the unique nature of the challenges presented by the New Disruption to the automotive supply chain when compared to previous disruptions and other industries?*

Research Question 2 *What recovery strategies could be applied to tackle those challenges?*

Research Question 3 *How could ASC organisations improve SCRES in terms of dealing with similar disruptions in the future?*

1.5 Layout of the Thesis

The chapters of the thesis are organised as shown in Figure 1-1.

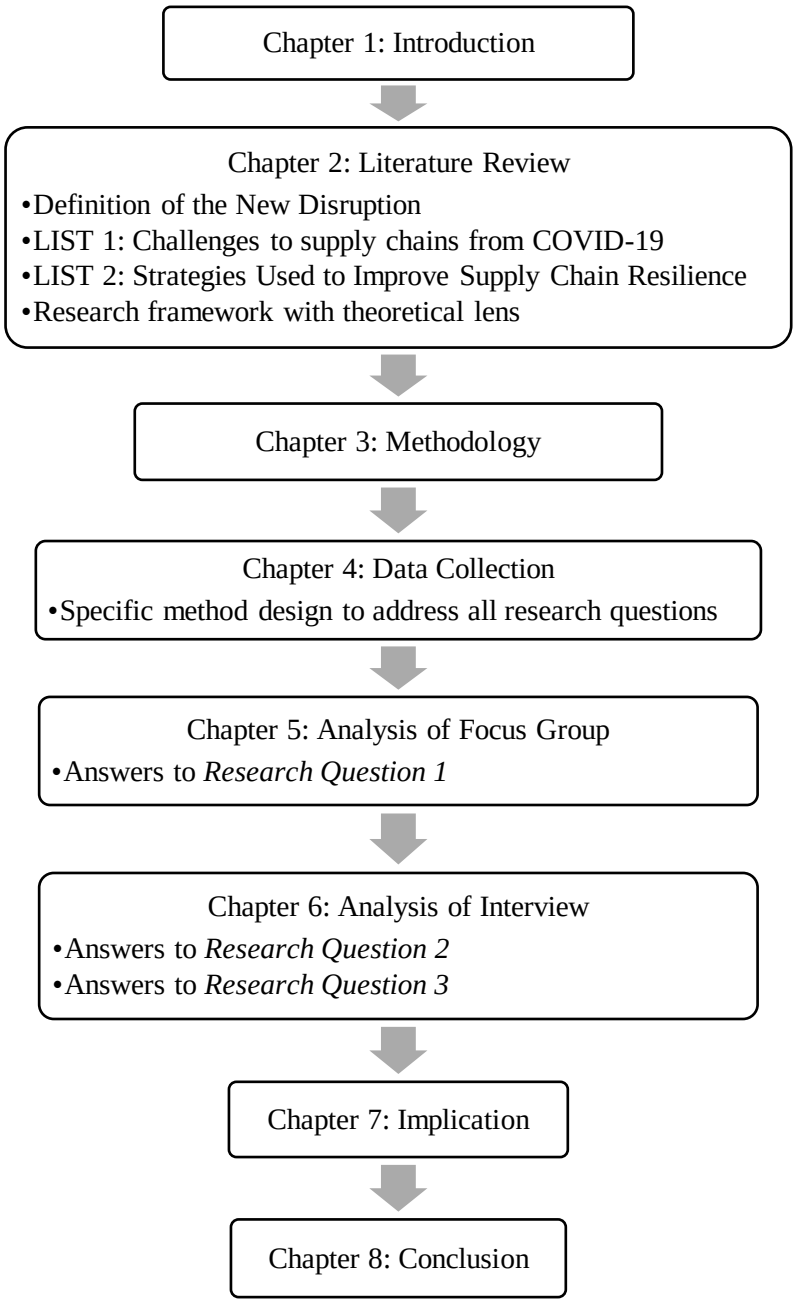


Figure 1-1 The layout of the thesis

Chapter 2 extensively examines the relevant literature on SCD and SCRES, with a particular focus on the conceptualisation and categorisation of SCD, and gives the definition of the New Disruption. In addition it reviews the theoretical perspectives of SCRES, and introduces the theoretical perspectives adopted in this study, namely Contingency Theory and Resource Dependency Theory, which are used to outline the research framework. This chapter also summarises two lists from the literature, which are the challenges of the New Disruption to other supply chains, and existing supply chain recovery approaches. It is to establish the groundwork for subsequent data collection and analysis.

Chapter 3 presents the research methodology. The chapter firstly demonstrates the philosophical assumptions and their implications for the research, and then describes the research design, including details of how the data were collected (focus groups and interviews) and analysed (thematic analysis, Interpretive Structural Modelling).

Chapter 4 further clarifies the methodological design of the data collection. The chapter first describes the specific process of data collection and then provides a detailed description of the rules for sample selection. This is followed by a brief description of the sampling organisations selected for this study. At last, additional details of the focus groups and interviews are provided, including information on participants and structures.

Chapter 5 presents the results of the focus groups. The chapter begins with detailed demographic information about the participants. It then explains the data analysis process, giving examples of the transcripts and coding. Subsequently, depending on the method of analysis, the chapter also presents the results obtained from the two methods of analysis and compares them to the existing literature. Finally, the chapter discusses the results of the data analysis and answers *Research Question 1*.

Chapter 6 presents the results of the interviews. This chapter similarly gives details about the participants' demographic information and themes. The chapter then focuses on the results obtained from the thematic analysis and links them to *Research Question 2* and *Research Question 3*.

Chapter 7 discusses the other findings of the empirical study. Based on the findings obtained from the analyses in the previous two chapters, this chapter discusses findings that go beyond answering the research questions, including for the manifestation of the ripple effect in this disruption and ways to mitigate it, and the important role of supply chain collaboration in the recovery process. Also, this chapter discusses the advantages of combining the theoretical perspectives of Contingency Theory and Resource Dependency Theory to view SCRES.

Chapter 8 concludes the thesis by summarising the main contributions to the academic discussion on SCRES and the implications for management practitioners. The chapter concludes with a list of research limitations and a discussion of possible avenues for future research.

2 LITERATURE REVIEW: FROM DISRUPTIOIN TO SUPPLY CHAIN RESILIENCE

2.1 Introduction

Chapter 1 lays the foundation of this thesis and highlights the purpose of this study, which is to investigate the impact of the New Disruption on the manufacturing industry and to explore effective strategies to improve SCRES. As the first step of the research, this chapter reviews the literature on SCD and SCRES. In doing so, the review focuses on understanding the unique aspects of the New Disruption compared to past disruptions, and why the methods of coping with disruptions in the literature have little effect on the New Disruption. This chapter further summarises two lists from the literature on the challenges reported in other industries in relation to the New Disruption, and past strategies and approaches to dealing with supply chain disruptions, in preparation for comparing the results of the later data analysis and answering the research questions.

Sections 2.2 begins with a discussion of existing research on SCD, including the definition and categorisation of disruptions, and justified why they are inadequate for the phenomena of the New Disruption; Section 2.3 highlighted the distinctive features of the New Disruption and accordingly formed a definition; Section 2.4 builds on this to summarise all the challenges that have been referred to in literature about the challenges posed by the New Disruption to supply chains; Section 2.5 shifts the topic to SCRES and covers the development of the concept; Section 2.6 introduces the main existing approaches to improve SCRES in the literature; Section 2.7 reviews theories that have been applied in this area, followed by the theoretical lens and the framework of this research in Section 2.8 and 2.9; Section 2.10 is a short summary of this chapter.

2.2 Definition and Categorisation of Supply Chain Disruption

With the increasing complexity of global supply chains, various uncertainties have emerged and the resulting supply chain disruptions have become more frequent (Kamalahmadi and Parast, 2016； Hosseini and Ivanov, 2019). Disruptions in supply chain management are usually caused by natural disasters (e.g., earthquakes, hurricanes, and floods) or man-made threats (e.g., fires, strikes, and terrorism) (Kleindorfer and Saad, 2005； Ivanov et al., 2017； Dolgui et al., 2018； Hosseini and Ivanov, 2019). These events have had a significant negative impact on the financial and operational performance of supply chain members and the supply chain as a whole. For example, in September 2017, Shanghai Jielong Metal Drawing Co Ltd, the sole supplier of needle bearings to Schaeffler, a leading global supplier

of automotive components, was forced to shut down for violating environmental laws. This incident resulted in 49 Chinese automakers experiencing supply shortages from Schaeffler, forcing them to cut production by 3 million vehicles, with total losses of up to RMB 300 billion (Xie and Chu, 2017). As a result, SCD has gradually become a hot issue of concern in industry and academia.

In order to better understand and manage SCD, scholars have conducted extensive research on various aspects of SCD, including its definition, categorisation, causes, consequences, influencing factors, assessment methods, mitigation strategies and resilience building. SCD is widely described as unplanned events that interrupt the flow of materials in the supply chain and have a significant impact on the entire network. The causes of SCD are multiple, including natural disasters, political unrest, economic crises, and product recalls (Craighead et al., 2007). The consequences can be very serious, including production disruptions, inventory shortages, increased costs, decreased revenues, and decreased customer satisfaction (Bode and Wagner, 2015). And there are many factors that affect the extent of SCD, including supply chain complexity, vulnerability, robustness and resilience (Hendricks et al., 2009). The assessment methods for SCD in the existing literature include both quantitative and qualitative approaches (Ambulkar et al., 2015). The mainstream strategies in mitigating SCD include risk identification, risk assessment, risk management, contingency planning, and recovery planning (Tang, 2006). And SCRES building includes improving supply chain transparency, agility, and sustainability, etc. (Kleindorfer and Saad, 2009). Overall, SCD is a complex and important research field, and its findings are important guidance for supply chain management practices of enterprises and governments.

Despite the fact that more and more scholars have conducted research and published papers on SCD in the past two decades (Qi et al., 2004; Chopra et al., 2007; Ivanov et al., 2014; Cui et al., 2016), the study of disruptions in complex supply chain networks and their associated risk management is still an emerging research field. From the perspective of indicators for identifying an emerging research field, Bier et al. (2020) observed evidence of all three indicators in a review of SCD-related literature: (1) new authors are attracted to the research field; (2) references are interdisciplinary; and (3) vocabulary is widely used (i.e., lack of standard terminology). They also found that the relevant literature is dominated by articles on modelling methods and surveys, with a lack of articles that formulate hypotheses or draw theoretical insights. Besides, there is a very limited number of research articles that combine disruption risk and structural equivalence in supply networks. However, this is

important because the impact of activities in complex networks is greater than the sum of the responses of the individual components, and this is certainly true for complex supply chains. Therefore, if the structure of a complex supply chain is ignored, a complete understanding of how disruptions may affect it is challenging, let alone targeting SCRES by anticipating the risk of disruption. Moreover, the terminology in this research area has not yet been clearly defined, and the definition of SCD, for example, still varies among scholars. As a result, there are still significant research opportunities in the area of SCD.

In this research, the focus would be understanding of the New Disruption as a SCD. This includes identifying the unique traits of the disruption, and comparing with the previous SCDs in the literature, thus to build a complete definition of this disruption. The propagation of the New Disruption has already demonstrated its severe impact on complex supply chain, which was more serious than any previous disruptions. Therefore, it is necessary to define this new type of disruption and extend the scope of SCD in the current literature, which will lay the foundation for future research.

2.2.1 From the perspective of sources of risk

For SCD, a wide-accepted approach to definition and categorisation in the literature is predicated on the source of risk. Christopher and Lee (2004) and Trkman and McCormack (2009) developed a theoretical framework that categorises the different sources of supply chain risk: (1) endogenous, (2) exogenous, (3) customer, and (4) supplier risks (see Table 2-1). These sources of risk are influenced by three key factors: environmental, network and organisational factors. Environmental factors are considered exogenous because they stem from external uncertainties caused by natural, political, and social events. Network factors relate to any uncertainty caused by fluctuations in demand, product life cycle patterns and logistics flows (Johnson, 2001). Organisational factors may affect disruptions to the internal organisation, including credit crunch, legal liabilities and operational uncertainty (Rao and Goldsby, 2009). They are a subset of network factors, which in turn are considered as part of environmental factors (Park et al., 2016). Bode and Wagner (2015) define SCD as unanticipated and unexpected triggering events occurring somewhere in the upstream supply chain (supply network), incoming logistics network, or purchasing (sourcing) environment, and the consequences of which seriously threaten the normal business operations of the target company. They explain that SCD can stem from supplier quality issues, delivery interruptions, supplier defaults, strikes or factory fires (see Table 2-1).

Table 2-1 Categories of SCD (Park et al., 2016)

Category	Definition	References
Endogenous Disruption	Supply chain disruption related to any disruptions and failures of resources to maintain a normal level of operation within an individual company	Chopra and Sodhi (2004), Kiser and Cantrell (2006)
Exogenous Disruption	Supply chain disruption that arises from any disruptions and failures outside the supply chain	Manuj and Menzter (2008), Tapiero and Grando (2008), Rao and Goldsby (2009), Altay and Ramirez (2010), Zsidisin and Wagner (2010)
Supplier Disruption	Supply chain disruption related to any disruptions and failures of product and/or service flow from suppliers	Choi and Krause (2006), Manuj and Menzter (2008), Rao and Goldsby (2009), Wagner and Neshat (2010), Zsidisin and Wagner (2010)
Customer Disruption	Supply chain disruption related to unpredictable or misunderstood customer demand	Chopra and Sodhi (2004), Trkman and McCormack (2009), Wagner and Neshat (2010)

Generally, endogenous disruptions arise from the disruption and failure of resources to maintain an organisation's normal level of operations, such as equipment, labour, technology, and systems (Kiser and Cantrell, 2006; Kaviani et al., 2020). Schmidt and Raman (2012) define endogenous disruptions as "the identification of disruptions caused by factors internal to the business operations or supply chain factors". These disruptions tend to adversely affect the performance of an organisation due to production/distribution interruptions in the form of strikes, machine downtime, and information system breakdowns (Chopra and Sodhi, 2004). Reasons why endogenous disruptions harm financial performance include strikes, equipment breakdowns and information system network failures (Chopra and Sodhi, 2004; Park et al., 2016). Meanwhile, Schmidt and Raman (2012) noted that operational performance is not improved by exogenous disruptions but by endogenous disruptions after investigating more than five hundred disruptions in different areas.

In contrast, exogenous disruptions come from any disruptions and failures outside the supply chain, such as natural disasters, political unrest, terrorism, and the global financial crisis (Tapiero and Grando, 2008; Park et al., 2016). In other words, they are disruptions attributed

to factors that are external to the company's operations or supply chain (Schmidt and Raman, 2012). Some exogenous disruptions are beyond the control of supply chain managers, so organisations need to adopt proactive strategies to mitigate such disruptions. Flexibility and redundancy strategies could be utilised to bounce back from exogenous disruptions (Linnenluecke, 2017).

Supplier disruptions are caused by interruptions in the flow of production and services from suppliers. Such risks include (1) business interruptions due to suppliers' inability to meet orders, (2) delivery delays from suppliers and their next tier suppliers, (3) unexpected bankruptcy of core suppliers, (4) conflicts with suppliers due to confusion over inventory ownership and intellectual property rights, and (5) opportunistic behaviour of suppliers due to asymmetric information (Manuj and Menzter, 2008). In addition, suppliers' less stringent quality standards, material shortages and spare parts limitations represent supplier risk (Rao and Goldsby, 2009). Also, late deliveries and quality failures may lead to supply disruptions (Zsidisin and Wagner, 2010).

Customer disruption is caused by unpredictability of customer demand or instability of customer loyalty, including incorrect demand forecasts, changes in customer needs and preferences, seasonal fluctuations and customer churn (Park et al., 2016). This type of disruption is more common in the media, retail, airline, and financial services industries.

The division of disruption into these four areas is from the perspective of the individual organisation. In fact, apart from endogenous disruptions, the sources of the other three types of disruptions are exogenous to the individual organisation. The advantage of this categorisation is that specific problems can be better analysed in order to identify the most appropriate disruption prevention and mitigation strategies for the organisation in the current perspective. Especially if the disruption comes from a single event or a single organisation, this is easier to anticipate and control, thus minimising the impact of the disruption on individual organisation. On the other hand, however, such a stance limits the holistic view of the supply chain and may lead to decisions that are only effective in the short term, without sufficient consideration of the timing of the disruption and its resulting ripple effects over time, thus fail to respond in a timely and appropriate manner when more situations arise. This was even more evident in the disruption caused by COVID-19. As a global event, all parts of the supply chain were directly affected by the disruption. At the same time, the longer duration of the disruption than in the past and the constant emergence of new situations made it difficult for the organisation to control the impact. The phenomenon also

proved that previous strategies were not effective during this period, and therefore categorising the disruption from the perspective of an independent organisation is not sufficient to fully understand the damage caused by this disruption.

2.2.2 From the perspective of supply chain

Christopher and Peck (2004) describe the risk of disruptions in supply and demand as "external to the organisation but internal to the supply chain network". This means that both types of disruptions are also endogenous when viewed in the context of the supply chain as a whole, whereas the real exogenous problems are the disruptions caused by environmental risks, as was the case with the COVID-19 outbreak. This is because the virus itself was not part of any of the global supply chains at source. Rather, the various changes in demand that occurred during the disruption were the result of changes in living conditions that impacted the supply chain, such as the surge in demand in the Personal Protective Equipment and Personal Electronic Device sectors, as well as fluctuations in demand in other industries (Chowdhury et al., 2020). Similarly, supply disruptions in this process arose from changes in the policy environment. Efforts by governments to limit the spread of the virus, including temporary embargoes and travel restrictions, have also created serious obstacles to production and logistics activities in many supply chains (Ivanov, 2020). Therefore, this New Disruption belongs to an exogenous one.

As mentioned earlier, exogenous disruptions mostly come from specific events in the environment, and these events have different consequences due to their different types and the extent of their impacts. Trkman and McCormack (2009) used a novel categorisation approach to classify these exogenous disruptions according to the probability distributions of these events into continuous and discrete disruptions. Continuous disruptions are those where the potential changes are continuous and relatively could be predicted. A typical example is changes in raw material prices. For this type of risk, the impact of a given price increase on profitability can be calculated and different insurance instruments such as futures and forward contracts that mitigate price fluctuations can be arranged in advance (Aggarwal and Ganeshan, 2007). Whereas discrete events are those that have a low probability of occurring but a high impact, including terrorism, spread of diseases, natural disasters, political events, etc. (Faisal et al., 2006). Disruptions in transport between links in the logistics chain can also cause significant delays or non-deliveries (Wilson, 2007),. These situations are often difficult to predict, and their consequences can be severe but difficult to measure.

The extant literature on the various types of SCD division is principally divided into two categories: endogenous and exogenous. The exogenous SCD relevant to this study is further subdivided into two categories: discrete events and continuous risk (see Figure 2-1). This division is important because different risk prevention and response strategies can be adopted. Generally, organisations plan against recurring, low-impact risks in their supply chains, but neglect high-impact, low-likelihood risks (Chopra and Sodhi, 2004; Faisal et al., 2006). This is one of the reasons why this time the disruption was able to have such a massive impact. Although organisations are often unable to manage the source of risk exposure, it is vital to identify the source and possible consequences of potential problems. This allows appropriate countermeasures to be taken, including avoiding, transferring, mitigating, monitoring and even accepting the risk (Khemani, 2007).

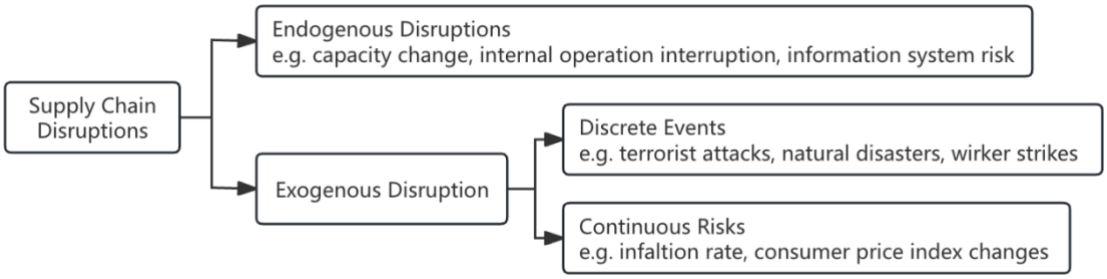


Figure 2-1 The categorisation of SCD in current literature (Ho et al., 2015)

However, this categorisation is still insufficient to thoroughly characterise the New Disruption. First, the disruption was caused by the spread of a disease, which is a discrete event. In terms of its impact on the global supply chain, it fulfilled the characteristics of a low-probability but high-impact event. Second, the disruption was also continuous. Although the outbreak of the epidemic was a single event, its subsequent problems, including changes in supply and demand among upstream and downstream, and the downward trend of the global economic situation after the pandemic, were continuous problems happened afterwards. Therefore, this study concludes that the disruption cannot be completely defined and characterised from the perspective of existing studies, and that an extension of existing classifications is needed to provide a comprehensive understanding of the mechanisms of the New Disruption. This study stands on the perspective of the entire supply chain, and observes the New Disruption as an exogenous disruption from the environment. It aims to understand and add the definition of this disruption, which consists of both continuous and discrete events, to the literature of SCD.

2.3 Defining the New Disruption

As stated in Section 1.2.1, the impact of the New Disruption is considerably different from the other SCD in terms of magnitude, duration, and recovery (See Table *2-2*).

Table 2-2 Distinctive features of the New Disruption

Dimension	Disruptions in Previous Studies	New Disruption
Magnitude	Generally only impacted a small area or a part of the supply chain (e.g. tsunami, earthquake)	Propagated through almost all the supply chains and organisations worldwide
Duration	Usually in a short period of time after the incidents (e.g. SARS)	Lasted for more than a year, and organisations still struggled in recovering, especially for lean supply chain which has less resilience.
Recovery	Many effective strategies have been proposed to proact or react	Barely tackled by existing methods, as uncertain situations continuously arose.

Disruption magnitude refers to the scale of the disruption impact to related enterprises, and duration refers to the time that a disruption's impact lasted on the supply chain (Guan et al., 2020). Unlike previous disruptions such as earthquakes in Japan or tsunamis in Southeast Asia, the COVID-19 pandemic has had a far-reaching and catastrophic impact (Moosavi and Hosseini, 2021). The disruption extended across global supply chains, affecting not only the regions directly impacted by the virus but also those indirectly connected. For instance, a survey conducted by the Chartered Institute of Procurement and Supply on 28 March 2020 revealed that 86% of supply chains worldwide were affected by the pandemic. In the case of the German automotive industry, which relies heavily on international supply chains (Mazur et al., 2015), both production and demand have suffered due to reduced demand from China and interruptions in raw material supply from countries such as Spain, Italy, and the United States. Thus, COVID-19 has disrupted both upstream and downstream aspects of global supply chains.

In addition to its scale, the duration of the pandemic is a significant factor that sets it apart from other disruptions. Different from natural disasters or terrorist attacks, which are typically short-lived, the COVID-19 pandemic has caused prolonged disruptions over the past two years (Ivanov and Das, 2020； Søreide et al., 2020). Additionally, the most recent global pandemic is notable for its similarity to the SARS outbreak in 2002, which was effectively contained through the implementation of medical treatments in a relatively short period of time (Liu et al., 2020). In contrast, the virus of COVID-19 has continuously

evolved into new variants, each presenting unique challenges and leading to recurring spikes in cases every few months, which complicates efforts to control its spread (Sharma et al., 2021). Supply chains designed for efficiency through lean approaches, such as just-in-time and single-sourcing strategies, have struggled to adapt, revealing their lack of resilience (Torabi et al., 2015; Hosseini and Ivanov, 2020). The extended duration of the crisis has also increased the risk of long-term financial instability for many firms, potentially leading to bankruptcies and challenges in resource allocation for recovery efforts (Choi, 2020; Liu et al., 2020).

Furthermore, the advent of the pandemic has engendered an unparalleled degree of uncertainty, constituting an unprecedented occurrence within the context of SCD. Measures such as lockdowns and travel restrictions have been implemented suddenly and vary by region, adding to the unpredictability faced by supply chains (Chowdhury et al., 2020; Barman et al., 2021). For example, the emergence of the Omicron BA.5 variant, which is more transmissible than previous variants (World Health Organisation, 2024), prompted a sudden lockdown in Shanghai in March 2022. This action disrupted major multinationals like Apple, Tesla, and Amazon, causing significant supply chain issues (Hollinger, 2022). Such measures have led to factory shutdowns, labour shortages, and logistical delays, creating severe uncertainties for organisations and complicating recovery efforts.

These aspects demonstrate how the New Disruption differs from previous SCD and the damaging implications for the global supply chain. Coupled with the inadequacy of the existing literature on the definition of SCD to the New Disruption, the Researcher gave it a revised definition:

> *Exogenous disruptions that affect supply chains on a global scale across multiple industries are characterised by episodic occurrences, accompanied by protracted and evolving adverse impacts, and engender a substantial degree of uncertainty that surpasses the supply chains' original resilience. Such disruptions are designated as the New Disruption.*

2.4 Challenges to Supply Chains from the New Disruption

Several recent studies have directly or indirectly reported some challenges, along with other findings, for supply chains in recovering from the COVID-19 pandemic. According to these studies, the potential impacts of the COVID-19 pandemic on business and the global economy can be profound in both the short and long term (Clarke and Boersma, 2017;

Ivanov and Dolgui, 2020； Chowdhury et al., 2021). Supply chains are expected to experience the heat of the global financial crisis in the longer term (Lalon, 2020； Sen et al., 2020； Singh et al., 2021). This long-term global financial crisis will impact the end-customer demand for certain products, especially non-essential garments, luxury and electronic products (Amankwah-Amoah, 2020； Majumdar et al., 2020； Chowdhury et al., 2021； Yuen et al., 2022). Specifically, such products will suffer from sharp and long-term demand drop (Lalon, 2020； Majumdar et al., 2021). As a result, producers of such products will experience frequent order cancellation and payment withholding from business buyers during the recovery phase of the outbreak (Sen, 2020). Hence, these supply chains will need longer to recover from the pandemic (Laing, 2020).

Some studies on the current COVID-19 pandemic identified the impacts or challenges of major outbreaks on supply chain operations. For example, Ivanov (2020) noted the simultaneous impact on demand, production, supply, and other logistics operations of this extraordinary outbreak. Considering the multiple implications of the COVID-19 pandemic, production recovery models must simultaneously address these multiple impacts (Chowdhury et al., 2020). Such holistic consideration in formulating recovery strategies is likely to increase complexity and ambiguity in supply chains. The impacts are immediate and greater for high-demand essential items (Deaton and Deaton, 2020； Hobbs, 2020； Quayson et al., 2020； Singh et al., 2021). For these supply chains, increasing production capacity and maintaining a smooth flow of material supply are vital challenges to recover from due to this outbreak (Chowdhury et al., 2020). Comprehensive and effective strategies need to be introduced, as coordination and horizontal collaboration among producers at the national level may be required for such products (Paul and Chowdhury, 2020).

Businesses have also been facing threats of shutting down due to temporary lockdowns in countries where their key supply chain partners operate. In the medium to long term, these firms will face economic shock, reduction of production capacity, fewer institutional supports, and other social challenges (Cappelli and Cini, 2020； Laing, 2020). Moreover, some supply chain partners may close their operations permanently if they cannot absorb the loss from temporary shutdowns (Majumdar et al., 2021). This will pose many challenges in the recovery phase. For example, in the automotive sector, the lack of a low-cost component in an automobile manufacturing site could stop the production line resulting in customer dissatisfaction and profit loss (Chirra and Kumar, 2018). China’s automobile export plunged

to a financial record low by 80 percent due to decreased demand (Segal and Gerstel, 2020). Also, disruption in China's automobile part exports resulted in large-scale car production disruption across Europe and assembly plant closure in the United States (Deloitte, 2020).

Difficulties in making prompt recovery decisions are also major challenges reported in the literature (Cui et al., 2019). While firms have faced several major outbreaks in the past, the intensity of the current COVID-19 pandemic is significantly higher than in previous events. As a result, a lack of preparedness to deal with such an outbreak has been reported (Sharma et al., 2021; Clarke and Boersma, 2020a; van Hoek, 2020), and this lack will delay decision-making (van Hoek, 2020). Further, due to deficits in infrastructure, digital technologies, and the latest applications and resources, supply chains are likely to struggle with implementing rapid recovery plans and strategies (Leite et al., 2020； Sharma et al., 2021).

Raj et al. (2022) categorised 10 supply chain challenges raised by the pandemic in three different clusters as supply side, demand side and logistical side. They find that multinational corporations faced a supply-shock, for instance, as the infection spread across India, exports of face masks stopped. Similarly, several companies faced a demand-shock. An increase in demand for essential products was witnessed, while, on the other hand, concerns arose regarding postponed deliveries, delays in securing merchandise, unanticipated travel disruption, and shortage of labour (due to reverse migration of labourers from cities). Therefore, gaps between supply and demand increased. However, these challenges more focused on the issues happened when the pandemic just initiated, compared with other literature recognising problems in long term. The fact here is that with the change of the global situation, what supply chains are facing is shifting as well. The challenges faced by organisations in the supply chain have changed over time from the onset of the pandemic to present.

In order to fully discover what supply chain has faced since the disruption and get prepared for the future, it is essential to understand what challenges might occur at different phases of the pandemic. There is no literature that systematically defines the different phases that supply chains face. Here, according to the various potential challenges mentioned in the literature, this study divides them into two stages: the outbreak stage and the moderation stage. The outbreak stage refers to the period when COVID-19 is raging around the world, and governments have adopted various control measures, such as lockdown and quarantine, in order to slow the spread of the epidemic. At this stage, the challenges faced by supply

chains in various industries include a significant reduction in production capacity and labour due to factory shutdowns, logistics delays, and unstable sources of raw materials. For different industries, the changes in demand are different at this stage. For example, the personal protective equipment (PPE) industry and the personal electronics industry saw a surge in demand, while most of the manufacturing and service industries had to deal with cancelled orders. The moderation stage represents the stage when the infection rate and fatality rate of COVID-19 are under control with the intervention of vaccines and other means, and most industries resume production. The use of the word 'moderation' rather than 'post-pandemic' here is because the current epidemic is not completely over, and the future situation is unclear with the emergence of various variants. From a supply chain perspective, the challenges at this stage include dealing with worse global economic conditions, reshaping supply chain networks and partnerships, balancing the economic and social sustainability of the organisation, and adopting new technologies and management methods to improve SCRES.

LIST 1 (see Table 2-3) concludes those challenges related to the New Disruption from the literature. Based on this list and its categorisation, this research could fully understand the impact of this disruption on the ASC by comparing the result to the specific situations in the automotive industry.

Table 2-*3* LIST 1: Challenges in recovering from COVID-19 pandemic

Stage	Likely recovery challenges reported		References
Outbreak	Uncertainty of demand	Order cancellation	Lalon (2020), Sen (2020)
		Surges in demand caused by hoarding and panic buying	Leite et al. (2020), Okorie et al. (2020)
	Supply disruption	Extended delivery times	Aday (2020), Biswas and Das (2020), van Hoek (2020)
		National lockdown	Barman (2021), Okorie et al. (2020)
		Out of stock	Leite et al. (2020), Sen (2020), Barman (2021)
		Limited operations of partners	Clarke and Boersma (2020), Chowdhury et al. (2020)
	Insufficient preparedness	Lack of applicability of existing contingency plans	Barman (2021), Sharma et al. (2021), van Hoek (2020)
		Lack of resources to implement rapid recovery plan	Leite et al. (2020)
Recovery	Re-construction of supply chain network	Supply chain relationship maintaining	Chowdhury et al., (2020), Ishida (2020), van Hoek (2020)
		Permanent closure of operations of supply chain partners	Choi (2020), Clarke and Boersma (2020), Majumdar et al. (2021),
		Synchronising processes, maintaining vertical integration	Ishida (2020), Sharma et al. (2020)
	Balance between economic and social sustainability	Layoff and availability of human resources	Chowdhury et al., (2020), Okorie et al. (2020), Singh et al. (2020)
		Health and safety concerns of workers	Barman (2021), Okorie et al. (2020),Sharma et al. (2020)
		Lack of government enforcement and regulations for social issues	Sarker (2021)
	Global economy recession	Demand falls in long term	Clarke and Boersma (2020), Majumdar et al. (2021)
		Shortage of working capital	Cui et al. (2019)
		Reduction in Return on Investment	Chowdhury et al., (2020), Lalon (2020)
	Adoption of new technologies and management methods	Adaption to shifts in channels and new modes of distribution	van Hoek (2020)
		Implementation of digital technologies	Gurbuz and Ozkan (2020), Sharma et al. (2020), van Hoek (2020)

2.5 Supply Chain Resilience

Those aforementioned disruptive events may lead to changes in the structural dynamics of the supply chain and the ripple effect, which refers to the propagation of disruptions through the supply chain and the scope for disruption-based changes in the supply chain design structure (Ivanov et al., 2014； Dolgui et al., 2018； Levner and Ptuskin, 2018). And for

reducing the impact of disruptions on supply chain members, resilience plays a key role in mitigating the ripple effects of disruptions. Resilience refers to the adaptive capacity of a supply chain to prepare for and/or respond to an SCD event (Tukamuhabwa et al., 2015), which includes redundancy, robustness, and flexibility. Establishing a resilient supply chain is usually based on redundancy, which is closely related to robustness and flexibility. Specifically, to improve supply chain robustness, proactive approaches (e.g., risk-mitigating inventories and standby facilities) are usually employed to maintain the planned execution and performance of the supply chain during the design and planning stages. To improve supply chain flexibility, reactive approaches (e.g., parametric recovery and structural recovery) are typically employed to redistribute inventory and capacity (indirectly using redundancy), taking into account resilience in the event of an unexpected SCD event (Ivanov et al., 2016； Dolgui et al., 2018).

2.5.1 The Evolution of SCRES Research

In recent years, there has been a significant increase in research on SCRES due to the interest in how to minimise disruptive events that supply chains may support (Christopher and Peck, 2004； Kochan and Nowicki, 2018； Adobor, 2019). Recent major disruptive events, such as the COVID-19 pandemic, have called for a new structure for managing supply chain operations, where individualised risk management is insufficient to minimise the impact of the increasingly complex vulnerabilities and uncertainties faced by global supply chains (Golan et al., 2020). Understanding the scope of SCRES management through its conceptualisation is critical to developing strategic, tactical and operational objectives that allow for continued operations after a disruption to adapt to the new market structure (Singh and Singh, 2019).

Considering the dynamic nature of supply chain decision-making, it is necessary to analyse the term 'resilience' in a broad sense. This term comes from other fields of study, mainly engineering, psychology and ecology, and has been used in many different ways to form a multidimensional and multidisciplinary concept (Ali et al., 2017). This concept has been applied to personal business management and then incorporated into supply chain management by extracting different aspects from these other fields (Ponomarov and Holcomb, 2009). In addition, other terms related to resilience are used indiscriminately in the analysis of the literature: risk management, vulnerability, uncertainty, robustness, agility and sustainability. SCRES management evolved from risk management analysis, applying risk minimisation actions in organisations to supply chains (Kumar and Anbanandam, 2019).

These leading practices focus on identifying, assessing and controlling sources of risk that may occur within an organisation. However, transferring these actions to a more complex, dynamic and unconstrained level, such as the supply chain, would increase the vulnerability and possible impacts on operations. This is because from a supply chain perspective, relationships exist between multiple nodes with different strategic objectives and different sources of risk (Kamalahmadi and Parast, 2016; Zavala-Alcívar et al., 2023). As a result, SCRES management has emerged as a different perspective that focuses on the characteristics of the system (supply chain members) rather than the sources of risk (Wieland and Durach, 2021). With the analysis of the concept of SCRES shown in Table 2-4, the development of SCRES has expanded to cover more stages in the management process. SCRES was initially associated with activities that enable the immediate resumption of normal business operations. Since 2009, it has started to focus on prevention and preparation of supply chain activities for possible disruptions (Ponomarov and Holcomb 2009). More recently, continuous improvement, cumulative learning and competitive advantage have been established in supply chain resilience management (Stone and Rahimifard, 2018).

Table 2-*4* The evolution of the concept of SCRES (Zavala-Alcívar et al., 2023)

Research	**Conceptualisation**
Christopher and Peck (2004)	"The ability of a system to return to its original state or move to a new, more desirable state after being disturbed."
Ponomarov and Holcomb (2009)	"The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function."
Ponis and Koronis (2012)	"The ability to proactively plan and design the Supply Chain network for anticipating unexpected disruptive (negative) events, respond adaptively to disruptions while maintaining control over structure and function and transcending to a post-event robust state of operations, if possible, more favourable than the one prior to the event, thus gaining competitive advantage."
Hohenstein et al. (2015)	"Supply chain's ability to be prepared for unexpected risk events, responding and recovering quickly to potential disruptions to return to its original situation or grow by moving to a new, more desirable state in order to increase customer service, market share and financial performance."
Kamalahmadi and Parast (2016)	"The adaptive capacity of a supply chain to reduce the likelihood of facing sudden disturbances, resisting the spread of disturbances while maintaining control over structures and functions, and recovering and responding through immediate and effective reactive plans to transcend the disturbance and restore supply chain to a solid state of operations."
Hosseini et al. (2019)	"Supply chain capability to utilize the absorptive capacity of supply chain entities to repulse and withstand the impacts of perturbations, to minimize the consequences of disruptions and their propagation by utilizing adaptive capacity and to recover performance level to normal operations in a cost-efficient manner using restorative capacity when absorptive and adaptive capacities are not sufficient."

2.5.2 The Manifestation of SCRES: Capabilities

The resilience of an organisation or supply chain is manifested in the capabilities required for resilience. Although the definitions of SCRES varied in the literature, there are common

capabilities agreed by researchers (Ali et al., 2017). Organisations can demonstrate organisational resilience through these capabilities by effectively managing disruptions and/or changing environments. Based on Hollnagel's (2013) taxonomy of resilience in the security sciences, four main groups have been identified: predictive, monitoring, responsive and learning capabilities. Three of the four (predictive, responsive, and learning) were positively supported by common themes in the definitions. Surprisingly, despite the importance of organisations monitoring supply chain performance before, during and after disruptions, only Ambulkar et al.'s (2015) definition mentions monitoring capability. One of the reasons for this may be that most authors have adapted previous definitions and therefore the definition of SCRES changes slightly over time (Hohenstein et al., 2015). Another explanation could be that monitoring capacity is seen as part of forecasting capacity and is therefore tacitly implied by other similar terms (e.g. preparation and planning). In this study, monitoring capacity is considered a component of predictive capacity. Building on Hollnagel's classification of resilience, Ali et al.'s (2017) reviewed definition reveals two more important SCRES capabilities that can support organisations in developing resilient supply chains: adaptive and recovery capacities.

Table 2-5 SCRES capabilities (Ali et al., 2017)

SCRES capabilities	Description
Ability to anticipate	Proactive capabilities necessary to identify and monitor potential events, changing environments, and performance before the ability of the supply chain to function is affected
Ability to adapt	Concurrent capabilities required to manage and adjust critical supply chain resources continually during disruptions and/or normal business activities
Ability to respond	Concurrent capabilities needed to react to supply chain events on time and efficiently, to lessen the impact of disruptions or change the effects to ensure a desirable outcome
Ability to recover	Reactive capabilities essential in the aftershock of a supply chain event, so as to restore or return to normal operations
Ability to learn	Reactive capabilities required after a supply chain event to understand what has happened and improve future performance based on the experience

Table 2-5 summarises the five SCRES capabilities derived from the literature. Current literature emphasises recovery and adaptive capacities with little focus on the capacity to learn from experience (Ali et al., 2017). A growing body of literature has begun to realise that SCRES research needs to focus on proactive capabilities (Knemeyer et al., 2009; Wieland and Wallenburg, 2013) and the wider role of learning capabilities in the establishment of SCRES processes (Blackhurst et al., 2011; Jüttner and Maklan 2011). However, the experience from the New Disruption has proved the ability to adapt, respond, and recover still play as the key role in SCRES. What supply chains had suffered showed

that there is of possibility that proactive capabilities could be ineffective as unprecedented situation occurs. Many strategies to improve the resilience had been developed but had little effect during the pandemic. Therefore, this study focuses on those strategies which could reinforce the capabilities of adaptation, recovery and learn for organisations and supply chains.

2.5.3 SCRES Strategies

Another concept addressed in most definitions is the strategy used to prepare for, respond to, and recover from SCD. These strategies are typically categorised as proactive, concurrent, or reactive (Hollnagel, 2013). Proactive strategies, which involve planning and preparation, are emphasised in definitions that highlight terms like "plan," "anticipate," "alert," and "prepare" (Ponomarov and Holcomb, 2009; Day, 2014; Ambulkar et al., 2015). Concurrent strategies, implemented during a disruption, focus on quick responses and adaptation, as reflected in terms such as "cope with change," "adapt," and "respond to unexpected events" (Knemeyer et al., 2009; Carvalho et al., 2012; Wu et al., 2013). Reactive strategies, deployed after a disruption, aim to restore normal operations, emphasizing terms like "bounce back" and "return to the original or desired state" (Schmitt and Singh, 2012; Brandon-Jones et al., 2014; Urciuoli et al., 2014).

While proactive and reactive strategies are explicitly discussed in SCRES literature, concurrent strategies are often implicitly referenced or grouped with reactive ones. For instance, Sheffi and Rice (2005) refer to concurrent strategies as a "first response," and Scholten et al. (2015) discuss them as an "immediate response." However, Hollnagel (2011) distinguishes between concurrent strategies, which involve real-time adjustments, and reactive strategies, which are implemented after a disruption. These strategies are the key point of this research. More on SCRES strategies can be found in the next section.

2.6 Strategies Used to Improve SCRES

The COVID-19 has made a severe disruption to the global supply chain since it occurred. According to what has been discussed above, this is an exogenous disruption. In some literature, it is also named Force Majeure, which is due to non-deliberate events that occur outside of the supply chain, from inadvertent and exogenous causes (DuHadway et al., 2019). These events disrupt the flow of materials within a supply chain due to external forces that are not deliberate and not focused on a single firm.

Disruption recovery for Force Majeure disruptions generally focuses on having a supply chain that can quickly readjust to replace any lost inventories or production capabilities. Such approaches consist of backup systems and contingency plans (Finch, 2004 ; Kleindorfer and Saad, 2005), supply chain agility (Braunscheidel and Suresh 2009), or redundant and responsive suppliers (Chopra and Sodhi 2004). Each of these allows the company to survive the disruptive event and return to normal operations. Specific strategies include consuming stockpiled inventory and changing to alternate supply sources for quickly recovering from a disruption. The alternative supply sources could either be internal production capabilities, secondary factories, or secondary suppliers to which demand can be rerouted. Because the disruption comes from outside of the supply chain's direct control, the supply chain typically does not need to be redesigned, although depending on the extent of the disruption, factories might need to be rebuilt as part of the recovery process (DuHadway et al., 2019).

Formulating recovery strategies to return to normal or better operational states after catastrophic events is vital to rapid recovery and survival (Ponomarov and Holcomb, 2009). Results of previous research show that 80% of companies that failed to design recovery strategies for SCD during major outbreaks have closed down their operations within two years after the event (Cerullo and Cerullo, 2004). Statistics indicate that the frequency of such major supply chain outbreaks has increased in recent years. For example, the World Health Organization (WHO) has tracked more than 1,400 epidemic outbreaks between 2011 and 2018 (Hudecheck et al., 2020). As such, developing strategies for recovering from a major outbreak has become critical for the long-term survival of supply chains.

Recent literature on supply chain recovery can be mainly divided into two categories. One category discusses contingency plans, including backup suppliers, backup logistics channels, buffer inventory and clustering effect (Ivanov, 2017). The cluster effect here refers to the operation that seeks to replace production in industrial concentrated areas when production interruption occurs. What this type of recovery strategy has in common is that they all require the organisation to have a plan in place before the outage occurs, in order to mitigate the impact of disruptions, for example, supply uncertainties and logistics delays. Macdonald and Corsi (2013) categorise this proactive concept as readiness, i.e., standing by for implementation when certain events occur in order to aid managers in responding to those events (Chen et al., 2019).

However, contingency plans are not always applicable to all disruptions. For example, this longer, wider, and more uncertain disruption caused by COVID-19 around the supply chain cannot be fully anticipated and prepared for in advance. Therefore, dynamically developing recovery strategies based on actual conditions is also important for organisations to mitigate the impact of disruptions. However, compared to contingency plans, there is less literature on dynamic adjustment. Methods mentioned in the current literature include capacity expansion, building a cross-functional response team, product type change, substitute development and supply chain redesign.

Meanwhile surprisingly, the extant literature on major epidemic and pandemic outbreaks mostly considers humanitarian supply chain issues. There is a lack of studies on how traditional commercial supply chains can quickly recover from epidemic or pandemic outbreaks (Clarke and Boersma, 2017; Paul and Chowdhury, 2021). Therefore, it would be necessary to produce research targeting the manufacturing supply chain recovery from the COVID disruption.

2.6.1 Contingency Plans

2.6.1.1 Backup Suppliers

The use of a backup supplier can reduce the unsatisfied amount and weaken the impact of the disruption duration on the retailer's profit (Moosavi, 2021). When the disruption duration is small, the retailer had better use a contingent supplier; while if the disruption frequently occurs, the use of a standby supplier takes more advantage (Wang et al., 2016). However, neither of these two strategies considered the situation of the New Disruption, which was a one-time discrete event but last a long time. Moreover, the unique part of this disruption was that it happened to almost all the echelons of the supply chain in multiple locations, and this led those planned backup suppliers likely to fail during the pandemic, and made the job of searching for alternative suppliers even more difficult.

