



University of
**Southern
Queensland**

SUPPLY CHAIN RESILIENCE IN CHINA'S COMMERCIAL AVIATION INDUSTRY

A Thesis submitted by

Maximilian D. Fahr
(BA, MBA)

For the award of

Doctor of Philosophy

2024

ABSTRACT

China's commercial aviation industry is facing profound challenges post COVID-19 particularly in meeting both rising demand for new aircraft and need for strategic supply chain sourcing. This trend has implications on the supply chain set-up, where resilience across the value-chain is a key capability to keep up with market demand. While literature discusses resilience in supply chains from a range of different perspectives, neither the aviation nor the China context has been adequately explored. Therefore, this research proposes to investigate this gap. It examines how and why resilience affects China's aviation industry through a two-stage qualitative (in-depth interview and case study) research methodology. In-depth interviews and case studies provide insights into the models of resilience identified and their relevance to this research. The resource-based view of the firm and dynamic capabilities theory (DCT) is used to provide the theoretical framework to explore how suppliers can prepare for resilience in its supply chain. As such, proposals to enhance resource-based view will be made on how financial, tangible and intangible resources are affecting resilience, through access to capital, infrastructure and collaboration. Evidence will substantiate the applicability of theory, for instance by discussing the role of inventories.

Nine in-depth interviews were conducted with industry experts from China, followed by nine case studies involving 18 interviews. Theoretical contribution includes the validity of the conceptual model of resilience building by evidence from cases in China. The distinct advantages of China's State-owned enterprises (SOEs) underscore their significant access to both financial resources and human capital. Their practical impact on business encompasses a detailed model of components of resilience that enhance adaptability, robustness, and transformability. Best practices of how resilience building was achieved through strategic partnership, technology and knowledge transfer was highlighted. Findings indicate that resilience varies among SOEs, private, and foreign enterprises in China due to differing strategies related to profitability, resource management, and customer partnerships. Moreover, it was found that proactive resilience planning improves a company's ability to handle unexpected challenges, but it requires financial investment and strategic management.

CERTIFICATION OF THESIS

I, Maximilian D. Fahr, declare that the PhD thesis entitled *Supply Chain Resilience in China's Commercial Aviation Industry* constitutes of 119'311 words in length, including quotes and exclusive of tables, figures, appendices, bibliography, references, and footnotes. The work is original and has not previously been submitted for any other award. I have acknowledged any key collaborations and their level and type of contribution, here deemed appropriate in the statement of contribution.

Date: 30/10/2024

Endorsed by:

Associate Professor Eric Ng

Principal Supervisor

Professor Julian Müller

Associate Supervisor

Student and supervisors' signatures of endorsement are held at the University.

ACKNOWLEDGEMENTS

I would like to express my heartfelt gratitude to all those who have contributed to this research, whether directly or indirectly. My sincere appreciation goes to my family for their unwavering support throughout the years of researching and writing my thesis, as well as for their encouragement.

I extend a special thank you to each interviewee who participated in this study, particularly for their candidness during the interviews.

Additionally, I am grateful to my thesis supervisors, Prof Dr Eric Ng from Australia, Prof Dr Julian Müller from Austria, and Dr Stefan Kueenzi from Switzerland, for their guidance and support.

Thank you.

DEDICATION

This Thesis is dedicated to my mother, whose unwavering support, love, and guidance have been the foundation of my journey. Her strength and resilience have inspired me to pursue my goals with determination and passion. This work also serves as a heartfelt tribute to the memory of my father, whose wisdom, kindness, and encouragement continue to resonate in my life. Though he is no longer with us, his influence remains a guiding light, motivating me to strive for excellence and to honour his legacy through my achievements. Together, they have shaped the person I am today, and this Thesis stands as a testament to their enduring impact on my life.

Table of Contents

ABSTRACT	i
CERTIFICATION OF THESIS.....	ii
ACKNOWLEDGEMENTS	iii
DEDICATION	iv
LIST OF TABLES	viii
LIST OF FIGURES.....	ix
ABBREVIATIONS	x
CHAPTER 1: INTRODUCTION	1
1.1 Background to the research and significance.....	3
1.1.1. Theme 1: Global commercial aviation and its growth.....	3
1.1.2. Theme 2: Vital role of SC to the industry.....	9
1.1.3. Theme 3: Introduction to the geographic focus of China.....	18
1.2 Research question, sub-questions, and objective of the research	22
1.3 Justification for the research.....	25
1.3.1 Gaps in the literature	25
1.3.2. Growing importance of main themes.....	26
1.3.3 Relevance and contribution on resilience in SC	32
1.4 Research methodology.....	33
1.5 Outline of the thesis structure.....	35
1.6 Delimitation of scope	37
1.7 Conclusion.....	39
CHAPTER 2: LITERATURE REVIEW	40
2.1 Introduction.....	40
2.2 Parent discipline one: SCM	42
2.2.1 Key theme 1: Strategic risk management in SCM.....	45
2.2.2 Key theme 2: Operational SCM capabilities	55
2.3 Parent discipline two: Resilience	60
2.3.1 Perspectives in the literature and consensus	61
2.3.2 Key components of resilience.....	70
2.3.3 Resilience across different categories of the aircraft.....	79
2.4 Gaps in the literature	89
2.5 Preliminary theoretical model	92