Under this circumstance, the strategy of using collective emergency sourcing capabilities to source more raw materials and increase production by Paul et al. (2020) sounds like a possible way to overcome the challenge on supplies during the pandemic. This process could foster supply chain flexibility as part of humanitarian supply chain activities (Paul et al., 2016). However, whether it would also work for the manufacturing supply chain still needs to be investigated. Aldrighetti et al. (2019) recommend focusing on tiers 1 and 2 supplier risk during pandemic situations to mitigate supply disruptions. They also suggested that

manufacturers should focus on buffer strategies to overcome long-lasting SCD. For example, finding and activating multiple backup suppliers with effective strategies. And this has brought the new question to the research of SCRES – what could be regarded as 'effective strategies' against the New Disruption – which is one of the aims of this study.

2.6.1.2 Backup Logistics Channels

Transportation disruption creates fragile delivery channels and hampers demand-supply calibration. For this type of problems, Li et al. (2013) found that collaborative transportation management can significantly improve organisation flexibility by tackling demand disruptions (Paul et al., 2017). On the other hand, Ivanov et al. (2017) and Sayed et al. (2021) argue building backup depot facilities and inbound and outbound transportation channels could help recover from the disruption quickly. And several studies suggested that retail shops should convert their operations to mimic a quasi-distribution centre by picking, packing, and delivering orders to end consumers to mitigate the enormous demand (Ang et al., 2017).

Similar to the situation of backup suppliers, the biggest problem from the New Disruption was that whether those backup logistics channels could still make an effect, as the disruption generally occurred and spread for all industries. In addition, these strategies did not discuss the scenario of lockdown and travel restrictions, which made them hard to be applied by organisation and not effective for recovery.

2.6.1.3 Buffer Inventory

In the literature of production and inventory, buffer inventory is also a popular strategy against SCDs. Gallego and Van Ryzin (1994)considered how to schedule production after a single schedule disruption by proposing a base stock policy. Their work was extended by Eisenstein (2005) who introduced the Dynamic Produce-Up-To (Dynamic PUT) policies.

Many studies regarded the disruption as a random parameter and focused on finding the optimal level of stock and reorder quantities by quantitative methods. For example, Federgruen and Yang (2011) present a general periodic review model to analyse the dynamic effects of inventory buffers in the case of unreliable suppliers. Qi (2013) develops a continuous review inventory model with random disruptions at the primary supplier. Hishamuddin et al. (2013) demonstrated a recovery model for a two-echelon serial supply

chain with consideration of transportation disruption. Their model is capable of determining the optimal ordering and production quantities during the recovery period to minimise total costs. Iakovou et al. (2010) analysed a single period stochastic inventory model for capturing the trade-off between inventory policies and disruption risks for an unreliable dual sourcing supply network for both the capacitated and incapacitated cases.

The results of these studies were also difficult to apply to the manufacturing supply chains during the New Disruption. In terms of buffer inventory, the longitude of the New Disruption should be considered, especially during the lockdown period. Because of the variety of lockdown, the level of stock and the time of reorder became hard to calculate by those models. The policy not only affected the stability of supply, but also significantly reduced the production process. Meanwhile, it should also be noted that different echelons of the supply chain may locate in different places, where the demographics, the situation of infections and the strictness of the policy varied. Moreover, buffer inventory means that organisations need to apply more resources to hold and use them, such as additional warehouses and additional vehicles. For automotive supply chains the inventories usually stand for large parts and components, which require even more spaces to store and transfer. Acquiring these resources could be difficult and costly when there was the New Disruption. Therefore, the reality of how organisations applied buffer inventory and balanced between sufficient supplies and reasonable cost still needs to be further observed.

2.6.1.4 Cluster Effect

Unlike previous strategies, the usage of cluster effect on minimising impact and shortening recovery time remains controversial. Chen et al. (2019) demonstrated that although most reviewed literature notes that an industrial cluster might exacerbate disruption's impact, the examples of cases in their research provide contrary perspectives, that the positive effects of the cluster function effectively in the aftermath of disasters. They pointed out the quality of the industrial cluster allows cooperating with other disrupted companies by sharing inputs, knowledge, and labour. In addition, a case company took advantage of the cluster effect to boost their process of negotiation during the capacity recovery. Based on this, the cluster effect is considered to be a stimulus for expediting the recovery process more efficiently, rather than worsening the disruptive event. As for the New Disruption, no research has come to the conclusion that cluster effect could help organisations to recover quickly or could amplify the negative effect of the disruption.

2.6.2 Dynamic Adjustment

2.6.2.1 Capacity Expansion

Expanding the manufacturing capacity by sharing information and resources and collaborating with local manufacturers have commonly been suggested in previous studies (Chang et al., 2019; Rahman et al., 2021). The diversification of manufacturing plants in different locations and establishing emergency operation centres also might mitigate manufacturing disruptions (Li et al., 2017). This strategy may be useful for disruption occurred at a single location, however, for the New Disruption, as it was a global event, it might not be possible for organisations to find an appropriate place in a short time. In addition, it could be extremely difficult and expensive to establish new facilities under policies like lockdown and travel restriction.

Paul et al. (2020) stated that production could be increased to mitigate manufacturing disruptions by utilising more shifts, hiring more operators, and buying more machines to help recover from disruptions. However, this could not work under the circumstance of a pandemic. Rules on social distancing instead decreased the allowed number of labours in the factory, thus reduced the capacity. They also suggest that essential product manufacturers should offer basic quality products rather than premium quality items and pack the items in a minimum standard size so the same production volume could reach more customers. This would reduce the demand for essential items during pandemics, but was not applicable for most manufacturing supply chains who make products like vehicles.

2.6.2.2 Response Team Setup

One recovery activity is the formation of a response (recovery) team. In this context, the "team" refers to the members of the organisation (or across organisations) who provide information about and make decisions regarding the recovery effort (Macdonald and Corsi, 2013). Response teams have several attributes that impact their perceived effectiveness and, ultimately, recovery performance (Macdonald and Corsi, 2013). The first attribute is the size of the recovery team and the designation of one or more of its members as decision-maker(s). The second response team attribute involves the characteristics of the decision-makers, such as their experience levels, their leadership qualities, and their perspective on the severity of the disruption. The third attribute involves team dynamics—for example, whether it is functional or dysfunctional in responding to the disruption.

This kind of information sharing strategy is not a new idea in terms of SCRES. However, one of the reasons that it is still not widely used is the trust among organisations (Bai, 2023). Therefore, how this strategy could help the ASC to recover from the New Disruption remains interesting to investigate.

2.6.2.3 Product Change/ Substitutes Development

Chen et al. (2021) used a mixed-integer linear programming model to develop a disruption recovery strategy for manufacturing companies to cope with the large-scale disruptions caused by the COVID-19 pandemic. When some or all suppliers cannot recover quickly in a short period, the manufacturer may consider changing the product type partly and select the new suppliers that provide the raw material for the changed product in order to decrease the profit loss caused by this special disruption of the supply chain. Numerical experiments show that although changing products could incur additional procurement costs and sales profit loss, it can effectively decrease the impact of large-scale SCD. In addition, several managerial insights are also provided for decision-makers to address the real-world disruption problems of the supply chain.

Similar to product change, another approach mentioned in the literature is to develop substitute products. Chen et al. (2019) emphasised that the initiation of preventive plans and the development of adaptive approaches should be carried out simultaneously at the beginning of the recovery process. This approach allowed affected companies to inhibit other potential disruptions from occurring and to accelerate the recovery process when facing dynamic disruptions. Thus, in the meantime, some companies whose supply side was interrupted formed a specialized technical team in their emergency team to conduct technical development of potential substitutes, which can be regarded as an adaptive approach.

2.6.2.4 Supply Chain Redesign

Chen et al. (2019) also mentioned that their participants consider supply chain redesign as an ongoing project that should be reformed annually. After the destructive earthquake in Taiwan, most interviewed companies indicated that they made several adjustments to their mechanisms to have a more resilient supply chain. The adjustments entailed redesigning proactive plans, developing and implementing new response teams, and new processes and tools to increase the company’s resiliency.

LIST 2 (see Table 2-6) summarises all the recovery strategies from the literature above. In the following chapters, it would be discussed in Chapter 6 about why these strategies had not been effective in improving SCRES during the New Disruption, and what kind of strategies would exactly work under such conditions.

Table 2-6 LIST 2: Recovery strategies in current literature

Recovery strategies		**Reference**
Contingency plans	Backup suppliers	Lim et al. (2011), Schmitt and Singh (2012), Li et al. (2013), Gupta et al. (2014), Sawik (2016), Ivanov et al. (2016), Ivanov (2017), Rezapour et al. (2017), Hou et al. (2010), Shao and Dong (2012)
	Backup logistics channels	Unnikrishnan and Figliozzi (2011), Lewis et al. (2013), Li et al. (2013), Gupta and Sethi (2015), Ivanov et al. (2016), Ivanov (2017), Rezapour et al. (2017)
	Buffer inventory	Vahdani et al. (2011), Carvalho et al. (2012), Shao and Dong (2012), Spiegler et al. (2012), Hu et al. (2013), Iakovou et al. (2010), Hasani and Khosrojerdi (2016) , Hishamuddin et al. (2013), Lewis et al. (2013), Rezapour et al. (2017)
	Cluster effect	Chen et al. (2019)
Dynamic adjustment	Capacity expansion	Li et al. (2017), Hsin Chang et al. (2019), Paul et al. (2020a), Rahman (2021)
	Response team setup	Macdonald and Corsi (2013)
	Original product type change	Chen et al. (2021)
	Potential substitutes development	Chen et al. (2019)
	Supply chain redesign	MacKenzie et al. (2014), Chen et al. (2019)

2.7 Theoretical Perspectives on the Study of SCRES

This section briefly reviews the theories used in SCRES research to date. A well-established theoretical perspective helps to understand the phenomenon, identify relationships between variables, and increase the generalisability of findings across contexts (Foy et al., 2011). Through an extensive literature review, several fundamental theories related to SCRES are identified as mentioned in Table 2-7.

Table 2-*7* Theoretical lens of SCRES

Theories	References
Contingency Theory	Park (2011), Brandon-Jones et al. (2014), Birkie et al. (2017), Ali et al. (2018), Drozdibob et al. (2023)
Contingent Resource-Based View	Brandon-Jones et al. (2014), Birkie et al. (2017), Chowdhury et al. (2019)
Dynamic Capabilities	Ponomarov (2012), Golgeci and Ponomarov (2013), Mandal (2017), Chowdhury and Quaddus (2017), Yu et al. (2019), Bag et al. (2019), Singh and Singh (2019)
Resource-Based View	Ponomarov (2012), Hazen and Byrd (2012), Mandal (2017), Dubey et al. (2017), Chowdhury and Quaddus (2017), Cheng and Lu (2017), Liu et al. (2018), Ali et al. (2018)
Resource Dependency Theory	Mishra and Banerjee (2018)
System Theory	Blackhurst et al. (2011), Azadegan and Jayaram (2018)

Overall, the most applied theory is the Resource Based View (RBV), which considers valuable, inimitable, scarce and irreplaceable endogenous organisational resources as a source of competitive advantage (Barney, 1991). The theory suggests that organisations consist of tangible and intangible resources, which can be combined to create capabilities that determine an organisation's ability, to respond to a number of endogenous and exogenous threats and opportunities (Wernerfelt, 1984; Barney, 1991). In SCRES research, RBV has been used to explain resources and capabilities that are seen as prerequisites for resilience, such as logistical capabilities (Ponomarov and Holcomb, 2009), human, organisational and inter-organisational capital resources (Blackhurst et al., 2011), redundancies, and flexibilities (e.g., Park 2011). Other studies (e.g. Ponomarov, 2012) incorporate a related dynamic capabilities perspective, arguing that the capabilities that enhance SCRES should be dynamic in order to adapt to changes in the environment (e.g. Teece, 2007). Dynamic capabilities are an extension of the RBV theory (Bowman and Ambrosini, 2003). Teece et al. (1997) state that dynamic capabilities are key to the creation of unique value and the sustainability of organisations in dynamic markets. Dynamic capabilities theory explains how SCRES can be achieved through an organisation's endogenous capabilities to achieve sustainable performance in uncertain and unpredictable markets (Lacerda et al., 2014).

Contingency Theory has begun to be widely used in the field of SCRES from recent years. The theory views strategy as a necessary response to the environment (Wagner and Bode, 2008). Contingency Theory plays a key role in understanding and enhancing SCRES by emphasising the need for adaptive strategies tailored to specific situational variables (Brandon-Jones et al., 2014; Ali et al., 2017). The theory suggests that there is no one-size-fits-all approach; rather, the effectiveness of supply chain practices depends on the context

in which they are applied. Applying this theory, Park (2011) argues that the ability to adopt and implement a redundant and flexible SCRES approach depends on the perception of and response to current and unexpected risks. Drozdibob et al. (2023) utilise Structural Contingency Theory to distinguish SCRES as a process from SCRES as a capability, and based on multiple case studies propose a framework that can be adapted to a variety of contingencies. An empirical study by Birkie et al. (2017) explores how the supply chain environment affects the relationship between resilience and operational performance and finds a positive effect of supply chain complexity on resilience. These studies suggest that Contingency Theory provides a powerful framework for understanding the dynamic and context-specific nature of SCRES, advocating tailored strategies that take into account a variety of endogenous and exogenous factors to improve overall supply chain performance and sustainability.

Resource dependency theory (RDT) suggests that organisations rely on external resources to function effectively. In the context of SCRES, this theory emphasises the importance of managing external dependencies to enhance resilience. The relationship between RDT and SCRES is evident in the literature. For example, Hofer et al. (2012) specifically explored the impact of key retail accounts on supplier performance through a collaborative perspective of RDT. Similarly, Ali et al. (2018) identified critical sources of risks and resources essential for building resilience in perishable product supply chains. The study highlighted the role of supply chain resilience as a moderator in the negative relationship between cold chain risks and firm performance. These findings underscore the significance of managing external dependencies and allocating resources effectively to enhance supply chain resilience. Overall, resource dependency theory provides valuable insights into how organizations can leverage external resources to build resilience in their supply chains.

In addition, authors such as Erol et al. (2010) and Blackhurst et al. (2011) have used System Theory to explain resilience as an intrinsic characteristic of a system comprising of flexibility, agility, adaptability and robustness. The supply chain is viewed as an open system that is susceptible to disruptions from environmental events, and the impact of the disruption on the system depends on its level of resilience (Blackhurst et al., 2011). Blackhurst et al. (2011) suggest from a System Theory perspective that due to stringent security, customs regulations, product complexity, or lack of supplier capacity can reduce SCRES due to SCD.

There exists an argument that the main theories used so far are insufficient to explain SCRES (Tukamuhabwa, 2015). This is even more so when considering the disruptive events and

resilience experienced by supply chains in the context of COVID-19. For example, the most used RBV theory in the SCRES literature focuses on the organisation's endogenous resources and does not usually extend beyond the organisational level. However, SCRES is a system-level phenomenon that occurs at the supply chain level rather than at the level of individual organisations and involves inter-organisational linkages. Furthermore, RBV assumes that the environment is reasonably predictable and that the future value of resources can be determined (Kraaijenbrink et al., 2010). However, SCRES is characterised by emergence due to the non-linear, dynamic and unpredictable nature of the environment to which it responds. RBV also focuses on the component level, i.e. the value of individual and separable resources; it ignores the synergistic effects of these resources, making it reductionist (e.g. Kraaijenbrink et al., 2010). In contrast, SCRES is a system-level model that arises from the collective, dynamic and non-linear interactions between firms in the supply chain. As such, it can be argued that it can neither be objectively measured nor properly characterised by reductionist approaches (e.g. Brownlee, 2007).

Like RBV, both the Dynamic Capabilities model and the Contingency Theory focus on the organisational level and cannot adequately explain the systemic nature of SCRES. For example, the Dynamic Capabilities model considers the dynamic nature of markets and the evolution of organisations over time (e.g. Wang and Ahmed, 2007). Meanwhile, Contingency Theory pays attention to the fit between organisational structures and their contingencies. Most of the other theories used so far suffer from similar shortcomings in the study of SCRES (Tukamuhabwa, 2015). While System Theory recognises resilience as a system characteristic, however, today's supply chains go beyond traditional systems - they are complex systems in which the elements constantly interact with each other and with the environment in an adaptive manner. Their resilience is realised through these processes of adaptation and co-evolution. Therefore, an alternative theoretical perspective that takes these characteristics into account is needed to make further progress in understanding and building SCRES.

Considering this, the theoretical perspective of this study will be different. On the one hand, it should capture the dynamic impact of the New Disruption on supply chains, including the impact on the entire supply chain as an external variable, as well as differential impacts on different echelons of the supply chain. In addition, it is essential to be able to characterise the disruption itself in terms of the scope and length dimension. On the other hand, the theoretical perspective should also demonstrate the SCRES in the complex supply chain. As the structure of the supply chain had made the effect of the disruption more complicated than

the sum of all individuals, the theoretical lens should reveal the resilience among organisations. More details of the theoretical perspective of this research could be found in the next chapter.

2.8 Theoretical Lens of This Research

The situation after the pandemic may likely continue to create significant complexity and uncertainty for managers. More broadly, to address the substantial changes occurring, firms must adapt to or shape their environments by identifying, creating, and exploiting opportunities. The extension to and heavier emphasis on resource orchestration, rather than specific resource attributes, illustrates an outcome of these boundary conditions. Likewise, the complexity and uncertainty may reduce the value of single-purpose theories, such as agency theory, and heighten the value of more systemic theories, such as stakeholder theory. Along these lines, Harrison (2020) argued that understanding value creation in this new non-ergodic world requires the integration of theories that explain systems, resources, and stakeholders.

In order to fully understand the effect of pandemic disruption on supply chains, and how organisations in the automotive industry could response, this research is going to integrate contingency theories and resource dependence theories as the theoretical lens. Contingency theories, especially Environmental Contingency Theory, could explain how the pandemic contingency would act on the global supply chain as a unique external environmental factor compared to previous disruptions. As for recovery strategy development, organisations need to harness the cognitive of critical stakeholders inside and outside the organisations (Hodgkinson and Healey, 2011). Hence, Resource Dependence Theory may support to recognise the collaborations with supply chain partners, for overcome those challenges with external resources and gain competitive advantages. The substantial uncertainty requires inter/intra-organisational capabilities to manage the complex resource acquisition, and organisational capability development processes (i.e., resource orchestration) needed to agilely design and implement innovative strategies to recover in the new era.

2.8.1 Contingency Theory

Contingency Theory posit that good management will look different based on situational variables. A more recent definition of contingency theories in the Encyclopedia of Management breaks them down into two categories: environmental contingencies and

internal contingencies (Helm, 2000, pp. 125-126). This research will pay close attention to the environmental part, which focuses mainly on the relative stability of the environment.

Environmental complexity and dynamism are important external contingencies that in part determine the feasibility of specific flexibility strategies (Smith et al., 2019). One plausible explanation of this is that managers are not free to choose which flexibility strategy to use, rather, they have to be able to choose the strategy that best fits the demands of the task environment. This interpretation is consistent with the structure-conduct-performance (SCP) hypothesis, which posits that firm conduct (strategy) reflects the environment (Porter 1983, p. 611). Moreover, the same industrial-organisation-economic logic can also be applied to other levels of analysis, and it explains why flexibility strategy and the task environment are causally linked: managerial choice is considerably restricted by the environment. That organisations adapt to their environments is also one of the key tenets of structural contingency theory: complexity and dynamism dimensions in particular have been proposed as the key contingencies in the environment (Dess and Beard 1984).

Contingency theory in the context of supply chain management has been a topic of interest in recent literature. Thomas (2002) developed a method to quantify the reliability of supply chains for contingency logistics systems, defining supply chain reliability as the probability of meeting mission requirements. Boon-itt and Paul (2006) conducted a study in the Thai automotive industry supply chain, highlighting the moderating effects of technological and demand uncertainties on the relationship between supply chain integration and customer delivery performance. Wong et al. (2011) extended this research by examining the contingency effects of environmental uncertainty on the relationships between supply chain integration and operational performance. Grötsch et al. (2013) investigated antecedents of proactive supply chain risk management from a contingency theory perspective, emphasising the importance of managing supply chain risk proactively to avoid disruptions. Flynn et al. (2016) developed a theoretical conceptualisation of supply chain uncertainty based on contingency theory, classical organisation theory, and information processing theory, suggesting that different types of uncertainty coexist in a supply chain and may interact with each other. Alves et al. (2017) explored the relationship between contingency theory, climate change, and low-carbon operations management, highlighting the importance of an adequate low-carbon management structure to improve organisations' perceptions of the benefits of adoption. Morais et al. (2022) analysed how stakeholder salience and contingency factors influence the implementation of governance mechanisms

to address social issues in supply chains, contributing to the literature by classifying social issues and outlining archetypes of social supply chain management practices. Ahmed et al. (2022) developed a framework to enhance understanding of blockchain technology applications in supply chains, considering motivations and contingency factors influencing adoption. These studies collectively contribute to the development of a contingency theory of supply chain management, emphasising the importance of considering uncertainties, environmental factors, and risk management strategies in optimising supply chain performance.

Corresponding to this study, all the challenges brought about by the disruption of COVID-19 belong to the contingencies of the external environment. And these contingencies (challenges) have affected the choice of strategies by the managers of the organisation to deal with this unprecedented external environment. Therefore, the environmental contingency theory established the theoretical basis for this study, that is, the managers of the automotive supply chain will make decisions of strategies in response to the challenges posed by the disruption of COVID-19 to meet the needs of the organisation and the supply chain for performance recovery.

It is interesting to observe that the reactive strategies are found more often in the relatively low-predictability environments, while proactive strategies are in turn used in the relatively more predictable environments (Smith et al., 2019). One interpretation of this could be that the potential of turning the technical core into a closed system using proactive strategies is easier in environments of relatively higher predictability: when demand is predictable even to an extent, the plants can develop more sophisticated forecasting systems to further reduce uncertainty. In contrast, when demand is highly or even completely unpredictable, no matter how technologically sophisticated the forecasts, they will always be useless. Thus, adaptation may be the only feasible strategy.

In this research, the environmental contingency factor includes those external variables that capture specific settings in which a firm operates. At its most basic level, external variables represent the industry in which the firm conducts its core business. Existing research suggests that industry is a relevant contingency factor for the management of firms (De Ruyter and Wetzels, 2000; Ponsignon et al., 2015; Contiero et al., 2016; Voss et al., 2016). From the perspective of SCD brought by COVID-19, the external factors faced by different industries have similarities and differences. The similarities are that the global supply chain of almost all industries has encountered a similar crisis, and they face common problems

including logistics delays, reduced productivity and labour due to lockdown, and unstable supply of raw materials. The differences among industries come from the impact of this environmental contingency on the consumption at the end of the supply chain. That is to say, there are great distinctions in the demand of different industries. Due to the impact of the pandemic on the public, the demand for some specific industries has greatly increased (e.g. personal protective equipment supply chain, personal electronic devices supply chain). And the vast majority of industries, including the automotive industry, have experienced a sharp drop in demand. Therefore, exploring the commonalities and differences of challenges brought by the New Disruption to different industries is an extension of the Environmental Contingency Theory in the field of SCRES and risk management.

2.8.2 Resource Dependence Theory

Resource Dependence Theory (RDT) characterises the corporation as an open system, dependent on contingencies in the external environment (Pfeffer and Salancik, 2015). In contrast to the resource-based view (RBV) that is more internally focused (e.g., Barney 1991), RDT proposes that organisations must respond to the external environment. It focuses exclusively on complementary resources that can be obtained from external sources for an organisation to survive or prosper (Barringer and Harrison 2000). RDT is based largely on the concept of interdependence, which exists when one actor does not control all of the conditions necessary for achievement of an action or a desired outcome (Handfield 1993). The needs and challenges of effective coordination and integration across different members in a supply chain present unique opportunities for competitive advantage (Chen and Paulraj, 2004; Chen et al., 2004). Therefore, by focusing on interorganisational coordination and relationships in the face of resource dependence, strategic supply management is positioned to engender competitive advantages.

The underlying assumptions of the resource dependence perspective are that (1) very few organisations are internally self-sufficient with respect to strategic and critical resources, thereby leading to dependence on other firms and (2) firms seek to reduce uncertainty and manage dependence by purposefully structuring their exchange relationships, establishing formal and semiformal links with other firms (Ulrich and Barney 1984). Conceptually, the establishment of such inter-firm relationships is viewed as dealing with problems of uncertainty and dependence by increasing the extent of coordination with exchange partners. According to resource dependence, organisations can synergistically combine their resource sets with the complementary resources of their partners, thereby creating a resource bundle

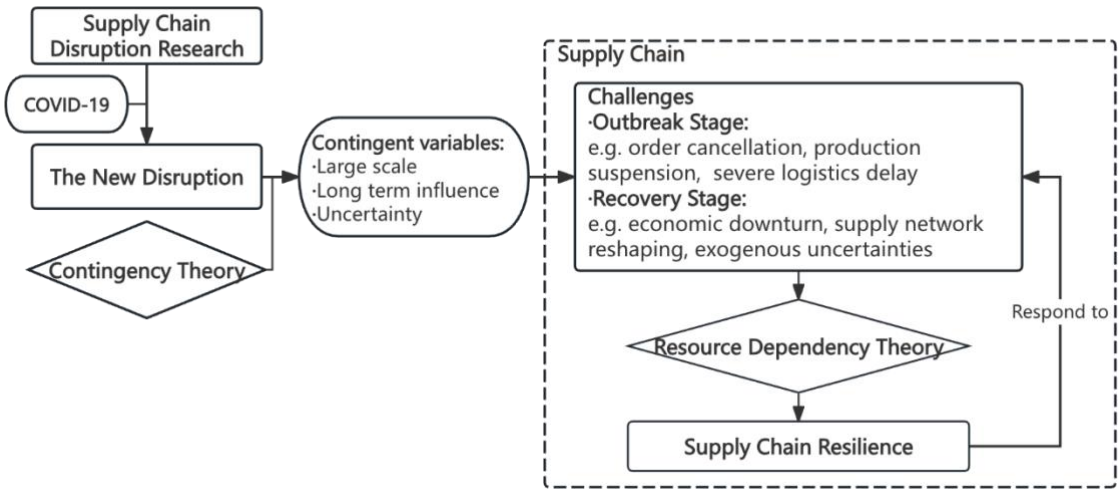
that is unique and difficult to imitate (Harrison et al., 1991). By fostering such relationship-specific capabilities that are far superior to what the firms may possess on their own (Dyer and Singh 1998), resource dependence can ultimately lead to sustainable competitive advantage.

The literature on RDT in the context of supply chain management offers valuable insights into the dynamics of inter-enterprise relationships. Trienekens and Beulens (2001) categorised approaches to inter-enterprise relationships into those focusing on business process integration, organisational collaboration, and the business environment, with RDT being one of the key perspectives. Sakaguchi et al. (2004) highlighted the role of RDT and information technology in successful supply chain integration for small and medium-sized firms, emphasising the need for a guiding model for managers. Hofer et al. (2012) provide a collaborative perspective on RDT, suggesting that engaging in supply chain relationships with key retail accounts can enhance supplier performance, particularly based on market share dynamics. Kembro et al. (2014) identified RDT as one of the predominant theories used to analyse information sharing in supply chains, alongside transaction cost economics, contingency theory, and relational governance theories. Furthermore, Qazi et al. (2018) introduced a supply chain risk management process grounded in Bayesian Belief Networks and RDT to prioritise interdependent risks and mitigation strategies. Agyabeng-Mensah et al. (2020) explored the influence of green warehousing, logistics optimisation, and social values on supply chain sustainability and economic performance through the lens of resource dependency theory in manufacturing firms. Kim et al. (2020) incorporate RDT to assess how trust, satisfaction, and commitment impact firms' decisions on logistics integration, highlighting the role of strategic relationships in improving business and operational performance in the supply chain. Lastly, Wontner et al. (2020) use RDT to examine the challenges of implementing community benefits in public procurement, emphasising the impact of resource dependence on the successful implementation of sustainable procurement policies. Overall, the literature review demonstrates the significance of resource dependency theory in understanding and enhancing supply chain relationships, risk management, sustainability, and performance across various industries and contexts.

2.9 Research Framework

Following the theoretical lens of this research, the framework is built as shown in Figure 2-2.

Figure 2-2 Research Framework



According the definition of the New Disruption, as a major change in the external environment, it has brought three main contingent variables in the automotive supply chain: Large scale indicates that the impact of the New Disruption is worldwide, which is fundamentally different from the everyday types of disruptions and disruptions of major natural disasters in the past; Long term influence indicates that many variants of the COVID-19 virus were created from the initial outbreak, which had made it medically take longer to fully overcome compared to the SARS virus, and therefore the duration of the New Disruption was also much longer compared to the past; Uncertainty represents a series of uncertain events during the New Disruption, which also includes travel restrictions and factory closures, and this increased the risk of uncertainty in supply chain activities significantly.

These variables in the external environment make it necessary for the supply chain to face a number of challenges that evolve as the disruption occurred and evolved. The challenges are categorised into two stages, the Outbreak Stage and the Recovery Stage, which cause different problems for the supply chain and face different supply chain segments. The answer to *Research Question 1* "What is the unique nature of the challenges presented by the New Disruption to the automotive supply chain when compared to previous disruptions and other industries?" is to identify the challenges encountered by the automotive supply chain due to these three external variables.

In addition to the challenges posed to the supply chain, these contingent variables also affected SCRES and the strategies of organisations within the supply chain to cope with the challenges. The impact of contingent variables on SCRES can be explained by the RDT, which means that organisations need to react to changes in the external environment. Many of the challenges posed by the New Disruption cannot be solved by the organisation's internal resources alone, and complementary resources from external sources are needed for the organisation to apply appropriate strategies to survive in the post-COVID era. Investigating which strategies are used by different organisations will answer *Research Question 2*, which is “What recovery strategies could be applied to tackle those challenges?”. Also, according to RDT, effective collaboration among supply chain members can create a competitive advantage for them in order to increase SCRES and better cope with various types of risks. Exploring the positive impact of supply chain collaboration on SCRES in this process can address *Research Question 3*, which is “How could ASC organisations improve SCRES in terms of dealing with similar disruptions in the future?”.

2.10 Summary

To summarise, this chapter reviews the literature on SCD and SCRES. With the increasing complexity of global supply chains and the frequency of disruptions, these areas are receiving increased academic attention and offer many new research opportunities.

Literature on the topic of SCD has expanded significantly over the past few years. Researchers have refined this area in terms of the definition, antecedents, and consequences of SCD. However, the study of SCD in the context of complex supply chains is still an emerging direction and there are many research gaps to be filled. This is also due to the fact that disruptions in the context of globalisation have become increasingly complex and organisations in supply chains are becoming more closely linked, thus making disruptions could no longer be solved through a single organisational perspective, but rather require multi-dimensional considerations.

The same situation also occurs in the categorisation of SCD. The generally accepted classification method of dividing disruptions into four categories is from the perspective of individual organisations. For the overall supply chain, there are only two types of disruptions: endogenous disruptions and exogenous disruptions. The disruption caused by COVID-19 is a typical type of exogenous disruption. But on the other hand, according to the existing classification of disruption from external environment, which consists of discrete events and continuous risks, it is difficult to put this disruption into any of them. Because the New Disruption is very special, it contains the characteristics of both types. Therefore, the definition of this disruption needs further research. On the other hand, both the existing literature and reality lack attention to this type of disruption with a low probability but a great impact, and this could be one of the reasons why this disruption will take a long time to overcome. Based on this, this research introduced the definition of the New Disruption.

In response to this disruption, the literature discusses the various consequences and problems caused by the impact of disruption in different industries. This study sorted out literature in the related topic and summarised the challenges caused by COVID-19 to the supply chain in order to compare with the results of subsequent studies and answer *Research Question 1*. At the same time, by comparing with the literature discussing previous disruptions, the uniqueness of the New Disruption compared with previous ones was obtained.

In order to cope with SCD, the resilience of the supply chain and its echelons is very important. The definition of SCRES is still under discussion after about twenty years of

development. It can be seen that different studies have different focuses on the description of SCRES. Therefore, it is difficult to make a unified definition of SCRES in different contexts. From these various definitions, literature specifically manifests the SCRES mechanism and its application in actual situations from the aspects of capabilities and strategies. And these studies use many different theoretical perspectives to view SCRES. However, similar to the research in the field of SCD, these theoretical perspectives currently mainly take the individual organisation as the starting point to view its resilience and the resources and capabilities to cope with the risk of disruption. When facing large-scale events such as the New Disruption, a supply chain perspective is urgently needed to find ways to improve resilience.

The theoretical lens of this research is based on Contingency Theory and RDT. Contingency Theory highlights the importance of adapting strategies to environmental variables. It helps explain how organisations in the automotive industry can respond to pandemic-induced disruptions. On the other hand, RDT emphasises the need for organisations to depend on external resources to manage uncertainty and gain competitive advantages. It focuses on inter-organisational coordination and relationships. Therefore, the research framework integrates pragmatism with Contingency Theory and RDT to address the unique disruptions caused by COVID-19, termed as the "New Disruption". The study identifies challenges in the automotive supply chain during the outbreak and recovery stages and explores strategies for enhancing SCRES through collaboration and external resource utilisation.

3 METHODOLOGY

3.1 Introduction

This chapter introduces the methodology of this research. As an empirical study, the epistemology and ontology of this research are based on pragmatism. The literature has proven that pragmatism is a good philosophical perspective for management studies (Parry et al., 2021). Upon it, this research takes the contingency theory and resource dependency theory as the theoretical lens, to support and guide the framework and methods applied. For data collection, it uses focus group and semi-structured interview to collect qualitative data. And for data analysis, this research applies thematic analysis and Interpretive Structural Modelling.

In the following parts, Section 3.2 demonstrates why pragmatism suits this research as the research paradigm; Section 3.3 and 3.4 introduce the methods for data collection and analysis Section 3.5 concludes the chapter.

3.2 Research Paradigm: Pragmatism

This research is to study the supply chain recovery from the New Disruption by COVID-19. Specifically, it aims to fully investigate the New Disruption, and validate its unique features from the previous scenarios. Besides, it aims to prioritise supply chain recovery strategies in terms of the challenges brought by the New Disruption and mitigate the impact of disruption shortages in the automotive industry. Therefore, this research focuses on an issue under a particular circumstance, which is compatible with the nature of pragmatism.

Pragmatism applies to the discipline of management by emphasising learning through action, problem solving and practical reasoning. It provides a framework for understanding the interplay between human behaviour, beliefs and the dynamic nature of service markets (Alford et al., 2008). Pragmatism in management involves focussing on solutions to problems rather than being guided solely by academic theory (Parry et al., 2021). This approach encourages critical reflection on organisational behaviour, revealing underlying beliefs and industry practices that may need to be modified. Furthermore, pragmatism in management philosophy shifts the focus from a decision-making perspective to an action perspective, highlighting the importance of understanding intentions and actions in management practice. Overall, pragmatism provides a flexible and practical framework for dealing with management challenges, emphasising the importance of adaptability, problem solving and a focus on outcomes based on real experience.

In terms of epistemology, pragmatism sees knowledge as a tool that humans use to respond effectively to their environment. Unlike the focus on abstract, absolute truths, pragmatists are concerned with effectiveness in practice. Knowledge is seen as provisional, evolving through experience and experimentation. Pragmatist approaches to epistemology emphasise the importance of empirical evidence, problem solving and the practical consequences of beliefs and actions. For example, on the research topic of "the impact of external environmental changes on supply chain resilience (SCRES)", past research has observed and investigated from many different perspectives. Scholars have adopted different theories to explain this issue, including the resource-based view, the dynamic capability view, and the stakeholder theory. Different theories bring diverse focuses and specific observation perspectives, allowing the actual problem to be viewed from different angles and providing effective and optimised solutions according to the needs of specific situations. At the same time, theories got the opportunity to be extended by combining them with case-specific conceptualisations, which serve as experiences and references for future related research. Therefore, the practical problems that this study attempts to address need to be flexibly positioned through the lens of pragmatic epistemology and related theories.

From the perspective of ontology, pragmatism is usually anti-metaphysical and anti-realist. Pragmatists are less concerned with the nature of reality itself and more focused on how people interact with and make sense of the world. Reality is seen as dynamic and conditional, subject to experience and interaction. As a result, rather than speculating on the ultimate nature of reality, the emphasis is on the practical consequences of beliefs and actions. Accordingly, there has been much research in the area of supply chain recovery from disruptions, but the conclusions drawn from these studies are not entirely applicable to the present situation. The New Disruption were regarded much more complex than those SCD in the past, and previously used recovery strategies may not be able to address this issue well. Similarly, the literature discusses the unprecedented supply chain challenges caused by the New Disruption. However, it is important to note that much of the current research focuses on how these challenges affected the pharmaceutical and food supply chains. Manufacturing, as represented by the automotive industry, may not face the same issues as these industries. For example, during the COVID-19 outbreak phase, the pharmaceutical and food supply chains faced a surge in demand, while the automotive supply chain suffered a crisis of lost orders. In other words, different industries may encounter different challenges during the outbreak and recovery phases of COVID-19. Therefore, a study specifically targeting the manufacturing sector is necessary.

As for axiology, pragmatism places great importance on values based on experience and practical consequences. Pragmatists believe that values emerge from human interaction with the world and change in response to new experiences and situations. Pragmatist values include measuring the practical consequences of different values and actions to determine their worth. For this study, the last several years have witnessed how much the automotive supply chain has struggled to deal with the problems caused by the New Disruption and try to recover from them. One reason for this is that the industry has never before went through an event such as COVID-19. As a result, supply chain participants may lack the experience to overcome it. In addition, the damage it has caused exceeded the capacity of current SCRES to withstand it. Therefore, the value of this research is that it can help to mitigate the adverse effects of disruption when organisations encounter similar problems in the future.

3.3 Methods for Data Collection

As a paradigm that emphasises the importance of practice, pragmatism has no limits on data collection methods (Guba, 1994). Therefore, this research looks for the proper methods for data collection from the perspective of the nature of the research questions.

The first step is to determine whether this study goes through qualitative or quantitative methods. There is much discussion and controversy in academia about the two terms and how to distinguish them. In this study, simple definitions are taken, as qualitative means that a studied phenomenon is related to (associated with) one or more categories (for example as done in content analysis), and quantitative refers to entities are dealt with in terms of an ordinal, interval or quote scale level of analysis (Allwood, 2011).

Tesch (2013) compiled a list of 26 qualitative methods and arranged these methods on a dimension from structured to holistic. The structured methods tend to focus on delimited parts of the studied phenomenon and to be systematic and controlled. When using holistic methods researchers try to intuitively grip their whole experience and these methods are often unstructured and theory inspired. He also argued that qualitative methods vary in their interest in regularities and patterns, where some methods search for regularities and patterns in the data while the aim of other methods primarily is to interpret meaning and actions, often in their broader social and historical context. In addition, some qualitative methods are concerned with generalising research findings to other places, times and categories of individuals. The goal of this type of approach is to identify one or a small number of

‘essential postures’ (basic postures) for a given ‘phenomenon’ (e.g., a real learning experience in life) (Giorgi, 1975; Bullington and Karlsson, 1984). Meanwhile, qualitative research basically does not use statistical methods (Corbin and Strauss, 2015).

While accordingly, the characteristic of the quantitative approach is that, it either (1) quantifies, (2) is not naturalistic or interpretative, (3) cannot use words as data, (4) does not treat, or study, meaning contents, or (5) assumes that there is an independent reality irrespective of whether it is investigated (interpreted) or not (Maxwell, 2004).

Considering *Research Question 1* and *Research Question 2*, it is to inductively understand how the New Disruption has affected the automotive industry. In other words, it tries to explore a phenomenon. Conducting the research qualitatively allows for a deep understanding of the context and mechanisms underlying the phenomenon, particularly in complex social interactions. This approach is essential for exploring realities embedded in specific contexts, which is crucial for addressing challenges. Qualitative methods enable researchers to capture the nuances of human behaviour and organisational dynamics, providing insights that quantitative methods may overlook. This depth of understanding is vital for effective management practices and decision-making in organisations (Hammoumi , 2024). And for *Research Question 3*, it requires the Researcher to conceptualise and generalise the result of this research to other industries in the manufacturing sector, and for a potential future situation. This means that an interpretive approach to the meaning contents of the phenomenon is crucial. In addition, qualitative research allows researchers to validate findings and derive rich arguments from them by using multiple sources of evidence, which is referred to as 'data triangulation' (Yin, 2009； Yazan, 2015). Therefore, this research takes qualitative approaches.

Furthermore, the actualist ontological and epistemological stance extends the methodological choices made in this study, and as Sayer (cited in Hurrell, 2014, p.343) comments in this regard, the methodological choices should "depend on the nature of the object of study and what one wants to know about it". Therefore, the main data collection techniques used in this study are focus groups and semi-structured interviews.

This section offers a succinct overview of focus groups and interviews, which have been chosen as the data collection methods. As focus groups and interviews are different methods of data collection, they often provide different types of data (Bloor and Wood, 2006). Based

on the distinction between focus groups and interviews, Morgan (1996, p. 13) notes that the two methods can be combined to enhance the research design. As Morgan states (ibid., p. 24), "Focus groups and individual interviews can be complementary techniques in a variety of different research designs. In particular, either of these methods can be used as a preliminary or follow-up to the other. This speaks to the larger issue that regardless of which method is the primary means of data collection, the purpose of combining research methods is to enhance the research project as a whole." Therefore, how the two methods were combined in this study depended on how it would be beneficial to address the research questions. This section covers fundamental principles, advantages, and limitations of both techniques. As for aspects such as data collection, sampling, and the specific application of focus groups and interviews in this study will be discussed in detail in Chapter 4.

3.3.1 Focus Group

As the name suggests, a focus group is a structured group discussion with selected individuals on a particular topic (Wilkinson, 1998; Litosseliti, 2003). A typical focus group usually involves two parties, the participants and the moderator (Parker and Tritter, 2006). Here, the moderator indicates the themes or issues to be discussed within the group and the participants share and discuss their comments and responses to a range of issues or themes. As many studies have pointed out, one of the most important elements in focus groups is group interaction (e.g. Kitzinger, 1994; Morgan, 1997, p. 3; Bloor and Wood, 2006). In addition, Wilkinson (1998) suggests that group interactions should be primarily between the participants, rather than moderator interaction with the group. That is, the role of the facilitator in a focus group should be to guide the discussion and listen to ideas rather than participate in the discussion (Krueger, 1998, p. 5). In summary, a focus group is a way of gathering participants' different opinions on a selected topic through group interaction under the guidance of a moderator.

3.3.1.1 Focus Group as a Research Method

In its early applications, the focus group method was mainly used in marketing to gather customer feedback and opinions on certain products or promotions. Later, focus groups were used in social and political sciences. Here, the main function of focus groups was to assist in collecting data covering the different perspectives of different groups (gender, age, education level, etc.). More recently, the use of focus groups has expanded with applications to management research. In its development, focus groups have different characteristics and

are applicable not only to marketing research but also to other social science research (Liamputtong, 2011).

In using focus groups as a research methodology, it can be argued that it is mostly recognised as a qualitative method. It has been noted that focus groups are only unique in terms of data collection, as data analysis has similarities to other qualitative methods such as content and thematic analysis (Wilkinson, 1998). This view is supported by other authors who have written about focus groups. For example, Bloor et al. (2000, p. 8) state that focus groups are better suited as an adjunct to other methods than as a stand-alone method. This is because focus groups can generate additional insights through group norms and group understanding. Thus, they further summarise how focus groups can be useful at the beginning, middle and end stages of a research project.

In contrast, there are also studies that discuss and apply focus groups as a stand-alone method. In response to one of the so-called 'myths' about focus groups, namely that it must be validated by other methods, Morgan (1998, p. 51) points out that the adequacy of focus group results to support certain research objectives depends on whether or not the research requires the results to be generalisable. Wilkinson (1998) gives examples of how focus groups can be used to either (1) explore new areas or research questions, or (2) study existing areas or research questions. Similarly, Kitzinger (1994) and Liamputtong (2011) give examples of how focus groups can be useful in different theoretical settings. These examples therefore demonstrate that focus group methods can be seen as effective 'stand-alone' methods in certain research environments.

In management research, focus groups can be used within or between organisations. By using this method within organisations, focus groups would be a helpful method of data collection for case studies. This study notes that many of the focus groups used in doctoral theses fall predominantly into this category. In terms of inter-organisational applications, focus groups can be used to gather different perspectives from different companies. For example, Dekkers et al. (2020) used focus groups as a 'stand-alone' methodology to study the integration of supply chain and finance. Therefore, using focus groups as a research methodology is an effective way to conduct management research that can lead to insightful results. The next sub-section will further discuss specific reasons when and why focus group research should be used.

3.3.1.2 The Rationale of Using Focus Group in this Research

As part of a qualitative empirical study, this research intends to conduct focus groups across different organisations. Using focus groups helps to "understand" the challenges in practice and answer *Research Question 1*. Here, "group understanding" is key, meaning that focus groups can capture different perspectives on the challenges faced by different organisations in supply chain activities or processes, and understand the different views of companies in different positions on the disruption. This is to try to accurately portray the entire automotive supply chain in China and make the results more representative of the whole industry. The concentration of the focus groups is to verify whether the challenges mentioned in the literature also occur in the automotive supply chain, while a relatively open discussion of the New Disruption challenges would provide insights into the first research question. Therefore, focus groups are suitable as one of the methods to investigate the New Disruption as part of this study.