2.6 Conclusion	100
CHAPTER 3: METHODOLOGY	101
3.1 Introduction	101
3.2 Justification of the research paradigm	103
3.3 Research design.....	109
3.3.1 Justification of exploratory research design	111
3.3.2 Stage one: In-depth interviews	112
3.3.3 Stage two: Case study research.....	125
3.4 Data analysis	137
3.5 Limits of this research and ethical considerations	140
3.6 Conclusion	143
CHAPTER 4: IN-DEPTH INTERVIEW FINDINGS	144
4.1 Introduction	144
4.2 Results of in-depth interviews.....	146
4.2.1 Profiles of interviewees.....	146
4.2.2 Findings of in-depth interviews	150
4.3 Revised theoretical model	214
4.4 Conclusion	216
CHAPTER 5: CASE STUDY FINDINGS	217
5.1 Introduction	217
5.2 Case study organisation	219
5.2.1 Description of cases	221
5.3 Findings of sub-question SQ1	225
5.4 Findings of sub-question SQ2	306
5.5 Conclusion	411
CHAPTER 6: CONCLUSION AND IMPLICATIONS	412
6.1 Introduction	414
6.2 Conclusion about the research sub-questions	416
6.2.1 Sub-question 1	416
6.2.2. Sub-question 2	419
6.3 Conclusion about the research question	424
6.4 Implications for theory	427
6.5 Implications for practice	430

6.6 Limitations of the research	434
6.7 Implications for future research	436
6.8 Conclusion	439
APPENDIX	440
Appendix I: Interview protocol in-depth interviews	440
Appendix II: Participant Information Sheet	441
Appendix III: Case study interview protocol.....	442
Appendix IV: Interview protocol case study.....	443
Appendix V: Ethical consent form.....	444
REFERENCES.....	445

LIST OF TABLES

Table 2.1 Theme and topics area in the literature	44
Table 2.2 Examples of definitions of resilience in the literature	63
Table 2.3 Multiple-generation supplier relationship model	81
Table 2.4 Theoretical models investigated	92
Table 3.1 Summary of paradigms in supply chain management	104
Table 3.2 Correlation of objective with interview question	114
Table 3.3 Extract of case study interview questions	128
Table 3.4 Schematic view of cases investigated	134
Table 4.1 Profiles of interviewees	147
Table 4.2 Supplier landscape in China	153
Table 4.3 Interviewees response to the key features	160
Table 4.4 Summary of key components of resilience	175
Table 4.5 Temporal view on appeal of resilience	191
Table 4.6 Proactive vs reactive capability building	198
Table 4.7 Comparative resilience building approaches	198
Table 5.1 Description of case study organisation and interviewees	220
Table 5.2 Components of resilience	283
Table 5.3 Features of resilience	335

LIST OF FIGURES

Figure 1.1 Outline of Chapter One	2
Figure 1.2 Global GDP by industry 2021	5
Figure 1.3 Global air traffic growth 2016-2035	7
Figure 1.4 Number of air routes between China and selected countries	8
Figure 1.5 Current themes of discussion about resilience in supply chains	13
Figure 1.6 Passenger turnover of Civil Aviation Industry in China	20
Figure 1.7 World economic growth vs air traffic growth	28
Figure 1.8 World aviation 1950-2023 in RPK and external shocks	28
Figure 1.9 World trade volume 2000-2021	30
Figure 2.1 Outline of Chapter Two	41
Figure 2.2 Hierarchy of the categories identified in the literature	62
Figure 2.3 Categories of components of resilience of an organisation	70
Figure 2.4 Key phases of resilience during supply chain disruption	77
Figure 2.5 Supplier relationship model	80
Figure 2.6 Component of resilience affecting supply chains	85
Figure 2.7 Research gap by categories and focus of research	89
Figure 2.8 Preliminary model of factors influencing supply chain resilience	98
Figure 3.1 Outline of Chapter Three	102
Figure 3.2: Research design content	109
Figure 3.3 Visualisation of the analysis process	137
Figure 4.1 Outline of Chapter Four	145
Figure 4.2 Key features of resilience in the supply chain	159
Figure 4.3 Key components of resilience	174
Figure 4.4 Visualisation of phases of resilience building	206
Figure 4.5 Revised theoretical model	214
Figure 5.1 Outline of Chapter Five	218
Figure 6.1 Outline of Chapter Six	413
Figure 6.2 Revised and finalised theoretical model	426

ABBREVIATIONS

Aviation is the activity of flying aircraft, or of designing, producing, and keeping them in good condition, according to the Cambridge Dictionary (Cambridge Dictionary, 2020).

Chinese Communist Party (CCP) is the sole governing political party that has been governing the People's Republic of China since 1949 (Dickson, 2017).

Concession with suffix is a technical limitation to a part due to divergence between the design, i.e. the drawing, and the part, i.e. the produced part. Depending on the degree of the limitation, it may restrict the performance, which is characterised by an "R suffix"; others include a "C suffix".

Dynamic Capabilities Theory (DCT) is concerned with enabling organisations to integrate, marshal and reconfigure their resources and capabilities to adapt to rapidly changing environments (Bleady et al., 2018).

Final Assembly Line located in Tianjin, China (FAL-C) for Airbus A320 aircraft and completion centre for the Airbus A330 that is set up as a joint venture between Airbus and a consortium consisting of the Tianjin Free Trade Zone and China's Aviation Corporation AVIC (Petrescu et al., 2017).

Gross Domestic Product (GDP) is an aggregate measure of production equal to the sum of the gross values added of all resident institutional units engaged in production (Vinet & Zhedanov, 2011c).

General Data Protection Regulation 2016/679 (GDPR) of the European Union ensures protection and processing standards for citizens of the European Union (Agarwal et al., 2017).

Original Equipment Manufacturer (OEM) (such as Airbus and Boeing) are integrators of components delivered by the supply chain. The OEM holds the type of certificate issued by the airworthiness authority, such as EASA and FAA (Goncalves & Kokkolaras, 2017).

People's Republic of China (PRC) is, for the purpose of this research, Mainland China, meaning its 22 provinces, four municipalities, and five autonomous regions. This research excluded two special administrative regions (Hong Kong and Macau) and the Island of Taiwan (Xu & Albert, 2016).

Resilience is a system's ability to recover and return to its original state (Chowdhury & Quaddus, 2017).

Resource-Based View (RBV) is a managerial framework used to determine the strategic resources a firm can exploit to achieve sustainable competitive advantage (Barney, 1991; Barney, 2012b).

Revenue Passenger kilometres (RPK) is an industry-standard measure for the volume of passengers flying on planes, i.e., occupying a seat and paying for it. It is imperfect as planes never reach 100% loading. Also, some passengers don't pay for flights but use rewards to purchase tickets. However, a consensus is that it is a good indicator of trends and growth (Japan Aircraft Development Company, 2019; Fu et al., 2015).

Supply Chain (SC) is the system of people and organisations that are involved in getting a product from the place where it is made to customers (Cambridge Dictionary)

Supply Chain Management (SCM) is the processes from the initial raw materials to the ultimate consumption of the finished product linking across supplier-user companies (McGaughey, 2005, p.319).

Supply Chain Resilience (SCR) is the ability of the SC to withstand changes of steady-state and converge to the original state or to a new desirable state (Shi et al., 2023; Pournader et al., 2020).

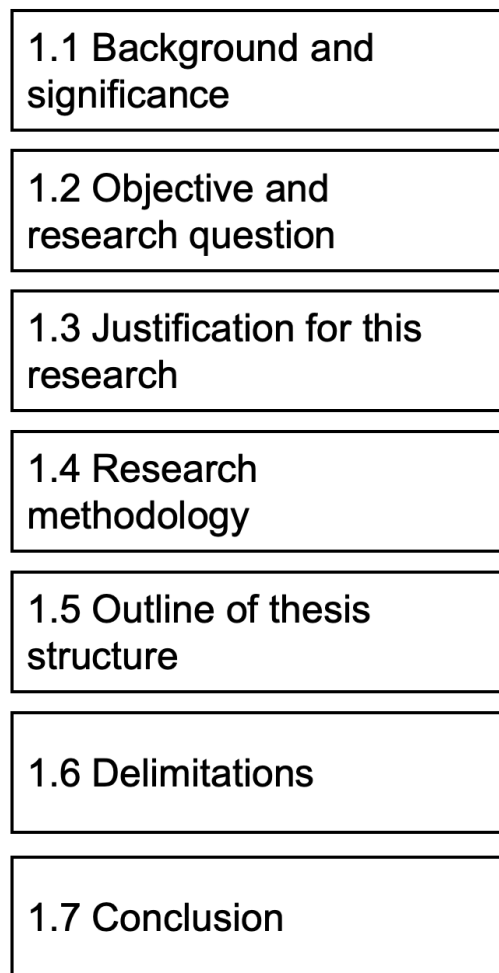
Supply Chain Quality is the consistent achievement of requirements by a supplier or partner (Zhang et al., 2011).

Total Quality Management (TQM) is a philosophy supported by tools and a continuously learning organisation as defined by Toyota (Sohal & Morrison, 1995).

CHAPTER 1: INTRODUCTION

This Chapter consists of seven sections, as depicted in Figure 1.1. It commences with an overview of the research background and its importance in Section 1.1. Section 1.2 outlines the research objectives, the primary research question, and associated sub-questions, followed by the rationale for the research in Section 1.3. A brief discussion of the research methodology is presented in Section 1.4, while Section 1.5 provides an outline of the thesis structure. Research delimitations are detailed in Section 1.6. Chapter One concludes with Section 1.7.

Figure 1.1 Outline of Chapter One



Source: Prepared for this research

1.1 Background to the research and significance

This section offers an overview of the research and explores three key themes that will be examined sequentially. The first theme focuses on the expansion of global commercial aviation, which will be detailed in Section 1.1.1. This is followed by a discussion on the critical role of the Supply chain (SC) in aviation, highlighting essential areas such as capabilities, skills, and organisations in Section 1.1.2. The final theme addresses the geographic context of China, as outlined in Section 1.1.3.

1.1.1. Theme 1: Global commercial aviation and its growth

This sub-section will examine the context of commercial aviation, focusing on:

- Revenue generation and economic impact and
- Growth in global passenger demand and the expansion of the aviation sector.

This analysis aims to provide a comprehensive overview of the global commercial aviation landscape and its growth trajectory. As globalisation continues to enhance interconnectedness across various domains, including international commerce, global financial systems, migration, educational exchanges, diplomatic relations, tourism, and familial connections, aviation emerges as a crucial facilitator in bridging distances and connecting individuals (International Air Transport Association (IATA), 2020; Boeing Commercial Airplanes, 2016).