3.3.2 Semi-structured interview

Qualitative interviews have been categorised in a variety of ways, with many contemporary texts loosely differentiating qualitative interviews as unstructured, semi-structured and structured (Bernard, 1988; Crabtree, 1999; Fontana and Frey, 2005). However, as structured interviews often produce quantitative data (Dicicco-Bloom and Crabtree, 2006), it does not fit in this study.

Unstructured interview refers to some relatively less formal, resembling guided conversations (Dicicco-Bloom and Crabtree, 2006). Researchers collect data through participant observation, recording field notes either by observing from the sidelines or by engaging in the activities of the people they are studying (Zhang and Wildemuth, 2009). They gather insights on the meaning of observed behaviours, interactions, artifacts, and rituals, with questions emerging gradually as understanding of the setting deepens (Burgess, 2003). What can be learned from the literature is that unstructured interview is suitable when the question is still vague and researchers need to discuss with and observe their participants to clarify the research aims. However, the aims of this study have been clearly identified. As a result, the method for data collection should be more straightly targeted at the aims and be more efficient.

Semi-structured interview is a method commonly used in research, particularly in development and geographical studies. Compared with unstructured interview which is

conducted in conjunction with the collection of observational data, semi-structured interview involves a blend of structured questions and open-ended discussions, allowing for a conversational approach while focusing on specific themes. This technique is valuable for exploring complex issues, motivations behind behaviours, attitudes, beliefs, and the impacts of policies or events on individuals' lives (Rubin and Rubin, 2011). Researchers often prepare a list of questions but engage in a conversational manner, enabling participants to delve into topics they find significant. Semi-structured interviews facilitate the collection of diverse experiences, opinions, and emotions, offering partial insights into people's thoughts and actions rather than a definitive truth. This method has gained popularity due to its ability to provide unexpected valuable information and its flexibility in adapting to various research contexts.

3.3.2.1 The Rationale of Using Interview

As another part of the qualitative data collection for this study, semi-structured interviews work well to allow participants to share their experiences of coping with the New Disruption and to mine as much information as possible based on each individual's responses. Unlike investigation about challenges using focus groups, which require participants to reach a consensus view of the literature and have a unified perception of what was going on in the automotive industry as a whole, the exploration of strategies requires getting as many different perspectives as possible. In practise, each company got different challenges to tackle, and also adopted different approaches and strategies even for the same type of problem, depending on their own operations and the environment they operate in. So in this part of the data collection process, the focus is to explore differentiated strategies among organisations and make a rich result. And semi-structured interviews are well suited to achieve it.

3.4 Methods for Data Analysis

There are many different approaches to qualitative data analysis. Mason (2006) outlines three possible approaches, labelling them "literal", "interpretive" and "reflexive". The first method is an analysis process that focuses on, for example, the exact use of a particular language or grammatical structure. The second approach involves understanding the narratives of study participants so that the researcher attempts to interpret what they mean. Finally, a reflective approach attempts to focus attention on the researcher and their contribution to the data creation and analysis process. In this study, the last two methods will be used to analyse the data collected by focus groups and interviews. For data collected by

focus groups, this research would use thematic analysis and Interpretive Structural Modelling to analyse the data. While for data from interviews, a thematic analysis would also be conducted, followed by further analysis to answer the research questions. The unit of analysis for this study is organisations, as the research investigates supply chain strategies implemented at the firm level.

Before applying specific analysis method, the first step is to convert the recordings obtained in the focus group/interview into text, classify them, and then remove the parts that do not contain valid information such as fillers. With these preparations in place, it will go through each citation and answer the following four questions, as suggested by Krueger and Casey (2002): 1) Did the participant answer the questions asked; 2) did the comments answer the different questions in the focus group/interview; 3) does the comment illustrate what is important about the topic; 4) has it been said before. By answering these questions, the data can be categorised according to pre-set questions and duplications are removed so that the data can be analysed more efficiently in the next stage.

Subsequently, the data would be prepared for the analysis phase, mapping and interpretation. One of the key objectives is to gain insight not only into the individual citations, but also into the relationships between them and the links between the data as a whole. In a seminal contribution, Krueger (1998) outlined seven established criteria, which were subsequently distilled into the following five headings by Krueger and Casey (2002): The five criteria are as follows: frequency; specificity; sentiment; broadness; and the big picture. The primary distinctions pertain to the exclusion of words, context, and internal consistency from the explanation, the separation of frequency and breadth into two discrete categories, the redefinition of the intensity and big ideas of reviews as sentiment, and the introduction of the big picture. While the introduction of the new category is a welcome development, as it offers clarity and concision, Rabiee (2004) posited through research that the inclusion of the three excluded criteria would prove beneficial for students and novice practitioners. These criteria, he suggested, would enhance the rigour of the process and yield more nuanced explanations. To this end, he proposed the addition of word, context, and internal consistency, thus establishing a total of eight criteria. The objective of this study is to employ this method for the analysis of the literalised data. This approach is intended to enhance the reliability and validity of the study through the application of the eight criteria, and to facilitate the preparation of the data for utilisation in subsequent analytical techniques.

3.4.1 Thematic Analysis

Thematic analysis is a widely used method of analysing qualitative data. It provides a systematic and flexible approach to analysing and interpreting complex information and plays a vital role in understanding qualitative data. Thematic analysis presents characteristics of accessibility, flexibility and theoretical freedom, with a rich and detailed account of information. And it enables researchers to identify patterns, themes, and meanings in data that can lead to deep contextual understanding of real-world problems (Levac et al., 2010; Squires, 2023). This approach is particularly valuable in social and organisational contexts, providing a powerful and flexible tool for qualitative research. By understanding its philosophical underpinnings and following clear guidelines, researchers can effectively use thematic analysis to derive meaningful insights from qualitative data (Majumdar, 2019). And by emphasising the importance of theoretical positions and the dynamic nature of the method, thematic analysis enhances the rigour and validity of qualitative research.

Thematic analysis is applicable to this study because of its ability to effectively explore different perspectives and experiences (Nowell, 2017). Both the focus groups and the semi-structured interviews were based on the participants' different perspectives on the New Disruption and their experiences of coping with it. These formed the core of the data collected for this study. The use of thematic analysis allows for the generalisation of challenges into major themes, to get for a broad overview of the challenges posed by the New Disruption to the automotive supply chain, as well as demonstrating the diversity of coping strategies within the sub-themes to correspond to different types of challenges. Its flexible and rich analytical capabilities make thematic analysis a valuable tool for discovering insights and generating meaningful interpretations from qualitative data of this research.

3.4.2 Interpretive Structural Modelling

Thematic analysis could help get the result of the focus group i.e. those challenges happened to the ASC. However, the limitation of this method is that it could only present the result in a cross-sectional way. Given the truth in Section 2.4 that the challenges from the New Disruption were evolved, it is necessary to involve another analysis method to offer a different perspective of viewing the challenges. This method is required to disclose how the challenges were changed in a timely manner.

The analysis of such problems is optimally facilitated by a multiple-criteria decision-making approach (MCDM) (Luthra et al., 2018； Raj et al., 2020). A variety of MCDM tools can be utilised, such as the Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Decision-Making Trial and Evaluation Laboratory (DEMATEL), and Interpretive Structural Modelling (ISM). AHP has been utilised to ascertain the relative ranking of elements; ANP has been employed to assess rankings, facilitate the identification of interdependencies between components, and address the issue of consistency, though its application is limited due to the intricacy of the procedure; The DEMATEL method has been shown to reveal the causal relationships between different factors, as well as to rank factors in relation to the types of associations (Raj et al., 2022).

In contrast to the provision of a binary outcome, i.e. cause and effect among factors, ISM possesses the unique advantage of assessing logical connections and presenting a multidimensional result (Mangla et al., 2018). It is a technique widely utilised to analyse complex relationships among different components, and aids in understanding the interdependencies and influences between various factors (Kumar and Goel, 2022； Sreenivasan et al., 2023). The basic principle of ISM is that for any complex problem under consideration, there may be many factors that are relevant to the problem or issue. In order to be able to analyse these complex issues more accurately, exploring the direct and indirect relationships between these factors could deliver a more precise description of the overall situation than looking at the individual relevant factors in isolation, and therefore ISM develops insights into collective understandings of these relationships.

In the field of supply chain management, ISM has been widely used. Mandal et al. (1994) developed a supplier selection model using ISM, emphasising the importance of quality, delivery performance and price in the selection process. Kannan et al. (2008) focused on the selection of green suppliers based on changing environmental requirements and analysed the interactions between the criteria using ISM and the Analytical Hierarchy Process (AHP) to analyse the interactions between the criteria. Mudgal et al. (2010) identified the barriers to implementing green supply chain practices through surveys and ISM methodology to provide insights for managers. Diabat et al. (2012) analysed the supply chain risks in the food industry by using ISM to identify various types of risks based on a literature review and expert consultation. Dubey and Ali (2014) used ISM and TISM analysis to identify the key variables and their relationships in flexible manufacturing systems. Thirupathi and Vinodh (2016) analysed the sustainable manufacturing factors in the automotive component

sector by combining ISM and structural equation modelling to establish structural relationships between the enablers. Lim et al. (2017) used the ISM to sustainable supply chain management in the context of knowledge management, aiming to improve firm performance in the textile industry. In conclusion, ISM has proved to be a valuable tool for analysing relationships, identifying key factors and improving decision-making processes in various fields.

Despite the extensive recognition and utilisation of ISM, its implementation may be hindered by inherent limitations. A notable limitation pertains to the intrinsic subjectivity of the process, as ISM relies heavily on expert opinion to establish relationships between elements, which can introduce bias and inconsistency, especially in group decision-making settings where consensus is difficult to achieve (Chen et al., 2023). To mitigate the impact of these biases, the application of data triangulation plays the pivotal role in the context of ISM in this research. Additionally, while ISM has the capacity to identify logical relationships and connections between factors, it is not able to present an accurate picture of the strength of these connections, since relationships between these factors are not always equal (Gorane and Kant, 2013). This is not a concern in the present study, however, as the objective of employing ISM is to explore the associations between challenges, rather than to compare the strength of these associations. The complexity of ISM could also act as a barrier, as it requires a deep understanding of the methodology and the ability to manage large amounts of data, which can be daunting for practitioners unfamiliar with the technique (Singh et al., 2017). This issue can be circumvented by ensuring that the Researcher has acquainted themselves with the relevant literature in order to comprehend the methodology, and by attending the requisite training.

Accordingly, this study applies ISM to the analysis of focus group data in order to understand the relationship between challenges from the New Disruption. The New Disruption itself is not a single event like a disaster such as an earthquake or a tsunami. It arose from the spread of the virus, but the various types of events that followed, whether the natural evolution of the virus or man-made influences, has made the situation very complex. Therefore, rather than simply investigating what challenges the automotive supply chain experienced during this period, this study uses ISM to understand the antecedents of the challenges and the interactions between them (see Figure 3-*1*). More specifically, ISM can help the Researcher to expose the propagation of challenges across the supply chain (also known as the ripple effect) from the data collected in focus groups. It can visualise the challenges at different levels, showing the causal relationships among them, and this could lead to more effective

decision-making. Therefore, ISM makes a substantial contribution to the response to *Research Question 1* of this study.

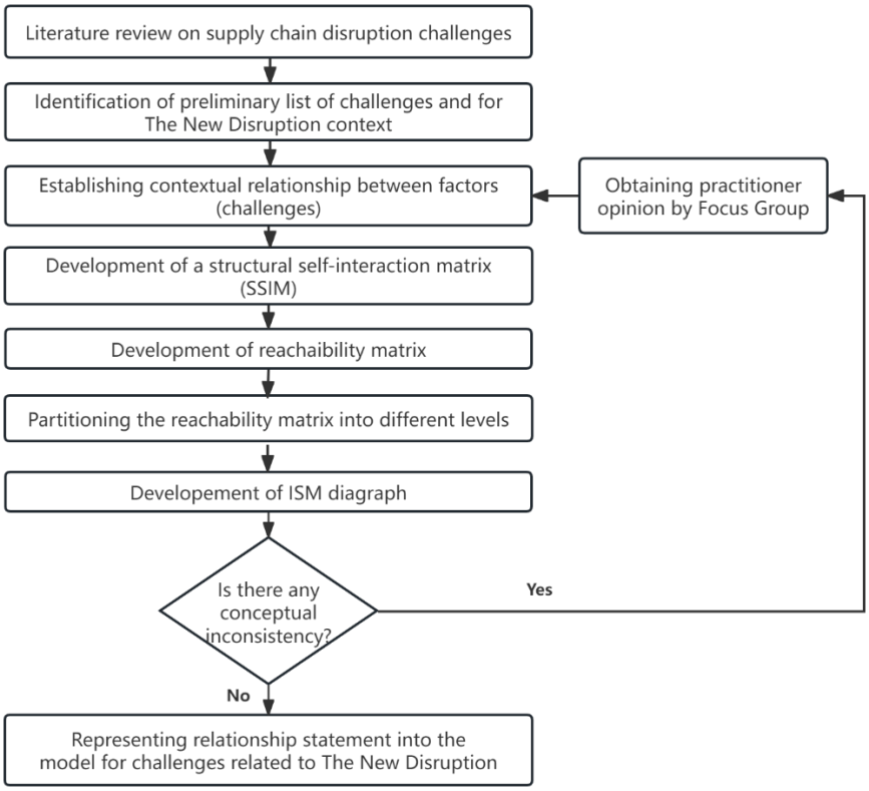


Figure 3-*1* Interpretive Structural Modelling process

3.5 Summary

The chapter effectively sets the stage for a detailed empirical investigation into supply chain recovery strategies in the context of the automotive industry during the COVID-19 pandemic. This chapter outlines the methodology used in the research, which is grounded in pragmatism. It is chosen for its suitability in addressing practical issues in dynamic environments. Pragmatism emphasises learning through action and problem-solving, making it ideal for studying supply chain recovery from disruptions like the New Disruption. The epistemology of it focuses on knowledge as a tool for effective response to the environment, emphasising empirical evidence, while the ontology part focuses on human interaction with the world and the practical consequences of beliefs and actions. As for axiology, values are based on experience and practical outcomes, stressing the importance of mitigating disruption impacts on the automotive supply chain.

This chapter also explains the use of focus groups and semi-structured interviews for data collection and thematic analysis alongside ISM for data analysis. These methods could

provide rich, triangulated data, and help validate findings and offer detailed insights into the research questions. More details could be found in the following chapters.

4 DATA COLLECTION

4.1 Introduction

This chapter describes the detailed process of data collection in this research, including the overall process, the criteria for sample selection, the underlying background of the participants, and the detailed data collection design. It is mentioned in Sub-section 3.5 that in order to answer all the three research questions, the data collection in this study consisted of two methods, which are focus groups and semi-structured interviews. This corresponds to the two stages of data collection. The focus group method was used in the first stage in order to collect data to validate the applicability of disruptions in the existing literature to the New Disruption and to refine the picture of it in the automotive supply chain, answering *Research Question 1* "What is the unique nature of the challenges presented by the New Disruption to the automotive supply chain when compared to previous disruptions and other industries?". Having grasped the specifics of the New Disruption in the automotive supply chain, semi-structured interviews were used in the second stage in order to investigate the ways in which organisations were responding to the challenges and the effect that supply chain collaboration made in the process, answering *Research Question 2* "What recovery strategies could be applied to tackle those challenges?" and *Research Question 3* "How could ASC organisations improve SCRES in terms of dealing with similar disruptions in the future?".

All data collection for this study was reviewed and approved by the Ethics Group of the College of Social Sciences at the University of Glasgow. Participant information sheets were provided to all participants and signed Consent Forms were collected prior to the start of each focus group and interview. The Consent Forms allowed for the audio recording of all elements of the discussions. In addition, the moderator of each focus group took notes during the discussions. These recordings and notes were the primary source of qualitative data for this research.

In this chapter, Section 4.2 introduces the overall process of the data collection; Section 4.3 demonstrates the criteria of selecting the sample organisations from the entire Chinese ASC, to ensure the result could be representative; Section 4.4 introduces the recruitment process of the participating organisations; Section 4.5 gives a brief background knowledge of these sample organisations involved in this research; Sections 4.6 and 4.7 provide more details how focus groups and interviews were designed and conducted; Section 4.8 shortly summarises the key points in the process.

4.2 The Overview of Data Collection Design

This sub-section provides an overview of the data collection process in this research. In order to address the research questions completely, the data collection consists of two stages – Stage I and Stage II – following Chapter 3.

The aim of Stage I is to identify the supply chain challenges faced by organisations in the automotive supply chain since the outbreak of COVID-19 and to answer *Research Question 1*. At this stage, the Researcher used a focus group format to discuss the challenges posed by the New Disruption identified from the comprehensive literature review in Chapter 2 with the experts from ASC organisations to verify whether these challenges existed in the context of ASCs, i.e. whether ASCs experienced these challenges during the New Disruption, and to provide additional information on more specific challenges existed in ASCs but were not covered by the literature. The focus of this stage was to reach a common understanding with practitioners about the challenges that the New Disruption posed to the ASC.

After having the answer to *Research Question 1*, the goal of Stage II is to find effective recovery strategies for these challenges posed by the New Disruptions. In this phase, more experienced people in supply chain related departments from the suppliers, OEMs, and distributors in the ASC were invited to participate in semi-structured interviews to gather as many types of recovery strategies as possible. In the interviews, the Researcher asked the respondents for effective strategies to overcome those challenges based on the results obtained at Stage I. Figure 4-1 shows the whole process of data collection in the methodology of this study.

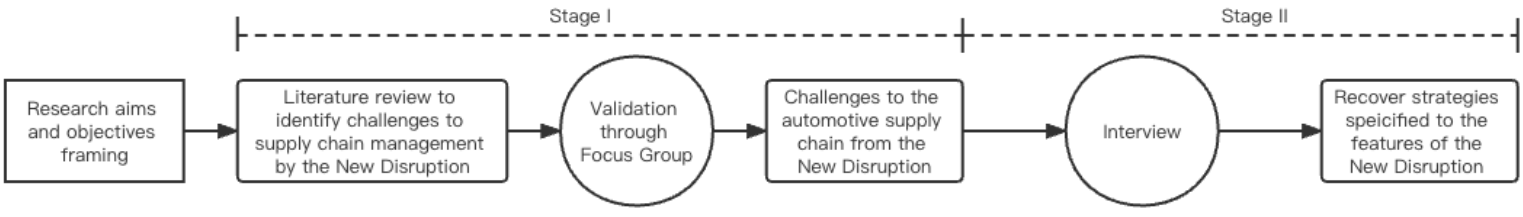


Figure 4-1 Overview of the data collection process

4.3 The Sampling Criteria of Automotive Supply Chains

This sub-section details how to select suitable organisations for qualitative data collection in this study. The ASCs and all individual organisations need to be selected based on theoretical

sampling and rigorous criteria to reduce exogenous variation and ensure comparability of results (Eisenhardt, 1989; Yin, 2014). First, ASC must rely on global supply and demand to adequately reflect the global challenges posed by the New Disruption. Second, to be considered part of the ASC, all nodes must have a long-term business relationship with at least one other node. This allows for analysing dichotomous relationships (Seuring , 2008) and, in particular identifying similar or different responses to specific environmental challenges (Kähkönen, 2011). Thirdly, considering cultural and regulatory characteristics that may influence the results, only nodes with a high market share in China are included, which may need to be taken into account when interpreting the results. With these features, the chosen ASCs could fulfil the representativeness and revelation criteria applicable to the analysis of this study (Seuring, 2008).

Based on the theoretical reference (Cox et al., 2004; Seuring, 2008), two of the most important criteria for choosing the sample organisations in this study are: the sample organisations should be as large as possible and have as high a market share as possible to ensure that the results obtained are representative of the automotive industry in China (where most passenger vehicles were produced, sold, and exported globally as a single market); and that the sample organisations' businesses are affected by the New Disruption as much as possible, so that the data collected are more diversified and relevant to the characteristics of the New Disruption. In addition to this, in order to enrich the source of data and better reflect the overall situation of the Chinese ASC, other criteria include the selection of organisations from different regions of China, as the policies adopted by different regions in response to COVID-19 may be different. In terms of the product type, the chosen organisations should be selected to encompass the majority of the automotive product market, including both traditional ICE vehicles and electric vehicles. In terms of the business scope of the organisations, in order to ensure that the globalised nature of the New Disruption can be revealed, the sample organisations should have a business scope that goes beyond the Greater China region, and their suppliers and customers should contain firms from overseas.

Finally, the selected sample organisations should have supply chain connections with each other, i.e., they are in the same supply chain, in order to enable the Researcher to observe from a supply chain perspective. After all the above conditions are met, secondary factors including accessibility to data, ease of conducting focus groups/interviews, and social reputation of the organisation were also considered.

The next step is to quantify or visualise these criteria as appropriately as possible to ensure that they have been accurately followed. With regard to the size and market share of the sample organisations, relevant reports published by the National Bureau of Statistics of China could be referred to, from which the selection could be narrowed down. As for the extent to which organisations have been affected by the New Disruption, the same could be done by referring to official statistical reports from the government, or the organisations' own annual reports if available. By comparing sales and revenue comparisons before and after the COVID-19 outbreak, it was possible to identify organisations that have been severely affected. Another way was to follow the news in the area where the organisation was based, and indirectly determine the extent to which the organisation has been affected based on the local situation of coronavirus infections. Because areas with more cases of infection were more likely to impose measures such as closures and travel restrictions, and more organisation's production activities would be affected. Other information, such as the scope of the sample organisation's operations and product portfolio, could be obtained from the organisation's official website or official reports. Information on the supply chain in which the organisation was located is based on the Researcher's past experience and connections in the automotive industry.

4.4 Recruiting Process

4.4.1 Focus Group

In accordance with the criteria outlined in Section 4.3, a group of organisations that satisfied the specified requirements was shortlisted by the Researcher. These organisations were contacted via the official email addresses provided on their websites, as well as via the professional networking platform LinkedIn, and through the Researcher's personal connections, in order to ascertain their willingness to participate in this study.

The recruitment of focus group participants employed a snowball sampling approach. This approach offers several advantages in the context of business research, including the ability to tap into organic social networks. This method allows researchers to gather rich, qualitative data from informants who are interconnected, thereby enhancing the depth of insights obtained. Additionally, it fosters trust and rapport, as referrals often come from known contacts, leading to higher quality interactions (Noy, 2008). This approach aligns with the research design and the objective of the focus group, as it facilitated the investigation of challenges and the formulation of responses to the research question from a supply chain perspective. The method employed enabled the identification of participants from the supply

chain through the solicitation of recommendations from existing participants. Finally, the participation of three organisations originating from the same supply chain in the focus groups was secured (See Figure *4-2*). It is important to note that, for ethical reasons, all organisations have been anonymised and referred to by numbers instead of their real names.

Figure 4-2 Focus group sample organisations

4.4.2 Interview

Following the similar rules of the recruitment process of focus groups, organisations participating in interviews comprised nine organisations: six OEMs, two material and component suppliers from the battery and tyre industries, and one distributor (see Table *4-1*). The recruitment process stopped at the ninth organisation because the data saturation was reached. More details could be found in Section 4.7.2.1.

Table 4-1 Overview of all organisations

Organisation	**Roles in supply chain**	**Product type** (ICEV = Internal combustion engine vehicle, HEV = hybrid electric vehicle, EV = electric vehicle)
Organisation 1	Supplier	Tyre
Organisation 2	OEM, supplier	ICEV, HEV, ICE powertrain, EV
Organisation 3	Distributor	Sale service
Organisation 4	OEM	EV
Organisation 5	OEM	ICEV, HEV, EV
Organisation 6	OEM	ICEV, EV
Organisation 7	OEM	ICEV, EV
Organisation 8	Supplier	Power battery
Organisation 9	OEM	ICEV, HEV, EV

For these organisations, they form into different supply chains as shown in Figure 4-3. The next section describes the basic background of all the participating organisations.

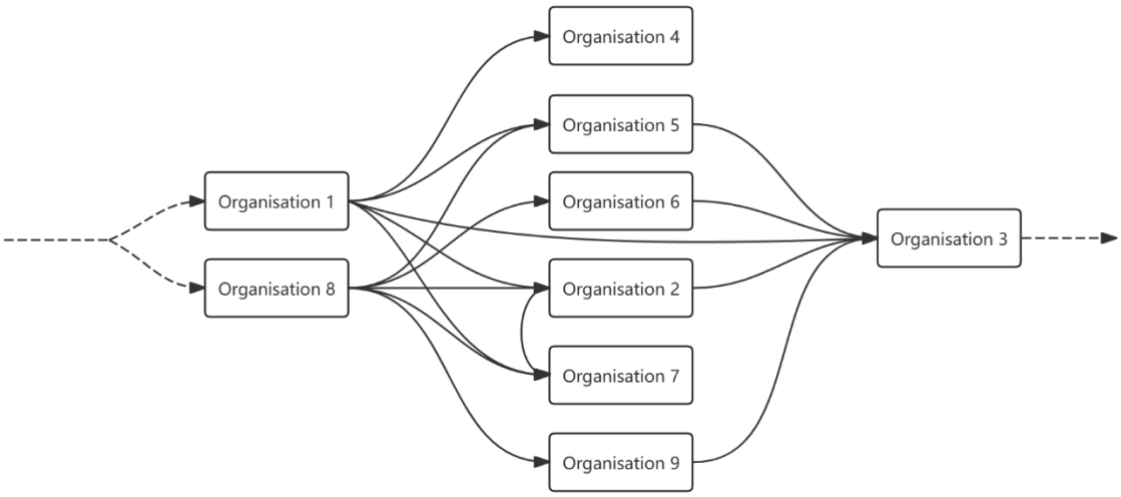


Figure 4-3 Interview sample organisations

4.5 Selected Organisations

This section provides the description of the organisations that participated in data collection, including their background and business operations. It aims to have a certain impression of the scope covered by the selected organisations and to prove that they could be the representatives of China's automotive supply chain.

It should be noted that data collection for this study was completed in 2023, and thus all statistics below are for 2022 and earlier. In accordance with the ethical considerations outlined previously, the sources of all related data will be identified exclusively as follows: the National Bureau of Statistics of China, the China Association of Automobile Manufacturers, the China Automobile Dealers Association, the China Passenger Car Association, the China Rubber Industry Association, and official reports published by participated organisations. These sources will no longer be referenced in context.

4.5.1 Organisation 1

Organisation 1 is an automotive tyre manufacturer from China. In 2021, it is one of the world's top 10 tyre manufacturers and one of the largest tyre manufacturers in China, with an annual operating revenue of over 30 billion RMB. Currently, Asia has become the world's tyre manufacturing centre, and China has become the world's largest tyre producer and an important tyre exporter. Organisation 1 has more than 25,000 employees and thousands of engineers and technicians, adopting international advanced production technology and international top tyre manufacturing and testing equipment, its tyre technology and production capacity is in the leading position in China.

Relying on a strong and completed domestic and overseas marketing network, Organisation 1's tyre products cover most of China's provinces and cities, and has set up production bases in Southeast Asia and wholly-owned subsidiaries in America and Europe. It exports to most of the countries and regions in the world, including Europe, the Americas, Africa, Oceania, Southeast Asia and the Middle East. And Organisation 1 has formed a solid sales mode combining direct sales and distribution sales. The direct sales mode is mainly for major domestic OEMs, to provide them with original tyre products; the distribution mode is mainly for the tyre replacement market, to meet the needs of consumers for various types of car tyre replacement.

4.5.2 Organisation 4

Organisation 4 is an overseas electric vehicle and energy company, which mainly produces and sells electric vehicles and energy storage equipment in the automotive industry. Since its establishment, Organisation 4 has launched a number of pure electric models and laid out the global market, and is one of the first brands to carry out electric vehicle business in China. In 2021, Organisation 4's total revenue was 53.7 billion USD, an increase of 71% year-over-year, demonstrating strong economies of scale and profitability.

Organisation 4 has a production plant in Shanghai and has delivered more than 400,000 vehicles to customers worldwide in 2021, including around 300,000 in the Chinese domestic market and more than 160,000 in overseas markets, fulfilling the demand from more than 10 countries in Europe and Asia. It is worth noting that Organisation 4 has established a supplier industrial cluster, covering the whole ecological chain of electric vehicle parts such as batteries, on-board chips, autonomous driving systems, passenger car interiors, precision machining, etc., and formed a complete industrial ecology. Its localisation rate of automotive parts produced in China exceeds 95%.

4.5.3 Organisation 5

Organisation 5's business scope in China includes the production, sales and service of automobiles, engines, transmissions and other parts. Through Organisation 5 and its subsidiaries in China, the group's passenger cars, commercial vehicles and a series of other high-, middle- and low-end brands and motorcycle brands operate in various market segments in China. Since entering the market, Organisation 5 has always been one of the market leaders in China. In 2021, Organisation 5 and its joint ventures delivered more than

three million vehicles in mainland China and Hong Kong, standing on the top of passenger car sales. Organisation 5 currently has more than thirty factories in nine provinces to produce vehicles and parts.

4.5.4 Organisation 6

Organisation 6 is a wholly owned subsidiary of an American automobile company established in China. This American company is one of the largest automobile companies in the world. It has a very strong presence in China and was the first American automaker to develop a business in the country. Organisation 6 is headquartered in Shanghai and provides consumers with fuel, electric and hybrid products and financial services for mid-range and luxury brands in the Chinese market. Despite continued supply chain disruptions, it achieved steady sales growth in 2021, with a total of more than 600,000 vehicles sold for the year, an increase of 3.7 per cent compared to the previous year. Organisation 6's strategic focus in China is on its commercial vehicle business, electric vehicles and exports, using its China operations as an “export hub” to export lower-priced electric vehicles and commercial vehicles to markets such as South America, Australia and Mexico.

Organisation 6 has a total of eight subsidiaries in China, including a large integrated automotive enterprise with vehicle, engine and transmission manufacturing. It has three existing production bases, forming a strategic layout distributed in the east, west and north of China. Totally there are seven plants, respectively five vehicle plants, an engine plant and a transmission plant. The one located in western China has become the brand's largest production base outside the United States. In addition to this, Organisation 6 operates an automotive engineering research company in China, which utilises Chinese engineering research capabilities to design and develop global products, as well as the introduction of its models into the local market. It has developed into one of the largest global product and technology development centres, providing research, development and test services for high technology on vehicles, automobile and parts manufacturing, localisation and sales, and procurement consulting services for parts and components.

4.5.5 Organisation 2

Organisation 2 is a private automotive group integrating the design, research and development, production, sales and service of complete automobiles, powertrain assemblies and key components, with more than 70,000 employees, and ranked top in the sales of Chinese-brand passenger cars for consecutive years. The Group has been listed in the

Fortune Global 500 for twelve consecutive years. The cumulative annual sales volume of Organisation 2 in 2021 was more than one million units, which was located in the top three places of the whole Chinese market share in terms of total volume, leading the independent brands. Its product range includes saloons, SUVs and MPVs, and covers fuel, hybrid, plug-in hybrid, alcohol-electric hybrid and pure electric powertrains.

Organisation 2 has styling and engineering R&D centres in east China, as well as in some Europe, North America and Southeast Asia countries. Its products are sold in 53 countries, with more than 1,400 sales outlets of various types, and its main export countries are located in Eastern Europe, the Middle East, Africa and Central America, ranking top among the car exporters in China.

4.5.6 Organisation 7

Organisation 7 is headquartered in Europe and currently employs over 40,000 people worldwide. Global sales of the company's cars were close to 699,000 in 2021, increased 5.6 per cent from 2020 despite continued component supply shortages due to the New Disruption. And the total car sales of Organisation 7 in mainland China reached 160,000, up 7.6 per cent year-on-year, and made the brand's highest-ever single-market sales volume globally.

Organisation 7 has based its Asia Pacific headquarters in China, and has automotive OEMs in the southwest, northeast and east regions of China. They are primarily responsible for the production of Organisation 7's ICE, hybrid and all-electric vehicles, which are sold to most of Asia, Oceania and parts of North America.

4.5.7 Organisation 9

Organisation 9 is a joint venture between a European luxury car brand and a Chinese company. The business of the organisation covers research and development, sourcing, production, sales and after-sales service of the luxury brand in China. More than 800,000 vehicles were delivered in the Chinese market in 2021, an increase of 8.9 per cent year-on-year, making it a leading luxury brand in the Chinese passenger car market.

With a state-of-the-art production base in northeast China and branches in large cities including Beijing and Shanghai, Organisation 9 employs nearly 26,000 people and has about 430 local suppliers. Organisation 9's production factory is one of the largest in the

automotive brand group's global production network, with two complete vehicle plants, a powertrain plant and a research and development centre. Its production system in China uses a wide range of state-of-the-art Industry 4.0 technologies, and in 2017 it was included in the 'Top 10 Technological Advances in Intelligent Manufacturing in China'. From 2020, Organisation 9 has produced the brand's first all-electric core model, which is produced exclusively in China and exported to the global market.

4.5.8 Organisation 8

Organisation 8 is the world's leading power battery and energy storage battery company. It is mainly engaged in the research and development, production and sales of power batteries, energy storage batteries and battery recycling products, and is committed to providing first-class solutions and services for global new energy applications. For the power battery field, which is an electric vehicle component and a part of the ASC, Organisation 8 ranked top in the world for five consecutive years in terms of power battery usage from 2017-2021, accounting for one third market share in terms of power battery usage in 2021. Organisation 8' power battery products include battery cells, battery modules and battery packs, with applications covering electric passenger cars, electric commercial vehicles, and other electric mobility tools and off-road mobile machinery. In the field of electric passenger cars, its power batteries have been widely used in pure electric passenger cars, plug-in hybrid passenger cars, hybrid passenger cars and micro hybrid passenger cars. It has long-term strategic partnerships with global customers such as Tesla, Volkswagen, Ford, Daimler, Toyota, Peugeot Citroen Group, and Nio. Headquartered on the southeast coast of China, Organisation 8 has set up thirteen battery manufacturing bases around the world located in China and Europe.

4.5.9 Organisation 3

Organisation 3 is a large automobile dealership group, ranking among the top ten in China. It is a core member company of its Fortune 500 parent company and has nearly 10,000 employees. It operates most of the domestic and international automobile brands in China, and has the agency rights for nearly 50 brand series, covering most of the mainstream brands. Organisation 3's business network covers the east, central and western regions of China, with nearly 200 member companies. Its core business involves new car sales service, automotive finance, used car sales, car parts, insurance agency, rescue service, travel service, automotive e-commerce, automotive recycling and other automotive eco-services.

4.6 Design of Focus Group

The goal of the focus group is to build consensus on the literature review and to identify the real challenges ASC encountered in the New Disruption. Existing literature discussing the impact of the New Disruption on supply chains mainly focuses on areas such as healthcare and food, with relatively little research on manufacturing. Hence, whether the automotive industry also encounters challenges faced by other industries needs to be confirmed. Focus group is a common qualitative research technique, usually consisting of 6-12 members (Guestet al., 2006). It is chosen for its ability to produce more in-depth information through interactive discussions (Goldman, 1962). Although the literature shows that more costly individual interviews tend to produce a larger number of responses, focus groups are more effective for investigating complex topics and result in uncovering ideas that may have otherwise been overlooked by the subjects individually (Morgan, 1996).

4.6.1 Types of Focus Group

Based on the categorisation of participants, Krueger and Casey (2015) identified four different types of focus group design. Table *4-2* summarises these types of focus groups. They also noted that the different types of designs were used in order to gather a greater diversity of opinions and to provide more control over the group discussions. The purpose of using focus groups in this study was to have an open discussion about the challenges posed by new disruptions to the automotive supply chain and to investigate whether the results in the literature are applicable to the automotive supply chain. Therefore, there was little need to define specific categories of participants and therefore a single-category design was considered more appropriate. Krueger and Casey (2015) also note that the key to a single-category design in focus groups is that the Researcher collects data until the discussion no longer yields additional insights.

Table 4-2 Types of focus groups

Design	**Description**
Single category	Conducting focus group discussions with no specified groups of participants
Multiple category	Conducting focus group discussions with pre-categorised audience groups
Double layer	Adopted when categorisation of participants in the group discussions can be further specified
Broad involvement	Allowing the focus groups to include participants from all relevant parties related to the topic

4.6.2 Participants

When it comes to the design of focus groups, the number and size of the groups should be considered carefully. The number of groups usually depends on how many variables need to be controlled for in a single category design (Liamputtong, 2011). As the aim of focus group in this research was not to pre-categorise participants, the decision on the number of groups here was based on considerations of data richness and encouraging group interaction. Therefore, it was decided to have at least three groups, so that the results of the group discussions could also be triangulated. In terms of the number of participants in each group, this usually ranges from 3 to 14 (Bloor et al., 2000, p. 26). In order to ensure that there was interaction in the discussion and that each participant had enough time to express their views, the number of participants in each group was set at three for this study. This contrasts with larger groups which provide participants with fewer opportunities to express their views, whereas smaller groups allow for more in-depth ideas to be explored (Polit and Beck, 2008).

It is common practice in focus groups that participants ideally share common experiences. However, it has been noted that there should still be a degree of variation among participants to ensure that insights are shared in group discussions (Bloor et al., 2000, p. 20; Liamputtong, 2011). The participants in each focus group were senior supply chain management professionals from ASCs in China. They came from different organisations involved in ASC and represent different stakeholders in the supply chain. The focus groups would be organised around the impact of new disruptions on ASCs. All discussions were recorded with the prior consent of the participants and then transcribed and summarised for analysis. In order to maintain appropriate anonymity, the names of contributing individuals and companies have been omitted and only the sector and its hierarchy in the supply chain were mentioned. The focus groups were expected to reflect different organisations and functions and were therefore well suited to integrating the perspectives of multiple parties (e.g. Tier 2 and Tier 1 suppliers, OEMs) to gain a wealth of ideas and insights. Table *4-3* shows the list of participants in the focus groups.

Table 4-3 Profile of participants in focus group

Participant	**Job**	**Years of experience**
1	Production Manager	9
2	Supply Chain Manager	13
3	Logistics Manager	11
4	Chief Operation Officer	18

5	Production Manager	8
6	International Logistics Manager	5
7	Procurement Manager	7
8	Logistics Planning Specialist	4
9	Production Manager	6

As interaction is recognised as one of the benefits that can be derived from focus group research, the Researcher also sought to achieve good group interaction by (i) allowing participants to use their own language, (ii) encouraging the production of fuller representations, and (iii) providing an opportunity to observe the process of forming a collective consciousness (following the guidelines in Wilkinson, 1998). These aspects can be ensured by using moderators for each group. In general, focus group moderators should not attempt to control the discussion within the group (Bloor et al., 2000, pp. 48-49). Therefore, moderators in this research were chosen based on their knowledge of the overall theme of 'disruption' and the moderator's familiarity with the focus group research format. This was achieved by hiring three PhD students in other research clusters (i.e. who have limited knowledge of SCD and SCRES) who conducted focus groups before or use focus group as their research methods. Besides they were less familiar with the subject of automotive supply chains to moderate the group discussions. This would help to avoid inadvertently steering the discussion towards ‘forced data’.

Differences in hierarchy between participants are another important factor. This is because the literature suggests that the more homogeneous the group members are, the more they are encouraged to share their views (Krueger and Casey, 2015). Similarly, some participants may be reluctant to disagree with their 'boss' on some of the issues raised as this may be ‘too risky professionally to agree with’ (Clark and Ivankova, 2015). Therefore, it should also be ensured that participants in the same group are from different organisations or different parts of the same organisation during the recruitment phase to mitigate this power imbalance.

4.6.3 Reflexivity

When adopting a qualitative approach like focus groups, critical reflection should be undertaken, to provide adequate information about any assumptions made by the researcher that may have affected the research process and results. This allows the transparency of the findings to be assessed (Morrow, 2005). This critical self-reflection in qualitative research is referred to as reflexivity and is considered indispensable when investigating research data

as it examines the researcher's understanding, their practice choices and any ethical dilemmas that may have guided the research process. It also emphasises the need for researchers to be highly self-aware and conscious of their role (Merriam et al., 2016). In addition, it contributes to an understanding of the culture under study and means that information is not only captured by the focus group participants on their own terms, but also through the lens of the researcher (Cutcliffe, 2003).

Many ways to address self-reflectivity have been discussed in the literature. One of the most helpful and valuable approaches is to self-reflect on the data from the start of the data collection to its completion (Morrow, 2005). Within this, researchers are expected to keep an ongoing record of their thoughts, experiences, reactions and new insights into any assumptions or biases that emerge, and these reflections could then be reviewed and incorporated into the final analysis as needed (Morrow, 2005). Another reflective approach involves working with a research team or peer debriefer (Hill et al., 2005) who will organise the ideas and the researchers' responses to the research process, and may also suggest alternative ideas and interpretations to those put forward by the researcher. In addition, Rallis and Rossman (2012) recommend using a "community of practice" where researchers discuss their work with knowledgeable colleagues, leading to ongoing critical discussions about the research process.

As part of this data collection, the concept of reflexivity was emphasised and it was recognised that the researcher's understanding, experience and awareness of the cultural context under investigation (i.e. China) did influence the shaping of the research process. The reflective process was recorded in field notes (i.e. debriefing/summary notes) and discussed with supervisors. As a result, the planning details involved in the research process and the implementation of the focus groups were discussed in an attempt to be transparent about any aspects of the research process that may have influenced the results.

4.6.4 Procedure of Focus Group

This sub-section describes in more detail how the focus group was conducted. For the ease of organising the moderator and participants of each group, all three focus groups were conducted online. The questions for the focus group were developed based on the laddered questioning technique (Price, 2002) as shown in Table *4-4*.

Table 4-4 Guiding Questions of the Focus Group

Topic	Questions
Non-intrusive icebreaker question	What changes has COVID-19 brought to your life so far?
Challenges from the New Disruption in the ASC	Have you ever faced challenges mentioned in the literature (as shown in LIST 1)?
	Have you encountered any problems that were not listed?
Categorisation of the challenges	Which categories do you think the challenges should be classified according to the affected departments/functions?
Conclusion	Is there anything that was missed?
	Is there anything you would like to add?

According to this technique, thematic questions begin with a non-intrusive icebreaker question to enhance rapport. For this reason, the first question for participants was "What changes has COVID-19 brought to your life so far?" This was intended to promote group cohesion and begin discussion on the topic (Price, 2002). Then it went with a 20-minute introduction by the Researcher. The purpose of the introduction was to provide an overview of this focus group study and some key terms such as the “New Disruption”. In addition, the introduction included information on how the focus group discussions would be conducted and what this study hoped to achieve through the focus groups.

The focus group discussion then began. The moderator started by listing on screen the challenges mentioned in the existing literature on the New Disruption as summarised by the Researcher. Participants would then be asked to determine, based on their own experiences, whether the challenges mentioned in the literature had also occurred or were being experienced, and whether they had encountered any problems that were not listed. After participants have reached a consensus, the next key step is to categorise the identified challenges. Participants were asked to categorise the challenges according to the affected departments/functions (e.g. raw material supply, production planning, logistics, demand shift) to understand the scope of the New Disruption. In addition, depending on the period of the New Disruption, the challenges were also categorised into which challenges appeared in the outbreak phase and which ones appeared in the recovery phase. This is to provide a more detailed understanding of the impact of the unique characteristics of the New Disruption on the ASC. The next step was that by categorising all focus group discussions, a complete list of the challenges posed by the New Disruption in ASC were obtained.

Finally, two concluding questions were asked to see if anything was missed: "Is there anything that was missed?" and "Is there anything you would like to add?" This helped to ensure that the Researcher had covered the topic completely, but also provided an opportunity for the participants to ask questions or raise ideas that may not have been previously raised. At the end of the focus group discussion, all moderators debriefed, sharing discussion notes and initial thoughts, including verbal and non-verbal communication (consistent with Kidd and Parshall, 2000, pp. 288-299). Figure 4-4 shows how the focus groups were conducted.

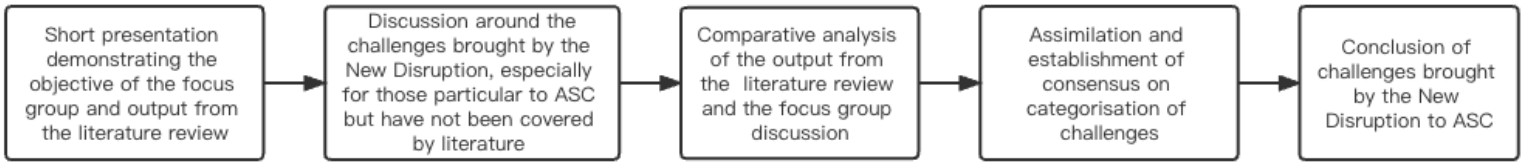


Figure 4-*4* Focus group process

4.7 Design of Interview

The primary function of the interviews in this study is to explore possible recovery strategies for the New Disruption in the ASC. This includes validating whether supply chain recovery strategies derived from the literature are effective in the automotive industry under the current circumstances, and what strategies practitioners in the ASC have adopted to address existing challenges in response to the New Disruption problems. As with the challenges posed by investigating the New Disruption, the methods for supply chain recovery gathered through the literature review were drawn from many industries, and their applicability to issues such as parts supply, transportation, and fluctuations in demand across the global automotive supply chain needs to be further explored. On the other hand, given that this disruption is an unprecedented event and that the recovery of the automotive supply chain has so far been less than satisfactory, how could existing recovery strategies be effective in helping organisations in the ASC, and where they fall short for the New Disruption also need further research. Therefore, this study plans to answer these questions by interviewing industry practitioners.

4.7.1 Structure of interviews

Semi-structured interviews were used in Stage II of data collection as the nature of this research may oscillate between exploration and interpretation. In semi-structured interviews, it was possible to focus on important issues for the subjects and allow for different views to be expressed (Silverman, 2013). Researchers can introduce the research topic in the

interview, asking for opinions and perceptions about the topic, but allowing enough space for a variety of data to emerge and insights to be generated (Saunders et al., 2009). Based on the research design, an interview guide (see Figure *4*-5) was developed prior to conducting the interviews (Castillo-Montoya, 2016). The interviews consisted of four sections: (1) the organisation's specific situation when experiencing the New Disruption, (2) past pre-planning for the disruption, (3) recovery strategies for specific challenges, and (4) future outlook. Based on the purpose of this qualitative study, these four sections addressed *Research Question 2* and *3*. To facilitate access to the data, all interviews were conducted online.

Interview guidelines

Type of interview: Semi-structured

Topic	Questions
Experiencing The New Disruption	What happened to your department and organisation during the COVID-19? Is there any major differences compared to the time before COVID-19, in terms of supply chain operations?
Past pre-planning	Do your department or organisation have any kinds of strategies to cope with disruption? Did they make an effect for The New Disruption? - If so, how did they help? - If not, why couldn't they?
Recovery strategies	According to the list of challenges here, what did your department or organisation do specifically to tackle this challenge? Is there any new method that came up just for The New Disruption? Is there any challenge that isn't covered in the list? If so, what strategy did you apply?
Future outlook	How would you rate the effectiveness of these strategies for The New Disruption? How would your department or organisation act for a similar situation in the future?

Figure 4-*5* Interview Guidelines

4.7.2 Participants

4.7.2.1 Sample size

In terms of deciding the sample size, generally, the concept of "data saturation" is widely used in qualitative research to determine the sample size. It means that the sample size needs to be large and diverse enough to achieve the purpose of the research (Kuzel, 1992; Marshall, 1996; Patton, 2014). The consensus among related studies is that sample size cannot be estimated by formulae or perceived redundancy as in quantitative studies. Therefore, the interview sample size in this research was not determined in advance, as it is advised to be determined by theoretical saturation, i.e. the point at which no new concepts emerge from the data. Interviews would commence with the people from the organisations that

participated in focus groups, as the access was already obtained, and continued until saturation occurred (Miles et al., 2014).

Then it comes to the question of how the Researcher determined when data saturation has achieved. The concept of data saturation may be easy to understand, but executing it is completely another matter. Guest et al. (2006) assumed a certain degree of homogeneity of participants because in purposive samples, participants are by definition selected on the basis of certain common criteria. In this case, the more similar the experiences of the participants in the sample are in terms of the research area, the faster saturation can be reached. At the same time, they point out that the concept of data saturation only applies to interviews with structure and not to unstructured and highly exploratory interviews. That is, all interviewees will always be asked a similar set of questions, otherwise the goal of the interview is fluid and there will always be new responses to new questions. And based on the structure of the interviews in this study, data saturation was appropriate as a way of determining the number of interviewees. Fusch and Ness (2015) summarise several specific criteria for implementation: when there is enough information to repeat the study, when the ability to obtain more new information has been achieved, and data saturation is reached when further coding is no longer feasible (Walker, 2012； O'reilly and Parker, 2013). For this study, these were feasible judgement criteria for determining the emergence of saturation, particularly as data collection for the interviews could be stopped when coding of the transcripts revealed that no new themes were no longer being generated.

In addition, this study used the information power model proposed by Malterud et al. (2016) for reference when designing the sample size of interviews. The information power model mentions quality of dialogue that would affect the number of needed participants. Strong and clear dialogue between the Researcher and participants may provide more information power and reduces the need for large quantities of interviewees. Therefore, in order to maximise the quality of the interview, the Researcher may need to undergo some additional interview training beforehand. In addition, this also means that the sample size may need to be dynamically adjusted as data collection progresses.

4.7.2.2 Interviewee selection

Unlike focus groups, the criteria for sampling in interviews placed more emphasis on breadth than on representativeness. Under most situations, a broad study requires more sample size than a narrow study to provide sufficient information, because the phenomena it faces may

be more complex. Following the aim of this study, in order to summarise the impact of the New Disruption on the automotive supply chain as comprehensively as possible, the scope of finding participants should be expanded from upstream and downstream. Since the main research object of this study is the automotive industry, all the interviewees would be practitioners in this industry. At the same time, specificity also pays attention to the fact that these participants from specific target groups also show some variations to provide richer data. For example, it designs to invite participants from companies that play different roles in the automotive supply chain.

Specifically, the selection criteria for interviewees included the following: 1) the Researcher first made sure that the selected interviewees understood the research topic, i.e. organisational resilience, including the organisation's previous coping strategies; 2) the selected interviewees had to have worked in the case organisation for at least five years, to have a minimum understanding of the organisation's development, and would most likely have experienced the phenomenon under study (the complete two phases of the New Disruption), and be able to compare the pre- and post- New Disruption different situations; 3) the selected respondents must be willing to talk freely about the topic; 4) the selected respondents should represent different functions and hierarchical levels, so they could see the topic from different perspectives, which helps to overcome informant bias, resulting in divergent and rich data (Eisenhardt and Graebner, 2007); 5) the selected respondents should have different functions and different areas of expertise. Finally, this study interviewed 15 practitioners from 9 organisations when data saturation has been achieved, as shown in Table *4-5*.

Table 4-5 Profile of participants in Interviews

Interviewee	**Organisation**	**Position**	**Years of experience**
1	Organisation 4	Production manager	7
2	Organisation 4	Supply chain manager	10
3	Organisation 5	Logistics manager	5
4	Organisation 5	Production manager	8
5	Organisation 6	Production manager	9
6	Organisation 6	International logistics manager	9
7	Organisation 2	Procurement manager	6
8	Organisation 2	Logistics planning specialist	7
9	Organisation 2	Production manager	11
10	Organisation 7	Export business manager	5

11	Organisation 9	Supply chain manager	8
12	Organisation 1	Chief operation officer	18
13	Organisation 1	Production planning manager	6
14	Organisation 8	General manager	10
15	Organisation 3	General manager	8

4.7.3 Procedure of Interview

This sub-section discusses the data collection of the interviews. The use of interviews as a method of data collection was considered and approved by the Ethics Committee of the College of Social Sciences at the University of Glasgow. The interviews were conducted face-to-face or online and each interview lasted approximately one hour. In preparation for the interviews, the Researcher learnt and built up some knowledge about how to conduct interviews for research purposes and sketched a framework to keep in mind during the interviews (see Figure *4*-6). It helped to maintain a degree of consistency and similarity in the interviews. The researcher reviewed this compilation of knowledge and tools in preparation for each interview.

Sequence of events

1 Introduction
- a. Researcher personal presentation
  - i. Make clear that our role is researcher (and not consultant or manager or other)
  - ii. Establish a relationship
- b. Overview of the study and its purposes
- c. Deliver "Participant Information Sheet" and "Consent Form"
  - i. Brief explanation of rules, confidentiality issues and boundaries
  - ii. Procedures of interview (audio recording), duration, follow-up
  - iii. Comment on why the participant was chosen
- d. Offer to answer questions later, after the interview
- e. Focus on the topic at hand (sense of urgency and focus)

2 Warm-up
- a. Simple initial questions
  - i. What is your role/function?
  - ii. How long have you been in this organisation? And in this function?
  - iii. How is it to work here?

3 Main body of the interview
- a. See *Interview guidelines*

4 Cool off questions
- a. Signal the nearing of the interview end
- b. Place easy questions (tension diffusion)

5 Closure (short, not to waste time)
- a. Expression of gratitude
- b. Next steps: sign official Consent Form, if ok to contact again for another interview
- c. Turn off audio recorder

6 "Off the record" time
- a. Continue to talk to participant, and register mentally (and write after he leaves)

Figure 4-*6* Interview sequence of events (Yin, 2009)

The interview process began with an introduction, where the Researcher presented himself and made it clear that his role was strictly that of a researcher, rather than a consultant, manager, or any other position that could be misinterpreted. The aim in this initial stage was to establish a comfortable rapport with the participant and create an environment conducive to open discussion. The Researcher provided an overview of the study, explaining its purposes and objectives. Alongside this, the Researcher delivered key documents, including the "Participant Information Sheet" and the "Consent Form," ensuring that the participant understood the scope of their involvement. Confidentiality issues were addressed, with the Researcher briefly explaining the boundaries and rules to ensure the participant felt secure. Additionally, the Researcher outlined the procedures of the interview, covering the use of audio recording, the expected duration, and the possibility of follow-up interviews if required. The Researcher also explained why the participant had been specifically chosen for the interview and offered to answer any questions after the session had concluded.

Following the introduction, the interview moved into a warm-up phase, where the Researcher posed simple, non-threatening questions to ease the participant into the conversation. These initial questions included asking about the participant’s role and function within the organisation, how long they had been with the organisation and in their current role, and a light-hearted question about what cars the participant owned. This phase was designed to build rapport and reduce any tension, allowing the conversation to flow smoothly into the main discussion.

The main body of the interview followed a semi-structured format, focusing on key topics related to the study’s objectives. The Researcher explored the participant's experience with a major disruption, specifically the impact of COVID-19 on their department and organisation. The Researcher asked how operations had changed compared to the time before the pandemic, encouraging the participant to reflect on significant differences. The Researcher also inquired whether the organisation had strategies in place to cope with such disruptions and, if so, whether these strategies were effective. If the strategies had helped, the Researcher asked the participant to explain how they were beneficial. Conversely, if the strategies had not worked, the Researcher sought to understand the reasons behind their ineffectiveness. The discussion also touched on recovery strategies, with the participant being asked to describe how their department addressed specific challenges during the disruption and whether any new methods were developed to manage the situation. The Researcher further inquired if there were any challenges not covered in the standard list and

what strategies were applied to deal with those. Finally, the Researcher asked the participant to evaluate the effectiveness of these strategies and consider how their organisation might respond to similar disruptions in the future.

As the interview drew to a close, the Researcher signalled that the session was nearing its end by asking a few light, easy-to-answer questions to help diffuse any tension that may have arisen during the main discussion. The closure was kept brief to respect the participant's time, and the Researcher expressed gratitude for their participation. If the participant agreed, they signed the official Consent Form, allowing the Researcher to contact them for any potential follow-up interviews. Once the interview ended, the Researcher turned off the audio recorder but continued informal conversations with the participant, making mental notes that would be documented afterward. This "off the record" time allowed for additional insights that may not have been captured during the recorded portion of the interview.

4.8 Summary

This chapter detailed the comprehensive process of data collection for the research, focusing on the sample selection criteria, the recruiting process, the background of participants, and the specific design of data collection methods. It ensures the research's robustness and the reliability of its findings.

This study utilised focus groups and semi-structured interviews across two stages to address the three research questions. The data collection was divided into two stages: At Stage I, focus groups were used to validate the applicability of disruptions identified in the literature to the ASC during the COVID-19 pandemic, addressing *Research Question 1*; At Stage II semi-structured interviews with more executives from suppliers, OEMs, and distributors were conducted to explore effective recovery strategies to counter those challenges, and ways of improving SCRES, addressing *Research Question 2* and *Research Question 3*.

The sample ASC organisations were selected based on rigorous criteria to ensure representativeness and comparability:

- Global Supply and Demand: Selected ASCs must rely on global supply and demand.
- Business Relationships: Organisations as nodes in the ASC must have interconnected and long-term business relationships with each other.
- Market Share in China: Only organisations with a high market share in China were included.

- Diverse Regions and Product Types: Organisations from different regions of China and covering both traditional ICE vehicles and electric vehicles were selected.

Nine organisations were selected, including six OEMs, two suppliers, and one distributor. They are diverse in their roles and product types, ranging from OEMs producing ICE, hybrid, and electric vehicles to suppliers of tyres and power batteries. This diversity ensures a comprehensive representation of the Chinese automotive supply chain.

For the design of data collection methods, focus groups aimed to build consensus on the literature review findings and identify the real challenges faced by the ASC during the New Disruption. The method was chosen for its ability to produce in-depth information through interactive discussions. And then, interviews were conducted to gather detailed insights on recovery strategies. Participants were asked about their plans to cope with disruptions and specific strategies they adopted in response to identified challenges.

5 DATA ANALYSIS AND FINDINGS – FOCUS GROUP

5.1 Introduction

This chapter presents the data collected in the first stage, which focuses on the challenges that organisations have faced from the New Disruption. This includes the detailed data analysis process, results, and discussion of findings from the focus group. The aim of this chapter is to answer the first research question, and produce the results of the focus group for the next stage of data collection (see Figure 5-1).

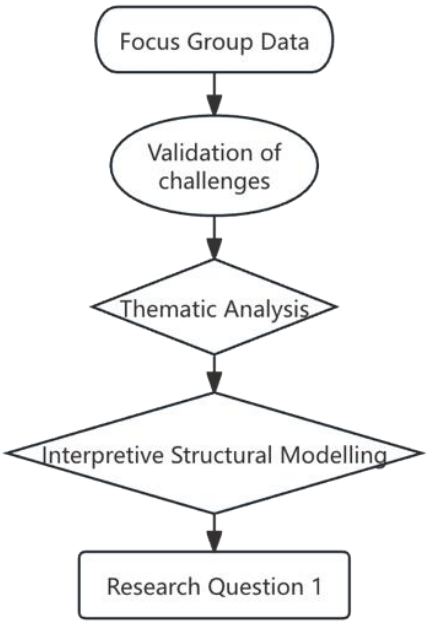


Figure 5-1 Framework of focus group analysis

The chapter is structured as follow: Section 5.2 gives demographic details of the participants of the three focus groups; Section 5.3 illustrates how the data was analysed, including important points while processing the data; Section 5.4 discusses the verification results compared to the literature; Sections 5.5 and 5.6 present the results from the thematic analysis and Interpretive Structural Modelling (ISM); Section 5.7 illustrates the key findings derived from three groups within the Focus Group and how *Research Question 1* was addressed; finally this chapter ends with a summary in Section 5.8.

5.2 Demographic Details of the Participants

Nine participants volunteered to participate and were divided into three groups; they were managers with between five- and thirteen-years' experience in the automotive industry. Their organisations are from different parts of China, which means they had different

conditions and local regulations. Further details of the respondents' characteristics could be found in Table *5-1*.

Table 5-1 Demographic data of the focus groups participants

Participant	Job	Years of experience	Location
1	Production Manager	9	Shanghai
2	Supply Chain Manager	13	Shanghai
3	Logistics Manager	11	Shanghai
4	Chief Operation Officer	20	Hangzhou
5	Production Manager	8	Hangzhou
6	International Logistics Manager	5	Hangzhou
7	Procurement Manager	7	Beijing
8	Logistics Planning Specialist	4	Beijing
9	Production Manager	6	Beijing

5.3 Data analysis

5.3.1 Transcribing

The Researcher transcribed the digital audio recordings of the three groups word-for-word within two weeks of each session. In order to provide space for initial thoughts on the corpus, and to ensure comments could be mapped back to participants, line numbers were inserted into the text, and line spacing and margins were increased. Participants' reactions, such as long pauses, and non-verbal communication (e.g. laughter) were also recorded in the text. This is to ensure that the formats of all data sets were comparable, to help resolve any inconsistencies, and to determine the context or tone of responses. Participants were also assigned a unique number. They were colour coded red to indicate respondents from an OEM and green to indicate respondents from a Tier 1 supplier. This process of coding and organising transcripts made the data from each respondent easy to review while providing structure and consistency to the analysis and supporting the indexing process. Once the

transcriptions were completed, the Researcher checked the entire content of each transcript for errors by listening back to the recordings and reading the transcripts simultaneously.

5.3.2 Field Notes

Participants' perspective could be learned through the observation of the Focus Group, however, field notes are also important to support this and are recommended for use during interviews and discussions (Mulhall, 2003). Therefore, the Researcher took field notes in this study to preserve and record behaviours, activities, events, and other features of interest (Clifford, 1990). Field notes often constitute all of the data collected for research, such as observational studies. It can also be supplemented with data from traditional interviews and discussions, as in this study. These notes are read by the Researcher and are provided as continuing evidence as they form an easily accessible record of research data (Muswazi and Nhamo, 2013). Another benefit of field notes is that they are key to capturing data in a more natural context. This ultimately creates meaning and understanding of the culture, social situation, or phenomenon being studied (Moll et al., 2006). It also helps researchers understand emotions of the participants and become part of the audit trail of understanding culture and development topics (Mulhall 2003).

Despite the advantages, it is worth mentioning some disadvantages of this strategy and how researchers have addressed them. Field notes can be highly subjective as they reflect the Researcher's own perspectives, interests, memories of the research, and what he or she thought was important at the time (Silverman, 2001). For this reason, this can cause differences in the data weighted by the research groups and the descriptions used (Muswazi and Nhamo, 2013). And most notes may never be included in the results because they are inconsistent. They are fragments of narratives and descriptions of things that were considered important at the time (Silverman, 2001). Accuracy problems can also be found if notetaking is delayed after the interview or discussion, as the moderator of each focus group may forget important details or remember the details differently than the participants (Muswazi and Nhamo, 2013). Confidentiality is also an issue if participants want to see notes taken during interviews or discussions (Mulhall 2003).

To address these issues, the Researcher developed two formats for recording field notes in this study. The first took place during the discussion, and its purpose was to capture the views, thoughts and interactions of the participants on the topic under discussion. A second form of notes is completed at the end of each group as a summary note to identify common

themes, emerging themes, issues identified during the discussion, and suggestions for future discussions. Both forms are intended to reduce the variability and fragmentation of the reported data and to increase the quality and consistency of the data collected. None of the participants expressed interest in reviewing field notes, expressed concern, or reported discomfort while taking notes.

In the analysis phase, both field notes were examined and combined for the overall analysis. The first type was extracted from the conversation notes and used to describe the participants' interactions in both verbal and non-verbal forms. These were taken into account during the discussion and their most agreed/disagree views were highlighted. In this way, the Researcher was able to identify the topics and quotes with which the research participants most agreed/disagreed. It also helps to inform about emerging themes and questionnaires at a later stage. Another type of note took place after each group and was used as an auxiliary memorandum for the Researcher. For example, the notes of each working group were carefully read and compared to identify common issues, and ultimately used to support the inferences about topics drawn from the recorded data. Summary notes also help to understand how the Researcher felt during the conversation. This information is used as an audit trail in the development of themes (Mulhall, 2003).

5.3.3 Translation

It should be noted that all focus groups in this study, as well as the one-to-one semi-structured interviews in the following sections, were conducted in Mandarin, and the transcriptions and field notes were presented in Chinese. This is because this study selected Chinese ASC as a case, and the participants, including the Researcher, are all Chinese nationals and native speakers of Chinese. Therefore, in the subsequent analysis of data and the writing of this paper, a job of translation into English must be done. Since translation is an interpretive process, not just a direct transfer of information from the source language to the target language, translating needs to systematically and accurately capture the full meaning of spoken language.

Attention has been paid to cross-language interview and translation in qualitative research (Al-Amer, 2016). As more and more scholars from the non-English-speaking world are mentored by English researchers, the issue of language differences in cross-language research has implications for different disciplines, including social sciences and management disciplines. For example, a particular concept in one language may not have

the same meaning in another language (Temple and Young, 2004). This can be problematic when research projects are based on a qualitative research paradigm that requires accurate interpretation of data in a cultural context, as effective translation is essential to convey participants' messages.

The methodological orientation of the research will also have an impact on the approach and accuracy of the translation. For example, if the aim of the study is to use a post-structuralist approach to explore how informants perceive their world, then there will be a high demand on the translator's knowledge of the cultural context of both the source and target languages and a tendency for data to be lost in the translation process (Al-Amer, 2016). Whereas, if the aim of the study is to conduct a traditional thematic analysis and to represent the narrative as an objective fact, which is the same as in this study, then the difficulty of translation is greatly reduced.

In order to reduce the potential loss of Chinese narrative data in cross-language research, the linguistic challenges encountered in this study are managed in two ways. First, focus groups and interviews were conducted by an "insider" who speaks the same language as the participant and understands the culture. Given that the participants in this study all belonged to the same ethnic group, this approach is important because it allows the Researcher to be as close to the data as possible and to retain records to support a rich description of what was observed and felt during the interview (Temple, 2002; Wallin and Ahlstrom, 2006). In addition, the Researcher conducted the analysis with Chinese as their mother tongue and translated it at a further stage, such as the thematic level, rather than translating the entire narrative at the initial stage. During the translation process, the Researcher used verbatim quotes. Verbatim quotes are used to provide detailed descriptions in qualitative research. The use of verbatim quotes is essential to support the interpretation of a particular experience and to strengthen the Researcher's claims (Corden and Sainsbury, 2006) as it can bring the experience to life and personalise the results. In addition, narrative text written by researchers is often clearer when supported by verbatim quotes (Corden and Sainsbury, 2006).

5.4 Validation of Challenges from the Literature

For the challenges related to the New Disruption in *List 1*, Table *5-2* shows the results of the discussions from the focus group, as whether they occurred in the automotive supply chain. For each of the row (i.e. the challenge), the result was determined by the participants'

answers. Specifically, it would be marked as “Yes” if any of the participants agreed that it has happened to their organisation, or “No” if none of the participants thought they have ever faced this kind of challenge. This is because as long as a certain challenge has occurred in any organisation, it should be regarded as existed in the ASC, no matter how many organisations or echelons in the supply chain have had the same problem. In that way, all the challenges in ASC could be recorded as the research design.

Table 5-2 Discussion result of LIST 1

Stage	**Likely recovery challenges reported**		**Occurred in ASC**
Outbreak	Uncertainty of demand	Order cancellation	Yes
		Surges in demand caused by hoarding and panic buying	No
	Supply disruption	Extended delivery times	Yes
		National lockdown	Yes
		Out of stock	Yes
		Limited operations of partners	Yes
	Insufficient preparedness	Lack of applicability of existing contingency plans	Yes
		Lack of resources to implement rapid recovery plan	Yes
Recovery	Re-construction of supply chain network	Supply chain relationship maintaining	Yes
		Permanent closure of operations of supply chain partners	No
		Synchronising processes, maintaining vertical integration	No
	Balance between economic and social sustainability	Layoff and availability of human resources	No
		Health and safety concerns of workers	Yes
		Lack of government enforcement and regulations for social issues	No
	Global economy recession	Demand falls in long term	No
		Shortage of working capital	Yes
		Reduction in Return on Investment	Yes
	Adoption of new technologies and management methods	Adaption to shifts in channels and new modes of distribution	No
		Implementation of digital technologies	Yes

From the responses in the data, it is clear that participants from different regions agreed on the challenges in the literature, with the differences mainly being in cases other than the

challenges in *List 1*. Challenges came in many different forms due to local policies, factory locations, import/export business models.

The result indicated that challenges in each of the seven broad categories have occurred in the ASC. For the more subdivided 19 specific challenges, 12 were confirmed by the focus group participants and 6 were deemed not to be occurring. Of the six challenges from the literature that were rejected, only one was from the outbreak phase, while the remaining five were in the recovery phase.

Specifically, most of the challenges related to the New Disruption mentioned in the literature were found in the ASC. This suggests that there was a great deal of commonality in the problems related to the New Disruption encountered by supply chains across industries, i.e. the characteristics of the New Disruption – global scale, long duration, and extreme uncertainty – were reflected across industries, and the ASC supply chain was no exception. This phenomenon means that these characteristics of the New Disruption were distinct enough to mask the differences between the vast majority of supply chains in different industries, to the extent that what they experience was similar, though there were some subtle differences. This makes conceptualising the New Disruption and defining its characteristics and impacts in their entirety very meaningful, as to some extent these can be rolled out to other industries to provide a basis for addressing similar issues.

5.4.1 Outbreak Stage

From the result of Table *5-2*, seven of the eight outbreak stage challenges appeared in the ASC, almost exactly as described in the literature for other supply chains. This suggests that the New Disruption had a significant impact on food supply chains, pharmaceutical supply chains, and manufacturing supply chains in the beginning phase. It highlights the impact of the New Disruption as an external contingency on the supply chain system, especially its globalised and highly uncertain nature in the outbreak stage. From the focus group with practitioners, what can be learned is that the ASC, like other supply chains, encountered problems such as demand uncertainty, supply disruptions and logistical delays during this phase. Furthermore, participants agreed that the lack of similar experience and preparedness

had prevented these problems from being resolved in the shortest possible time, leading to further subsequent disruptions to SCRES.

The only one of these eight challenges that did not apply to the ASC, "Surges in demand caused by hoarding and panic buying," was a common occurrence during natural disaster-type disruptions, and generally only occurred for essential goods that were relevant to the end consumer, such as food and toilet papers (Xu et al., 2020). A similar situation occurred with medical supplies in the case of disasters associated with infectious diseases (Li et al., 2023). However, according to all the answers from the three focus groups, this was rarely the case for manufacturing. In fact, the changes in demand that the ASC supply chain faced during the New Disruption were even more complex. In conversations with participants from OEMs, the Researcher found that OEMs experienced many order cancellations in the early days of the New Disruption. This was from both consumers, who were out of pessimistic estimates of the situation; and downstream dealers, who were unable to receive new inventory from OEMs as planned, as their retail automotive stores were unable to operate normally in response to the blockade caused by the New Disruption. However, this situation did not last throughout the cycle of the New Disruption from start to finish, and the order situation in the ASC improved later on, and arguably even gained strength. From two groups of participants from Shanghai and Hangzhou, after the transition to the middle and late stages of the outbreak, consumer demand for travel increased considerably as travel restrictions were relaxed. Moreover, for the concern that public transport might increase the probability of virus transmission, a number of consumers chose to buy private cars for travelling. As a result, with the exception of one participant, all participants reported that orders for cars were able to pick up or even increase slightly. It is worth noting that this was not limited to China, but was a global phenomenon. According to one participant, his organisation's export business had increased compared to the past. Therefore, the automotive industry as a whole had seen a trend of orders plummeting, then increasing and exceeding original forecasts. This was a new phenomenon brought by the New Disruption, which was significantly different from past disruptions. The only denial was from a participant who worked for a luxury car brand. This may be considered as that the overall economy was still under recovering, the demand for high-value consumption maintained at a low level, although the

entire market had showed a positive signal. More analysis on the economy downturn would be discussed in the next sub-section.

5.4.2 Recovery Stage

The New Disruption in the recovery phase was slightly more complex than in the outbreak phase, with a wider variety of challenges, but at the same time the differences between the ASC and other supply chains came through more clearly. This is reflected in the fact that five out of eleven challenges were rejected by the participants, accounting for nearly half of the challenges. In each of the four broad categories of challenges encapsulated in the literature, there were instances where some of the challenges were endorsed and some were not. This suggests that the recovery phase of the ASC, or rather the different areas of the supply chain, were more distinctly characterised compared to the outbreak phase, and that the process of recovering from the initial disruption encountered relatively different conditions.

For those challenges marked as "No", they demonstrated how the high level of uncertainty characterising the New Disruption manifested itself in different supply chains. "Synchronising processes, maintaining vertical integration" represented the need of a part of the industry to streamline supply chain processes during the recovery phase, in order to achieve cost savings and faster recovery, which is in line with lean thinking; "Layoff and availability of human resources" came from some labour-intensive supply chains that encountered difficulties in balancing economic and social sustainability during the recovery process; "Lack of government enforcement and regulations for social issues" was similar; "Demand falls in long term", as presented in Section 5.4.1, did not apply to automotive supply chains; "Adaption to shifts in channels and new modes of distribution" existed in supply chains where the logistics function needed to make significant changes to alleviate delays in the delivery of goods in the previous period. Conversely, the ASC also encountered new problems in addition to these challenges at this stage, based on its own characteristics. Therefore, it is important to investigate this further. Section 5.5 analyses more about the challenges from the New Disruption experienced by the ASC via thematic analysis.

As for the challenges labelled as having also emerged in the ASC, the role of the New Disruption as a contingency for the supply chain as a whole was also reflected, particularly in its long duration. This feature was mainly reflected in the impact on the supply chain and its internal organisations at an economic level, with a long time needed to allow them to

recover from the disruption to previous levels of profitability. Common problems experienced by many supply chains in this process consisted of changes in supply chain participants, including the maintenance of partnerships, as well as a lack of liquidity and a significant reduction in return on investment.

5.5 Thematic Analysis

The transcribed data were then analysed using thematic analysis to identify themes (in this study, challenges), this is described in more detail in the following sections. The aim of the analysis is to further understand the challenges brought exactly to the ASC, after the validation of those from the literature. Apart from the challenges in *List 1* that have been confirmed by the practitioners, there were more information given by the participants and included challenges that had not been mentioned in the literature. Therefore, it is necessary to analyse this kind of information systematically. Another point is that there are a number of challenges mentioned in the literature that have arisen in the automotive industry, but have not had a very significant impact compared to other industries. For example, the health of employees needs to be considered after the resumption of production during recovery stage, but the risks in the automotive supply chain are relatively low compared to the healthcare sector. For such challenges, their categorisations were also adjusted as appropriate during the thematic analysis to ensure that the results highlight the characteristics of the automotive supply chain.

In addition, the identified themes would be applied in a later ISM process. In order to use ISM to analyse data, it is essential to sort the factors related to the data, and Thematic Analysis can do this task well. Also, as explained in the Field Notes section, information from the field notes was used to support themes emerging from the transcripts and to recall and record information and reflect on findings.

5.5.1 Data Processing

Thematic analysis consists of five key steps that are performed in a sequential process: familiarisation, generating initial codes, searching for themes, review, and defining themes (Braun and Clarke, 2006). This section would cover the first four steps, and leave defining

and explanations in the next section, which is about findings. The four-step application instructions are as follows.

5.5.1.1 Familiarisation with the Data

The researcher listened to the recordings several times, and read and compared the transcriptions with the recordings. Also the Researcher read all the notes of the three focus groups discussions several times to understand and integrate the information. This process allowed the Researcher to get an overview of the diversity and richness of information. And during this phase, notes and coding ideas were taken for subsequent phases.

5.5.1.2 Generating Initial Codes

After familiarising with the text, the Researcher carefully read it line by line and applied the initial code to each part of the text. Codes refer to data properties of interest to the analyst (semantic content or latent properties) and refer to "the most fundamental part or element of raw data or information that enables an average and valid assessment of a phenomenon" (Boyatzis, 1998, p.63). In this research, they can be any recurrent values, beliefs or impressions that are relevant and important to the research topic. The process of coding is part of analysis (Miles, 1994) because it is the organisation of data into meaningful groups (Tuckett, 2005). Table *5-3* is an example of the coding process. It should be noted that all coding processes are in the original language (i.e. Chinese). This example is a direct translation of the coding process, so it may differ from the actual results.

Table 5-3 A coding example

Extracted data	**Codes**
... “There is no plan, because the blockade was very fast at that time. The whole of Shanghai was suddenly announced to be closed in early April. For example, it was not said that Pudong and Puxi would only be closed for three days starting on March 30. At that time, it took only three days for the government to send out the news. We did not expect that it would suddenly continue to impose a blockade. However, during the blockade, we had no production,” ...	1. Sudden lockdown 2. Complicated situation 3. Production suspension 4. Long time interruption

5.5.1.3 Searching for Themes

At this stage, the Researcher has preliminarily coded and analysed the data, and the different codes identified in the entire data set have been listed. The analysis here was focused on a

broader thematic level and involved categorising the different codes into potential themes and collating all relevant coded data extracts into identified themes. By reading the codes, narratives, and field notes of the previous step, any ideas, insights or experiences considered as possible new codes were also recorded, which were told and referred to the page and line numbers of each participant. Once completed, the emergent codes were collated and discussed to form 'themes' that captured broader concepts from the data: see Figure *5-2* below for an example of the whole process. Again, it may be slightly different from the result due to the translation process.

Figure 5-2 An example of theme and subthemes

This was very important for thematic analysis because it develops logical and intuitive thinking, helped the Researcher make judgments about meaning, and understand the importance of connection between ideas from the participants (Gale et al., 2013).

5.5.1.4 Reviewing Themes

Step four started with the initial themes acquired in the previous step and includes refining these themes. At this point, the Researcher noticed that some initial themes were not actual themes as there was not enough data to support them, and some may merge (i.e. two seemingly independent themes may form one). The double standard of judgment categories/internal homogeneity and external heterogeneity/ proposed by Patton (1990) is worth considering here. Information within themes should be meaningfully consistent, and that between themes should have clearly discernible differences. The final four themes were identified as shown in Figure 5-3.

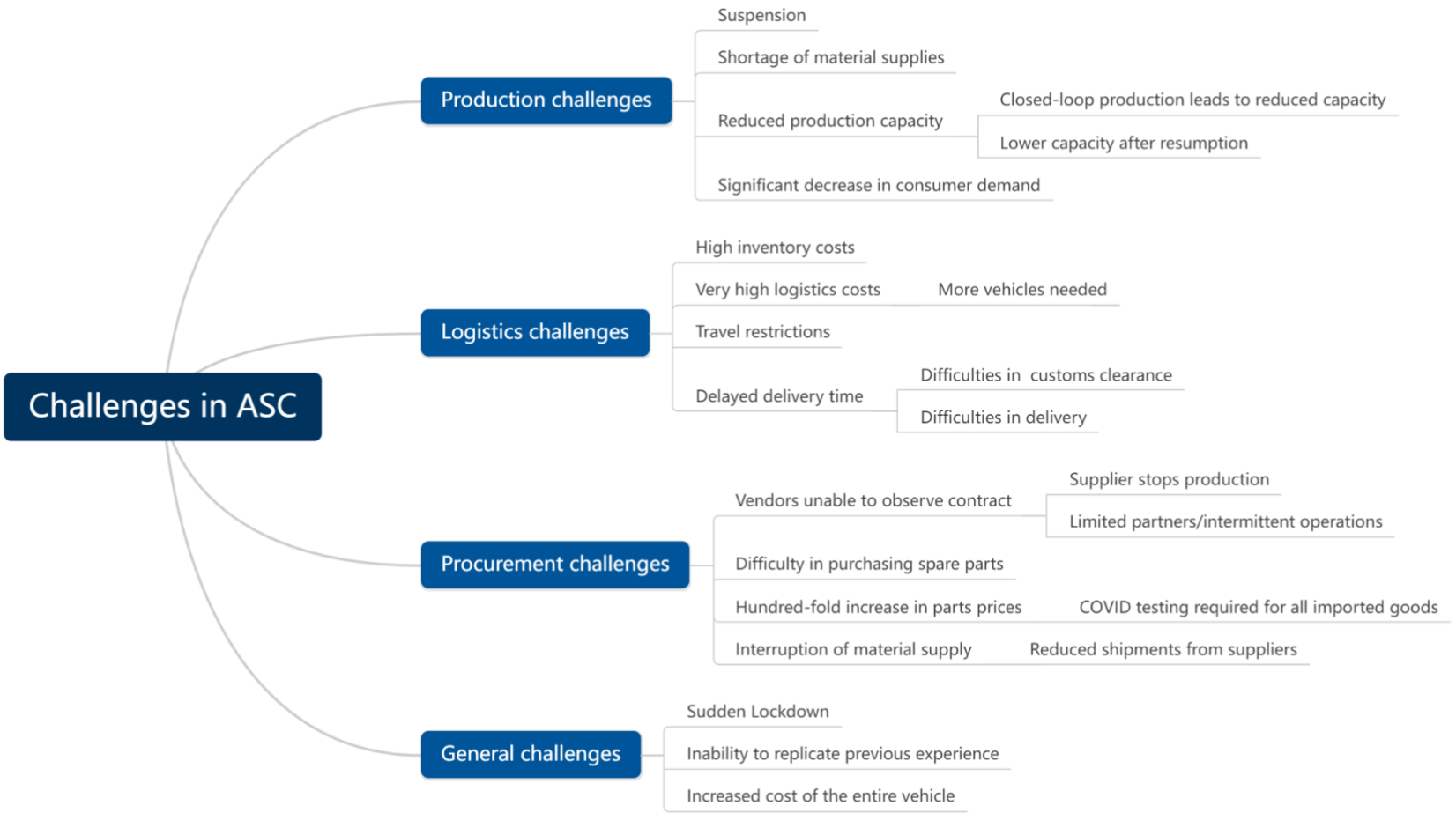


Figure 5-3 Themes of Focus Group

5.5.2 Identified themes

After the transcription, coding and translation steps described above, the data obtained from Focus Group were divided into four major themes: Production, Logistics, Procurement, and General Challenges. The logic behind the categorisation was from the answers of participants. As an individual participant usually focuses on a particular business or activity of the supply chain, classifying by production, logistics and procurement would effectively integrate answers of respondents from different organisations expertise in the same area, so as to compare and contrast the challenges among various organisations and supply chain echelons. During the discussion and theme generation, the Researcher noticed that a group of challenges were mentioned by participants from all sectors of the supply chain, as a result they could not be categorised to any of the single supply chain activity as they actually had a broader impact. Therefore, the theme of General Challenges refers to challenges that were related to all other three themes. More details of the themes are shown below.

5.5.2.1 Production Challenges

The ‘Production challenges’ theme includes any challenges related to production mentioned by the participants. Five participants mentioned relevant content in the discussion, with a total of four sub-themes: ‘suspension’, ‘increased cost of the entire vehicle’, ‘reduced production capacity’ and ‘significant decrease in consumer demand’. Among these sub-themes, shutdowns, lockdowns, and lack of relevant experience are challenges that ASC organisations faced directly during the COVID-19 outbreak phase. The increase in vehicle costs, the reduction in production capacity and the decline in demand are more likely to be the consequences or occur in the recovery phase.

‘Suspension’ was the most serious of the challenges in production. This sub-theme also includes ‘shortage of material supplies’, which was one of the causes. This is discussed in more detail in a later section. However, more participants attributed the suspension to a ‘sudden lockdown’. They believed that it was government regulations that forced them to close their factories and stop production. And this led to another challenge that had a significant impact on ASC as a whole: ‘inability to replicate previous experience’. What the challenges of both have in common is that they represent the uncertainty feature of the New Disruption. Nothing like this had ever happened before in ASC, which was why organisations are so frustrated. As an important exogenous environment variable brought about by the New Disruption, uncertainty had brought many challenges not mentioned in the

literature, and made them appear randomly, while making the past countermeasures ineffective.

Similar to ‘Increased cost of the entire vehicle’, ‘Reduced production capacity’ came from the longitudinal impact of the New Disruption. In the outbreak stage, due to the need to comply with government regulations such as social distancing, participants said they were limited to closed-loop production, which means only a limited number of workers could participate in production, and capacity was reduced accordingly. On the other hand, due to supply and logistics challenges, production capacity could only be maintained at a low level during the recovery phase. More details are provided in the next section.

‘Significant decrease in consumer demand’ was mainly due to changes in the external social environment as previously discussed. In short, the impact of the New Disruption on the economy had reduced the consumer desire of the public, and therefore the demand for cars had fallen.

5.5.2.2 Logistics Challenges

The second theme to emerge from this study was ‘logistics challenges’. Few challenges were mentioned from the participants and mainly concentrated on the outbreak stage. These described logistics activities as the ‘blood’ of the supply chain have faced several issues and diffused and magnified along the upstream or downstream of the supply chain. Three sub-themes were uncovered in this are: ‘High inventory costs’, ‘Very high logistics costs’, and ‘delayed delivery time’.

By summarising the statements of participants, it is not hard to find that ‘High inventory costs’ and ‘Very high logistics costs’ are caused by ‘Delayed delivery time’ to some extent. Specifically, 'Delayed delivery time' includes two sub-themes: ‘Difficulties in delivery’ and ‘Difficulties in customs clearance’. During the epidemic, the Chinese government adopted a strict policy to limit the spread of the virus, with each province setting up temporary regulations on blockades or restrictions on movement, depending on the extent of infection within its jurisdiction. As a result, many problems were encountered for logistics and transport, especially for long-distance delivery across provinces. For example, some participants mentioned segmented freeway restrictions, and more check points on the roads, which greatly slowed down the speed and efficiency of transport. It is also interesting to note that given Shanghai's unique situation (as a municipality with a large number of OEMs, but

at the same time the majority of their suppliers come from outside the city), participants from both OEMs and suppliers emphasised the situation where non-local Shanghai drivers were required to be forcibly quarantined by the local government upon their return from a transport assignment to Shanghai. This significantly lengthens the turnaround time for drivers and prevents activities in the supply chain to proceed smoothly. Also it led to the need of hiring more drivers in case, described as ‘more vehicle needed’, which significantly increased the logistics costs.

Another problem arose in organisations with overseas operations. Because of strict customs policies and work restrictions, imported and exported parts or completed vehicles could not be loaded or unloaded properly and were so left in container yards near ports, instead of being shipped to factory warehouses or loaded onto ships. What made it even worse is that, because the countries where the partners or parent companies are located ran the less stringent policies against the pandemic, their production was hardly affected. In order to reduce the pressure on their own inventories, imported parts are shipped to Chinese factories continuously and then piled up in the yards. As a result, a lot of demurrage charges are incurred, which led to a very high inventory cost.

5.5.2.3 Procurement Challenges

Another important theme is 'Procurement challenges' with four sub-themes. Compared to the first two themes, the challenges in the procurement activities were the consequences from a supply chain perspective. Problems here were more related to the supply of the raw materials. Thus, ‘Procurement challenges’ would in turn intensify ‘Production challenges’ when factories could not get the right replenishment at right time. The four new sub-themes under this category are: ‘Vendors unable to observe contract’, ‘Difficulty in purchasing spare parts’, ‘Hundredfold increase in parts price’, ‘Interruption of material supply’.

‘Vendors unable to observe contract’ was mainly mentioned by participants from OEMs, who complained that they could not receive the material supplies from their suppliers as they previously agreed in the contract. At the same time, however, they understood it as it was also a tough time for their collaborators to produce at full capacity. Under this sub-theme, there are two subsidiary challenges, ‘Suppliers production suspension’ and ‘Partners limited/intermittent operation’. Therefore, this procurement challenge was a result of the

challenges which their vendors received in the production process. And it caused OEMs difficult to follow their production plans.

‘Difficulty in purchasing spare parts’ stands for that OEMs found it hard to get alternative material supplies. This is related to the large scale characteristic of the New Disruption. When OEMs realised that it was impossible to have components as stated in the original contracts, they tried to seek for new suppliers who could fulfil their demand. However, as almost all organisations across the world were suffering from the New Disruption, those participants’ organisations could not find suppliers who had extra capacity to take their orders. And even suppliers had the same issues to deal with their upstream suppliers.

And these two challenges had led to the ‘Hundredfold increase in parts prices’ and ‘Interruption of material supply’ for OEMs. For the price increase, it was because organisations had to invest more to find proper alternative suppliers. Also the costs for suppliers to manufacture also increased sharply due to challenges in production and logistics. An example here is mentioned by one of the participants that, for imported goods, a COVID testing was required by the customs, which costed for the test and the storage fees of the goods when waiting for the result at the port. On the other hand, the interruption of supply happened more often as factories could not have stable replenishment from the vendors. In addition, reduced shipment (i.e. issues with the transportation) had made the situation even worse.

5.5.2.4 General Challenges

‘General challenges’ refers to the category of challenges that happened to all links and activities among the ASC, such as ‘Sudden lockdown’ and ‘Lack of experience’. In other words, this means that they are somehow combined with the remaining three themes, or that they are causally linked to the sub-themes (challenges) in the remaining three themes. For example, the ‘Sudden lockdown’ directly led to ‘Suspension’ in the Production Challenges and ‘Travel restrictions’ in the Logistics Challenges. Meanwhile, it also caused sub-themes including ‘Close-loop production’ (which means workers had to stay in the factories for isolation with restricted shift time, at the same time keeping social distance meant less available working space) and ‘difficulties in custom clearance’. On the other hand, ‘Lack of experience’ did not immediately caused any problems, but had prolonged the duration of challenges to the supply chains or amplified the impacts of challenges as no effective actions could be taken. In other words, it could work with ‘Sudden lockdown’ and other

unprecedented challenges to made further problems to the ASC. These relationships are difficult to accurately derive through Thematic Analysis, so the Researcher used ISM in Section 5.6 to explore this further. Results could be found in Sub-section 5.6.2.

Besides those two challenges, the 'Increased cost of the entire vehicle' was the result of organisations adopting recovery strategies after the initial disruption. Rather than a temporary shutdown issue, it had a negative impact on the long-term sustainability of the organisation or supply chain. And this also corresponded to the long duration of the New Disruption. Participants estimated that it would take longer for their organisations to fully return to pre-pandemic operating conditions.

In addition, the Researcher also found that challenges in this category were all mentioned in LIST 1 i.e. they were observed in other industries and supply chains as well. The reason could be that ‘Sudden lockdown’ was a public policy and worked for all industries; ‘Lack of experience’ was caused by the nature of the New Disruption, as no similar situation had ever occurred to any supply chains; ‘Increase cost of the entire vehicle’ (or other products in other industries) was the result of trade-offs that organisations made to tackle those current or short-term challenges. Therefore, from the perspective of the commonalities shared by different industries, these challenges should be categorised as General Challenges.

5.6 Interpretive Structural Modelling

Thematic analysis helped the Researcher find four major themes and several sub-themes from the participants' transcripts, so that the data obtained through the Focus Group can be better displayed. However, during the thematic analysis process, the Researcher realised that this analysis method had certain flaws. Not all challenges mentioned by participants can be simply classified into these four major themes. There are some sub-themes (such as lack of relevant experience) that belong to all themes. They seem to be duplicated while they actually have different meanings under different circumstances i.e. different themes. On the other hand, some sub-themes are cross-thematic. If only categorised them into one of the themes, it could result in data lost. In other words, thematic analysis did not fully reflect the information contained in the data obtained from the Focus Group, especially for connections between cross-thematic challenges and others. Moreover, according to the classification of challenges in different stages in the literature review, that is, whether they belong to the outbreak stage or the recovery stage, has not yet been revealed in the thematic analysis.