Commercial aviation

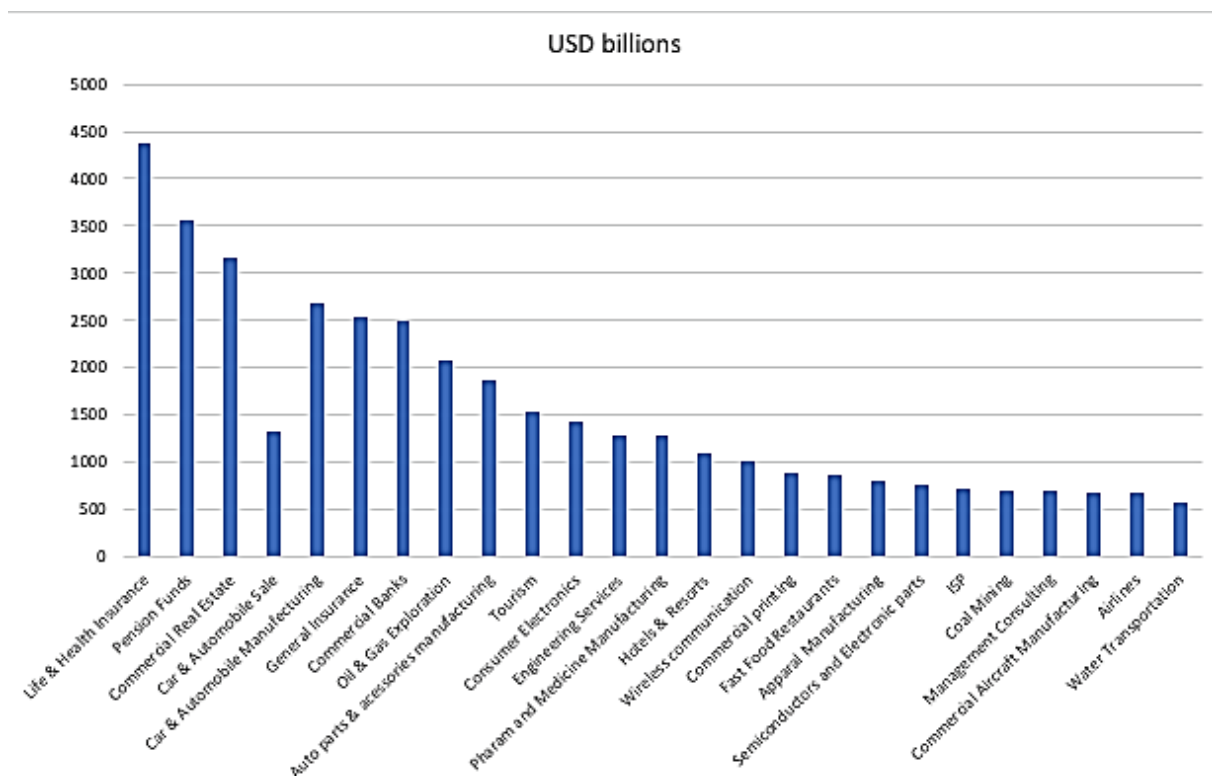
Commercial aircraft manufacturing operates in a highly regulated environment compared to the military and seeks an optimum balance during decision-making between cost, schedule, weight, and fuel consumption (Cameron, 2020; Gössling, 2020; Soshkin, 2016). Furthermore, commercial aviation offers a context of shared information and communication and reporting where the visibility of information is deemed more reliable and transparent than in the military (Liao, 2015; Li & Trani, 2014). The commercial aircraft manufacturing landscape is limited to two main players (duopoly), Boeing of the United States and the pan-European Airbus, and their primary business activities are research, design and manufacture of aircraft (Davies, 2019; He et al., 2017; Figueiredo et al., 2008; Galy & Germain, 2007). The slow emergence of regional players, including China's Comac, Russia's Sokoi and Brazil's Embraer, is observed.

Airlines such as the Netherlands' Royal Dutch Airlines Koninklijke Luchtvaart Maatschappij, namely KLM, Qantas of Australia or Air China and partners are then responsible for the operating and maintaining of these aircraft (Razali et al., 2020; Davies, 2019; Gregson et al., 2015). Many of these airlines have been around for decades, have seen volatile times, and have witnessed an overall growth trend in the aviation industry.

In comparison, sectors like electronics, automotive, and agri-business lack several defining features found in the aviation industry, including extremely high development costs and prolonged development cycles, high switching costs within the SC, stringent regulatory requirements, rigorous testing protocols, ongoing airworthiness standards, compulsory maintenance at certified facilities by trained personnel, and a considerable level of product complexity (Modarress Fathi et al., 2023; Althaf & Babbitt, 2021; Belhadi et al., 2021; Nematollahi et al., 2021). Consequently, the aviation sector is uniquely differentiated from these other industries.

Revenue and economic activity of airlines in 2019 (pre-COVID-19) was worth US\$607 billion for passenger traffic and US\$100 billion for cargo. While the revenue for passenger traffic had dipped to US\$189 billion in 2020, cargo revenue had risen to US\$140 billion. In the year 2022, revenue had significantly increased to US\$430 billion and US\$207 billion, respectively, for passenger traffic and cargo (International Air Transport Association (IATA), 2023). The aviation industry employed over 65 million people globally in 2018 in a variety of roles ranging from pilots and cabin personnel, maintenance technicians, to airport staff such as air-traffic controllers, baggage handlers and security personnel (International Air Transport Association (IATA), 2020; lacus et al., 2020). All economic activities related to aviation were worth US\$2.7 trillion (3.6%) of the world's gross domestic product (GDP) in 2019 (Asquith, 2020; May, 2020). In 2021, air transport contributed to global GDP worth 4.1% or US\$3.5 trillion and employed 87.7 million people, of which aircraft manufacturing generated US\$700 billion (IBISWorld, 2021) and was part of the top 25 global industries, as illustrated in Figure 1.2.

Figure 1.2 Global GDP by industry in 2021



Source: Prepared for this research, data source: (IBISWorld 2021)

Growth in aviation

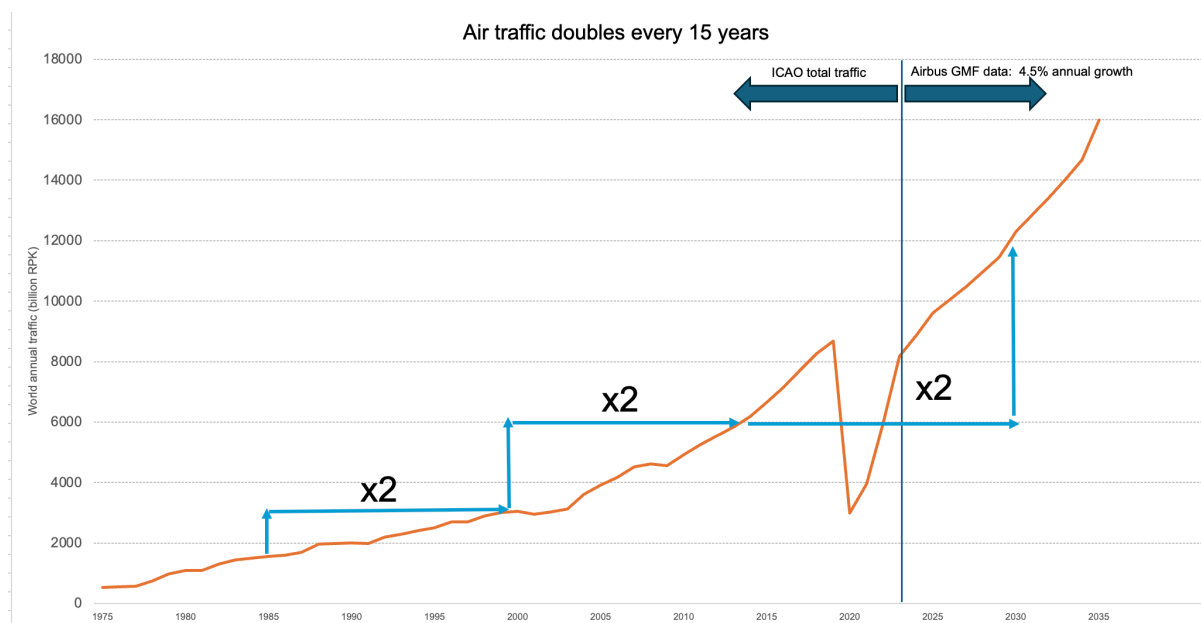
The aviation sector is experiencing a significant upward trend, highlighting its growing relevance to both commerce and society. This expansion can be categorised into two primary segments: commercial air traffic, which encompasses the transportation of passengers, such as tourists and business travellers, and cargo transport (Vinet & Zhedanov, 2011a), in which cargo such as airmail, fresh fruit or microchips (Klein et al., 2020) is being flown in the haul of aircraft or on dedicated freighter aircraft. Both categories will be discussed in turn.

Growth in global passenger demand is measured as a function of growing passenger traffic, also known as revenue passenger kilometres (RPK). Despite significant events (e.g. oil crisis, terrorism, financial crisis, wars, pandemics) affecting the global aviation industry, global RPK has seen continuous growth since 1978 (as shown in Figure 1.3) with an annual growth rate of approximately 4.8% (Becken & Carmignani, 2020; Singh et al., 2019; Bouarfa et al., 2013). In 2019, the global RPK

was 8.3 trillion, and this is expected to double by 2037 (Scherer, 2019; Cooper, 2016; Bouarfa et al., 2013; Vinet & Zhedanov, 2011b; Galy & Germain, 2007). This growth trend is a result of three main factors:

1. De-regulating of markets and lower economic costs;
2. Increasing supply of aircraft and deployment on new routes; and
3. Reducing barriers such as wavering visa requirements (Doerr et al., 2020; Lin & Ai, 2020; Mhlana, 2017; Redondi et al., 2011).

Figure 1.3 Global air traffic growth 1975 – 2035



Adapted from: Scherer 2019

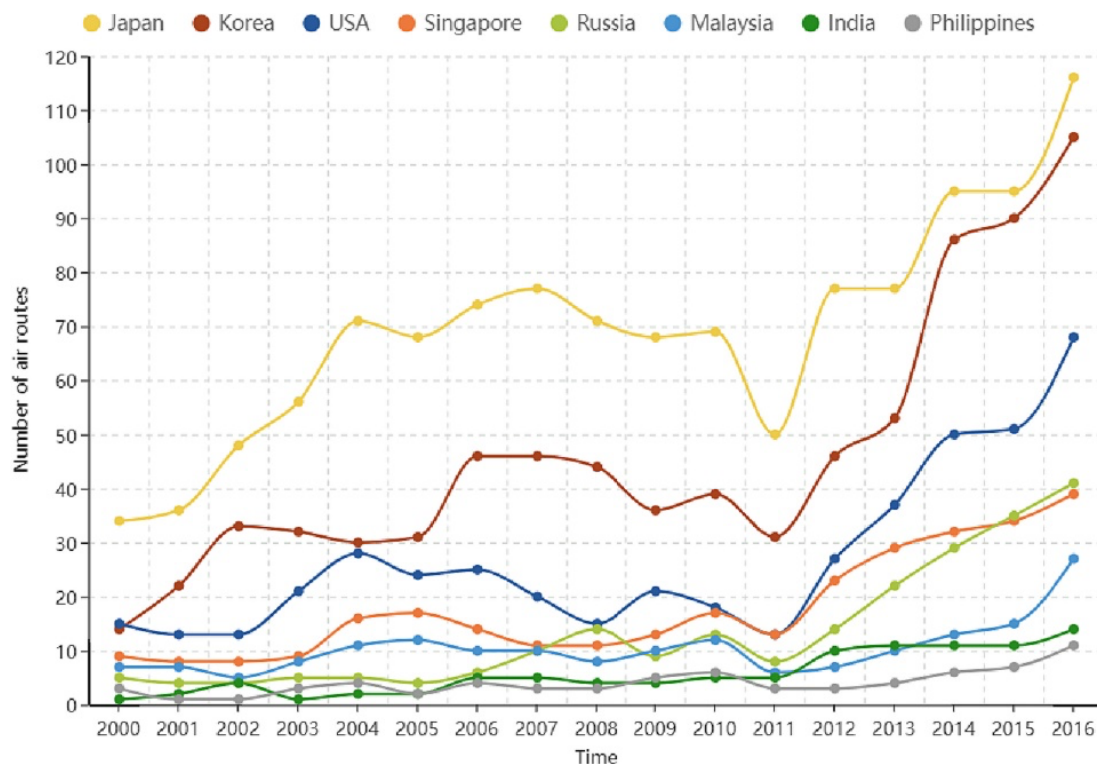
Source: Airbus Global Market Forecast 2023, International Civil Aviation Organization 2023,