Therefore, this section focuses on the findings from ISM analysis to further investigate those challenges.

5.6.1 Model building

In order to understand clearly the interactions between these challenges and their impact on the entire supply chain, the various logical structural relationships are sorted out using an explanatory structural model to find out the hierarchical level relationship situation of each challenge. Here, all the challenges are converted into factors in the context of ISM (see Table *5-4*).

Table 5-4 Conversion of challenges to factors in ISM

Factors	Challenges
C_1	Suspension
C_2	Sudden lockdown
C_3	Increased cost of the entire vehicle
C_4	Reduced production capacity
C_5	Significant decrease in consumer demand
C_6	High inventory costs
C_7	Very high logistics costs
C_8	More vehicles needed
C_9	Difficulties in delivery
C_{10}	Delayed delivery time
C_{11}	Travel restrictions
C_{12}	Difficulties in customs clearance
C_{13}	Vendors unable to observe contract
C_{14}	Lack of materials
C_{15}	Limited partners/intermittent operations
C_{16}	Difficulty in purchasing spare parts
C_{17}	Hundred-fold increase in parts prices
C_{18}	Inability to replicate previous experience
C_{19}	Interruption of material supply

5.6.1.1 Structural self-identification matrix (SSIM)

Firstly, the raw data is mathematically matrixed to obtain the Structural self-identification matrix as shown in Table 5-5. This SSIM was built with opinions from all the participants of the Focus Group who are industrial experts, and uses 3 symbols:

i) V_{ij} indicates that factor *i* has an influence relationship on factor *j*,

ii) A_{ij} indicates that factor *j* has an influence relationship on factor *i*, while

iii) 0 indicates that the two factors are directly not directly related.

Table 5-5 Structural self-identification matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}
C_1	0	A	0	V	0	0	0	0	V	V	0	0	0	0	0	0	0	0	0
C_2		0	0	V	V	0	0	V	V	0	V	V	0	0	V	0	0	V	0
C_3			0	0	0	A	A	0	0	A	0	0	0	0	0	A	A	0	0
C_4				0	0	0	0	0	V	V	0	0	A	A	0	A	0	0	A
C_5					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C_6						0	0	0	A	A	A	A	0	0	0	A	0	0	0
C_7							0	A	0	0	A	A	A	0	0	A	0	A	0
C_8								0	A	V	A	A	A	0	0	A	0	A	0
C_9									0	A	A	A	A	A	A	A	0	A	A
C_{10}										0	0	0	0	V	0	V	0	V	V
C_{11}											0	0	V	V	0	V	0	0	V
C_{12}												0	V	0	0	0	0	V	0
C_{13}													0	V	A	V	0	0	V
C_{14}														0	A	0	V	0	A
C_{15}															0	V	V	0	V
C_{16}																0	A	V	V
C_{17}																	0	V	0
C_{18}																		0	V
C_{19}																			0

5.6.1.2 Reachability matrix

With the initial SSIM, the next step would be forming the Reachability matrix. This kind of matrix indicates that if a factor finally would affect another factor after going through various paths, and the formula for the Reachability matrix is:

Reachability matrix = Adjacency matrix + Unit matrix

As shown in the equation, An Adjacency matrix is required to get the Reachability matrix. SSIM could be used to develop an Adjacency matrix based on two rules (Karadayi-Usta, 2019; Kumar et al., 2021; Vigneshvaran & Vinodh, 2020), which are:

i) V_{ij} entrance becomes "1" when factor *i* exerts effect on factor *j*, and V_{ji} entrance becomes "0" when factor *j* exerts effect on factor *i*;

ii) A_{ij} entrance becomes "0" when factor *i* exerts effect on factor *j*, and A_{ji} entrance becomes "1" when factor *j* exerts effect on factor *i*.

Based on these rules, the Adjacency matrix as shown in Table *5-6* was created. Letters "V", "A" are transformed into binary digits (0, 1) (Goel et al., 2022).

Table 5-6 Adjacency matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}
C_1	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
C_2	1	0	0	1	1	0	0	1	1	0	1	1	0	0	1	0	0	1	0
C_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C_4	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
C_5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C_6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C_7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C_8	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
C_9	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
C_{10}	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0	1	0	1	1
C_{11}	0	0	0	0	0	1	1	1	1	0	0	0	1	1	0	1	0	0	1
C_{12}	0	0	0	0	0	1	1	1	1	0	0	0	1	0	0	0	0	1	0
C_{13}	0	0	0	1	0	0	1	1	1	0	0	0	0	1	0	1	0	0	1
C_{14}	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
C_{15}	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	1	0	1
C_{16}	0	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	1	1
C_{17}	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
C_{18}	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1
C_{19}	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0

Then the Reachability matrix is calculated in

Table 5-7:

Table 5-7 Reachability matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}
C_1	1	0	1	1	0	1	1	1	1	1	0	0	0	1	0	1	1	1	1
C_2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C_3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C_4	0	0	1	1	0	1	1	1	1	1	0	0	0	1	0	1	1	1	1
C_5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C_6	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
C_7	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C_8	0	0	1	1	0	1	1	1	1	1	0	0	0	1	0	1	1	1	1
C_9	0	0	1	1	0	1	1	1	1	1	0	0	0	1	0	1	1	1	1
C_{10}	0	0	1	1	0	1	1	1	1	1	0	0	0	1	0	1	1	1	1
C_{11}	0	0	1	1	0	1	1	1	1	1	1	0	1	1	0	1	1	1	1
C_{12}	0	0	1	1	0	1	1	1	1	1	0	1	1	1	0	1	1	1	1
C_{13}	0	0	1	1	0	1	1	1	1	1	0	0	1	1	0	1	1	1	1
C_{14}	0	0	1	1	0	1	1	1	1	1	0	0	0	1	0	1	1	1	1
C_{15}	0	0	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	1	1
C_{16}	0	0	1	1	0	1	1	1	1	1	0	0	0	1	0	1	1	1	1
C_{17}	0	0	1	1	0	1	1	1	1	1	0	0	0	1	0	1	1	1	1
C_{18}	0	0	1	1	0	1	1	1	1	1	0	0	0	1	0	1	1	1	1
C_{19}	0	0	1	1	0	1	1	1	1	1	0	0	0	1	0	1	1	1	1

The number 1 in the Reachability matrix indicates that there is a path between one factor and the other factor, and the number 0 indicates that there is no path from one factor to another factor.

5.6.1.3 Level Partitioning

Level partitioning is to visualise the result of the reachability matrix and identify the hierarchical relations among factors. At this stage, three sets are extracted: the reachability set, the antecedent set, and the intersection set (see Table *5-8*). The reachability set R was built with a specific challenge and others that it contributes to. Antecedent set Q was built with a particular challenge and other enabling challenges (Goel et al., 2022). The intersection

set A is identified based on the same factors as the reachability set and the antecedent set, i.e., $A = R \cap Q$.

Table 5-8 The reachability set R, antecedent set Q, and intersection set A

Factor	***Reachability set R***	***Antecedent set Q***	***Intersection set A***
C_1	[1, 3, 4, 6, 7, 8, 9, 10, 14, 16, 17, 18, 19]	[1, 2]	[1]
C_2	[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]	[2]	[2]
C_3	[3]	[1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]	[3]
C_4	[3, 4, 6, 7, 8, 9, 10, 14, 16, 17, 18, 19]	[1, 2, 4, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]	[4, 8, 9, 10, 14, 16, 17, 18, 19]
C_5	[5]	[2, 5]	[5]
C_6	[3, 6]	[1, 2, 4, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]	[6]
C_7	[3, 7]	[1, 2, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]	[7]
C_8	[3, 4, 6, 7, 8, 9, 10, 14, 16, 17, 18, 19]	[1, 2, 4, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]	[4, 8, 9, 10, 14, 16, 17, 18, 19]
C_9	[3, 4, 6, 7, 8, 9, 10, 14, 16, 17, 18, 19]	[1, 2, 4, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]	[4, 8, 9, 10, 14, 16, 17, 18, 19]
C_{10}	[3, 4, 6, 7, 8, 9, 10, 14, 16, 17, 18, 19]	[1, 2, 4, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]	[4, 8, 9, 10, 14, 16, 17, 18, 19]
C_{11}	[3, 4, 6, 7, 8, 9, 10, 11, 13, 14, 16, 17, 18, 19]	[2, 11]	[11]
C_{12}	[3, 4, 6, 7, 8, 9, 10, 12, 13, 14, 16, 17, 18, 19]	[2, 12]	[12]
C_{13}	[3, 4, 6, 7, 8, 9, 10, 13, 14, 16, 17, 18, 19]	[2, 11, 12, 13, 15]	[13]
C_{14}	[3, 4, 6, 7, 8, 9, 10, 14, 16, 17, 18, 19]	[1, 2, 4, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]	[4, 8, 9, 10, 14, 16, 17, 18, 19]
C_{15}	[3, 4, 6, 7, 8, 9, 10, 13, 14, 15, 16, 17, 18, 19]	[2, 15]	[15]
C_{16}	[3, 4, 6, 7, 8, 9, 10, 14, 16, 17, 18, 19]	[1, 2, 4, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]	[4, 8, 9, 10, 14, 16, 17, 18, 19]
C_{17}	[3, 4, 6, 7, 8, 9, 10, 14, 16, 17, 18, 19]	[1, 2, 4, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]	[4, 8, 9, 10, 14, 16, 17, 18, 19]
C_{18}	[3, 4, 6, 7, 8, 9, 10, 14, 16, 17, 18, 19]	[1, 2, 4, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]	[4, 8, 9, 10, 14, 16, 17, 18, 19]
C_{19}	[3, 4, 6, 7, 8, 9, 10, 14, 16, 17, 18, 19]	[1, 2, 4, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]	[4, 8, 9, 10, 14, 16, 17, 18, 19]

With these sets, the first iteration of factor partitioning ended after reaching level 1 (referring to similar reachability sets and intersection sets). In the next iteration, the factors assigned to a particular level were removed, and so on until the last iteration. The results in Table *5-9* illustrate the final partitions from all iterations.

Table 5-9 Level partitioning result

Level	Factors
1	[3, 5]
2	[6, 7]
3	[4, 8, 9, 10, 14, 16, 17, 18, 19]
4	[1, 13]
5	[11, 12, 15]
6	[2]

As it shows, all the factors are divided into a total of six layers, of which the sixth layer is the bottom layer, which includes only C_2 one factor. The fifth layer is C_{11}, C_{12} and C_{15}, representing that they have the most direct connection with C_2 and are directly influenced by it. By analogy, the fourth layers C_1 and C_{13} are also directly influenced by the fifth layer. Layer 3 is the most unusual because it contains the most factors, significantly more than the other layers. This could mean that factors C_1 and C_{13} of the fourth layer are two key nodes and thus directly influence close to half of the factors. The second and first layers contain two factors each, with the first layer being the top layer, indicating that the two factors C_3 and C_5 are only affected by other factors (C_6 and C_7) but have no more effect on factors.

5.6.1.4 Mapping

The last step of ISM was that the challenges represented by each element were substituted to visualise the results of the analysis, i.e., to obtain a hierarchical distribution of all the challenges as shown in Figure *5-4*.

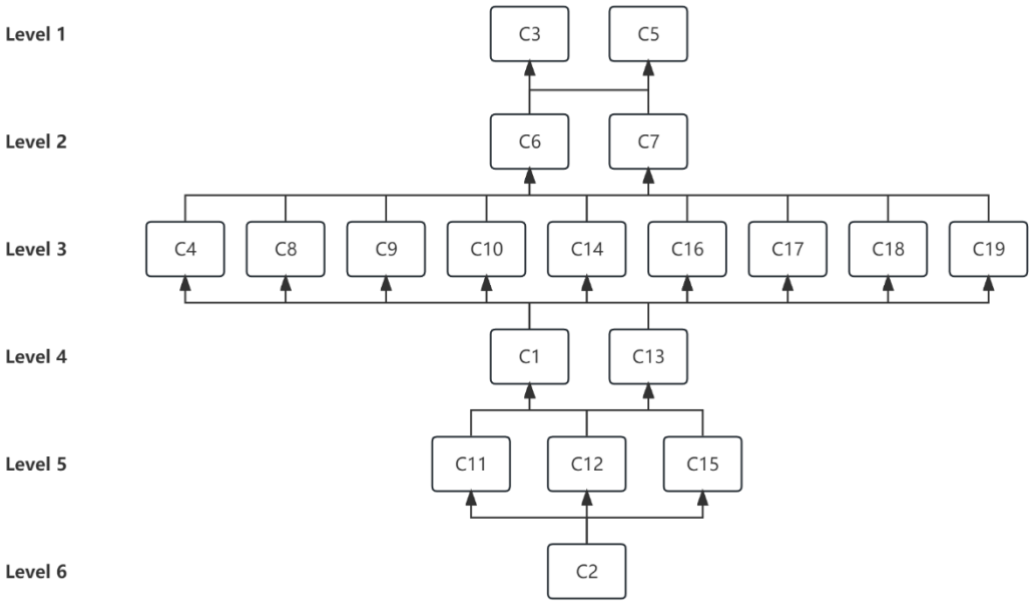


Figure 5-4 ISM result

The Researcher then decoded the result and had another online meeting with all the participants in the focus group. To ensure the anonymity, all the participants were asked to switch their cameras off and replace their name with nicknames. After discussing this result and reached an agreement with the experts, the final result was shown in Figure *5-5*.

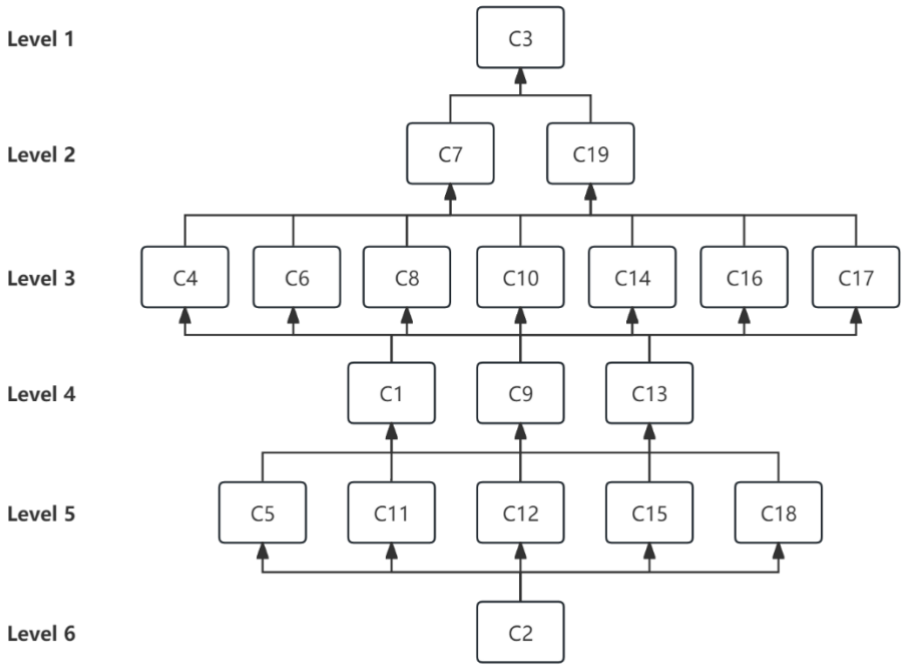


Figure 5-5 Revised ISM result

5.6.2 Analysis of the ISM results

In order to understand clearly the interactions between these challenges and their impact on the entire supply chain, the various logical structural relationships are sorted out by ISM. After that, the hierarchical levels of each challenge were positioned (see Figure *5-5*).

5.6.2.1 Level 6

It is relatively clear from the results that the sudden lockdown is at the bottom of all challenges, which means that it was the source of all the challenges. Since challenges in the recovery phase were the evolution of those of the outbreak phase, they were fundamentally caused by some types of lockdown during the outbreak stage. Regardless of OEMs, distributors or suppliers at any tier, and regardless of where they come from, organisations in the ASC were all in trouble because of the New Disruption. Information gained from the Focus Group participants was that no organisation was prepared for a disruption like the New Disruption in advance, either in terms of inventory or production planning, because this

was an unprecedented situation. And organisations suffered from the lockdown encountered a series of subsequent problems, which then spread up and down the supply chain.

5.6.2.2 Level 5

The most immediate results of the blockade were reflected in two aspects, namely logistics and production. The impact on logistics was mainly manifested in road restrictions and obstacles encountered in port clearance. As analysed in the *Logistics Challenges* part of thematic analysis, logistical challenges significantly extended lead times and delayed the delivery of raw materials. This made it impossible for organisations to follow their original production plans and therefore to deliver the finished products on schedule. In order to coping with these challenges, a lot of resources had to be expended, such as hiring more temporary drivers and vehicles, or renting more warehouses. However, these had brought more problems.

For production, the mandatory lockdowns imposed by the government also include restrictions on factories. The operating hours of factories have been shortened or, in extreme cases, shut down completely (as in Shanghai). At the same time, because the factory itself is a labour-intensive place, the social distancing required to buffer the spread of COVID-19 has greatly reduced the number of workers on the job at the same time. Compared with other processes, production is obviously not able to work from home. All of these reasons have resulted in the operations of upstream and downstream organisations being restricted or intermittent. Limited operating hours significantly reduced production capacity and, could even lead to shutdown because of the shortage of materials from the upstream.

As an unprecedented situation, the large-scale lockdown was very different from previous risks and disruptions, and therefore there was a lack of effective responses for the entire supply chain. Practitioners found that past experiences and approaches did not help organisations and their partners to solve the problem immediately on this occasion. An example of this was when some OEMs realised that their suppliers had been affected by the embargo and were unable to produce properly and were facing shortages of parts, they tried to turn to alternative suppliers that had been selected in premade risk plans. However, unlike previous minor disruptions, the alternative suppliers could not help as they were experiencing the same problems. According to the participants, many other methods also failed and supply chain members needed to find new strategies to overcome these challenges.

Meanwhile, as analysed in Sub-section 5.4.1, the automotive industry experienced a significant drop in demand and sales during this period.

5.6.2.3 Level 4

With challenges such as access restrictions in some areas and customs barriers in some organisations, logistics challenges were spreading to more parts of the supply chain, and the distribution of raw materials and components became increasingly difficult. Logistics is like the blood of the supply chain, and the raw materials and components it transports are the nutrients and oxygen. When logistics activities are blocked, the organs in the supply chain – the individual echelon – could not get replenished on time, which further negatively impacts the supply chain.

The shutdown occurs primarily because of the lockdown embargo. In order to control the spread of the virus, the government required places like factories where people gathered to cease operations, and suppliers and OEMs were forced to stop their production activities. Both logistical delays and disruptions, as well as a sharp drop in production capacity, had made it impossible for those organisations in the chain to produce and replenish inventory in a timely manner, as originally planned. As one of the most core processes in the entire ASC, once production ran into trouble, whether it is from the supplier or the OEM, it would cause more serious follow-up problems.

5.6.2.4 Level 3

As expected, challenges on production and replenishment had brought many corresponding issues. For all organisations in the automotive supply chain, especially OEMs, timely replenishment of raw materials is crucial, as their factories always produce at a specific pace (for example, one participant mentioned that their production pace is 60 vehicles per minute), which ensures efficient operation and creates economies of scale to spread costs evenly. When one or more parts are missing, the pace is interrupted and the entire production line may have to shut down, which can be very costly.

As a result, the impact of all aspects not being delivered as planned was significant, especially for upstream suppliers, leading to new challenges. The most direct consequences include increased difficulty in delivering downstream orders (i.e., difficulty in fulfilling previously agreed quantities of finished goods) and longer delivery times. For OEMs and other organisations relatively in the downstream link, they faced the challenge of raw material shortage or even complete supply interruption, and further reduced production

capacity. It is worth noting that due to the New Disruption's negative impact on the global supply chain, it was difficult for downstream supply chains to solve these challenges by simply finding alternative suppliers when they encounter these problems, since literally every organisation suffered from the same issue. Therefore, there will be difficulties in purchasing parts and a significant increase in procurement costs. At the same time, almost all organisations lack effective countermeasures to the drastic changes in the external environment brought about by the New Disruption.

5.6.2.5 Level 2

By reaching Level 2, the ripple effects of the New Disruption had spread along the supply chain, and almost all echelon was already experiencing challenges from its negative effects. When these challenges were brought together and tried to be solved, the cost issue, namely the logistics and inventory costs mentioned by Focus Group participants, came to the fore. The reasons for the increase in costs were comprehensive, and here discussed some common problems highlighted by the participants.

As mentioned in the previous section, in order for organisations to be able to continue to maintain transportation and turnover, they had to spend money on more containers and venues, thus incurring additional rental costs, storage fees, error costs, etc. In addition, many organisations have been confronted with the fact that the freight charges on contracts negotiated with carriers prior to pandemic have been unable to be honoured. Because the carriers' costs have significantly increased and these freight charges are no longer covered. These added costs included more labour costs, extra subsidies for drivers, the cost of taking a detour due to road closures, and extra money for Shanghai businesses to dispatch vehicles from other cities. These challenges were vital for organisations, as they evolved from simple supply issues to organisational survival issues, threatening the sustainability. In fact, many organisations (especially those SME suppliers) did not survive and permanently shut down their business during this period.

There seems to be a paradox here, that organisations lacked timely replenishment of raw materials, but at the same time needed to lease more warehouses or find more transportation resources. However, this is not in conflict, as both challenges existed at different nodes in the supply chain. When the disruption was in the outbreak phase, just after the lockdown was put in place, almost all the factories were shut down. However, as the situation gradually improved, some areas took the lead in unlocking the blockade, and local factories, as a result,

led in resuming production, while their upstream enterprises were still shut down. And this led to the challenge of material shortage. For the downstream of these enterprises that started to resume production relatively early, due to the many restrictions on the resumption of production (such as the number of people in a shift and the flow of personnel), the production capacity could not be rapidly increased in a short time, so the accumulation of raw materials occurred. Moreover, logistical constraints remained, and organisations in ASC continued to face transportation challenges. In addition, some participants also provided an explanation that their original warehouse location was relatively serious, so it was still in a state of lockdown by the government and could not be put into operation, so they had to seek other temporary storage sites. On the other hand, for organisations with overseas operations, because different countries have adopted different epidemic prevention policies, they continued to receive parts from overseas partners, while their factories could not reach the same capacity level as before the epidemic, so there was still a demand for more storage space.

5.6.2.6 Level 1

Finally, all of these challenges led to a significant increase in the cost of complete vehicles, which became a long term challenge in the recovery stage. Respondents admitted that in order to overcome previous challenges, especially those ones during the outbreak stage, organisations had put extra resources to buffer the impact from the disruption, such as extra fleets to transport the materials and extra warehouses to store parts for limited production. Moreover, what made this dilemma even worse was that organisations could not get profits as the demand dropped sharply at the beginning of the New Disruption and no sale activities were allowed during the lockdown period. That means organisations had to invest more capital to stay afloat. Lower sales meaned the entire supply chain could not get cash back quickly, participants from two suppliers mentioned that their organisations once suffered financial issues during the New Disruption. These added up and made these challenges to evolve into longer-term sustainability issues. Fortunately organisations involved in focus groups did not face the impasse that they had to permanently shut down their business for

fund breakdown. However, organisations still need to work more about how to survive than any other disruptions they had in the past.

5.7 Answering Research Question 1: Challenges from the New Disruption to Chinese automotive supply chain

By combining the analyses in the previous Sub-sections 5.4, 5.5 and 5.6, it is possible to have a very complete understanding of the challenges brought by the New Disruption to the ASC in China.

First of all, through the verification of the challenges of the New Disruption to the supply chain mentioned in the literature, it can be clearly seen the characteristics of the New Disruption as a contingency, i.e., it is a factor of the supply chain from the external environment, which brought contingent variables including a large scope, a long period of time, and a high degree of uncertainty. A concrete manifestation of these variables is that most of the *List 1* challenges are present in the ASC.

Based on a review of the literature, the thematic analysis further refines the picture of the impact of the New Disruption on the ASC. Compared to other supply chains studied in the literature, the ASC supply chain had distinctive challenges due to its own uniqueness. From the results of the thematic analyses, it is clear that the challenges posed by the New Disruption encompassed all aspects of the ASC and had had some negative impact on almost all segments. Systematically, these challenges affected the three most important types of activities in the ASC: production, logistics and procurement. This included a number of general challenges posing problems for all segments, as well as a range of challenges in the individual activities that derived from them. In addition to a more complete understanding of the situation of the ASC, by comparing the results of Sections 5.4 and 5.5, it is possible to further uncover some of the characteristics of the automotive supply chain and the impact of these characteristics on the outcomes (challenges encountered) of the supply chain in the context of the New Disruption contingency.

Finally, the ISM provides another perspective by adding a time dimension to these challenges, allowing a clearer view of the stages at which the challenges emerged, and the causal relationships between them, for the next phase of the research. The full results of the focus group analysis are shown in Figure 5-6.

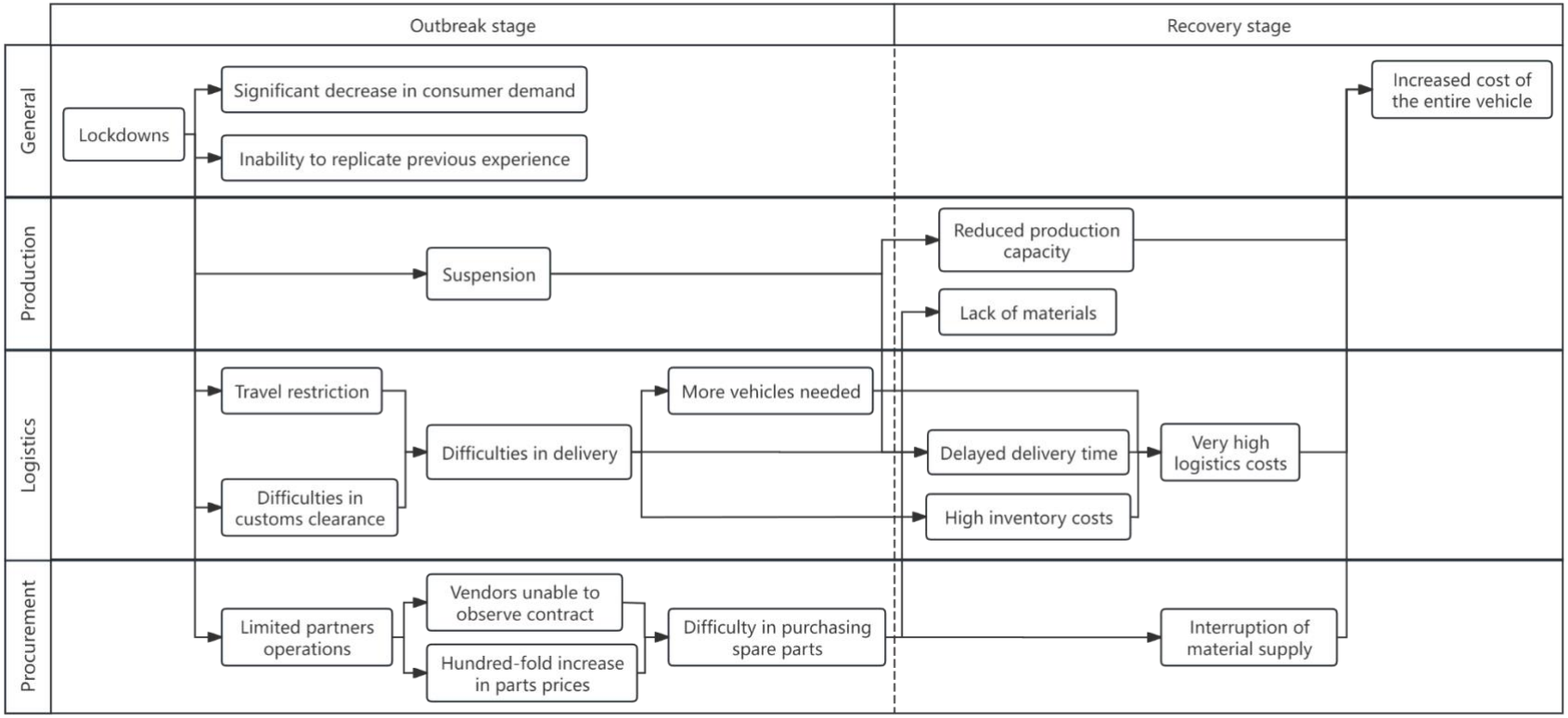


Figure 5-6 Challenges in the ASC from the New Disruption

5.8 Summary

This chapter analysed the results of the focus groups to answer *Research Question 1* " What is the unique nature of the challenges presented by the New Disruption to the automotive supply chain when compared to previous disruptions and other industries?". There are three steps in total, the first step was to validate the situation in the summarised literature to identify the characteristics of the New Disruption as a contingency and how the situations in ASC differed from other supply chains.

The second step was to use thematic analysis to show the complete picture of the New Disruption on the ASC. Four themes were extracted from the thematic analyses, namely, "Production Challenges", "Logistics Challenges", "Procurement Challenges" and "General Challenges". These themes and the several sub-themes they contain expanded on the challenges posed by the New Disruption and constituted a more complete framework. At the same time, this step also revealed the existence of hidden relationships between the challenges, e.g. "production challenges" and "logistics challenges" may lead to "procurement challenges", which in turn may lead to "production challenges" and "logistics challenges".

The third step was to further apply the ISM to the results of the thematic analysis to disclose the linkages between all the challenges. The results of the ISM showed more clearly how the challenges interacted with each other. This helped the Researcher to gain a deeper understanding of the causality of these challenges and thus to analyse how the New Disruption with its unique characteristics affected ASCs and spread through the supply chain. With these findings, the next chapter will discuss how organisations could address these challenges and improve SCRES.

6 DATA ANALYSIS AND FINDINGS – INTERVIEW

6.1 Introduction

This chapter presents the analysis of the data collected in the second stage, which focuses on the strategies that organisations in the ASC applied. This includes the detailed data analysis process, results, and discussion of findings from the semi-structured interviews. The aim of this chapter is to answer the *Research Question 2:* "What recovery strategies could be applied to tackle those challenges?" and *Research Question 3:* "How could ASC organisations improve SCRES in terms of dealing with similar disruptions in the future?". This phase consists of (i) investigating the recovery strategies used by the respondents' organisations to cope with the challenges; (ii) comparing them with existing solutions in the literature and refining the description of the impact of the New Disruption on the ASCs; and (iii) conceptualising these recovery strategies to provide theoretical lessons for potentially similar scenarios in the future. Where (i) is intended to answer *Research Question 2*, while (ii) and (iii) are intended to answer *Research Question 3* (see Figure 6-1).

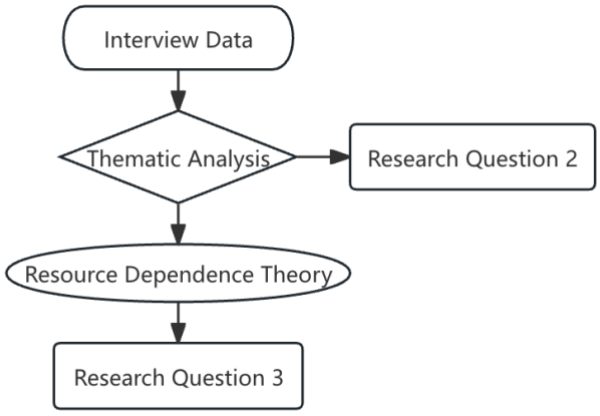


Figure 6-1 Framework of interview analysis

In the following parts of this chapter, Section 6.2 first introduces the demographic details of the interview participants; Section 6.3 demonstrates how the interview data was analysed by thematic analysis and shows the results from interviews including the identified themes; Section 6.4 elaborates some key findings from different perspectives and addressed the *Research Question 2*; Section 6.5 discusses the innovativeness of those strategies from literature and the importance of collaboration based on RDT; Section 6.6 gives a summary of the chapter.

6.2 Demographic Details of the Participants

From the initial invitation of nine people to the final data saturation, a total of 15 people working in the Chinese automotive industry participated in this interview. Unlike the

participants in focus groups, who were all managers or above, the interviewees' years of experience ranged from 3 to 15 years. The organisations in which the interviewees worked were from different parts of China, and between them they formed five different supply chains, encompassing roles ranging from secondary suppliers to distributors (see Table 6-1). Within this, most of the supply chains (all but the third) contained at least three tiers of structure, forming chains; some organisations were involved in more than one supply chain, forming a supply network (see Figure 4-3); and some organisations played different roles in different supply chains. Such a composition of the sample adds some complexity to the cases in this study and makes the results more representative.

Table *6-1 The roles of organisations in the interview*

Supply Chain	Organisations	Role in ASC
1	Organisation 5	Joint OEM
	Organisation 1	Tier 1 supplier
	Organisation 3	Distributor
2	Organisation 9	Joint OEM
	Organisation 8	Tier 1 supplier
	Organisation 3	Distributor
3	Organisation 4	FDI OEM
	Organisation 1	Tier 1 supplier
4	Organisation 6	Joint OEM
	Organisation 8	Tier 1 supplier
	Organisation 3	Distributor
5	Organisation 1	Tier 1 supplier
	Organisation 7	FDI OEM
	Organisation 8	Tier 2 supplier
	Organisation 3	Distributor

6.3 Thematic Analysis

The pre-processing of the data from the interviews was consistent with that in focus groups, including transcription and translation. These processed data were then put into thematic analysis. The steps for processing interview data are basically the same as for Focus Group, including transcribing, processing field notes, and translation. After digitisation, the data were analysed using thematic analysis as well. Similarly, the thematic analysis for interview

data consisted of five steps: familiarisation, generating initial codes, searching for themes, review, and defining themes. However, compared with the thematic analysis for Focus Group, these five steps were completed in the analysis for interview, followed by an analysis of how these strategies could better achieve not only the organisational, but from a supply chain perspective, the performance of SCRES. In addition, field notes also contributed much to the analysing process.

6.3.1 Data Processing

6.3.1.1 Familiarisation with the data

Same as the data collection in the Focus Group, the Researcher conducted all the interviews, and was familiar with the supply chain roles of all the interviewees' organisations. The researcher listened to the recording, read the transcript and all the notes from the interviews multiple times, in order to understand the information provided by all interviewees in the transcript and integrate the potentially useful parts of all the above. The variety and richness of information was also well reflected in the transcription of the interviews. Familiarity with the data also provided ideas for subsequent stages of coding.

6.3.1.2 Generating initial codes

The researcher then carefully read the collated transcripts and applied initial codes to the text. This process was consistent with the initial coding process for the Focus Group, and also used the original language (i.e., Chinese), leaving the translation work until the end to ensure that information was not lost during the coding process.

6.3.1.3 Searching for themes

At this point, the Researcher has initially conducted coding and analysis of the interview data with identified codes. Subsequently, this stage entailed categorising the different codes into potential themes and subsuming what was recorded into these potential themes. At the same time, the Researcher also reviewed previous codes and transcriptions of interviews and recorded new codes that may have emerged during this process. This resulted in "themes" of broad concepts captured from the interview data.

6.3.1.4 Review

After capturing the initial themes in the previous step, the next step is to review these themes and check if they need to be further optimised. As in the process of reviewing initial themes of the Focus Group, some initial themes from interviews may not be actual topics due to

insufficient data support, or seemingly separate themes may be merged. In the optimisation process, the principle observed by the Researcher remained that the information within the theme should be meaningfully consistent, and the information between the themes should be clearly discernible.

When reviewing existing themes to see if they reflect the entire data set, new themes may be discovered, in which case they need to be recoded. Different from the data analysis of the Focus Group, thematic analysis is the only technique used to process data collected by interview in this study. Therefore, the previous steps here are iterated once again to ensure that no themes are left out. This step resulted in five themes.

6.3.1.5 Defining themes

Following the last step, there are five themes defined: looking for temporary resources, strengthening collaboration, creating more redundancies, resorting to the government, and digitalising workflows. Each theme also contains several sub-themes. In defining these five, it was important to make sure that the content contained in each theme was relatively independent, but at the same time existing some connection between the themes. Together they formed a collection that reflected all the approaches taken by the interviewed organisation to the New Disruption.

6.3.2 Identified Themes

6.3.2.1 Looking for temporary resources

It could be found from the interview data that looking for temporary resources to mitigate the various challenges posed by the New Disruption was the most common approach, as all respondents mentioned relevant solutions. The resources here include two aspects, namely supplier resources (or procurement resources) and logistics resources, which exactly correspond to the backup suppliers and backup logistics channels of the contingency plan in the literature. However, due to the particularity of the New Disruption, past strategies were not fully applicable in this situation.

The use of contingent suppliers mentioned in the literature was also one of the approaches that organisations in Chinese ASC have adopted in response to the New Disruption to minimise the amount of raw material shortages (Moosavi, 2021). However, in most literature, such method is applied when a limited number of organisations in the supply chain are interrupted (e.g. Wang et al., 2014). What they do not take into account is that almost all

suppliers are suffering from a similar crisis, making the search for alternative suppliers less effective. Moreover, the difficulty of finding alternatives temporarily lies in the intellectual property rights of components and the quality certification of products from new partners. So, this strategy alone was not enough for organisations in the New Disruption scenario.

> *"…Particularly for this kind of parts with intellectual property rights and patents of, it's not possible to find a second supplier in a short time. For a component, usually we get it from at least two suppliers, and the two suppliers have different share ratios, so we try to avoid the two suppliers be blocked at the same time… This kind of (temporary replacement) has actually been found, but it does not involve some finished product suppliers, Tier 1, because from what I've been exposed to, such cases are more involved in Tier 2 or tier 3, it may involve some stamping parts or electric welding, some relatively early preparatory work. Because the technology in this kind of work does not need a technical change or certification, and there are many such manufacturers, so there is barely any impact on the quality of our products. In other cases, if it is really impossible to use the original supplier, and our quality (assurance department) and our R&D (department), and our boss are all agree, we would use some temporary alternative supplier that we can find." (Interviewee 5, 2022)*

Besides, organisations in the ASC also tried to find other temporary resources based on the specific problems they encountered during the outbreak phase, such as migrating production to low-risk areas, and changing business modes to avoid risky areas. Taking an OEM as an example, by converting foreign trade into domestic trade mode, the vehicles that needed to be exported were transferred to ports in other low-risk areas for export, in order to avoid the travel restrictions in the high-risk areas where the departure port was originally located. Although this process involved more legal and tax issues and added a lot of costs to the company, it was still an effective solution for the period. Another strategy from the interviewee working for the OEM was seeking resources within the organisation, and dynamically adjusting the allocation of scarce parts. Specifically, at a certain point of time, the chip became a bottleneck for the ASC, which was due to the surge in demand for personal electronic products caused by work-from-home during the pandemic. In response to this situation, some OEMs have adopted the method of prioritising the limited stock supply to regions or models with better sales, so that the organisation could continue to obtain income and maintain cash flow.

Another type of resource that organisations were looking for was logistics resources. According to the answers of the interviewees, those resources included temporary fleet of vehicles and temporary warehouses, which was consistent with the literature (Ivanov et al., 2017; Sayed et al., 2020). This was to be able to move the entire inventory to the next echelon in the supply chain before the supplier was forced to shut down. However, what is different from the literature was, although the study by Li et al. (2012) showed that collaborative transportation management could effectively improve organisational flexibility, according to the data obtained from interviews, the same echelons in the supply chain, i.e. OEM or peer suppliers, were competitive rather than cooperative during the pandemic. Although one respondent mentioned shared transportation resources, more data showed that organisations sought these additional logistics resources to 'snatch' goods and even materials from suppliers, which was due to the production of most suppliers being affected, resulting in a significant reduction in overall capacity. In addition, similar strategies included circumventing travel restrictions by cross docking, arranging urgent shipping tasks, and finding additional shipping routes.

Comparing the findings from the interview and literature, the most outstanding difference is that, while both focus on finding additional resources to alleviate the distress, the methods in the literature are more focused on scheduling ahead (Lim et al., 2010; Schmitt and Singh, 2012), implementing planned changes to backup providers or seeking cooperation on transportation resources after an outage occurs. However, from the results of interview data analysis, it can be seen that in the actual situation, the strategies adopted by organisations were mainly the reaction to the interruption. The New Disruption was an extraordinary disruption that brought new challenges that were unprecedented, and past plans or experiences, such as finding alternative suppliers, were not entirely appropriate. In such cases, organisations tended to adopt temporary solutions to resolve short-term problems. Those challenges and strategies for the recovery stage of the New Disruption will be discussed in the later section.

6.3.2.2 Resorting to the government

The theme of resorting to the government refers to strategies where organisations sought for help from the government. This was a new kind of strategy that has never appeared in the literature. This type of strategy mainly occurred during the outbreak phase of the New Disruption. In particular, faced with lockdowns and travel restrictions during this period, respondents especially who are from OEMs mentioned that they applied passes to the

government for permits to transport raw materials and vehicles, as well as limited production permits. In addition, organisations also maintain close contact with relevant departments to obtain the latest relevant policies and adjust strategies. It is necessary to point out that such strategies were applicable to ASC in China due to the relevant policies and epidemic prevention measures of the Chinese government during the New Disruption. It needs further investigations and research whether these methods are applicable in other regions, or whether similar strategies existed in other regions.

6.3.2.3 Strengthening collaboration

Increasing collaboration between upstream and downstream in the supply chain is another common strategy among interviewed organisations. Supply chain collaboration in SCRES and recovery has not been fully researched in the literature (Scholten and Schidler, 2015). The collaboration respondents mentioned was mainly between OEMs and suppliers. What is more common is that OEMs used their larger volume and richer resources to provide help to Tier 1 or Tier 2 suppliers. For example, respondents from more than one organisation mentioned that they helped SME (Small and medium-sized enterprises) suppliers to communicate with the local government to obtain more licenses through their stronger bargain power, so that suppliers could carry out closed production. Also, they freed up a part of the passes to the supplier to ensure the transportation of parts, and choose logistics solutions according to the supplier's inventory level. Moreover, some interviewees also shared their strategies to match supplier capacity and boost supplier production. For suppliers located in the region that be blocked and so led to production suspension, the OEM directly moved the supplier's machinery and raw materials, and produce parts themselves.

> *"... As soon as there is a little sign (of blockade) around it, we will arrange emergency vehicles, and then personnel will go to the supplier's house to empty out all their goods, as well as the raw materials. Because the raw materials, Some suppliers may produce in multiple bases, and there may be problems with one base, but as long as the raw materials are available, we can pull them out and put them into certain bases for production." (Interviewee 7, 2022)*

Besides providing help to suppliers, on the other hand, OEMs also put forward more requirements. An example would be the requirement to disinfect parts in advance for overseas suppliers during the outbreak. There were also requirements for suppliers to get higher inventory levels or directly switch some components to Vendor-managed inventory (VMI).

In addition, collaboration existed between other supply chain links as well, corresponding to the clustering effect and response team setup in the literature (Macdonald and Corsi, 2013; Chen et al., 2019). In one case, for OEMs with similar geographical locations, logistics resources were shared under the condition of shortage. Specifically, they shared the same bunch of materials transported by one of them from the supplier, if they were all supplied by that supplier. More than logistics resources, information sharing also existed between the organisations of the respondents. Companies in the same supply chain have formed a group to exchange information on the New Disruption and discuss strategies to maximise the efficiency of the entire supply chain. More details were discussed in Section 6.5.

6.3.2.4 Creating more redundancies

In contrast to the strategies in the previous themes, which focus on the challenges of the outbreak stage, creating more redundancies includes not only solutions for the upfront problems, but also strategies for the recovery stage, or ways to improve the resiliency of an organisation or supply chain in the long run.

For short-term issues, the strategies covered under this theme include increasing inventory levels, changing Just-in-time (JIT) to an agile strategy, and increasing the number of suppliers. Among them, increasing inventory levels and the number of suppliers are strategies that have appeared in the literature and overlap with some ideas in 2.2.1.

> *"... So at that time, some of our own warehouses around us were full, just to stock up." （Interviewee 9, 2023）*

Changing parts supplied by the JIT mode to a more flexible inventory mode is another strategy to increase redundancy. This is a response to logistics constraints. Parts that originally used JIT mode (such as automotive engines) are not suitable for large inventory due to size, loss, cost, etc., but need to be shipped directly from the supplier to a specific station in the OEM factory and completed installation. In order to achieve this purpose, the logistics channel must be unimpeded to ensure that these components can arrive at the designated location on schedule. However, with the New Disruption, this was almost impossible to achieve. Therefore, in order to ensure production, some of these parts have to be hoarded.

> *"... Then we have some JIT goods, because JIT itself is very short time, and then need timely delivery, we usually only send to the factory and directly consumed.*

> *But during the epidemic, we put this JIT goods in a dock yard, because they need to stock. Because the JIT pieces are generally large, so we didn't put them in the warehouse, because the warehouse itself was also, to put the seized materials, has been fully packed, so we put it (JIT) in the dock yard… it was left for a few days, we backed up for a few days, and then we consume it when we produce. JIT, you can't say, in case there is something on the road, like close off the road or something, you have no way but to stop the line, so just put them in the yard in advance..." (Interviewee 1, 2022)*

These strategies were primarily designed to overcome capacity and logistics constraints during the outbreak stage, by temporarily increasing the organisation's redundancy to cope with the various uncertain scenarios brought about by the New Disruption.