Deregulation means that monopolies on routes are broken up, and private operators may enter the market (Agasti, 2022). Consequently, established flagship airlines are facing competition from private enterprises, leading to the rise of low-cost carriers such as Southwest in the United States, Ryanair in Europe, AirAsia in Asia or JetStar in Australia. This shift can be attributed in part to deregulation, which has enabled China to expand its international air routes from 133 in 2000 to 507 by 2013 (Wang et al., 2019).

Further to deregulation comes the privatisation of SOEs, which enhances the competitive landscape (Czerny & Lang, 2021). This makes flying more affordable (Kumari & Aithal, 2020) by maximising load factors on routes, optimising fleet planning, and developing market-driven networks (Denning, 2013). Historical data from US deregulation noted a 60% increase in passenger traffic and a 10% increase in cargo over one decade (Klein et al., 2020). Due to the purchase of additional aircraft, new routes may be added, which offers the possibility of connecting more people. Between 2000 and 2020, 324 B747 and 246 A380 were delivered to operators globally (Grimme et al., 2022). China, in particular, has grown its total flight by 68 times between 1979 and 2016, representing an average annual growth rate of 12% (Li & Yu, 2018).

A third factor contributing to increased international travel is the reduction of barriers, including the implementation of visa waivers. This macroeconomic phenomenon has been particularly evident in the context of China, which has established visa waivers with South Korea, Thailand, Russia, and an additional 43 nations. As depicted in Figure 1.4, the removal of visa requirements for South Korea in 2013, Japan in 2015, and Malaysia in 2016 coincided with a notable surge in air connectivity (Tang et al., 2023).

Figure 1.4 Number of air routes between China and selected countries



Source: (Tang et al. 2023)

Regarding **cargo traffic**, growth is observed on three grounds:

Firstly, flying cargo is increasingly becoming economically feasible as a result of enhanced efficiencies, particularly through the optimisation of loads facilitated by advancements in technology. (Klein et al., 2020). Secondly, the rapid transportation of capital-intensive goods, such as electronics, as well as perishable items like fruits and flowers, can justify the associated costs. For example, electronics are lightweight and subject to rapid obsolescence, making airfreight a cost-effective option compared to the lengthy three-month shipping process. Thirdly, air transport offers significant technical advantages, particularly in connecting remote regions, such as landlocked countries, which may have limited or no access via maritime or rail networks.

In this sub-section 1.1.1, the continuous growth trajectory in the commercial aviation industry and its economic impact on passenger and cargo traffic are discussed. The next sub-section, 1.1.2, will outline the importance of SCs in aviation and outline some relevant topic areas, such as Supply chain resilience (SCR), the status, key themes

such as collaboration, capacities management, and risk management, and introduce some key attributes of SCR.

1.1.2. Theme 2: Vital role of SC to the industry

This sub-section aims to discuss five topic areas:

- Importance of SC in aviation,
- Outsourcing to the SC as a strategic element of business decisions,
- Concept of SCR through the illustration of a typical SC,
- Key themes from the literature and
- Key attributes of SCR.

Importance of SC in aviation

As technology advances, there is a growing expectation among regulators, airlines, and passengers for aircraft to enhance safety through the integration of additional systems and redundancies while also achieving greater cost efficiency via global sourcing from countries with optimal cost structures. Consequently, this trend leads to a gradual increase in complexity, both in terms of product development and within the SC framework (Adobor, 2020; Brown, 2017; Denning, 2013; Christopher & Peck, 2004). Furthermore, innovative technologies are being created and incorporated throughout the SC, including hydrogen, fuel cells, electrification, battery-powered engines, and single-pilot operations. (Musa Ardo et al., 2022). Original Equipment Manufacturers (OEMs) depend heavily on the SC to provide components for final assembly lines, such as those located in Toulouse, France, for most Airbus aircraft or in Everett, Washington, where Boeing conducts its final assembly. Additionally, the proportion of outsourcing has risen markedly over the last five decades, with some contemporary aircraft models exhibiting an outsourcing rate that reaches as high as 80% of the total aircraft value (Singamneni et al., 2019; Denning, 2013; Wu et al., 2013). The ability to satisfy increasing demand within the SC is achieved through investments in machinery and the presence of qualified personnel and operators. Consequently, it is crucial for suppliers to adhere to timelines, maintain quality standards, and control costs to avoid adversely affecting the OEM and its ability to deliver aircraft to airlines.

Outsourcing, a strategic business decision

The production of significant aircraft components, including the fuselage, doors, engines, avionics, systems, cabin furnishings, and interiors, is conducted across a global SC because of strategic business decisions. Following their delivery, these components are assembled by the OEM into fully operational aircraft (Singamneni et al., 2019; Aguila, 2018; Chowdhury & Quaddus, 2017). A sufficient degree of resilience within the SC is thus strategically essential for the effective functioning of the aircraft manufacturing model. (Gössling, 2020; Raj et al., 2015; Pettit et al., 2010).

As companies evolve in their lifecycle, the need for outsourcing increases due to cost sensitivity, availabilities of technology, capacity optimisation and capability reasons (Han et al., 2017; Wang, 2017; Horgos & Tajoli, 2015). Companies, particularly in the aviation industry, move from being a manufacturer (having a high in-house-manufacturing ratio) to being an integrator (managing requirements and integrating the final sub-components such as wings, fuselage, engines, systems, and the cabin). For example, older models, such as the B727 or the A300, had less than 20% of outsourced content (Denning, 2013; Pritchard & Macpherson, 2004), whereas newer models, such as the B787 Dreamliner or the A350 XWB, reach levels of up to 80% (Boeing Commercial Airplanes, 2016; Wu et al., 2013; Doerfler et al., 2012; Cooke & Ehret, 2009). As the OEMs strongly rely on the external capability and capacity of suppliers (they no longer have these internally), the SC must be able to demonstrate a strong degree of resilience and be able to deliver no matter the adverse condition, as illustrated in the following example.

Concept of SCR: a typical work package is expected to delineate the context of the global framework, elucidate the connections among SC participants, and underscore the regulatory challenges associated with the SC configuration within the aviation sector (Meijer, 2022; Schmuck, 2020).

Beginning at the upstream segment of the value chain, the procurement of raw materials, specifically aluminium, must occur from certified and qualified mills, many of which are situated in the United States. This aluminium is subsequently processed and distributed by authorised distributors, including those based in Germany

(Schmelzle & Mukandwal, 2023; Gibbons et al., 2021). Following this, approximately 20 to 30 specialised processes involved in the manufacturing of components—totalling nearly 3,000-part numbers for a passenger door—must be validated and are subject to regular audits conducted by independent auditors, particularly in China (Hughes, 2022; Magnusson & Pettersson, 2019). In addition to the raw materials and metallic components, various mechanisms, rods, and equipment must be sourced, each accompanied by specific drawings and part numbers from approved suppliers. The tier-1 supplier bears the responsibility of coordinating material flows from a diverse array of suppliers, ensuring that all sources meet qualification standards (Saraçyakupoğlu, 2020). Furthermore, traceability to the original source is maintained, ensuring that all components arrive precisely when needed for the assembly process, adhering to standards comparable to those in the pharmaceutical industry (Uddin, 2021). At last, quality inspection occurs, foreign objects are cleared, and testing and interchangeability are confirmed. The work package is subsequently dispatched to the OEM, whether located within China, Europe, or the United States, considering the lead times associated with logistical flow. Furthermore, it is imperative that all relevant documentation accompanies the work package to guarantee complete traceability, a critical requirement within the industry (Ståhl et al., 2017).

In the context of theme two, which addresses the significance of SCR in the aviation sector, several critical aspects warrant attention for further exploration. These include the status, essential attributes, and pivotal themes such as dynamic capabilities, skills and competencies, organisational agility, capacity management, process definition, governance, and outsourcing strategies, all of which will be examined in subsequent discussions.

Status of resilience in SC

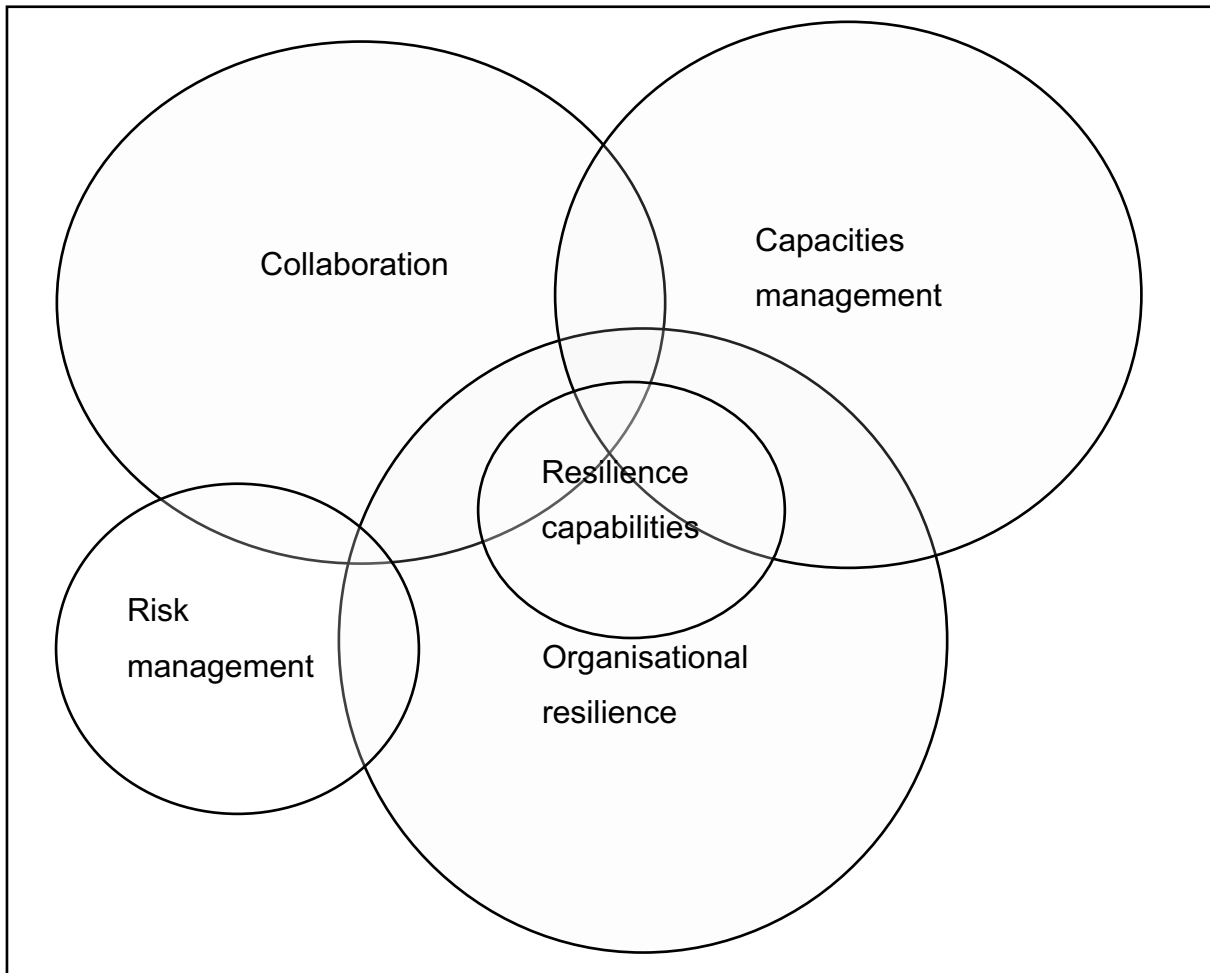
The resilience of the aviation industry is currently precarious, having endured substantial challenges from recent disruptions. These include the restrictions imposed due to the COVID-19 pandemic, ongoing conflicts in Ukraine and Israel, rising inflation and interest rates, as well as uncertainties surrounding energy supply and the transition towards sustainability goals, particularly in relation to CO₂ emission reductions (Shen & Sun, 2023; Nikookar & Yanadori, 2022). Furthermore, significant