After a gradual transition to a recovery period, redundancy was created more to improve an organisation's risk management capabilities and SCRES over the long term. The methods used by OEMs include the establishment of a pool of suppliers (that is, finding multiple suppliers for the same part). Compared with the strategy of alleviating problems through temporary suppliers and logistics channels in the previous section, the deployment of these resources here is closer to the concept of "backup" under the contingent plan in the literature (Ivanov et al., 2013; Gupta and Sethi, 2015). As opposed to temporary substitution, as a long-term plan, suppliers in the pool could meet the quality requirements and delivery rules of the organisation. Interviewees also mentioned ways such as to expand new cooperation opportunities, prepare ahead for long-cycle parts, and make overall provisioning plans.

6.3.2.5 Digitalising workflows

Supply chain digitalisation is a popular research field in recent years. However, how digitalisation has a positive effect on SCRES is still unclear (Zhao et al., 2023). Limited by minimal social distancing, working from home has gone mainstream during the pandemic. It is also what suitable for the automotive industry, because of the features of the New Disruption, some parts of ASCs have been digitalised passively. Respondents mostly mentioned the concept of electronic office. In addition to the digitalisation of some basic processes within the organisation, the procedures and documents related to the import and export of parts and vehicles have also basically completed the digital transformation. This also facilitated information sharing on the supply chain and improves the efficiency of information flow transmission on the chain. As a result, it not only buffered the organisation's difficulties in facing lockdowns during the outbreak phase, but also improved

the efficiency and transparency of the supply chain in the long term. Nevertheless, regarding digitalising workflows as a recovery strategy is limited in that it can only be applied to organisations that have not undergone digital transformation or are not fully digital, and not to organisations that have implemented digital processes. In other words, this strategy could not be repeated. It might be effective for the New Disruption or similar occasional disruptions, but may be restricted for frequent daily disruptions. All the themes and subthemes could be found from Figure 6-2.

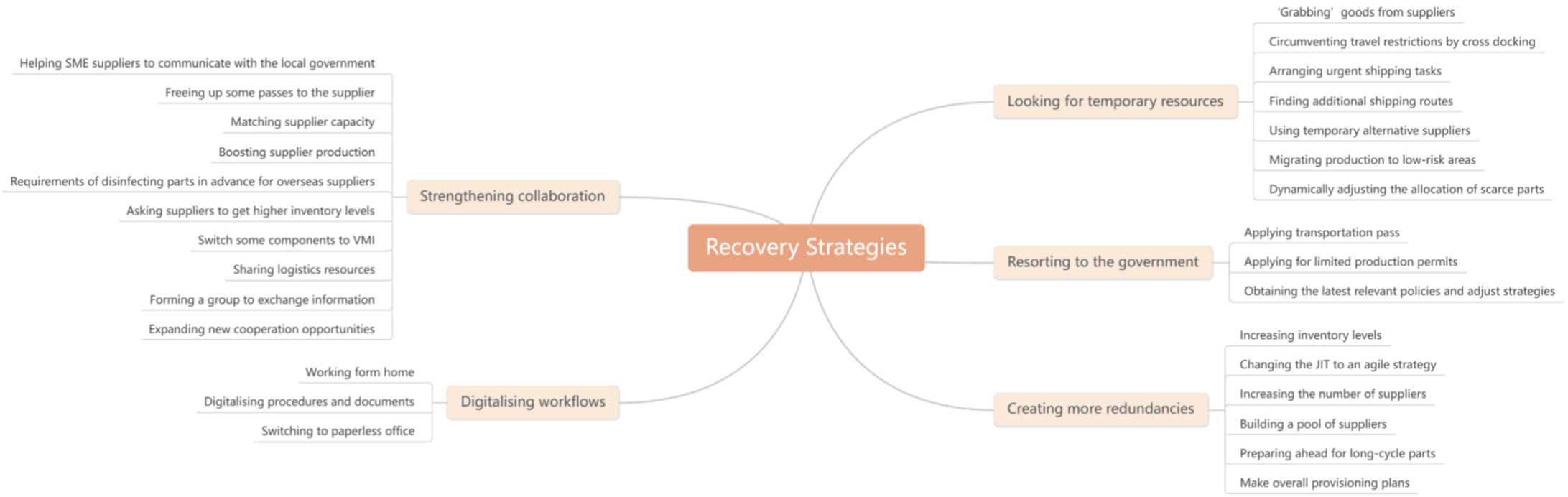


Figure 6-2 Recovery strategies by themes

6.4 Answering Research Question 2: Mapping Strategies to Challenges

In order to better identify the connection between these strategies and the challenges discussed previously, all strategies can also be classified according to the problems they address. In this way it is convenient to correspond these strategies with the challenges above, find out the relationship between specific challenges and strategies, and provide references for organisations to further improve their risk management capabilities, in case of similar situations in the future.

According to the results of the Focus Group thematic analysis, the challenges are first divided into production challenges, logistics challenges, and procurement challenges. Then, only the first level of subthemes is retained, because the more subdivided themes represent the same challenges from different sources, and are irrelevant when considering coping strategies. As for problems where relevant experience is lacking or past methods are not applicable, these would be discussed later in Section 6.4.4. The result is shown in Table 6-2.

Table 6-2 Challenges from Focus Group

Themes	Challenges
Production Challenges	Suspension
	Shortage of material supplies
	Reduced production capacity
Logistics challenges	High inventory costs
	Very high logistics costs
	Delayed delivery time
	Travel restrictions
Procurement challenges	Vendors unable to observe contract
	Difficulty in purchasing spare parts
	Hundred-fold increase in parts prices
General challenges	Sudden lockdown
	Previous experience not applicable
	Significant decrease in consumer demand
	Increased cost of the entire vehicle

6.4.1 Response to Production Challenges

The challenges in production came mainly at outbreak stage. For the issue of suspension, most cases happened during lockdown. The strategy most respondents, especially those from OEMs, gave was to apply for production permits from the government. But this could not completely solve the problem, because government came with some restrictions. In order to protect the health of the workers, production was required to be carried out in a closed state, which means that staff had limited access, and the organisation needed to care about their

food and accommodation. And keep a social distance is still a must. So, in this case, only part of the capacity could be restored, but this was the optimal solution at the time.

Shortage of raw materials was a pervasive challenge at all levels of the supply chain, negatively impacting multiple organisations. Due to the different circumstances encountered by different supply chains or different echelons, organisations had adopted a variety of approaches. A few OEMs tackled this by "grabbing" goods as much as possible from their suppliers. This strategy was born out of the inability of suppliers to guarantee timely supply to all their downstream customers, because their capacity was also affected. OEMs therefore shipped as many parts as possible to their own factories to meet their own demand, by deploying additional vehicles. However, there were also OEMs that adopted a relatively soft approach, choosing to match the capacity of suppliers. In the case that the material supply could not meet the demand for maximum capacity, a part of the capacity (personnel, equipment) was reduced to adapt to the current supply level. This strategy was most common in organisations that were already productivity constrained. In contrast, some organisations with excess capacity had developed a very different strategy to alleviate material shortages by boosting production from suppliers. They used their idle resources to transport suppliers' equipment and raw materials to their own factories for processing and production, and supply directly to themselves. This amounted to a temporary vertical integration of the supply chain, partially replacing the function of the supplier.

There were also strategies that approach supply chain collaboration. OEM respondents mentioned that through their greater influence and bargain power to help SME suppliers communicate with their local government, so that suppliers can obtain production permission. More details could be found latter in 6.5. In addition, there was internal adjustment strategy too. that was, dynamically adjust the allocation of scarce parts, so that different lines or stations could obtain certain resources to meet the basic production conditions (e.g. the chip dilemma mentioned in 6.3.2.)

Another challenge that has emerged in production was reduced production capacity. In addition to addressing the problem through the aforementioned collaborative approach, it was also possible for organisations with affected capacity to move production to a lower risk area. Risk here refers to the risk of an uncertain situation occurring during the New Disruption, such as a blockade. It could also be understood as areas with a low risk of COVID-19 infection would have relatively less prone to outbreaks. As a result, production could then be executed as much as possible. This strategy was mainly applicable to

organisations that have more than one plant, which would be simple to transfer and the added costs were manageable. As the reduction in capacity was temporary, this strategy was not optimal for an organisation which has only one production site.

6.4.2 Response to Logistics Challenges

Logistics challenges also almost all appeared in the outbreak phase. In general, there are two main aspects: one is the disruption of logistic channels caused by travel restrictions, which led to problems such as delays; the other is the sharp increase in costs caused by the failure of the original logistics plan and the need to find alternative and temporary resources.

In response to the travel restrictions, ASC organisations have adopted the method of applying for passes from the government, which was also the only way to solve this problem. This can also be seen as a strategy of cooperating with the government to ensure production as much as possible during the lockdown. Regarding the passes, there was also a phenomenon that large organisations (mainly OEMs) shared some of their passes with their suppliers, which were in the same trouble but could not get enough permits to deliver their products. According to the information provided by the interviewees, the suppliers here were mainly Tier 2 suppliers, and the passes were used to ensure that the goods of the Tier 2 suppliers could be smoothly transported to the Tier 1 suppliers. One possible reason was that compared with Tier 1 suppliers, secondary suppliers were smaller in terms of size and influence, as a result it was more difficult for them to negotiate with the government on their own. However, this phenomenon only occurred when the secondary supplier and the OEM were in the same city, because the policies of different cities and regions were different, and the passes were not universal.

> *"... But there are also lower-level suppliers, that is, second-level suppliers, and second-level suppliers are also faced with a difficulty, because if second-level suppliers cannot deliver the goods, and the first-level supplier or first-level fleet cannot go to second-level to pick up the goods, they cannot produce the materials at first-level, our side will still have an impact, because the supply chain is closely connected. At this time, we also need to vacate some passes for these second-level suppliers, so that the goods of second-level suppliers can smoothly go to first-level suppliers." (Interviewee 1, 2022)*

For the case of different regions, the more common methods were relay transportation or cross docking. The essence of these two methods was the same, that was, to ensure that the

vehicles and drivers in a certain area only operated in that area and did not need to cross provinces or cities. This was because, as mentioned before, the policies of different regions were different, and vehicles could only move freely in the region where they were located, otherwise they would face a long period of quarantine. The difference between relay transportation and cross docking was that the designated point for relay transportation was located at the junction of two regions, such as a service area on a motorway; while cross docking took place in a transit warehouse, which could belong to the OEM or be rented temporarily.

In addition to these strategies, other measures were taken in response to travel restrictions, including arranging emergency transportation tasks. As mentioned in Section Strengthening collaboration, emergency transportation tasks mainly involved immediately arranging maximum transportation capacity to transport all inventory products and even raw materials from a certain upstream echelon to the downstream to ensure the normal operation of the supply chain. In some cases, organisations in the same location would also share logistic resources and help each other to obtain raw materials supplies.

Challenges of significantly increased logistics costs were not explicitly addressed by the respondents with any specific solutions. During the particular period of the New Disruption, especially the outbreak phase, the primary concern was ensuring the continuity of production and logistics activities, with cost increases being the secondary place. Moreover, these costs were short-term, and as moving to the recovery phase, many costs returned to their original levels, thus requiring no special attention. One cost-related strategy mentioned by an interviewee from an OEM was their transition of raw materials from the JIT mode to the VMI mode, thus shifting the cost pressure of inventory onto the suppliers. It is worth mentioning that this OEM has maintained this strategy until now. According to the respondent, this strategy not only reduced their costs but also shortened the lead time of related components, from the original six to seven hours to less than an hour, as the suppliers' warehouses were closer instead.

6.4.3 Response to Procurement Challenges

The procurement challenges actually stemmed solely from upstream suppliers being affected by lockdowns, resulting in component shortages and significant increases in part prices. During the outbreak phase of the New Disruption, organisations didn't have very effective solutions; they could only strengthen communication with upstream partners and seek

alternative suppliers where possible. However, as described in Section 6.3.2 above, finding substitutes was extremely difficult due to copyright and quality issues.

The strategies contained in the data mainly focus on the recovery phase. "Building a pool of suppliers," mentioned in 6.3.2.4, is a mainstream strategy. The key to making this strategy effective is to ensure that each supplier in the pool has the capability to meet downstream quality and delivery requirements for components, and it can effectively enhance SCRES. In addition, similar methods include making overall provisioning plans and preparing in advance for components with long procurement cycles.

6.4.4 Handling of the New Disruption Features

Additional strategies were implemented throughout the New Disruption period, covering all the three aspects: production, logistics, and procurement. These strategies mainly targeted the challenges caused by the unique characteristics of the New Disruption. They were neither specific to a single link or activity of the supply chain nor limited to the outbreak or recovery stages. Therefore, they were classified as General Challenges. Consequently, these strategies were designed to address the characteristics of the New Disruption, namely its large scale, long duration, and high uncertainty.

One of the most direct problems brought about by the unique characteristics of the New Disruption is that pre-set plans and past experience in dealing with disruption-related issues were ineffective in the face of these challenges. For various emergencies and unprecedented situations during the outbreak stage, such as the lockdown of production activities and the closure of logistics channels, organisations had no way or experience to deal with similar problems. Therefore, it was only possible to adopt countermeasures based on existing resources and the situation when facing specific problems.

> *"In terms of logistics, due to the pandemic, every shipment actually becomes quite unique. So, previously, there weren't really any set plans because now it's about figuring out solutions for each individual shipment. Whenever we encounter problems during the process, we tackle them and once resolved, we implement the solution. We provide guidance to our partners, but the effectiveness is uncertain. Why? Because what works now might not work later. We have to adapt constantly, based on the actual circumstances and the reasons behind them. We take practical and effective temporary measures according to the situation. Different time periods present different challenges…Because these*

> *situations are something we couldn't foresee before and haven't experienced, there aren't perfect plans sitting there waiting for us. So basically, it's about encountering problems and solving them as they come up, similar to this kind of approach." (Interviewee 11, 2022)*

In response to the challenges posed by the sudden lockdown and travel restrictions from the authorities, organisations could only respond by establishing a small group to exchange information and try to obtain the latest policies, and making necessary adjustments to production or logistics strategies based on the information collected, such as to adjust production schedules and hire additional lorries. More discussion on information sharing can be found in 6.5.2. In addition, accelerating the transition to digital work is also part of the response to the outbreak of the New Disruption.

After transitioning to the recovery phase through these strategies, new challenges like significant reduced customer demand and increased vehicle cost emerged. Faced with these problems, organisations tried to solve them by expanding the scope of cooperation and looking for new cooperation opportunities. Specifically, they wanted to reduce costs by finding new partners and building new supply networks, and attract more customers by launching new models and features. These were the same methods used to deal with similar problems in the past, but the reasons for such problems in the past are not exactly the same as the New Disruption. Therefore, whether these strategies can effectively work in the recovery stage needs further investigation.

6.5 Answering Research Question 3: Improving SCRES by Collaboration

After finding suitable recovery strategies for the challenges posed by the New Disruption, the next question that needs to be addressed – also known as the *Research Question 3* – is what ASC organisations should do to improve SCRES to cope with similar scenarios that may arise in the future. This section explores the role of supply chain collaboration in this response to the challenges of the New Disruption and how it can help improve SCRES. From an RDT perspective, collaboration is a form of organisational interdependence that they need to leverage to achieve recovery from disruption. Indeed, interviewees also made several references in their solutions to their organisations and partners working together to address certain challenges, particularly when they found that past approaches were not sufficient to fully address the New Disruption.

6.5.1 Comparison of Recovery Strategies Based on RDT

In order to improve SCRES for the future, it is necessary to understand why approaches from the literature did not work in the New Disruption scenario, and why the strategies in the interview data did compared to those past ones (see Table 6-3).

Table 6-3 Effectiveness of strategies in the literature in the New Disruption

Recovery strategies		**Whether worked in the New Disruption**
Contingency plans	Backup suppliers	Yes
	Backup logistics channels	No
	Buffer inventory	Partially worked
	Cluster effect	Yes
Dynamic adjustment	Capacity expansion	No
	Response team setup	Yes
	Original product type change	No
	Potential substitutes development	No
	Supply chain redesign	Yes

From the results in Table 6-3, it appears that most of the strategies mentioned in the literature (5 out of 9) were not represented at all in the interview data. This is dissimilar from the previous results of comparison between the focus group discussion on challenges and *List 1* in Section 5.4. Furthermore, during the comparison the Researcher found that although the remaining four strategies similarly appeared in the empirical results, there was still a significant gap between the specifics described by the interviewees and the literature, in terms of the form or content of the actual application of those strategies. This is consistent with what the invalidation of past experience in the challenge describes.

Specifically, there is an almost complete mismatch between the literature and the reality of the New Disruption in the category of Contingency plans. As presented in Table 6-3, although "Backup logistics channels" and "Buffer inventory" have been shown in the literature to be effective contingency plans for mitigating disruptions, the New Disruption was much larger in scope and duration than organisations can cushion with the safety stocks they have in place. Coupled with the fact that policies such as travel restrictions did not only apply to a single region or form of transport, the organisation’s back-up channels were similarly disrupted and therefore ineffective. As for strategy 'Backup suppliers', although it was mentioned by the interviewees, the specific application of this was quite different from what is described in the literature. Backup suppliers in the literature are emphasised more as a proactive strategy that is set up before an outage occurs (Moosavi, 2021), and are also mentioned as being used when the disruption lasts for a relatively short period of time (Wang

et al., 2014). However, the use of alternate suppliers included in the interview data is a reaction to the New Disruption. The start of the search for alternative options only happened when came the pressure of raw material shortages caused by problems with the original supplier's supply. This is fundamentally different from the situation in the literature due to the scale and duration of the New Disruption. This is also why, in the thematic analysis, this type of strategy was named "Finding alternative suppliers" rather than "Backup suppliers".

> *"[Interviewer: The process of looking for alternative suppliers is when these problems are encountered and then the alternative suppliers are found, rather than maybe we have had agreements with certain suppliers beforehand, that is to say that there may need to be a process of looking for alternatives at that point in time, isn't that right?"] Most of them were selected after the outbreak. And…there is also a part that we have some suppliers whose capacity was not good, and there is a risk, so we may make a programme of these cases in advance, and some of them have already begun. [So… is it like part of them are having contacted in advance, part are temporary?] Yes, because after all there are so many suppliers, it's not possible to open a second track for each supplier, it's not good for the supplier's cooperation. " (Interviewee 3, 2022)*

Another category of strategies in the literature sit in a similar position. Although Dynamic adjustment is representative of those strategies that provide a reasonable response to disruptions, its applicability to the New Disruption is still low. Again, this is due to the fact that these strategies are not designed and used with the severity of the New Disruption in mind. "Capacity expansion" is almost impossible to achieve in the context of the New Disruption, especially during the COVID-19 outbreak phase. According to descriptions in the literature (Hsin Chang et al., 2019; Rahman, 2021), this strategy is achieved by coordinating plants in different regions to compensate for the weakening of capacity in the event of a disruption. However, in the face of the large-scale disruption, this approach was not helpful. The scenarios described by 'original product type change' and 'potential substitutes development' are not applicable to the automotive supply chain at all. In contrast, "Response team setup" and "Supply chain redesign" are the two effective strategies. Setting up a response team with partners for the New Disruption was a strategy mentioned by many interviewees. The purpose of this team was to be able to communicate information to the upstream and downstream members of the supply chain in a timely manner, so that decisions could be made on the basis of the actual situation. The term "supply chain redesign" is used in the literature to refer to the adaptation of supply chain mechanisms to achieve better resilience (Chen et al., 2019). In response to the New Disruption, a similar approach was

applied as OEMs re-coordinated inventory models with suppliers to achieve higher levels of inventory management and corresponding cost reductions. More details are discussed in the next section.

What emerges from these comparisons is that none of the strategies included in *List 2*, which involve only individual organisations, can effectively meet the challenges posed by the New Disruption, whereas ones that involve working with supply chain partners still hold true in the context of the New Disruption, even if some are slightly different from what were described in the literature. The empirical findings suggest that organisations find it difficult to counteract the impact of the New Disruption through their own resources and strengths, while need to rely on partners. In other words, the findings from the interview section prove that collaboration is an effective way to deal with the New Disruption and increase SCRES. This is exactly the view represented by the Resource Dependency Theory (RDT), which provides a valuable framework for understanding such collaborative relationships by highlighting how organisations can manage their dependence on external resources to reduce risk and improve performance. This theory argues that organisations cannot be self-sufficient and must collaborate with other firms to obtain necessary resources, leading to interdependencies that can either enhance or limit supply chain flexibility (Celtekligil, 2020, pp. 131-148). For example, supply chain information sharing is a key strategy for achieving SCRES as it promotes better coordination and responsiveness among supply chain partners (Fernández, 2022). And trust, satisfaction and commitment in strategic relationships can improve logistics integration and overall supply chain performance (Kim et a., 2020). Such dependencies between organisations can be symbiotic, favouring SCRES (Hofer, 2012). Overall, RDT highlights the importance of managing dependencies and leveraging strategic relationships to enhance SCRES, enabling organisations to better cope with uncertainty and disruption (Alkhuzaim et al., 2022, pp. 153-167; Seppala et al., 2019; O'Keeffe, 2016). Therefore, both the facts reflected by the comparison between the interview results and literature, and the RDT perspective supports the idea that collaboration has played a very important role in the recovery of ASC from the New Disruption.

6.5.2 Forms of Enhancing Collaboration

After confirming that collaboration is an effective strategy to tackle the New Disruption, this sub-section elaborates detailed ways of collaboration that have been applied to ASC. Among all the themes derived from the interviews, strategies to strengthen collaboration for building SCRES have not been fully explored by literature. Existing research emphasises the positive

effect of collaboration on SCRES, but there is a lack of detailed research on specific implementation strategies. In order to fully understand how these strategies affect SCRES and answer the last research question, Table 6-4 classifies the collaborative recovery strategies from different dimensions according to the combination of data and literature, echoing the thinking in the research question on how to improve SCRES. The data from the interviews confirmed that collaboration has played an important role in helping the automotive supply chain cope with this new disruption, confirming the positive impact of supply chain collaboration on resilience in the literature. And there are more detailed methods to achieve supply chain collaboration in the data compared with the existing literature. A total of 11 strategies involved supply chain collaboration from the interview data, and they are here divided into three categories: information sharing, resource sharing, and adjustment. The methods of the information sharing appeared more in the recovery phase, and the other two categories were basically in the outbreak phase. Collaborative methods generally exist between the supply chains in which the organisation is located, and rarely cross supply chains.

Table 6-4 Recovery strategies from different ways of collaboration

Collaboration	**Strategies**
Information Sharing	Form an information exchange group
	Expand new collaboration opportunities
	Develop an overall stockpiling plan
Resource Sharing	Release some passes for suppliers
	Enhance supplier production
	Help SME suppliers communicate with local governments
	Utilize cluster effect for transportation
Adjustment	Require overseas suppliers to disinfect parts in advance
	Ask suppliers to increase inventory levels
	Convert certain components to VMI (Vendor Managed Inventory)
	Match supplier capacities

6.5.2.1 Information Sharing

Information sharing strategies in the supply chain primarily involved the exchange of critical information amongst organisations, such as production capacity and inventory during lockdowns. During the outbreak of the pandemic, an effective method was to establish an information exchange group within the supply chain, composed of personnel from each echelon. The group's responsibility was to synchronise information across organisations, reasonably accumulating and allocating limited resources to overcome challenges. In addition to sharing basic information, it could also improve communication efficiency

between organisations, allowing for timely coordination when issues arose at any point in the chain, effectively suppressing the ripple effect and mitigating the spread of disruptions throughout the supply chain.

> *"And then we urgently formed a group at that time. I was responsible for deciding which goods from the suppliers should be stored in the warehouse, and then sending via the free trade zone. For the rest, they were assigned to different people, by the factory, some were in Thailand, some in Vietnam… Our team had many people, each with different tasks. Besides what I just mentioned, there was also a group specifically tracking the updates of epidemic prevention policies in each city, because at that time, the policies were changing constantly, every day was different, one day you needed a pass, the next day something else, so we had to update these things every day." (Interviewee 14, 2022)*

In addition to establishing information sharing groups during the outbreak phase to address unprecedented situations, collaborative efforts in information sharing also extended into the recovery period. This includes developing annual backup plans for parts in coordination with supply chain partners. By coordinating inventory levels of critical parts, such as sharing capacity statuses and sales data, initiating larger-scale parts reserves ahead of time, and negotiating details with collaborative supply partners, including funding, delivering, and inventory space, a reasonable advance plan would be completed to create more redundancy. This also involves exploring new collaborative opportunities, such as OEMs partnering with new suppliers or creating additional distribution channels, which also created more room for the supply chain to respond to unexpected situations.

6.5.2.2 Resource Sharing

Resource sharing is when an organisation shares resources with other entities in the supply chain, both upstream and downstream, to meet challenges and keep operations running smoothly. The sharing is more physical than information sharing. According to the RDT, the sharing of resources by organisations in the supply chain reflects their interdependence and shows that they work together to overcome problems caused by disruptions. According to the interview data, shared resources were usually related to production and transport capacity, and the main problems they overcome usually occurred during the outbreak stage of disruptions.

Due to the characteristics of the ASC, many resources in the automotive supply chain are concentrated in the OEMs and suppliers are always centred on them. Therefore, sharing resources between OEMs and partner suppliers plays a very important role in it. Although these strategies are rarely discussed in the literature, they were specifically designed to assist small and medium-sized suppliers during the New Disruption. This assistance could take many forms, such as providing passes to suppliers during embargos and travel restrictions, and facilitating communication between suppliers and local authorities to speed up the resumption of production, especially when facing shutdowns due to government policies. Such collaborative efforts had not been common in the literature, but have proved valuable in mitigating the knock-on effects of disruptions and minimising the overall negative impact on the supply chain. The data from the interviews suggest that it was precisely the implementation of these two approaches that allowed many of the affected upstream suppliers to maintain a limited portion of their production and avoid subsequent negative impacts on the entire supply chain. It is worth noting here that the permanent shutdown of production by some firms, especially small and medium-sized suppliers, due to the pandemic, as mentioned in the literature, was not reflected in this study. The smaller firms in the ASC are predominantly many of the secondary suppliers. Organisations with more say in the supply chain (usually OEMs) have helped them to secure more favourable terms, as discussed in 6.4.1. On a related topic, organisations participating in the survey confirmed that it was rare for their upstream partner companies to go out of business permanently and have to find a new partner. This highlights the importance of resource sharing as a collaborative approach to building SCRES.

Helping suppliers to increase their production capacity was likewise a particular approach adopted during the New Disruption. Specifically, this strategy involved moving some of a supplier's moulds or equipment to another location for processing and production, thus ensuring continuity of production for the supplier and its downstream. There were several different scenarios for this approach. In some cases, production was moved to an alternative production facility where the supplier was not severely impacted. In other cases, alternative suppliers were sought to provide auxiliary materials (parts for components). In still other cases, moulds were redeveloped using the supplier's data and then processed elsewhere. Whichever form this took, the aim was to address the problem of production disruption from upstream suppliers. However, this strategy requires a high level of inter-organisational trust (Papadopoulos, 2016) as it involves key technologies and some of the organisation's core competencies, notably for suppliers. It is therefore impractical to implement this approach by finding new partnerships after a disruption has occurred. The emergence of these

particular methods reflects the dependency between partners and is a good example of the role of RDT in improving SCRES. However, at the same time, the high requirement of these methods for trust in supply chain collaboration proves that there is a certain threshold for supply chain collaboration to be implemented in practice, and that long-term trust needs to be established between partners in order to effectively improve SCRES.

Besides the aforementioned resource-sharing strategies, another form of sharing exists in the data, namely utilising the cluster effect for transportation. The cluster effect is generally understood as the spatial agglomeration of industry-related enterprises and other supporting organisations, which gain economic benefits through co-location and collaboration (Fromhold-Eisebith, 2008). In China, there are numerous automotive industrial parks composed of ASC organisations and supported by policies and infrastructure from local government. Some respondents' organisations are located in such industrial parks and described how they employ the cluster effect to address the New Disruption challenges.

> *“There are a bunch of car companies in Shanghai, and we all have some transportation resources. Sometimes, we even collaborate with our peers (competitors), meaning we work together to transport stuff. For example, let's say there's Company A and Company B. Since most auto suppliers have multiple plants across the country, if we Company A doesn't have a plant in this city, we might not be well-prepared for the local environment or government relations. But our peer Company B does have a plant there, so they have more transportation resources than Company A. If Company B's local fleet can help A transport stuff, and they have some extra space and resources, we'll coordinate and pay them." (Interviewee 14, 2022)*

This strategy was highly effective in addressing logistical challenges. It maximised the utilisation of limited logistical resources while reducing waste and reliance on permits by organisations. However, this strategy had not been widely adopted and appeared only in a few organisations. The reason for this was that ASCs in China, particularly OEMs, are geographically dispersed, with only a few regions having more than one OEM, such as Shanghai. While many related enterprises are located in most automotive industrial parks, there is typically only one OEM. Therefore, this method cannot be generalised for use in most OEMs, but could be considered to apply for other echelons as a way to enhance collaboration and improve resilience.

6.5.2.3 Adjustment

Unlike resource sharing, which involves organisations sharing resources with partners, alignment strategies involve reaching out to partners when organisations are unable to achieve certain goals or overcome challenges on their own. These adjustments involve the entire supply chain, from suppliers to OEMs, both upstream and down-stream. Feedback from interviewees suggests that these strategies arose from the contingency stage, where an emergency exceeded the organisation's resilience and external assistance was required. While these strategies reflect the organisation's dependence on partners or the external environment, they are not directly related to the need for a particular resource or information. For example, one strategy is to require upstream suppliers to sterilise goods prior to shipment to prevent delays caused by customs inspections. Suppliers may also be required to maintain higher inventory levels due to reduced logistics capacity. In addition, suppliers may seek help from downstream partners, such as asking original equipment manufacturers to match their reduced production capacity to meet current challenges. These strategies help mitigate the impact of disruptions in the short term, highlighting the positive impact of supply chain collaboration on overall resilience.

In addition to short-term strategies, transitioning certain components to Vendor Managed Inventory (VMI) was also a strategy adopted by one of the OEMs surveyed after the outbreak phase. They initially implemented this strategy with one supplier during the outbreak, and then recognised that VMI was a more effective way of improving the long-term resilience of their supply chain compared to the pre-outbreak approach, and adopted it as standard practice. These adapted strategies face more complex situations than the first two forms of collaboration, so rather than relying on one type of resource, they are more like turning to supply chain partners when problems arise and relying on the collective power of the organisation to solve them together, thus improving overall resilience.

6.6 Summary

This chapter analysed the data obtained through semi-structured interviews and applied thematic analysis to classify all strategies into five themes: looking for temporary resources, strengthening collaboration, creating more redundancies, resorting to the government, and digitalising workflows. Each theme contains more subthemes, which refers to the specific strategies that have been applied by the participated organisations. These themes explained how China's automotive supply chain solved the disruption problem during the outbreak and recovery of the New Disruption, and improved SCRES from different dimensions.

To answer the *Research Question 2*, the strategies were divided into for production challenges, logistics challenges, procurement challenges, procurement challenges, as well as general challenges which targets at the special characteristics of the New Disruption. This categorisation is according to the classification of the challenges, for the match of strategies and them. Through the mapping process, this research found practical and feasible methods for each specific challenge to improve the resilience of the supply chain, and provided reference for similar situations that may occur in the future.

Subsequently, in comparing the strategies in the literature with the interview data, this study found that recovery strategies that emphasise collaboration between organisations performed more effectively in coping with the New Disruption than organisational-level (or intra-organisational) solutions. Therefore, further analysis of the strategies related to collaboration in the recovery strategies yielded specific ways in which organisations enhanced collaboration, including information sharing, resource sharing, and adjustment. The supply chain collaboration behaviours between suppliers, OEMs, and distributors reflected in these strategies confirm the interdependence between organisations and the external environment in RDT and answerer the *Research Question 3*. This section refines the theoretical foundation of supply chain collaboration for improving resilience, expands the scope of collaboration, and provides specific methodological guidance for improving supply chain collaboration.

7 IMPLICATION

7.1 Introduction

This chapter discusses implications that emerged during the analysis, and further contribute to the field of SCRES from both theoretical and practical perspectives. In addition, the chapter reflects on the literature and highlights the contribution of this study within a coherent intellectual framework.

Section 7.2 begins by discussing the added value of the focus groups and interviews and identifies other noteworthy extensions to existing theory and literature, exploring the knowledge contribution of to SCRES; Section 7.3 further strengthens the discussion of the New Disruption and expands the application of the Contingency Theory and Resource Dependency Theory to SCRES, by revisiting both theories in the literature and situating the concept of the New Disruption within the lens of these two integrated theories; Section 7.3 marks the end of the chapter.

7.2 Inferences of the Empirical Findings

The empirical findings presented in Chapters 5 and 6 answered the three research questions and depicted (i) the impact of the external environmental factors brought about by the New Disruption on the manufacturing sector, i.e. how the characteristics of the New Disruption are manifested in the manufacturing sector, and (ii) the ripple effect of the challenges brought about by the New Disruption in the automotive supply chain. This allows for a more complete understanding of the New Disruption than just sorting out the challenges it has brought. On the other hand, the coping strategies in terms of answering the research questions were designed to address those arisen challenges. From a perspective of extending the results to knowledge, comparing them with the approaches in the literature can provide a more precise guide to understanding the mechanisms that are effective in improving SCRES in a changing external environment. The following discussion attempts to extract inferences from these key findings and link them to a coherent body of knowledge, contributing to the body of knowledge in the process.

7.2.1 The Ripple Effect of Challenges along the Supply Chain

Section 5.6 analysed the New Disruption challenge through ISM to obtain a causal relationship between the challenges. This causal relationship is known in the literature as the ripple effect. The ripple effect in supply chain management refers to the propagation of disruptions through a supply chain, with significant impact on the performance and structural

dynamics of the supply chain (Ivanov, 2021). This phenomenon is particularly critical because it can lead to a series of cascading failures that affect both upstream and downstream entities in the supply chain. The ripple effect differs from the bullwhip effect, which primarily deals with supply-demand mismatches and does not alter the structural design of the supply chain (Dolgui, 2020). The COVID-19 pandemic is a classic example of a super-disruption, which amplifies the ripple effect by causing simultaneous long-term disruption to supply, demand and logistics (Kinra et al., 2020). The literature shows the impact of these disruptions varies depending on the type, combination and duration of the risk, with retailers and manufacturers being particularly vulnerable (Hosseini, 2019). The complexity and interconnectedness of global supply chains further exacerbates the ripple effect, making localisation and control of disruptions challenging (Dolgui, 2021; Ghadge, 2022).

The empirical results of this study emphasise the transmission and amplification of the impact of ripple effects across the automotive supply chain caused by the New Disruption and add to the existing literature. Ripple effects have a significant impact on production scheduling by propagating disruptions and changes throughout the supply chain, thereby affecting all aspects of production planning and execution. For example, disruptions at ports, factories and warehouses can lead to a reduction in labour force participation, which reduces an organisation's ability to meet customer demand and affects the entire cross-border supply chain network of organisations with overseas operations. This impact is further exacerbated by the structural dynamics of the supply chain, where severe disruptions can lead to demand fulfilment problems spreading downstream. In addition, localised disruptions can spread from one company in the supply network to another, ultimately affecting the resilience and operational policies of the entire network (Dolgui et al., 2020).

The ripple effect spreads disruptions throughout the supply chain, which can have a significant impact on inventory management, leading to complex challenges in maintaining optimal stock levels. Multiple participants in the focus groups referred to their organisations' difficulties with inventory, including inventory depletion in the event of supply shortages and inventory hoarding in the event of production shutdowns. The dynamic nature of these difficulties requires an integrated approach to inventory management, supplier selection, and disruption risk assessment, as traditional approaches often fail to address the interconnectedness and complexity of modern supply chains. Furthermore, the impact of ripple effects on supply chain performance highlights the importance of resilience and flexibility in inventory management, as disruptions can lead to significant changes in supply chain structural design and operational policies (Spiegler et al., 2019).

In addition, the propagation characteristics of the ripple effect have a significant impact on supplier relationships. Trust is a key factor in enhancing the resilience of supply networks as it positively affects the network's ability to adapt to disruptions, although its impact varies depending on the network topology (Giannoccaro and Iftikhar, 2022). The propagation mechanism of the ripple effect suggests that both man-made and natural risks amplify operational risk, which in turn reduces supply chain performance. The results of Chapter 5.6.2 have shown that regional embargo policies can lead to a reduction in the supply of raw materials, which can strain the relationship between upstream suppliers and manufacturers, leading to competition for raw materials. Financial pressures within the supply network are exacerbated by downturns in overall economic conditions and more conservative strategic behaviour by organisations, further propagating risk and potentially disproportionately affecting firms with stronger bargaining power. The interconnected nature of supply networks means that disruptions at the organisational level can amplify and spread, creating a cascade of failures that affect global performance (Chauhan, 2021). Disruptive behaviours that change the design of supply chain structures and operational policies highlight the importance of resilience in mitigating these effects.

The dominant approach in the existing literature to cope with the ripple effect is to understand its possible impact on the supply chain through prediction and simulation. For example, when responding to relevant questions about inventory management, the use of dynamic Bayesian networks helps to estimate the risk of disruption and to manage inventory more efficiently by understanding the probabilistic relationships between supply chain participants (Hosseini, 2019; Dolgui et al., 2021). Simulation models, such as agent-based simulations and multi-table spreadsheets, provide valuable insights into how different parameters and responses affect the ripple effect, allowing for better preparedness and response strategies (Dolgui et al., 2018).

However, the results of this study challenge this perspective. Firstly, forecasting and simulation methods are inherently limited in the extent to which they can probe the actual supply chain situation and do not provide a complete simulation of the supply chain and the events that occur within it. Non-linearities in supply chain systems complicate the response and recovery process and place high demands on predictive models and analytical methods. Trying to manage the complex activities of supply chains under ripple effects through these approaches is difficult. Second, the empirical evidence presented in Chapters 5 and 6 clearly shows that proactive methods are difficult to use when faced with a major event such as the

New Disruption. Organisations have to constantly face one unprecedented situation after another. Therefore, it is not enough to understand the ripple effects of supply chains by modelling predictions. This is partly echoed by some literature, for example, Liu et al. (2021) suggest that alternative procurement policies are more effective than building inventory buffers when faced with an inventory problem, highlighting the need for adaptive strategies to mitigate supply capacity shortfalls and maintain inventory stability.

Identifying the location of disruptions and preventing them from propagating downstream is critical to maintaining supply chain performance, judging from the responses of the interviewees in the interviews conducted in the second half of this study (Hosseini, 2019). The New Disruption and the challenges it posed required managers to adjust their strategies to realise the full potential of the innovation and adapt to external variables. Production wise, effective production scheduling must take into account the dynamics of the external situation to ensure smooth operations, reduced throughput times and adherence to due dates (Kinra, 2020). These approaches highlight the need for supply chain adaptability to the external environment and resilient scheduling methods for managers. On the other hand, fostering resilient supply networks through trust, strategic financial planning, and robust policy frameworks is essential to mitigate the adverse effects of ripple effects on supplier relationships (Giannoccaro, 2022).

7.2.2 The Role of Supply Chain Collaboration in Building SCRES

The empirical findings of this study highlight supply chain collaboration as organisations in the automotive supply chain aim to improve their resilience in the face of risk. As described in the findings in Chapter 6, collaboration plays a key role in building SCRES by increasing flexibility, visibility and speed, which is essential for mitigating disruptions.

Contemporary literature on supply chain collaboration also highlights its role in improving SCRES, and collaborative resource sharing, including labour, material and information resources, has been identified as an effective strategy for recovering from SCD (Ivanov, 2023). However, many of the conclusions have limitations, and the results of this study have extended them appropriately. For example, Sharma et al. (2023) highlighted that resource sharing and information sharing were identified as effective strategies for improving SCRES in medium-sized enterprises in developing economies. This research is also set in a developing economy, but the results of this study support this view on the one hand, that information sharing and resource sharing in coping with the New Disruption did provide a

great deal of assistances to those medium-sized volume suppliers and distributors in recovering from the disruption. On the other hand, this study extends this finding to large organisations, including many multinational OEMs. they likewise gained benefits in resource and information sharing and improved SCRES. Similarly, Nunes et al. (2022) demonstrated that effective communication, interdependence, and trust within a collaborative framework can significantly enhance SCRES in regions prone to natural disasters. The results of this study, however, suggest that even when not in a natural disaster-prone region, collaboration within the supply chain could still significantly increase SCRES and help organisations to overcome difficulties. The epidemic that caused the New Disruption, although a natural disaster, was itself highly contingent and not a frequent event from a historical perspective. At the same time, its impact is much greater than that of a natural disaster at the regional level. The results of this study illustrate that collaboration remains one of the most effective ways to improve resilience in such global supply chain disruptions.

Besides, the empirical findings of this study expanded on the ways in which supply chain collaboration can build SCRES. In addition to resource and information sharing, which are often mentioned in the literature, adjustment between ASC organisations also played an important role as a form of collaboration in helping organisations recover from the New Disruption. As discussed in sub-section 6.5.2, adjustment in this context refers to supply chain members dynamically adjusting production capacity and inventories in response to upstream and downstream partners. These strategies achieved the goal of increasing resilience by enhancing the connectivity of the supply chain. This is close to the concept of "coordination" in existing research, but not identical. Coordination in supply chain collaboration in the literature refers to the strategic alignment and synchronisation of activities, decisions, and information among supply chain partners to achieve common goals and enhance overall efficiency. Effective coordination involves various mechanisms such as contractual practices, joint decision-making, and information-sharing practices, which help in reducing costs and improving the sustainability of supply chains (Ghasemi , et al., 2023). It is clear to see that coordination itself is more focused on inter-organisational cooperation during normal times (i.e. non-disruptive periods). Moreover, compared to these static processes or information coordination mentioned in the literature, the adjustment in the interview data is more oriented towards organisations dynamically adjusting their production and inventory activities in real time to the current environment, emphasising the adaptation to the changing environment. Wankmüller (2020) in their study on relief supply chain management mention the role of coordination of stakeholders' activities in mitigating the

impacts of a disaster that has similarities with the adjustment activities in this study. The findings of this study suggest that collaborative emergency adjustments, including coordinated adjustments to capacity and shared inventory usage, can significantly slow the propagation of disruptions and improve the recovery performance of supply chains with suppliers. At the same time, a collaborative approach in the category of adjustment can improve supply chain connectivity and coordination during the recovery process from the New Disruption in ASC organisations, thus improving SCRES. In addition, the clustering effect that existed among some OEMs expands new types of supply chain collaboration. This horizontal collaboration (cross supply chain) on logistics resource further highlights the importance of working together to manage disruption risk and optimise cost, sustainability and responsiveness.

It is also interesting to note that all the forms of collaboration mentioned in Sub-section 6.5.2 occurred after the outbreak, while previously it was not very strong. Interviewees agreed that prior to the New Disruption, organisations and their partners were mostly in basic contractual employment relationships or were themselves competitors in the industry. Most organisations tended to turn to their external environment and look for opportunities to collaborate only when they encountered major problems that they could not solve on their own. This is why some of the strategies were ineffective for the New Disruption because they are based on long-term co-operation and a high level of trust. And, it also explains the ripple effect of the New Disruption in ASCs, where organisations do not choose to embrace collaboration as soon as the disruption occurred, but chose to look for external help when the situation was beyond their control. This then raises another question about whether these relationships and forms of collaboration will continue after the New Disruption. With the data collected so far, the relationships that these organisations rely on each other for are likely to be short-term and project-based, and the lack of enduring relationships can hinder supply chain cohesion and flexibility (Donato et al., 2013, pp 1-21). Apart from the strategy mentioned by one of the interviewees regarding VMI which has been retained until now, the continuity of all other collaborations requires further research.

In summary, it is shown that there are still many specific details of collaboration as a widely recognised way of improving SCRES in the literature that deserve to be studied in depth. This study extends the scope of the role of collaboration for resilience and summarises additional forms of collaboration based on practical data. The results suggest that supply chain collaboration not only enhances SCRES from disruptions, but also promotes sustainability, efficiency and competitive advantage during the organisational recovery

phase. Overall, collaboration is a multifaceted strategy that is critical to building resilient supply chains that can withstand and recover from disruptions.

7.3 Bridging Contingency Theory and RDT in SCRES

7.3.1 Extension of Contingency Theory and RDT

This research is theoretically grounded in Contingency Theory and RDT. The empirical evidence from this study has confirmed that organisations would rely on external environment (the New Disruption and situations during and after the pandemic) and external resources (through collaborations with other supply chain partners) to improve the SCRES. More importantly, however, the findings have proved that both the environment and resources are crucial in terms of performance and decision making, and the adaptation and improvement could not be realised without any of them. Therefore, this study extends the views of these two theories.

Contingency Theory posits that there is no one-size-fits-all approach to management; instead, the optimal course of action is contingent upon internal and external factors, such as environmental variables and organisational resources (Bai, 2023). This theory emphasises the situational aspects of management, suggesting that organisational effectiveness results from fitting organisational characteristics to contingencies like technology, environment, and size (Williamson, 2009). For instance, contingency models in ecology suggest that animals optimise their feeding strategies based on the abundance and type of available resources, which can be analogised to how organisations adapt to environmental changes (Sherer, 2019). Corresponding to the situation of the New Disruption, the adaptability of organisations to their environment was reflected in their attempts to recover from the various impacts caused by the New Disruption. The present study built upon the insights of Contingency Theory by demonstrating its applicability not only to organisations, but also to the perspective of the entire supply chain. Firstly, it is evident that there are commonalities in the challenges faced by organisations in ASCs, which provide a factual basis for the supply chain perspective. Secondly, the unique challenges that arose in the ASC reflect the matching of the ASC's own characteristics with environmental contingencies. Therefore, when considering the recovery strategy, it is necessary to focus on the unique characteristics of this disruption and the ASC itself. This also explains why previous recovery strategies were not useful in this instance.

On the other hand, RDT focuses on how organisations manage dependencies on external resources to reduce uncertainty and ensure survival. It posits that organisations are not passive entities but actively seek to secure critical resources (Aldrich, 1976; Gillespie, 1979). For example, organisations may adopt various strategies, such as forming alliances or altering contract designs, to manage dependencies and reduce uncertainty (Malatesta, 2011). Moreover, this theory is particularly important in understanding how organisations prioritise different resilience strategies to adapt to long-term disruptions (Alikhani et al., 2023). This study corroborates the notion that various collaborative strategies adopted by organisations in the ASC are indeed effective. Among the five major themes of the recovery strategies, not just the 'strengthening collaboration' them but also 'looking for temporary resources' and 'resorting to the government' are related to different means of collaboration. This study also found that the role of sharing and collaboration in achieving supply chain agility highlights how organisations align their strategies with their dependencies upstream and downstream in the supply chain. This is reflected in the fact that organisations in the ASC learned about their partners' production and inventories, and accordingly adjusted their own strategies and shared their resources. This suggests that good resource dependency relationships can lead to better competitive advantage. Furthermore, in terms of utilising external resources, this research combined the argument of Contingency Theory and highlighted that adaptability to external resources would also depend on the environment. This theoretical framework elucidates the reasons why prior strategies concerning collaboration proved to be either inapplicable or ineffective in the context of the New Disruption. Consequently, numerous novel strategies have emerged from empirical data, particularly the concept of 'Adjustment'. Therefore, the RDT is expanded to encompass the notion that an organisation's adaptation and utilisation of external resources is also contingent on environmental factors.

7.3.2 Synthesisation of the two theories

The rationale for integrating these two theories is based on that they share several common arguments, including external environmental influence, adaptation and flexibility, organisational survival, and strategic management, to enhance organisational effectiveness and resilience (See Table 7-1). Furthermore, a bibliometric analysis of the SCRES literature suggests that there is a growing recognition of the need for an overarching theory that integrates a variety of perspectives to construct a global theory of SCRES (Gebhardt et al., 2022).

Table 7-1 Arguments of Contingency Theory and RDT

Dimension of Argument	Commonality	Contingency Theory	RDT
External environment influence (Sherer and Lee, 2002; Sohl et al., 2024; Tarifa Fernández, 2022)	Both theories emphasise the importance of the external environment in shaping organisational behaviour and outcomes.	Focuses on how external factors influence organisational structure and strategies.	Highlights the dependence of organisations on external resources.
Adaptation and flexibility (Gillespie and Mileti, 1979; Mohr et al., 2016; Sherer et al., 2019)	Both theories are concerned with organisational survival and effectiveness in a dynamic and uncertain environment.	Emphasises the need for organisations to align their structures and strategies with environmental contingencies to thrive.	Argues that organisations must manage their external dependencies to adapt to resource constraints.
Strategic Management (Malatesta and Smith, 2014; Yeager et al., 2014)	Both theories advocate for strategic management practices that take into account external factors and dependencies.	Highlights the importance of aligning organisational strategies with environmental contingencies for optimal performance.	Emphasises the strategic management of external relationships to minimise vulnerability

In attempting to combine the two theories, the existing literature generally agrees that external factors have a significant impact on the application of RDT to supply chain management by shaping the dynamics of inter-organisational relationships and dependencies. For example, government policy risks motivate firms to accumulate inventories to buffer against potential policy changes, especially in the context of high policy uncertainty and industry dynamics (Craighead et al., 2020). This is confirmed by ASC under the New Disruption. Overall, external factors such as technological advances (Wang, 2021), relational dynamics (O'Keeffe, 2016; Schnittfeld, 2016), and power structures (Alexander and Wells, 2008; Abdurakhmonov, 2021) profoundly influence the application of RDT in the area of supply chain management, driving organisations to adapt and strategically manage their dependencies. However, the extant literature on this subject primarily focuses on inter-organisations within the system, with limited consideration given to the impact of

external environmental factors on resource dependence across the entire system, which is the ASC in this research. RDT could not suggest which environmental contingencies hold the most influence over organisational actions and outcomes (Hillman et al., 2009). Therefore, expanding with the environmental dimensions of Contingency Theory may highlight different segments/sources of interdependency.

Based on this, the key argument in bridging Contingency Theory and RDT in this research is that, it explores the impact of the external environment on an organisation's dependence on external resources. It is further demonstrated that organisations can attain their objectives by adapting to the external environment in which they function and by adeptly managing dependencies. The findings of this study illustrate how organisations in the automotive supply chain could adapt to changes in the external environment due to the New Disruption and collaborate with their supply chain partners to recover from disruptions and enhance the overall SCRES. By integrating these two theories, this study conceptualises organisations as entities that strategically manage their dependencies by cultivating collaborative relationships to mitigate the risks associated with external uncertainty and augment autonomy and flexibility. This viewpoint is further substantiated by extant literature, including the assertion that the sustainability of strategic alliances in supply chains can be more readily explicated by giving due consideration to the internal and external environmental conditions that influence these partnerships (Drees and Heugens, 2013). Moreover, this research posits that the establishment of interdependent relationships is imperative for organisations seeking to manage environmental contingencies and achieve their objectives in highly uncertain external environments. Considering the internal capabilities and external dependencies of organisations, it allows for nuanced approaches to SCRES, like those mentioned in Chapter 7 that are specific to helping organisations recover, such as the sharing of authorised travel passes. Thus, the integration of the focus of adapting to the environment from Contingency Theory with the strategic management of dependencies emphasised in RDT offers a comprehensive framework for organisations to navigate complex environments, enhance their performance, and ensure sustainability. Moreover, this framework could further explore how the digital transformation driven by the New Disruption, as a technological environment variable, enhances SCRES by optimising resource allocation and improving supply chain visibility in future research.

7.4 Summary

This chapter illustrated more insights on supply chain disruption and resilience gained from the empirical results from the focus groups and interviews. Specifically, it focused on the theoretical contributions of extending the research of the ripple effect of supply chain, and the collaboration in SCRES. Moreover, it discussed how Contingency Theory and RDT could be combined together in terms of SCRES.

The propagation of the New Disruption on the ASC has shown the great impact of ripple effect on supply chains. The findings from the focus group have disclosed that the ripple effect of The Disruption had strongly affected the production, logistics activities, and inventory management throughout the entire supply chain, and impair relationships between suppliers. And those solutions to the ripple effect were not effective enough to deal with the New Disruption as they lacked practice and could not suit for the changing environment.

On the other hand, what organisations put into effect to tackle those challenges brought by the New Disruption emphasized collaborations among supply chain partners. According to the interview data, collaboration had become an effective way to overcome the difficulties specially from the characteristics of the New Disruption. It has proved that resource and information sharing would be helpful to the whole supply chain regardless of the size of the organisations, during an occasional disruption like this. Meanwhile, the findings demonstrated new ways of collaboration to strengthen the SCRES. Adjustment –following the up- and downstream and dynamically adjusting the production capacity and inventory management – could improve the connectivity and coordination of the supply chain. And horizontal collaborations such as the clustering effect could bring benefits across supply chains.

From the theory perspective, this research has significatively bridged the Contingency Theory and RDT together to provide a more comprehensive view of SCRES. Based on the fact that the application of RDT on supply chain management would be influenced by external contingencies, this research stands on the view that organisations in ASC were together facing the ever-changing external environment due to the New Disruption, and interdependently collaborated to overcome the challenges it brought. It emphasises the dependencies among organisations, including the interoperability of information and the complementarity of resources, in resisting external uncertainty. And this could be a supportive theoretical framework for SCRES research in a global context.

8 CONCLUSION

8.1 Introduction

This chapter brings the study to its conclusion. It begins with a summary of the overall research, followed by the contribution of the research to knowledge and practice. After that it presents a consideration of the study's limitations and suggestions for future research. The chapter ends with some concluding remarks.

8.2 Research Summary

This study aimed at extending the research on SCRES under the New Disruption by COVID-19 in manufacturing sector. In doing so, this study focused on the impact of this disruption on the automotive supply chain and examined strategies to improve SCRES from a holistic perspective. In order to fulfil its research intent, this study considers the automotive supply chain in China.

In reviewing the existing literature, it was found that the definitions and categorisations of disruptions in existing Supply Chain Disruption (SCD) studies are insufficient to characterise the New Disruption and the impact it caused to supply chains. Therefore, this study provided a complete definition of the New Disruption based on past studies to accurately conceptualise its difference relative to past disruptions and to lay the foundation for subsequent research. On the other hand, research on SCRES is still immature, and scholars still disagree on its concept and the areas it encompasses. This study looked at supply chains and organisations' ability to recover from disruptions in the context of SCRES. Approaches to recovery from SCD mentioned in previous studies have focused on quantitative modelling to determine whether there is a positive impact on a particular metric of the organisation. The conclusions drawn from such an approach are limited to specific conditions and lack practical value for improving SCRES. This is considered as one of the reasons why many of the strategies mentioned in the literature did not work in the context of the New Disruption. On the contrary, this study went beyond and filled the gap of improving SCRES by empirically investigating the recovery strategies adopted by organisations and supply chains in real situations.

Data collection activities for this study included in-depth focus groups and semi-structured interviews. The focus groups helped to conceptualise the New Disruption more accurately and to investigate the impact it caused in the automotive supply chain. Data from the interviews were used to explore effective strategies for improving SCRES. The data

collected was analysed using thematic analysis, which was the main source of evidence for this study. In addition to this, the themes generated in the focus groups were analysed and enhanced through ISM to further understand the ripple effects of the New Disruption on the automotive supply chain, i.e. the mechanism by which the disruption propagates through the supply chain.

The empirical findings from the focus groups revealed interesting and unique challenges of the New Disruption for the Chinese automotive supply chain (ASC). The common challenges posed by the New Disruption across industries clearly demonstrated its strong influence, by comparing with studies targeting at other industries. At the same time, the challenges specific to the ASC reflected the complexity of the supply chain's structure. The results of the thematic analysis highlighted the uniqueness of the New Disruption compared to past disruptions, expanding the definition of disruption in the field of SCD and confirming the conceptualisation of the New Disruption. Subsequent ISM analysis further refined the impact of the New Disruption on ASCs, making a complete link between the antecedents of disruptions to different supply chain activities at different disruption stages. This part of the results further strengthened the understanding of the mechanism of the New Disruption on supply chains.

The interviews helped the Researcher to obtain a full sight of the decisions made by organisations when dealing with the New Disruption in real-world situations, both in individual and supply chain perspectives. It is important to note that compared to the solutions collected through the literature review, the data from the interviews clarified the specific implementation of strategies. This could help academics to better understand the scope of application of these strategies and the barriers in their implementation, which is one of the important implications of empirical research. In addition, through the thematic analysis, effective recovery strategies for coping with the New Disruption at different times were identified. On this basis, this study recognised the critical role of collaboration for SCRES for large disruptions experienced by complex supply chains. Although this is not a new idea, the applicability and specific forms of collaboration had not been thoroughly investigated, and the results of this study fulfilled these gaps.

8.3 Contributions

8.3.1 Contribution to SCD and SCRES Research

This study contributes to research and methodology in the field of SCD and SCRES. The study conceptualised the characteristics of the New Disruption and its resulting impacts, and extended existing concepts and types of SCD. As an unprecedented type of disruption, this study systematically summarised the challenges that its own characteristics posed to the supply chain. Although a number of studies had focused on the impact of this disruption brought about by COVID-19 on the supply chain, there has been no rigorous conceptualisation of it as a complement to existing SCD research. And this study focuses on the manufacturing sector, represented by the automotive supply chain. This is because little of the current literature on pandemic disruption focused on manufacturing. The New Disruption had wreaked havoc on many global supply chains, and the challenges faced by different industries may share some of common points, but also differed in some specific manifestations due to their own industry characteristics. Therefore, this study integrated the challenges that supply chains may face when recovering from the COVID-19 crisis as mentioned in the existing literature, and focused on the commonalities and differences between the challenges faced by the ASC and other industries at different stages of the New Disruption, which improved the relevant theoretical foundations of SCD. At the same time, this study's exploration of the propagation mechanism of the New Disruption complemented the understanding of the ripple effect of SCD.

On the other hand, based on identifying the challenges that the New Disruption has brought to the ASC, this study found effective and efficient strategies to deal with these challenges. Due to the unique nature of the New Disruption, previously studied strategies did not function well on helping organisations recover. Therefore, this study explored effective recovery strategies applicable to ASCs to address the challenges faced by manufacturing organisations in this disruption. In doing so, this study has found collaboration to be very effective in coping with such disruptions. Although in recent conceptual studies, researchers have agreed to some extent on the positive effects of collaboration for SCRES, none of these studies have involved empirical investigations. Through empirical research, this study put forward the idea that collaboration is an effective approach for improving overall SCRES, enabling the supply chain to recover quickly from disruptions, by information sharing, resource sharing, and adjustment.

8.3.2 Contribution to Theoretical Framework

This study adopted Contingency Theory and Resource Dependence Theory as the dominant theoretical perspectives. Contingency theory has been widely used in SCRES research to emphasise the adaptability of organisations to changes in the exogenous environment. In the context of this study, the theory provided organisational-level insights into challenges and recovery strategies. However, the theory has limitations in explaining SCRES, especially in the face of global events such as the New Disruption, as it is always from the perspective of individual organisations; conversely, disruptions to organisations in the supply chain and their reactions would have an impact on upstream and downstream. Therefore, this study validated the proposition of Contingency Theory from the supply chain perspective, arguing that the external environment could have a significant impact on a system (i.e. supply chain), and strategies need to be adapted to the characteristics of the environment.

In addressing the enhancement of SCRES, RDT proposes that alignment with supply chain partners and the leveraging of external dependencies can facilitate progress. However, the emergence of the New Disruption has underscored the vulnerability of external dependencies to environmental contingencies. Consequently, this research synthesises Contingency Theory and RDT, offering a more comprehensive perspective on SCRES. Empirical evidence in this study has been presented which supports the argument that the utilisation of external resources must adapt dynamically to the environment in which the supply chain is situated, in order to develop appropriate strategies to improve the SCRES and performance of not only organisations but the entire supply chain. This theoretical perspective elaborated the importance of the supply chain's flexibility in adapting to external variables at the macro level, as well as the flow of information and resources between organisations endogenous to the supply chain at the micro level. It could effectively explain the various strategies for coping with challenges found in the study - both for individuals and the whole supply chain. It is also distinct from other contemporary studies which view increasing individual organisational resilience as a means of improving SCRES.

8.3.3 Implication for Practice

Through empirical investigations, the conclusion of this study could also be a reference to the real business world. A common response from the interviewees in the interviews was that their organisations lacked relevant plans to cope with such large-scale disruptions. This study established a correspondence between challenges and recovery strategies in order to answer *Research Question 2*, providing more practical recovery strategies for large SCD.

This can provide organisations in the supply chain with a basis for decision making when dealing with similar situations that may recur in the future. Moreover, given that collaboration is still not used as a regular strategy by most participating organisations, the study's viewpoints and specific approaches to collaboration can also be a novel idea for many other organisations. Meanwhile, in the focus group, participants from different organisations gained more information about the upstream and downstream of the supply chain through communication with each other, which facilitated the exchange of information.

8.4 Limitations

Considering that this may be the first attempt to systematically study the New Disruption, this doctoral study is not without limitations. Overall, this study has limitations in terms of overall research design and data collection. Nevertheless, addressing these limitations may provide valuable ideas for future research.

In terms of overall design, this study was limited to ASCs in China. The fact that this study only used data from Chinese companies means that this study did not take into account the possible effects of regional context. In the early stages of this study, the Researcher had considered setting the target at ASCs in different continents and countries so that the disruption in ASC could be fully investigated and those ASCs could be directly compared. They are not the same in different regions and the policies adopted by governments towards COVID-19 vary from place to place. However, due to the time requirements of the doctoral programme and the accessibility of the data, this study was ultimately narrowed down to the more representative Chinese ASCs. There is also a limitation in the time dimension. At the stage of this study's data collection, Chinese ASCs had not long moved into the recovery phase of the New Disruption. Although the organisations had already encountered some new challenges in this phase and identified corresponding recovery strategies, it could not be sure whether there would be new situations, considering the long-term effects of the New Disruption. Until July 2024, there were still over 150,000 reported cases in 28 days. While in the long term the problems caused by the New Disruption may morph into other known problems, such as the economic downturn, its subsequent impact on ASCs is still worth continuing to explore.

In terms of the data collection component of this study, limitations existed mainly due to limited contact with companies as a PhD student. Firstly, recruiting more participants from other countries and markets could have provided more insights and stronger evidence to

address the research questions in terms of global supply chains. For the focus group, the majority of participants were from OEMs, which could have led to results obtained that lacked a more in-depth look at suppliers and distributors. Whilst the aim was to gain an understanding of ASCs as a whole, more detail could have been added to enable better comparisons to be made between OEMs, Suppliers and Distributors, as well as between Tier 1 suppliers and Tier 2 suppliers. This could also lead to single or multiple case studies.

8.5 Direction for Future Research

Following the limitations, several directions for future research could be built from this study.

For example, a reasonable direction could be continuing to explore the impact of the New Disruption on the automotive supply chain in other countries and continents. In addition to being able to compare the results with those in China, it would be possible to continue to expand the overall perspective and look at the issues raised by the New Disruption in the context of the global supply chain. Global ASCs are more complex in structure and involve more supply chain activities, and new forms of supply chain collaboration are likely to exist.

The second direction for future research lies in focus on suppliers, if more data sources can be obtained to encompass more aspects of the supply chain. The difference between different tiers of suppliers in the ASC could be huge. Some large Tier 1 suppliers may have even more power than some OEMs in the upstream and downstream, while some small and medium-sized Tier 2 suppliers have only a very small volume. As a result, their resilience is different, as are their strategies for dealing with risks, and the role they play in collaboration. There is a potential research interest in this area.

Finally, another direction worth investigating is public-private partnerships in supply chain collaboration. This aspect is superficially touched upon in this study in reference to OEMs helping SME suppliers to resume production and logistics by communicating with the local government in 6.5.2. It is more emphasised as a way of collaboration between supply chain partners in this research, while the contained public-private cooperation was also crucial. Public-private partnerships depart from the definition of supply chain collaboration in existing research, as it involves collaboration not between endogenous members of the supply chain, but rather with the government or an authority. Li et al.'s (2024) study has already found that public-private partnerships in Taiwan during the COVID-19 outbreak significantly improved the production and distribution of equitable medical masks,

demonstrating how centralised coordination can mitigate disruption and increase resilience. Therefore, this could be a future direction for research on supply chain collaboration.

8.6 Concluding Remarks

This study attempts to contribute to the existing knowledge on SCD and SCRES by conceptualising a topical research question, which is the impact of the New Disruption from COVID-19 on the supply chain. To do so, this study conducted empirical research to support the concepts. It also concluded that supply chain collaboration is an effective method to improve SCRES in the face of such disruptions and is worth replicating. Despite some limitations, the results of this study achieved its objectives. Thus, this study contributes to the discussion on the types of disruptions and the definition of SCRES. This study also provided new theoretical perspectives for looking at SCRES. Based on these findings, this study contributes to both the theoretical system and practice of supply chain management.

APPENDIX I ETHICAL RELATED DOCUMENTS

Content on page 161 removed due to confidentiality issues

Consent Form

Consent Form

Title of Project: Supply Chain Recovery of Automotive Industry under the New Disruption by COVID-19

Name of Researcher: Weiyuan Li

Name of Researcher: Ming Lim, James Wilson

I confirm that I have read and understood the Participant Information Sheet for the above study and have had the opportunity to ask questions.

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

I acknowledge that participants will be referred to by pseudonym.

I acknowledge that there will be no effect on my employment arising from my participation or non-participation in this research.

- All names and other material likely to identify individuals will be anonymised.
- The material will be treated as confidential and kept in secure storage at all times.
- Personal data will be removed once the collection finish, and research data will be retained for a period of ten years in line with the University of Glasgow Guidelines.
- The material will be retained in secure storage for use in future academic research
- The material may be used in future publications, both print and online.
- I agree to waive my copyright to any data collected as part of this project.

I acknowledge the provision of a Privacy Notice in relation to this research project.

I consent / do not consent (delete as applicable) to interviews being audio-recorded.

I agree / do not agree (delete as applicable) to take part in the above study.

Name of Participant ..... Signature .....

Date .....

..... End of consent form .....

Participant Information Sheet for Focus Group

University of Glasgow

College of Social Sciences

Participant Information Sheet

Supply Chain Recovery of Automotive Industry under the New Disruption by COVID-19

Weiyuan Li Supervisor: Ming Lim

You are being invited to take part in a research study. Before you decide to take part, it is important for you to understand why the research is being done and what it will involve. Please read the following information carefully and discuss it with others if you wish. Ask the researcher if there is anything that is not clear or if you would like more information. Take some time to decide whether or not you wish to take part.

Thank you for reading this.

This project is going to investigate how COVID-19 like disruption would challenge global supply chains, and take automotive supply chain as an example to explore available recover strategies for similar situations in the future. Participants are asked to voluntarily join a focus group discussion. The discussion is about the challenges faced by the automotive industry, and will take approximately one to two hours.

At any stages of data collection in this research, the names of the participants will not be recorded, but are replaced by numbers. Only the participants' positions and their companies' principal business would be noted and used for data analysis. However, it is the nature of focus group that participants could meet and speak to each other, so the personal data confidentiality cannot be guaranteed during the activity.

> Please note that assurances on confidentiality will be strictly adhered to unless evidence of wrongdoing or potential harm is uncovered. In such cases the University may be obliged to contact relevant statutory bodies/agencies.

The data collected will be used for the production of the dissertation of the researcher own. All personal data will be removed or replaced immediately after the data collection by pseudonymisation. The rest research data will then be analysed, and will be retained for a period of ten years in line with the University of Glasgow Guidelines.

This project has been considered and approved by the College Research Ethics Committee.

To pursue any complaint about the conduct of the research: contact the College of Social Sciences Lead for Ethical Review, Dr Susan Batchelor: email socsci-ethics-lead@glasgow.ac.uk

_____End of Participant Information Sheet_____

Participant Information Sheet for Interview

University of Glasgow

College of Social Sciences

Participant Information Sheet

Supply Chain Recovery of Automotive Industry under the New Disruption by COVID-19

Weiyuan Li Supervisor: Ming Lim

You are being invited to take part in a research study. Before you decide to take part, it is important for you to understand why the research is being done and what it will involve. Please read the following information carefully and discuss it with others if you wish. Ask the researcher if there is anything that is not clear or if you would like more information. Take some time to decide whether or not you wish to take part.

Thank you for reading this.

This project is going to investigate how COVID-19 like disruption would challenge global supply chains, and take automotive supply chain as an example to explore available recover strategies for similar situations in the future. Participants are asked to voluntarily have an interview, which runs about an hour.

At any stages of data collection in this research, the names of the participants will not be recorded, but are replaced by numbers. Only the participants' positions and their companies' principal business would be noted and used for data analysis.

Please note that assurances on confidentiality will be strictly adhered to unless evidence of wrongdoing or potential harm is uncovered. In such cases the University may be obliged to contact relevant statutory bodies/agencies.

The data collected will be used for the production of the dissertation of the researcher own. All personal data will be removed or replaced immediately after the data collection by pseudonymisation. The rest research data will then be analysed, and will be retained for a period of ten years in line with the University of Glasgow Guidelines.

This project has been considered and approved by the College Research Ethics Committee.

To pursue any complaint about the conduct of the research: contact the College of Social Sciences Lead for Ethical Review, Dr Susan Batchelor: email socsci-ethics-lead@glasgow.ac.uk

End of Participant Information Sheet

APPENDIX II FOCUS GROUP NOTES FOR MODERATOR

The purpose of this focus group is to discuss about the challenges happened to the automotive supply chain during the New Disruption. It shall include getting practitioners to discuss whether the types of challenges that appeared in the literature (which will be provided as slides to be used in the discussion) also appear in their organisations. But most importantly, to generate open discussion of the situation during the entire period of the New Disruption. Hence, you will first need to know the definition of the New Disruption, here it is:

Disruptions that affect supply chains in more than one industry on a global scale, with varying and changing negative impacts in the short and long term, and that are accompanied by a high degree of uncertainty beyond the original resilience of the supply chain, are referred to as the New Disruption.

In this study it basically just refers to the disruption caused by COVID-19. However, to use the term "New Disruption" instead of COVID-19 disruption is to make participants aware of the challenges that not only arose during the pandemic, but also in the phase of recovery. In other words, challenges from the outbreak of the virus in 2020 until now.

Before the discussion starts, you may want to mention your role and how this discussion may unfold. Here is an example but feel free to use your own words:

"Good morning/afternoon and welcome to our session today. Thank you for taking time to join this group discussion. My name is XXX, I will be the moderator of our group. Before we begin, let me suggest something that will make our discussion more productive. Please speak up and talk with others during the discussion. There are no wrong answers, only different points of view. We're recording the session because we don't want to miss any of your comments. And in our later reports there will not be any names attached to comments. My role here is to ask questions and listen. I won't be participating in the conversation." At the beginning of the group discussion, please ask the participants to introduce themselves, this may include their name, job title, and what their organisation do in the automotive supply chain.

At the beginning of the session, participants will be given a piece of paper with all the challenges listed in the literature. Before the discussion, please ask the participants to circle out items that they feel fits their organisations (i.e. challenges that happened to their organisation). Please allow 5-10 minutes for this.

You may start the discussion based on this paper, or with an icebreaker if you think that would help. Here are some questions you may want to include:

- What changes has COVID-19 brought to your life so far?
- (Start with one person and go through the whole group) Could you share with the group what you have circled out and give more details of what happened?
- Have you encountered any problems that were not listed in the paper? Could you describe in more details?
- Which categories do you think the challenges should be classified according to the affected departments/functions?
- Is there anything you would like to add?

Please collect those papers back after the session for ethical considerations.

REFERENCE

ABDURAKHMONOV, M., RIDGE, J. W. & HILL, A. D. 2021. Unpacking Firm External Dependence: How Government Contract Dependence Affects Firm Investments and Market Performance. *Academy of Management Journal,* 64**,** 327-350.

ADAY, S. & ADAY, M. S. 2020. Impact of COVID-19 on the food supply chain. *Food Quality and Safety,* 4**,** 167-180.

ADOBOR, H. 2019. Supply chain resilience: a multi-level framework. *International Journal of Logistics Research and Applications,* 22**,** 533-556.

AGGARWAL, P. & GANESHAN, R. 2007. Using risk-management tools on B2Bs: An exploratory investigation. *International Journal of Production Economics,* 108**,** 2-7.

AGYABENG-MENSAH, Y., AFUM, E. & AHENKORAH, E. 2020. Exploring financial performance and green logistics management practices: examining the mediating influences of market, environmental and social performances. *Journal of cleaner production,* 258**,** 120613.

AHLQVIST, V., NORRMAN, A. & JAHRE, M. 2020. Supply chain risk governance: towards a conceptual multi-level framework.

AHMED, W. A., MACCARTHY, B. L. & TREIBLMAIER, H. 2022. Why, where and how are organizations using blockchain in their supply chains? Motivations, application areas and contingency factors. *International Journal of Operations & Production Management,* 42**,** 1995-2028.

AL-AMER, R., RAMJAN, L., GLEW, P., DARWISH, M. & SALAMONSON, Y. 2016. Language translation challenges with Arabic speakers participating in qualitative research studies. *Int J Nurs Stud,* 54**,** 150-7.

ALDRICH, H. E. 1976. Resource Dependence and in Terorganiza Tional Relations Local Employment Service Offices and Social Services Sector Organizations. *Administration & Society,* 7**,** 419-454.

ALDRIGHETTI, R., ZENNARO, I., FINCO, S. & BATTINI, D. 2019. Healthcare supply chain simulation with disruption considerations: A case study from Northern Italy. *Global Journal of Flexible Systems Management,* 20**,** 81-102.

ALFORD, J. & HUGHES, O. 2008. Public Value Pragmatism as the Next Phase of Public Management. *The American Review of Public Administration,* 38**,** 130-148.

ALI, A., MAHFOUZ, A. & ARISHA, A. 2017. Analysing supply chain resilience: integrating the constructs in a concept mapping framework via a systematic literature review. *Supply Chain Management: An International Journal,* 22**,** 16-39.

ALI, I., NAGALINGAM, S. & GURD, B. 2018. A resilience model for cold chain logistics of perishable products. *The International Journal of Logistics Management,* 29**,** 922-941.

ALIKHANI, R., RANJBAR, A., JAMALI, A., TORABI, S. A. & ZOBEL, C. W. 2023. Towards increasing synergistic effects of resilience strategies in supply chain network design. *Omega,* 116**,** 102819.

ALLWOOD, C. M. 2011. The distinction between qualitative and quantitative research methods is problematic. *Quality & Quantity,* 46**,** 1417-1429.

ALTAY, N. & RAMIREZ, A. 2010. Impact of disasters on firms in different sectors: implications for supply chains. *Journal of Supply Chain Management,* 46**,** 59-80.

ALVES, M. W. F. M., JABBOUR, A. B. L. D. S., KANNAN, D. & JABBOUR, C. J. C. 2017. Contingency theory, climate change, and low-carbon operations management. *Supply Chain Management: An International Journal,* 22**,** 223-236.

AMANKWAH-AMOAH, J. 2020. Stepping up and stepping out of COVID-19: New challenges for environmental sustainability policies in the global airline industry. *Journal of Cleaner Production,* 271**,** 123000.

AMBULKAR, S., BLACKHURST, J. V. & CANTOR, D. E. 2015. Supply chain risk mitigation competency: an individual-level knowledge-based perspective. *International Journal of Production Research,* 54**,** 1398-1411.

ANG, E., IANCU, D. A. & SWINNEY, R. 2017. Disruption risk and optimal sourcing in multitier supply networks. *Management Science,* 63**,** 2397-2419.

ARTO, I., ANDREONI, V. & RUEDA CANTUCHE, J. M. 2015. Global Impacts of the Automotive Supply Chain Disruption Following the Japanese Earthquake of 2011. *Economic Systems Research,* 27**,** 306-323.

BAI, C., GOVINDAN, K. & HUO, B. 2023. The contingency effects of dependence relationship on supply chain information sharing and agility. *The International Journal of Logistics Management,* 34**,** 1808-1832.

BARMAN, A., DAS, R. & DE, P. K. 2021. Impact of COVID-19 in food supply chain: Disruptions and recovery strategy. *Current Research in Behavioral Sciences,* 2**,** 100017.

BARNEY, J. 1991. Firm Resources and Sustained Competitive Advantage. *Journal of Management,* 17**,** 99-120.

BARRINGER, B. R. & HARRISON, J. S. 2000. Walking a tightrope: Creating value through interorganizational relationships. *Journal of management,* 26**,** 367-403.

BARYANNIS, G., VALIDI, S., DANI, S. & ANTONIOU, G. 2019. Supply chain risk management and artificial intelligence: state of the art and future research directions. *International Journal of Production Research,* 57**,** 2179-2202.

BERNARD, H. R. 1988. Research methods in cultural anthropology.

BIER, T., LANGE, A. & GLOCK, C. H. 2020. Methods for mitigating disruptions in complex supply chain structures: a systematic literature review. *International Journal of Production Research,* 58**,** 1835-1856.

BIRKIE, S. E. & TRUCCO, P. 2020. Do not expect others do what you should! Supply chain complexity and mitigation of the ripple effect of disruptions. *International Journal of Logistics Management,* 31**,** 123-144.

BIRKIE, S. E., TRUCCO, P. & FERNANDEZ CAMPOS, P. 2017. Effectiveness of resilience capabilities in mitigating disruptions: leveraging on supply chain structural complexity. *Supply Chain Management: An International Journal,* 22**,** 506-521.

BISWAS, T. K. & DAS, M. C. 2020. Selection of the barriers of supply chain management in Indian manufacturing sectors due to Covid-19 impacts. *Operational Research in Engineering Sciences: Theory and Applications,* 3.

BLACKHURST, J., DUNN, K. S. & CRAIGHEAD, C. W. 2011. An Empirically Derived Framework of Global Supply Resiliency. *Journal of Business Logistics,* 32**,** 374-391.

BLOOR, M., THOMAS, M. & FRANKLAND, J. 2000. *Focus groups in social research*, Sage.

BLOOR, M. & WOOD, F. 2006. Keywords in qualitative methods: A vocabulary of research concepts.

BODE, C. & WAGNER, S. M. 2015. Structural drivers of upstream supply chain complexity and the frequency of supply chain disruptions. *Journal of Operations Management,* 36**,** 215-228.

BOON-ITT, S. & PAUL, H. 2006. A study of supply chain integration in Thai automotive industry: a theoretical framework and measurement. *Management research news,* 29**,** 194-205.

BOWMAN, C. & AMBROSINI, V. 2003. How the resource-based and the dynamic capability views of the firm inform corporate-level strategy. *British journal of management,* 14**,** 289-303.

BOYATZIS, R. 1998. *Transforming qualitative information: Thematic analysis and code development*, Sage.

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**,** 55-73.

BRAUN, V. & CLARKE, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3**,** 77-101.

BRAUNSCHEIDEL, M. J. & SURESH, N. C. 2009. The organizational antecedents of a firm's supply chain agility for risk mitigation and response. *Journal of operations Management,* 27**,** 119-140.

BROWNLEE, J. 2007. Satisficing, optimization, and adaptive systems. *Complex Intelligent Systems Laboratory, Centre for Information Technology Research, Technical Report A,* 70305.

BULLINGTON, J. & KARLSSON, G. 1984. Introduction to phenomenological psychological research. *Scandinavian Journal of psychology,* 25**,** 51-63.

BURGESS, R. G. 2003. The unstructured interview as a conversation. *Field research.* Routledge.

CAI, M. & LUO, J. 2020. Influence of COVID-19 on manufacturing industry and corresponding countermeasures from supply chain perspective. *Journal of Shanghai Jiaotong University (Science),* 25**,** 409-416.

CAPPELLI, A. & CINI, E. 2020. Will the COVID-19 pandemic make us reconsider the relevance of short food supply chains and local productions? *Trends in food science & technology,* 99**,** 566.

CARVALHO, H., BARROSO, A. P., MACHADO, V. H., AZEVEDO, S. & CRUZ-MACHADO, V. 2012. Supply chain redesign for resilience using simulation. *Computers & Industrial Engineering,* 62**,** 329-341.

CASTILLO-MONTOYA, M. 2016. Preparing for interview research: The interview protocol refinement framework. *Qualitative report,* 21.

CERULLO, V. & CERULLO, M. J. 2004. Business continuity planning: A comprehensive approach. *Information systems management,* 21.

CHANG, H. H., WONG, K. H. & CHIU, W. S. 2019. The effects of business systems leveraging on supply chain performance: Process innovation and uncertainty as moderators. *Information & Management,* 56**,** 103140.

CHAUHAN, V. K., PERERA, S. & BRINTRUP, A. 2021. The relationship between nested patterns and the ripple effect in complex supply networks. *International Journal of Production Research,* 59**,** 325-341.

CHEN, C., ZHANG, X., ZHANG, P., FENG, F., SUN, C. & ZHANG, X. An Improved Total Interpretive Structural Modeling Method for Constructing Indicator Systems in Multi-Criteria Decision-Making Problems: The Case of Ship Design Evaluation and Selection. ASME 2023 42nd International Conference on Ocean, Offshore and Arctic Engineering, 2023. V005T06A038.

CHEN, H. Y., DAS, A. & IVANOV, D. 2019. Building resilience and managing post-disruption supply chain recovery: Lessons from the information and communication technology industry. *International Journal of Information Management,* 49**,** 330-342.

CHEN, I. J. & PAULRAJ, A. 2004. Towards a theory of supply chain management: the constructs and measurements. *Journal of operations management,* 22**,** 119-150.

CHEN, I. J., PAULRAJ, A. & LADO, A. A. 2004. Strategic purchasing, supply management, and firm performance. *Journal of operations management,* 22**,** 505-523.

CHEN, J., WANG, H. & ZHONG, R. Y. 2021. A supply chain disruption recovery strategy considering product change under COVID-19. *Journal of Manufacturing Systems,* 60**,** 920-927.

CHENG, J.-H. & LU, K.-L. 2017. Enhancing effects of supply chain resilience: insights from trajectory and resource-based perspectives. *Supply Chain Management: An International Journal,* 22**,** 329-340.

CHIRRA, S. & KUMAR, D. 2018. Analysis of SCF under sales promotional schemes: an application of interpretive structural modelling approach. *International Journal of Production Research,* 56**,** 6015-6033.

CHOI, T.-M. 2020. Innovative "Bring-Service-Near-Your-Home" operations under Corona-Virus (COVID-19/SARS-CoV-2) outbreak: Can logistics become the Messiah? *Transportation Research Part E: Logistics and Transportation Review,* 140**,** 101961.

CHOI, T. Y. & KRAUSE, D. R. 2006. The supply base and its complexity: Implications for transaction costs, risks, responsiveness, and innovation. *Journal of operations management,* 24**,** 637-652.

CHOPRA, S., REINHARDT, G. & MOHAN, U. 2007. The importance of decoupling recurrent and disruption risks in a supply chain. *Naval Research Logistics (NRL),* 54**,** 544-555.

CHOPRA, S. & SODHI, M. 2004. Supply-chain breakdown. *MIT Sloan management review,* 46**,** 53-61.

CHOWDHURY, M. T., SARKAR, A., PAUL, S. K. & MOKTADIR, M. A. 2020. A case study on strategies to deal with the impacts of COVID-19 pandemic in the food and beverage industry. *Operations Management Research*.

CHOWDHURY, P., PAUL, S. K., KAISAR, S. & MOKTADIR, M. A. 2021. COVID-19 pandemic related supply chain studies: A systematic review. *Transportation Research Part E: Logistics and Transportation Review,* 148**,** 102271.

CHRISTOPHER, M. & LEE, H. 2004. Mitigating supply chain risk through improved confidence. *International journal of physical distribution & logistics management,* 34**,** 388-396.

CHRISTOPHER, M. & PECK, H. 2004. Building the resilient supply chain.

CLARK, V. L. P. & IVANKOVA, N. V. 2015. *Mixed methods research: A guide to the field,* Sage publications.

CLARKE, T. & BOERSMA, M. 2017. The Governance of Global Value Chains: Unresolved Human Rights, Environmental and Ethical Dilemmas in the Apple Supply Chain. *Journal of Business Ethics,* 143**,** 111-131.

CLIFFORD, J. 1990. Notes on (field) notes. *Fieldnotes: The makings of anthropology,* 1990**,** 47-70.

CONTIERO, E., PONSIGNON, F., SMART, P. A. & VINELLI, A. 2016. Contingencies and characteristics of service recovery system design: insights from retail banking. *International Journal of Operations & Production Management*.

CORBIN, J. & STRAUSS, A. 2015. *Basics of qualitative research*, sage.

CORDEN, A. & SAINSBURY, R. 2006. *Using verbatim quotations in reporting qualitative social research: researchers' views*, University of York York.

COX, A., WATSON, G., LONSDALE, C. & SANDERSON, J. 2004. Managing appropriately in power regimes: relationship and performance management in 12 supply chain cases. *Supply Chain Management: An International Journal,* 9**,** 357-371.

CRABTREE, B. F. 1999. *Doing qualitative research*, Sage.

CRAIGHEAD, C. W., BLACKHURST, J., RUNGTUSANATHAM, M. J. & HANDFIELD, R. B. 2007. The severity of supply chain disruptions: design characteristics and mitigation capabilities. *Decision sciences,* 38**,** 131-156.

CRAIGHEAD, C. W., KETCHEN JR, D. J. & DARBY, J. L. 2020. Pandemics and supply chain management research: toward a theoretical toolbox. *Decision Sciences,* 51**,** 838-866.

CUI, J., ZHAO, M., LI, X., PARSAFARD, M. & AN, S. 2016. Reliable design of an integrated supply chain with expedited shipments under disruption risks. *Transportation Research Part E: Logistics and Transportation Review,* 95**,** 143-163.

CUI, L., CHAN, H. K., ZHOU, Y., DAI, J. & LIM, J. J. 2019. Exploring critical factors of green business failure based on Grey-Decision Making Trial and Evaluation Laboratory (DEMATEL). *Journal of Business Research,* 98**,** 450-461.

CUTCLIFFE, J. R. 2003. Reconsidering reflexivity: Introducing the case for intellectual entrepreneurship. *Qualitative health research,* 13**,** 136-148.

DAY, J. M. 2014. Fostering emergent resilience: the complex adaptive supply network of disaster relief. *International Journal of Production Research,* 52**,** 1970-1988.

DE RUYTER, K. & WETZELS, M. 2000. Customer equity considerations in service recovery: a cross-industry perspective. *International Journal of Service Industry Management,* 11**,** 91-108.

DEATON, B. J. & DEATON, B. J. 2020. Food security and Canada's agricultural system challenged by COVID-19. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie,* 68**,** 143-149.

DEKKERS, R., DE BOER, R., GELSOMINO, L. M., DE GOEIJ, C., STEEMAN, M., ZHOU, Q., SINCLAIR, S. & SOUTER, V. 2020. Evaluating theoretical conceptualisations for supply chain and finance integration: a Scottish focus group. *International Journal of Production Economics,* 220**,** 107451.

DELOITTE 2020. Understanding the impact of COVID-19.

DESS, G. G. & BEARD, D. W. 1984. Dimensions of organizational task environments. *Administrative science quarterly***,** 52-73.

DIABAT, A., GOVINDAN, K. & PANICKER, V. V. 2012. Supply chain risk management and its mitigation in a food industry. *International Journal of Production Research,* 50**,** 3039-3050.

DICICCO-BLOOM, B. & CRABTREE, B. F. 2006. The qualitative research interview. *Med Educ,* 40**,** 314-21.

DOLGUI, A., IVANOV, D. & SOKOLOV, B. 2018. Ripple effect in the supply chain: an analysis and recent literature. *International Journal of Production Research,* 56**,** 414-430.

DOLGUI, A., IVANOV, D. & SOKOLOV, B. 2020. Reconfigurable supply chain: the X-network. *International Journal of Production Research,* 58**,** 4138-4163.

DONATO, M., KAMRUL, A. & HIMANSHU, S. 2013. The influence of resource dependency on collaboration in the construction supply chain.

DREES, J. M. & HEUGENS, P. P. M. A. R. 2013. Synthesizing and Extending Resource Dependence Theory. *Journal of Management,* 39**,** 1666-1698.

DROZDIBOB, A., SOHAL, A., NYLAND, C. & FAYEZI, S. 2023. Supply chain resilience in relation to natural disasters: Framework development. *Production Planning & Control,* 34**,** 1603-1617.

DUBEY, R. & ALI, S. S. 2014. Identification of flexible manufacturing system dimensions and their interrelationship using total interpretive structural modelling and fuzzy MICMAC analysis. *Global Journal of Flexible Systems Management,* 15**,** 131-143.

DUHADWAY, S., CARNOVALE, S. & HAZEN, B. 2019. Understanding risk management for intentional supply chain disruptions: Risk detection, risk mitigation, and risk recovery. *Annals of Operations Research,* 283**,** 179-198.

DUONG, L. N. K. & CHONG, J. 2020. Supply chain collaboration in the presence of disruptions: a literature review. *International Journal of Production Research,* 58**,** 3488-3507.

DYER, J. H. & SINGH, H. 1998. The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Academy of management review,* 23**,** 660-679.

EISENHARDT, K. M. & GRAEBNER, M. E. 2007. Theory building from cases: Opportunities and challenges. *Academy of management journal,* 50**,** 25-32.

EISENSTEIN, D. D. 2005. Recovering cyclic schedules using dynamic produce-up-to policies. *Operations research,* 53**,** 675-688.

EL HAMMOUMI, A., SEGHYAR, N., GOUIOUEZ, M., AMANE, M. & BERDI, A. 2024. The Adoption of a Qualitative Approach in Management Science: An Exploratory Survey on the Effects of Big Data on the Performance of Companies. *Applying Qualitative Research Methods to Management Science.* IGI Global.

ELDEM, B., KLUCZEK, A. & BAGIńSKI, J. 2022. The COVID-19 Impact on Supply Chain Operations of Automotive Industry: A Case Study of Sustainability 4.0 Based on Sense–Adapt–Transform Framework. *Sustainability,* 14.

EROL, O., SAUSER, B. J. & MANSOURI, M. 2010. A framework for investigation into extended enterprise resilience. *Enterprise Information Systems,* 4**,** 111-136.

FAISAL, M. N., BANWET, D. K. & SHANKAR, R. 2006. Mapping supply chains on risk and customer sensitivity dimensions. *Industrial Management & Data Systems,* 106**,** 878-895.

FEDERGRUEN, A. & YANG, N. 2011. Procurement strategies with unreliable suppliers. *Operations research,* 59**,** 1033-1039.

FINCH, P. 2004. Supply chain risk management. *Supply chain management: an International Journal,* 9**,** 183-196.

FLYNN, B. B., KOUFTEROS, X. & LU, G. 2016. On theory in supply chain uncertainty and its implications for supply chain integration. *Journal of Supply Chain Management,* 52**,** 3-27.

FONSECA, L. M. & AZEVEDO, A. L. 2020. COVID-19: outcomes for global supply chains. *Management & Marketing,* 15**,** 424-438.

FONTANA, A. & FREY, J. H. 2005. The interview. *The Sage handbook of qualitative research,* 3**,** 695-727.

FOY, R., OVRETVEIT, J., SHEKELLE, P. G., PRONOVOST, P. J., TAYLOR, S. L., DY, S., HEMPEL, S., MCDONALD, K. M., RUBENSTEIN, L. V. & WACHTER, R. M. 2011. The role of theory in research to develop and evaluate the implementation of patient safety practices. *BMJ quality & safety,* 20**,** 453-459.

FUSCH PH D, P. I. & NESS, L. R. 2015. Are we there yet? Data saturation in qualitative research.

GALE, N. K., HEATH, G., CAMERON, E., RASHID, S. & REDWOOD, S. 2013. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC medical research methodology,* 13**,** 1-8.

GALLEGO, G. & VAN RYZIN, G. 1994. Optimal dynamic pricing of inventories with stochastic demand over finite horizons. *Management science,* 40**,** 999-1020.

GEBHARDT, M., SPIESKE, A., KOPYTO, M. & BIRKEL, H. 2022. Increasing global supply chains' resilience after the COVID-19 pandemic: Empirical results from a Delphi study. *J Bus Res,* 150**,** 59-72.

GHADGE, A., ER, M., IVANOV, D. & CHAUDHURI, A. 2022. Visualisation of ripple effect in supply chains under long-term, simultaneous disruptions: a system dynamics approach. *International Journal of Production Research,* 60**,** 6173-6186.

GHASEMI, E., LEHOUX, N. & RöNNQVIST, M. 2023. Coordination, cooperation, and collaboration in production-inventory systems: a systematic literature review. *International Journal of Production Research,* 61**,** 5322-5353.

GIANNOCCARO, I. & IFTIKHAR, A. 2022. Mitigating ripple effect in supply networks: the effect of trust and topology on resilience. *International Journal of Production Research,* 60**,** 1178-1195.

GILLESPIE, D. F. & MILETI, D. S. 1979. Action and Contingency Postulates in Organization-Environment Relations. *Human Relations,* 32**,** 261-271.

GIORGI, A. 1975. An application of phenomenological method in psychology. *Duquesne studies in phenomenological psychology,* 2**,** 82-103.

GOLAN, M. S., JERNEGAN, L. H. & LINKOV, I. 2020. Trends and applications of resilience analytics in supply chain modeling: systematic literature review in the

context of the COVID-19 pandemic. *Environment Systems and Decisions,* 40**,** 222-243.

GOLDMAN, A. E. 1962. The group depth interview. *Journal of marketing,* 26**,** 61-68.

GORANE, S. J. & KANT, R. 2013. Modelling the SCM enablers: an integrated ISM-fuzzy MICMAC approach. *Asia Pacific Journal of Marketing and Logistics,* 25**,** 263-286.

GREENING, P. & RUTHERFORD, C. 2011. Disruptions and supply networks: a multi-level, multi-theoretical relational perspective. *The International Journal of Logistics Management,* 22**,** 104-126.

GRöTSCH, V. M., BLOME, C. & SCHLEPER, M. C. 2013. Antecedents of proactive supply chain risk management–a contingency theory perspective. *International journal of production research,* 51**,** 2842-2867.

GUAN, D., WANG, D., HALLEGATTE, S., DAVIS, S. J., HUO, J., LI, S., BAI, Y., LEI, T., XUE, Q., COFFMAN, D., CHENG, D., CHEN, P., LIANG, X., XU, B., LU, X., WANG, S., HUBACEK, K. & GONG, P. 2020. Global supply-chain effects of COVID-19 control measures. *Nat Hum Behav,* 4**,** 577-587.

GUEST, G., BUNCE, A. & JOHNSON, L. 2016. How Many Interviews Are Enough? *Field Methods,* 18**,** 59-82.

GURBUZ, I. B. & OZKAN, G. 2020. Transform or Perish: Preparing the Business for a Postpandemic Future. *IEEE Engineering Management Review,* 48**,** 139-145.

HALLIKAS, J., KARVONEN, I., PULKKINEN, U., VIROLAINEN, V.-M. & TUOMINEN, M. 2004. Risk management processes in supplier networks. *International Journal of Production Economics,* 90**,** 47-58.

HANDFIELD, R. B. 1993. A resource dependence perspective of just-in-time purchasing. *Journal of Operations Management,* 11**,** 289-311.

HANDFIELD, R. B., GRAHAM, G. & BURNS, L. 2020. Corona virus, tariffs, trade wars and supply chain evolutionary design. *International Journal of Operations & Production Management*.

HARRISON, J. S., HITT, M. A., HOSKISSON, R. E. & IRELAND, R. D. 1991. Synergies and post-acquisition performance: Differences versus similarities in resource allocations. *Journal of management,* 17**,** 173-190.

HASANI, A. & KHOSROJERDI, A. 2016. Robust global supply chain network design under disruption and uncertainty considering resilience strategies: A parallel memetic algorithm for a real-life case study. *Transportation research part e: logistics and transportation review,* 87**,** 20-52.

HELM, P. 2000. *Faith with reason,* Oxford University Press, USA.

HENDRICKS, K. B., SINGHAL, V. R. & ZHANG, R. 2009. The effect of operational slack, diversification, and vertical relatedness on the stock market reaction to supply chain disruptions. *Journal of operations management,* 27**,** 233-246.

HILL, C. E., KNOX, S., THOMPSON, B. J., WILLIAMS, E. N., HESS, S. A. & LADANY, N. 2005. Consensual qualitative research: an update. *Journal of counseling psychology,* 52**,** 196.

HILLMAN, A. J., WITHERS, M. C. & COLLINS, B. J. 2009. Resource dependence theory: A review. *Journal of management,* 35**,** 1404-1427.

HISHAMUDDIN, H., SARKER, R. A. & ESSAM, D. 2013. A recovery model for a two-echelon serial supply chain with consideration of transportation disruption. *Computers & Industrial Engineering,* 64**,** 552-561.

HITTLE, B. & MOUSTAFA LEONARD, K. 2011. Decision making in advance of a supply chain crisis. *Management Decision,* 49**,** 1182-1193.

HO, W., ZHENG, T., YILDIZ, H. & TALLURI, S. 2015. Supply chain risk management: a literature review. *International Journal of Production Research,* 53**,** 5031-5069.

HOBBS, J. E. 2020. Food supply chains during the COVID-19 pandemic. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie,* 68**,** 171-176.

HODGKINSON, G. P. & HEALEY, M. P. 2011. Psychological foundations of dynamic capabilities: Reflexion and reflection in strategic management. *Strategic management journal,* 32**,** 1500-1516.

HOFER, C., JIN, H., SWANSON, R. D., WALLER, M. A. & WILLIAMS, B. D. 2012. The impact of key retail accounts on supplier performance: A collaborative perspective of resource dependency theory. *Journal of Retailing,* 88**,** 412-420.

HOHENSTEIN, N.-O., MARIA JESUS SAENZ, P., XENOPHON KOUFTEROS, D., FEISEL, E., HARTMANN, E. & GIUNIPERO, L. 2015. Research on the phenomenon of supply chain resilience. *International Journal of Physical Distribution & Logistics Management,* 45**,** 90-117.

HOLLINGER, P. 2022. Shanghai lockdown exposes global supply chain strains. *Financial Times*, 2022-05-15.

HOLLNAGEL, E. 2013. *Resilience engineering in practice: A guidebook*, Ashgate Publishing, Ltd.

HOSSEINI, S. & IVANOV, D. 2019. A new resilience measure for supply networks with the ripple effect considerations: a Bayesian network approach. *Annals of Operations Research*.

HOSSEINI, S. & IVANOV, D. 2020. Bayesian networks for supply chain risk, resilience and ripple effect analysis: A literature review. *Expert systems with applications,* 161**,** 113649.

HOU, J., ZENG, A. Z. & ZHAO, L. 2010. Coordination with a backup supplier through buy-back contract under supply disruption. *Transportation Research Part E: Logistics and Transportation Review,* 46**,** 881-895.

HU, X., GURNANI, H. & WANG, L. 2013. Managing Risk of Supply Disruptions: Incentives for Capacity Restoration. *Production and Operations Management,* 22**,** 137-150.

HUDECHECK, M., SIRéN, C., GRICHNIK, D. & WINCENT, J. 2020. How companies can respond to the Coronavirus. *MIT Sloan Management Review*.

IAKOVOU, E., VLACHOS, D. & XANTHOPOULOS, A. 2010. A stochastic inventory management model for a dual sourcing supply chain with disruptions. *International Journal of Systems Science,* 41**,** 315-324.

ISHIDA, S. 2020. Perspectives on Supply Chain Management in a Pandemic and the Post-COVID-19 Era. *IEEE Engineering Management Review,* 48**,** 146-152.

IVANOV, D. 2017. Simulation-based single vs. dual sourcing analysis in the supply chain with consideration of capacity disruptions, big data and demand patterns. *International Journal of Integrated Supply Management,* 11**,** 24-43.

IVANOV, D. 2020. Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case. *Transportation Research Part E: Logistics and Transportation Review,* 136**,** 101922.

IVANOV, D. & DAS, A. 2020. Coronavirus (COVID-19/SARS-CoV-2) and supply chain resilience: a research note. *International Journal of Integrated Supply Management,* 13**,** 90.

IVANOV, D. & DOLGUI, A. 2020. Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak. *International Journal of Production Research,* 58**,** 2904-2915.

IVANOV, D. & DOLGUI, A. 2021. A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0. *Production Planning & Control,* 32**,** 775-788.

IVANOV, D., DOLGUI, A., SOKOLOV, B. & IVANOVA, M. 2017. Literature review on disruption recovery in the supply chain. *International Journal of Production Research,* 55**,** 6158-6174.

IVANOV, D., PAVLOV, A., DOLGUI, A., PAVLOV, D. & SOKOLOV, B. 2016. Disruption-driven supply chain (re)-planning and performance impact assessment with consideration of pro-active and recovery policies. *Transportation Research Part E: Logistics and Transportation Review,* 90**,** 7-24.

IVANOV, D., SOKOLOV, B. & DOLGUI, A. 2014. The Ripple effect in supply chains: trade-off 'efficiency-flexibility-resilience'in disruption management. *International Journal of Production Research,* 52**,** 2154-2172.

IVANOV, D., TSIPOULANIDIS, A. & SCHöNBERGER, J. 2021. *Global supply chain and operations management,* Springer.

JIN, S., HE, Y., LI, S. & ZHAO, X. 2023. Break up or tolerate? The post-disruption cooperation in global supply chains. *International Journal of Production Research***,** 1-16.

JOHNSON, M. E. 2001. Learning from toys: Lessons in managing supply chain risk from the toy industry. *California management review,* 43**,** 106-124.

JüTTNER, U. & MAKLAN, S. 2011. Supply chain resilience in the global financial crisis: an empirical study. *Supply chain management: An international journal*.

KäHKöNEN, A.-K. & VIROLAINEN, V. M. 2011. Sources of structural power in the context of value nets. *Journal of Purchasing and Supply Management,* 17**,** 109-120.

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.

KANNAN, G., HAQ, A. N., SASIKUMAR, P. & ARUNACHALAM, S. 2008. Analysis and selection of green suppliers using interpretative structural modelling and analytic hierarchy process. *International Journal of Management and Decision Making,* 9**,** 163-182.

KAVIANI, M. A., TAVANA, M., KOWSARI, F. & REZAPOUR, R. 2020. Supply chain resilience: a benchmarking model for vulnerability and capability assessment in the automotive industry. *Benchmarking: An International Journal,* 27**,** 1929-1949.

KEMBRO, J., SELVIARIDIS, K. & NäSLUND, D. 2014. Theoretical perspectives on information sharing in supply chains: a systematic literature review and conceptual framework. *Supply chain management: An international journal,* 19**,** 609-625.

KEOW CHENG, S. & HON KAM, B. 2008. A conceptual framework for analysing risk in supply networks. *Journal of Enterprise Information Management,* 21**,** 345-360.

KHEMANI, K. 2007. COMMENTARY-spotlight on supply management-bringing rigor to risk management. *Supply Chain Management Review,* 11**,** 67.

KIDD, P. S. & PARSHALL, M. B. 2000. Getting the focus and the group: enhancing analytical rigor in focus group research. *Qualitative health research,* 10**,** 293-308.

KIM, S. T., LEE, H.-H. & HWANG, T. 2020. Logistics integration in the supply chain: a resource dependence theory perspective. *International Journal of Quality Innovation,* 6.

KINRA, A., IVANOV, D., DAS, A. & DOLGUI, A. 2020. Ripple effect quantification by supplier risk exposure assessment. *International Journal of Production Research,* 58**,** 5559-5578.

KISER, J. & CANTRELL, G. 2006. Supply chain risk management in six steps. *Supply chain Management Review,* 10**,** 12-17.

KITZINGER, J. 1994. The methodology of focus groups: the importance of interaction between research participants. *Sociology of health & illness,* 16**,** 103-121.

KLEINDORFER, P. R. & SAAD, G. H. 2005. Managing disruption risks in supply chains. *Production and operations management,* 14**,** 53-68.

KLEINDORFER, P. R. & SAAD, G. H. 2009. Managing Disruption Risks in Supply Chains. *Production and Operations Management,* 14**,** 53-68.

KNEMEYER, A. M., ZINN, W. & EROGLU, C. 2009. Proactive planning for catastrophic events in supply chains. *Journal of operations management,* 27**,** 141-153.

KOCHAN, C. G. & NOWICKI, D. R. 2018. Supply chain resilience: a systematic literature review and typological framework. *International Journal of Physical Distribution & Logistics Management,* 48**,** 842-865.
KRAAIJENBRINK, J., SPENDER, J.-C. & GROEN, A. J. 2010. The resource-based view: A review and assessment of its critiques. *Journal of management,* 36**,** 349-372.
KRUEGER, R. A. 1998. *Analyzing and reporting focus group results,* Sage.
KRUEGER, R. A. & CASEY, M. A. 2002. *Designing and conducting focus group interviews,* Citeseer.
KUMAR, R. & GOEL, P. 2022. Exploring the Domain of Interpretive Structural Modelling (ISM) for Sustainable Future Panorama: A Bibliometric and Content Analysis. *Archives of Computational Methods in Engineering,* 29**,** 2781-2810.
KUMAR, S. & ANBANANDAM, R. 2019. An integrated Delphi–fuzzy logic approach for measuring supply chain resilience: an illustrative case from manufacturing industry. *Measuring Business Excellence,* 23**,** 350-375.
KUMAR, S. & HAVEY, T. 2013. Before and after disaster strikes: A relief supply chain decision support framework. *International Journal of Production Economics,* 145**,** 613-629.
KUZEL, A. J. 1992. Sampling in qualitative inquiry.
LACERDA, R. T. D. O., ENSSLIN, L. & ENSSLIN, S. R. 2014. Research opportunities in strategic management field: a performance measurement approach. *International Journal of Business Performance Management,* 15**,** 158-174.
LAING, T. 2020. The economic impact of the Coronavirus 2019 (Covid-2019): Implications for the mining industry. *The Extractive Industries and Society,* 7**,** 580-582.
LALON, R. M. 2020. COVID-19 vs Bangladesh: Is it Possible to Recover the Impending Economic Distress Amid this Pandemic? *Journal of Economics and Business,* 3.
LEITE, H., LINDSAY, C. & KUMAR, M. 2020. COVID-19 outbreak: implications on healthcare operations. *The TQM Journal,* 33**,** 247-256.
LEVAC, D., COLQUHOUN, H. & O'BRIEN, K. K. 2010. Scoping studies: advancing the methodology. *Implementation Science,* 5**,** 69.
LEVNER, E. & PTUSKIN, A. 2018. Entropy-based model for the ripple effect: managing environmental risks in supply chains. *International Journal of Production Research,* 56**,** 2539-2551.
LEWIS, B. M., ERERA, A. L., NOWAK, M. A. & CHELSEA C, W. 2013. Managing Inventory in Global Supply Chains Facing Port-of-Entry Disruption Risks. *Transportation Science,* 47**,** 162-180.
LI, Q., ZENG, B. & SAVACHKIN, A. 2013. Reliable facility location design under disruptions. *Computers & Operations Research,* 40**,** 901-909.
LI, S., HE, Y. & CHEN, L. 2017. Dynamic strategies for supply disruptions in production-inventory systems. *International Journal of Production Economics,* 194**,** 88-101.
LI, X. & BARNES, I. 2008. Proactive supply risk management methods for building a robust supply selection process when sourcing from emerging markets. *Strategic Outsourcing: An International Journal,* 1**,** 252-267.
LIAMPUTTONG, P. 2011. International students in Australia: Their challenges and implications for university counseling services. *International Journal of Students' Research***,** 8-11.
LIM, M., BASSAMBOO, A., CHOPRA, S. & DASKIN, M. 2011. Use of chaining strategies in the presence of disruption risks. Working paper, University of Illinois Urbana–Champaign, Champaign.
LIM, M. K., TSENG, M.-L., TAN, K. H. & BUI, T. D. 2017. Knowledge management in sustainable supply chain management: Improving performance through an interpretive structural modelling approach. *Journal of cleaner production,* 162**,** 806-816.

LINNENLUECKE, M. K. 2017. Resilience in business and management research: A review of influential publications and a research agenda. *International journal of management reviews,* 19**,** 4-30.

LITOSSELITI, L. 2003. Using focus groups in research. *A&C Black*.

LIU, Q., XU, K., WANG, X. & WANG, W. 2020. From SARS to COVID-19: What lessons have we learned? *Journal of Infection and Public Health,* 13**,** 1611-1618.

LUCKSTEAD, J. & DEVADOSS, S. 2020. Impacts of COVID-19-induced labor and income shocks on the broiler supply chain. *Journal of Agricultural and Resource Economics,* 46**,** 189-213.

LUTHRA, S., MANGLA, S. K., SHANKAR, R., PRAKASH GARG, C. & JAKHAR, S. 2018. Modelling critical success factors for sustainability initiatives in supply chains in Indian context using Grey-DEMATEL. *Production Planning & Control,* 29**,** 705-728.

MACDONALD, J. R. & CORSI, T. M. 2013. Supply Chain Disruption Management: Severe Events, Recovery, and Performance. *Journal of Business Logistics,* 34**,** 270-288.

MACKENZIE, C. A., BARKER, K. & SANTOS, J. R. 2014. Modeling a severe supply chain disruption and post-disaster decision making with application to the Japanese earthquake and tsunami. *IIE Transactions,* 46**,** 1243-1260.

MAJUMDAR, A. 2019. Thematic Analysis in Qualitative Research. *In:* GUPTA, M., SHAHEEN, M. & REDDY, K. P. (eds.) *Qualitative Techniques for Workplace Data Analysis.* Hershey, PA, USA: IGI Global.

MAJUMDAR, A., SHAW, M. & SINHA, S. K. 2020. COVID-19 debunks the myth of socially sustainable supply chain: A case of the clothing industry in South Asian countries. *Sustainable Production and Consumption,* 24**,** 150-155.

MAJUMDAR, A., SINHA, S. K. & GOVINDAN, K. 2021. Prioritising risk mitigation strategies for environmentally sustainable clothing supply chains: Insights from selected organisational theories. *Sustainable Production and Consumption,* 28**,** 543-555.

MALATESTA, D. & SMITH, C. R. 2011. Resource Dependence, Alternative Supply Sources, and the Design of Formal Contracts. *Public Administration Review,* 71**,** 608-617.

MALATESTA, D. & SMITH, C. R. 2014. Lessons from Resource Dependence Theory for Contemporary Public and Nonprofit Management. *Public Administration Review,* 74**,** 14-25.

MALTERUD, K., SIERSMA, V. D. & GUASSORA, A. D. 2016. Sample Size in Qualitative Interview Studies. *Qualitative Health Research,* 26**,** 1753-1760.

MANDAL, A. & DESHMUKH, S. 1994. Vendor selection using interpretive structural modelling (ISM). *International journal of operations & production management,* 14**,** 52-59.

MANGLA, S. K., LUTHRA, S., RICH, N., KUMAR, D., RANA, N. P. & DWIVEDI, Y. K. 2018. Enablers to implement sustainable initiatives in agri-food supply chains. *International Journal of Production Economics,* 203**,** 379-393.

MANUJ, I. & MENTZER, J. T. 2008. Global supply chain risk management. *Journal of business logistics,* 29**,** 133-155.

MARSHALL, M. N. 1996. Sampling for qualitative research. *Family Practice,* 13**,** 522–526.

MASON, J. 2006. Mixing methods in a qualitatively driven way. *Qualitative research,* 6**,** 9-25.

MAXWELL, J. A. 2004. Causal explanation, qualitative research, and scientific inquiry in education. *Educational researcher,* 33**,** 3-11.

MAZUR, C., CONTESTABILE, M., OFFER, G. J. & BRANDON, N. 2015. Understanding the drivers of fleet emission reduction activities of the German car manufacturers. *Environmental Innovation and Societal Transitions,* 16**,** 3-21.

MILES, M. B. 1994. Qualitative data analysis: An expanded sourcebook. *Thousand Oaks*.

MILES, M. B., HUBERMAN, A. M. & SALDAñA, J. 2014. Qualitative data analysis: A methods sourcebook. 3rd. Thousand Oaks, CA: Sage.

MOHR, A., WANG, C. & FASTOSO, F. 2016. The contingent effect of state participation on the dissolution of international joint ventures: A resource dependence approach. *Journal of International Business Studies,* 47**,** 408-426.

MOLL, J., MAJOR, M. & HOQUE, Z. 2006. The qualitative research tradition. *Methodological issues in accounting research: Theories and methods.* Spiramus Press.

MOOSAVI, J. & HOSSEINI, S. 2021. Simulation-based assessment of supply chain resilience with consideration of recovery strategies in the COVID-19 pandemic context. *Comput Ind Eng,* 160**,** 107593.

MORAIS, D. O. C. & BARBIERI, J. C. 2022. Supply chain social sustainability: Unveiling focal firm's archetypes under the lens of stakeholder and contingency theory. *Sustainability,* 14**,** 1185.

MORGAN, D. L. 1996. *Focus groups as qualitative research,* Sage publications.

MORROW, S. L. 2005. Quality and trustworthiness in qualitative research in counseling psychology. *Journal of counseling psychology,* 52**,** 250.

MUDGAL, R. K., SHANKAR, R., TALIB, P. & RAJ, T. 2010. Modelling the barriers of green supply chain practices: an Indian perspective. *International Journal of Logistics Systems and Management,* 7**,** 81-107.

MULHALL, A. 2003. In the field: notes on observation in qualitative research. *Journal of advanced nursing,* 41**,** 306-313.

MUSWAZI, M. & NHAMO, E. 2013. Note taking: A lesson for novice qualitative researchers. *Journal of Research & Method in Education,* 2**,** 13-17.

NOWELL, L. S., NORRIS, J. M., WHITE, D. E. & MOULES, N. J. 2017. Thematic Analysis. *International Journal of Qualitative Methods,* 16**,** 160940691773384.

NOY, C. 2008. Sampling Knowledge: The Hermeneutics of Snowball Sampling in Qualitative Research. *International Journal of Social Research Methodology,* 11**,** 327-344.

NUNES, M., ABREU, A., BAGNJUK, J., NUNES, E. & SARAIVA, C. 2022. A Strategic Process to Manage Collaborative Risks in Supply Chain Networks (SCN) to Improve Resilience and Sustainability. *Sustainability,* 14**,** 5237.

O'KEEFFE, P. 2016. Supply chain management strategies of agricultural corporations: A resource dependency approach. *Competition & Change,* 20**,** 255-274.

O'REILLY, M. & PARKER, N. 2013. 'Unsatisfactory Saturation': a critical exploration of the notion of saturated sample sizes in qualitative research. *Qualitative research,* 13**,** 190-197.

OKORIE, O., SUBRAMONIAM, R., CHARNLEY, F., PATSAVELLAS, J., WIDDIFIELD, D. & SALONITIS, K. 2020. Manufacturing in the Time of COVID-19: An Assessment of Barriers and Enablers. *IEEE Engineering Management Review,* 48**,** 167-175.

OKUYAMA, Y. & SAHIN, S. 2009. Impact Estimation of Disasters: A Global Aggregate for 1960 to 2007. *World Bank Policy Research Working Paper*.

PARK, K., MIN, H. & MIN, S. 2016. Inter-relationship among risk taking propensity, supply chain security practices, and supply chain disruption occurrence. *Journal of Purchasing and Supply Management,* 22**,** 120-130.

PARK, Y., HONG, P. & ROH, J. J. 2013. Supply chain lessons from the catastrophic natural disaster in Japan. *Business Horizons,* 56**,** 75-85.

PARKER, A. & TRITTER, J. 2006. Focus group method and methodology: current practice and recent debate. *International Journal of Research & Method in Education,* 29**,** 23-37.

PARRY, E., FARNDALE, E., BREWSTER, C. & MORLEY, M. J. 2021. Balancing Rigour and Relevance: The Case for Methodological Pragmatism in Conducting Large-

Scale, Multi - country and Comparative Management Studies. *British Journal of Management,* 32**,** 273-282.

PATTON, M. Q. 1990. Qualitative evaluation and research methods. Sage.

PATTON, M. Q. 2014. *Qualitative research & evaluation methods: Integrating theory and practice,* Sage publications.

PAUL, S. K. & CHOWDHURY, P. 2020. Strategies for managing the impacts of disruptions during COVID-19: an example of toilet paper. *Global Journal of Flexible Systems Management,* 21**,** 283-293.

PAUL, S. K., CHOWDHURY, P., MOKTADIR, M. A. & LAU, K. H. 2021. Supply chain recovery challenges in the wake of COVID-19 pandemic. *Journal of Business Research,* 136**,** 316-329.

PAUL, S. K., SARKER, R. & ESSAM, D. 2015. Managing risk and disruption in production-inventory and supply chain systems: A review. *Journal of Industrial and Management Optimization,* 12**,** 1009-1029.

PAUL, S. K., SARKER, R. & ESSAM, D. 2017. A quantitative model for disruption mitigation in a supply chain. *European Journal of Operational Research,* 257**,** 881-895.

PECK, H. 2005. Drivers of supply chain vulnerability: an integrated framework. *International Journal of Physical Distribution & Logistics Management,* 35**,** 210-232.

PFEFFER, J. & SALANCIK, G. 2015. External control of organizations—Resource dependence perspective. *Organizational behavior 2.* Routledge.

POLIT, D. F. & BECK, C. T. 2008. *Nursing research: Generating and assessing evidence for nursing practice,* Lippincott Williams & Wilkins.

PONIS, S. T. & KORONIS, E. 2012. Supply Chain Resilience? Definition of concept and its formative elements. *The Journal of Applied Business Research,* 28**,** 921-935 2157-8834.

PONOMAROV, S. Y. & HOLCOMB, M. C. 2009. Understanding the concept of supply chain resilience. *The International Journal of Logistics Management,* 20**,** 124-143.

PONSIGNON, F., KLAUS, P. & MAULL, R. S. 2015. Experience co-creation in financial services: an empirical exploration. *Journal of Service Management*.

PORTER, M. E. 1983. *Cases in competitive strategy*, Simon and Schuster.

PRICE, B. 2002. Laddered questions and qualitative data research interviews. *Journal of advanced nursing,* 37**,** 273-281.

PUJAWAN, I. N. & BAH, A. U. 2021. Supply chains under COVID-19 disruptions: literature review and research agenda. *Supply Chain Forum: An International Journal,* 23**,** 81-95.

QAZI, A., DICKSON, A., QUIGLEY, J. & GAUDENZI, B. 2018. Supply chain risk network management: A Bayesian belief network and expected utility based approach for managing supply chain risks. *International Journal of Production Economics,* 196**,** 24-42.

QI, L. 2013. A continuous-review inventory model with random disruptions at the primary supplier. *European Journal of Operational Research,* 225**,** 59-74.

QI, X., BARD, J. F. & YU, G. 2004. Supply chain coordination with demand disruptions. *Omega,* 32**,** 301-312.

QUAYSON, M., BAI, C. & OSEI, V. 2020. Digital inclusion for resilient post-COVID-19 supply chains: Smallholder farmer perspectives. *IEEE Engineering Management Review,* 48**,** 104-110.

RABIEE, F. 2004. Focus-group interview and data analysis. *Proceedings of the Nutrition Society,* 63**,** 655-660.

RAHMAN, T., TAGHIKHAH, F., PAUL, S. K., SHUKLA, N. & AGARWAL, R. 2021. An agent-based model for supply chain recovery in the wake of the COVID-19 pandemic. *Computers & Industrial Engineering,* 158**,** 107401.

RAJ, A., DWIVEDI, G., SHARMA, A., LOPES DE SOUSA JABBOUR, A. B. & RAJAK, S. 2020. Barriers to the adoption of industry 4.0 technologies in the manufacturing sector: An inter-country comparative perspective. *International Journal of Production Economics*, 224.

RAJ, A., MUKHERJEE, A. A., DE SOUSA JABBOUR, A. B. L. & SRIVASTAVA, S. K. 2022. Supply chain management during and post-COVID-19 pandemic: Mitigation strategies and practical lessons learned. *Journal of Business Research*, 142**,** 1125-1139.

RALLIS, S. F. & ROSSMAN, G. B. 2012. *The research journey: Introduction to inquiry*, Guilford Press.

RAO, S. & GOLDSBY, T. J. 2009. Supply chain risks: a review and typology. *The international journal of logistics management*, 20**,** 97-123.

REZAPOUR, S., FARAHANI, R. Z. & POURAKBAR, M. 2017. Resilient supply chain network design under competition: A case study. *European Journal of Operational Research*, 259**,** 1017-1035.

RUBIN, H. J. & RUBIN, I. S. 2011. *Qualitative interviewing: The art of hearing data*, sage.

SAKAGUCHI, T., NICOVICH, S. G. & DIBRELL, C. C. 2004. Empirical evaluation of an integrated supply chain model for small and medium sized firms. *Information Resources Management Journal (IRMJ)*, 17**,** 1-19.

SARKER, M. R., MOKTADIR, M. A. & SANTIBANEZ-GONZALEZ, E. D. R. 2021. Social Sustainability Challenges Towards Flexible Supply Chain Management: Post-COVID-19 Perspective. *Global Journal of Flexible Systems Management*, 22**,** 199-218.

SAUNDERS, M., LEWIS, P. & THORNHILL, A. 2009. *Research methods for business students*, Pearson education.

SAWIK, T. 2016. Integrated supply, production and distribution scheduling under disruption risks. *Omega*, 62**,** 131-144.

SAYED, M., HENDRY, L. C. & ZORZINI BELL, M. 2021. Sustainable procurement: Comparing in-house and outsourcing implementation modes. *Production Planning & Control*, 32**,** 145-168.

SCHMIDT, W. & RAMAN, A. 2012. *When supply-chain disruptions matter*, Harvard Business School Boston, MA.

SCHMITT, A. J. & SINGH, M. 2012. A quantitative analysis of disruption risk in a multi-echelon supply chain. *International Journal of Production Economics*, 139**,** 22-32.

SCHNITTFELD, N. L. & BUSCH, T. 2016. Sustainability Management within Supply Chains – A Resource Dependence View. *Business Strategy and The Environment*, 25**,** 337-354.

SCHOLTEN, K. & SCHILDER, S. 2015. The role of collaboration in supply chain resilience. *Supply Chain Management: An International Journal*, 20**,** 471-484.

SEGAL, S. & GERSTEL, D. 2020. The global economic impacts of COVID-19, critical questions. *Center for Strategic and International Studies (CSIS). Retrieved from https://www. csis. org/analysis*.

SEN, S., ANTARA, N., SEN, S. & CHOWDHURY, S. 2020. The Unprecedented pandemic'COVID-19'effect on the Bangladesh apparel workers by shivering the apparel supply chain. *Sen, S., Antara, N., Sen, S., & Chowdhury, S.(2020). The Unprecedented Pandemic'COVID-19'Effect on the Apparel Workers by shivering the Apparel Supply Chain. Journal of Textile and Apparel, Technology and Management*, 11**,** 1-20.

SERRANO, C., DELORME, X. & DOLGUI, A. 2021. Cross-dock distribution and operation planning for overseas delivery consolidation: A case study in the automotive industry. *CIRP Journal of Manufacturing Science and Technology*, 33**,** 71-81.

SEURING, S. A. 2008. Assessing the rigor of case study research in supply chain management. *Supply Chain Management: An International Journal,* 13**,** 128-137.

SHARMA, A., BORAH, S. B. & MOSES, A. C. 2021. Responses to COVID-19: The role of governance, healthcare infrastructure, and learning from past pandemics. *Journal of Business Research,* 122**,** 597-607.

SHEFFI, Y. 2015. Preparing for disruptions through early detection. *MIT Sloan Management Review,* 57**,** 31.

SHERER, P. D. & LEE, K. 2002. Institutional Change in Large Law Firms: A Resource Dependency and Institutional Perspective. *Academy of Management Journal,* 45**,** 102-119.

SHERER, P. D., SUDDABY, R. & COQUET, M. R. D. 2019. Does Resource Diversity Confer Organizational Autonomy In Arts Organizations? Extending Resource Dependence Theory. *Journal of Arts Management Law and Society,* 49**,** 224-241.

SILVERMAN, D. 2013. What counts as qualitative research? Some cautionary comments. *Qualitative sociology review,* 9**,** 48-55.

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**,** 2318-2342.

SINGH, R., KUMAR, D. & SAGAR, B. B. Interpretive structural modelling in assessment of agile methodology. 2017 International Conference on Infocom Technologies and Unmanned Systems (Trends and Future Directions) (ICTUS), 18-20 Dec. 2017 2017. 1-4.

SINGH, S., KUMAR, R., PANCHAL, R. & TIWARI, M. K. 2021. Impact of COVID-19 on logistics systems and disruptions in food supply chain. *International Journal of Production Research,* 59**,** 1993-2008.

SMITH, S. J., JAYARAM, J., PONSIGNON, F. & WOLTER, S. J. 2019. Service recovery system antecedents: a contingency theory investigation. *Journal of Service Management,* 30**,** 276-300.

SNYDER, L. V., ATAN, Z., PENG, P., RONG, Y., SCHMITT, A. J. & SINSOYSAL, B. 2016. OR/MS models for supply chain disruptions: a review. *IIE Transactions,* 48**,** 89-109.

SOHL, T., HAMELIN, A. & FITZA, M. A. 2024. A resource dependence perspective on the business group effect in developed markets: Evidence from Western European firms. *European Management Review*.

SOMBULTAWEE, K., LENUWAT, P., ALEENAJITPONG, N. & BOON-ITT, S. 2022. COVID-19 and Supply Chain Management: A Review with Bibliometric. *Sustainability,* 14**,** 3538.

SøREIDE, K., HALLET, J., MATTHEWS, J. B., SCHNITZBAUER, A. A., LINE, P. D., LAI, P., OTERO, J., CALLEGARO, D., WARNER, S. G. & BAXTER, N. N. 2020. Immediate and long-term impact of the COVID-19 pandemic on delivery of surgical services. *Journal of British Surgery,* 107**,** 1250-1261.

SPIEGLER, V. L., NAIM, M. M. & LIN, J. 2019. The Rippling Effect of Non-linearities. *Handbook of Ripple Effects in the Supply Chain***,** 65-84.

SPIEGLER, V. L. M., NAIM, M. M. & WIKNER, J. 2012. A control engineering approach to the assessment of supply chain resilience. *International Journal of Production Research,* 50**,** 6162-6187.

SQUIRES, V. 2023. Thematic Analysis. *In:* OKOKO, J. M., TUNISON, S. & WALKER, K. D. (eds.) *Varieties of Qualitative Research Methods: Selected Contextual Perspectives.* Cham: Springer International Publishing.

SREENIVASAN, A., MA, S., NEDUNGADI, P., SREEDHARAN, V. R. & RAMAN, R. R. 2023. Interpretive Structural Modeling: Research Trends, Linkages to Sustainable Development Goals, and Impact of COVID-19. *Sustainability,* 15**,** 4195.

STONE, J. & RAHIMIFARD, S. 2018. Resilience in agri-food supply chains: a critical analysis of the literature and synthesis of a novel framework. *Supply Chain Management: An International Journal,* 23**,** 207-238.
TAN, W.-J. & ENDERWICK, P. 2006. Managing threats in the global era: The impact and response to SARS. *Thunderbird International Business Review,* 48**,** 515-536.
TANG, C. S. 2006. Perspectives in supply chain risk management. *International journal of production economics,* 103**,** 451-488.
TANG, O. & NURMAYA MUSA, S. 2011. Identifying risk issues and research advancements in supply chain risk management. *International Journal of Production Economics,* 133**,** 25-34.
TAPIERO, C. S. & GRANDO, A. 2008. Risks and supply chains. *International Journal of Risk Assessment and Management,* 9**,** 199-212.
TARIFA FERNáNDEZ, J. 2022. Dependence and resource commitment as antecedents of supply chain integration. *Business Process Management Journal,* 28**,** 23-47.
TEECE, D. J. 2007. Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic management journal,* 28**,** 1319-1350.
TEECE, D. J., PISANO, G. & SHUEN, A. 1997. Dynamic capabilities and strategic management. *Strategic management journal,* 18**,** 509-533.
TEMPLE, B. & EDWARDS, R. 2002. Interpreters/translators and cross-language research: Reflexivity and border crossings. *International journal of qualitative methods,* 1**,** 1-12.
TEMPLE, B. & YOUNG, A. 2004. Qualitative research and translation dilemmas. *Qualitative research,* 4**,** 161-178.
TESCH, R. 2013. *Qualitative research: Analysis types and software*, Routledge.
THE BRITISH ACADEMY The COVID Decade: understanding the long-term societal impacts of COVID-19.
THE BRITISH ACADEMY 2021. The COVID Decade: understanding the long-term societal impacts of COVID-19.
THIRUPATHI, R. & VINODH, S. 2016. Application of interpretive structural modelling and structural equation modelling for analysis of sustainable manufacturing factors in Indian automotive component sector. *International Journal of Production Research,* 54**,** 6661-6682.
THOMAS, M. U. Supply chain reliability for contingency operations. Annual Reliability and Maintainability Symposium. 2002 Proceedings (Cat. No. 02CH37318), 2002. IEEE, 61-67.
TOMLIN, B. 2006. On the Value of Mitigation and Contingency Strategies for Managing Supply Chain Disruption Risks. *Management Science,* 52**,** 639-657.
TORABI, S., BAGHERSAD, M. & MANSOURI, S. 2015. Resilient supplier selection and order allocation under operational and disruption risks. *Transportation Research Part E: Logistics and Transportation Review,* 79**,** 22-48.
TRAUTRIMS, A., SCHLEPER, M. C., CAKIR, M. S. & GOLD, S. 2020. Survival at the expense of the weakest? Managing modern slavery risks in supply chains during COVID-19. *Journal of risk research,* 23**,** 1067-1072.
TRIENEKENS, J. H. & BEULENS, A. J. 2001. Views on inter-enterprise relationships. *Production Planning & Control,* 12**,** 466-477.
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**,** 247-258.
TUCKETT, A. G. 2005. Applying thematic analysis theory to practice: A researcher's experience. *Contemporary nurse,* 19**,** 75-87.
TUKAMUHABWA, B. R., STEVENSON, M., BUSBY, J. & ZORZINI, M. 2015. Supply chain resilience: definition, review and theoretical foundations for further study. *International Journal of Production Research,* 53**,** 5592-5623.

UK RESEARCH AND INNOVATION 2024. COVID-19's impact on our lives.
ULLRICH, C. A. 2014. Supply Chain Scheduling: Makespan reduction potential. *In:* ULLRICH, C. A. (ed.) *Issues in Supply Chain Scheduling and Contracting.* Wiesbaden: Springer Fachmedien Wiesbaden.
ULRICH, D. & BARNEY, J. B. 1984. Perspectives in organizations: resource dependence, efficiency, and population. *Academy of Management Review,* 9**,** 471-481.
UNNIKRISHNAN, A. & FIGLIOZZI, M. 2011. Online freight network assignment model with transportation disruptions and recourse. *Transportation research record,* 2224**,** 17-25.
URCIUOLI, L., MOHANTY, S., HINTSA, J. & GERINE BOEKESTEIJN, E. 2014. The resilience of energy supply chains: a multiple case study approach on oil and gas supply chains to Europe. *Supply Chain Management: An International Journal,* 19**,** 46-63.
VAHDANI, B., ZANDIEH, M. & ROSHANAEI, V. 2011. A hybrid multi-stage predictive model for supply chain network collapse recovery analysis: a practical framework for effective supply chain network continuity management. *International Journal of Production Research,* 49**,** 2035-2060.
VAN HOEK, R. 2020. Research opportunities for a more resilient post-COVID-19 supply chain–closing the gap between research findings and industry practice. *International Journal of Operations & Production Management,* 40**,** 341-355.
VASILIKI, S. & APOSTOLOS, P. The impact of information systems on the logistics industry. 2022 17th International Workshop on Semantic and Social Media Adaptation & Personalization (SMAP), 3-4 Nov. 2022 2022. 1-8.
VOSS, C., PERKS, H., SOUSA, R., WITELL, L. & WüNDERLICH, N. V. 2016. Reflections on context in service research. *Journal of Service Management,* 27**,** 30-36.
WAGNER, S. M. & BODE, C. 2008. An empirical examination of supply chain performance along several dimensions of risk. *Journal of business logistics,* 29**,** 307-325.
WAGNER, S. M. & NESHAT, N. 2010. Assessing the vulnerability of supply chains using graph theory. *International journal of production economics,* 126**,** 121-129.
WAKOLBINGER, T. & CRUZ, J. M. 2011. Supply chain disruption risk management through strategic information acquisition and sharing and risk-sharing contracts. *International Journal of Production Research,* 49**,** 4063-4084.
WALKER, J. L. 2012. Research column. The use of saturation in qualitative research. *Canadian journal of cardiovascular nursing,* 22.
WALLIN, A. M. & AHLSTRöM, G. 2006. Cross‐cultural interview studies using interpreters: systematic literature review. *Journal of advanced nursing,* 55**,** 723-735.
WANG, C. L. & AHMED, P. K. 2007. Dynamic capabilities: A review and research agenda. *International journal of management reviews,* 9**,** 31-51.
WANKMüLLER, C. & REINER, G. 2020. Coordination, cooperation and collaboration in relief supply chain management. *Journal of Business Economics,* 90**,** 239-276.
WERNERFELT, B. 1984. A resource‐based view of the firm. *Strategic management journal,* 5**,** 171-180.
WIELAND, A. & DURACH, C. F. 2021. Two perspectives on supply chain resilience. Wiley Online Library.
WIELAND, A. & WALLENBURG, C. M. 2013. The influence of relational competencies on supply chain resilience: a relational view. *International journal of physical distribution & logistics management,* 43**,** 300-320.
WILKINSON, S. 1998. Focus group methodology: a review. *International journal of social research methodology,* 1**,** 181-203.
WILSON, M. C. 2007. The impact of transportation disruptions on supply chain performance. *Transportation Research Part E: Logistics and Transportation Review,* 43**,** 295-320.

WONG, C. Y., BOON-ITT, S. & WONG, C. W. 2011. The contingency effects of environmental uncertainty on the relationship between supply chain integration and operational performance. *Journal of Operations management,* 29**,** 604-615.
WONTNER, K. L., WALKER, H., HARRIS, I. & LYNCH, J. 2020. Maximising "Community Benefits" in public procurement: Tensions and trade-offs. *International journal of operations & production management,* 40**,** 1909-1939.
WORLD HEALTH ORGANISATION. 2024. *Number of COVID-19 cases reported to WHO* [Online]. Available: https://data.who.int/dashboards/covid19/cases?n=c [Accessed].
WTO 2022. WTO Statistics: Trade and tariff data.
WU, T., HUANG, S., BLACKHURST, J., ZHANG, X. & WANG, S. 2013. Supply Chain Risk Management: An Agent-Based Simulation to Study the Impact of Retail Stockouts. *IEEE Transactions on Engineering Management,* 60**,** 676-686.
XU, S., ZHANG, X., FENG, L. & YANG, W. 2020. Disruption risks in supply chain management: a literature review based on bibliometric analysis. *International Journal of Production Research,* 58**,** 3508-3526.
YANG, B. & YANG, Y. 2010. Postponement in supply chain risk management: a complexity perspective. *International Journal of Production Research,* 48**,** 1901-1912.
YAZAN, B. 2015. Three approaches to case study methods in education: Yin, Merriam, and Stake.
YEAGER, V. A., MENACHEMI, N., SAVAGE, G. T., GINTER, P. M., SEN, B. P. & BEITSCH, L. M. 2014. Using resource dependency theory to measure the environment in health care organizational studies: A systematic review of the literature. *Health Care Management Review,* 39.
YIN, R. K. 2009. *Case study research: Design and methods,* sage.
YUEN, K. F., TAN, L. S., WONG, Y. D. & WANG, X. 2022. Social determinants of panic buying behaviour amidst COVID-19 pandemic: The role of perceived scarcity and anticipated regret. *Journal of Retailing and Consumer Services,* 66**,** 102948.
ZAVALA-ALCíVAR, A., VERDECHO, M.-J. & ALFARO-SAIZ, J.-J. 2023. Supply chain resilience: a conceptual evolution analysis. *Dirección y Organización***,** 5-17.
ZHANG, Y. & WILDEMUTH, B. M. 2009. Unstructured interviews. *Applications of social research methods to questions in information and library science,* 2**,** 222-231.
ZSIDISIN, G. A., MELNYK, S. A. & RAGATZ, G. L. 2005. An institutional theory perspective of business continuity planning for purchasing and supply management. *International journal of production research,* 43**,** 3401-3420.
ZSIDISIN, G. A. & WAGNER, S. M. 2010. DO PERCEPTIONS BECOME REALITY? THE MODERATING ROLE OF SUPPLY CHAIN RESILIENCY ON DISRUPTION OCCURRENCE. *Journal of Business Logistics,* 31**,** 1-20.