delivery delays are observed, material shortages occur, delays in aeroplane deliveries to airlines and operators arise, and recalls are to be expected due to quality issues, labour force unavailability or not sufficiently qualified staff (Shen & Sun, 2023). These delays originate in the SC where, for reasons of globalisation, SCs have expanded globally: it is observed that resources and skills have vanished, and dependencies have increased significantly without a full partnership approach with suppliers (Shen & Sun, 2023). Due to this context, the status of resilience is fragile, and key themes such as collaboration, risk management, resilience and capacities management (Feizabadi et al., 2021; Gligor et al., 2019) will be discussed next.

Development of key themes that emerge from the literature

Five categories emerge from the literature review and outline key considerations, themes and attributes about resilience in current SC literature, including a bibliometric analysis of co-occurrences of attributes associated with resilience (Moosavi et al., 2022a; Rajesh, 2022; Suryawanshi & Dutta, 2022). They are illustrated in Figure 1.5. These five categories include organisational resilience, risk management, capacities management, collaboration, and resilience capabilities (Shishodia et al., 2023; Shekarian & Mellat Parast, 2021; Zhang et al., 2020). Each of these will be briefly outlined below, followed by a detailed discussion in the literature review chapter (Chapter 2).

Figure 1.5 Current themes of discussion about resilience in supply chains



Source: Prepared for this research

1. **Organisational resilience**, part of parent discipline 1, discussed in sub-section 2.2.3 (Kamalahmadi & Parast, 2016; Stevenson & Spring, 2007) proposes little consensus; however, the literature distinguishes: (1) resilience as an outcome, (2) resilience as a process, and (3) resilience capabilities (Pretorius et al., 2022; Ivanov, 2021a). Organisational resilience is defined as *“a firm’s ability to effectively absorb, develop situation-specific responses to, and ultimately in transformative activities to capitalise on disruptive surprises that potentially threaten organisation survival”* (Lengnick-Hall et al., 2011, p. 244). Organisational resilience and its characteristics will be discussed in detail in Chapter 2 (Section 2.2.1) with a specific focus on the aviation industry and its constraints (highly regulated, long development cycle).

2. SC **risk management culture** (Sawyer & Harrison, 2020) operates with structured corporate **governance** (Lu et al., 2023; Lin et al., 2023). The cultivation of culture within management teams, along with the enhancement of risk management awareness and the implementation of knowledge management, are essential themes concerning the resilience of SCs (Meuwissen et al., 2019). Subsequent research will provide an in-depth examination of risk management perspectives, specifically relating to the aviation sector, which is characterised by a risk-averse culture. This aspect will be elaborated upon in Section 2.2.1 of the literature review.
3. **Capacities management**, in the context of SCs, is about the predictability of demand (Urciuoli et al., 2014; Skilton, 2014; Krause et al., 2000). Recent instances, particularly in relation to COVID-19, involve the provision of vaccines and the ongoing simulation and enhancement of demand predictability models in partnership with various stakeholders (Dubey et al., 2021). This attribute of resilience is linked to item four: collaboration within the SC. Additional investigation into capacity management within the aviation SC is necessary. This attribute will be examined in relation to skills management in Section 2.2.1. Furthermore, capacity management will be analysed from a technical standpoint in Section 2.3.2, as it is a crucial element of resilience.
4. High level of SC **collaboration** as a topic area is observed, including the effective information sharing that is often discussed in the logistics industry (not specifically in the aviation context) refers to information sharing, risk and revenue sharing, contract flexibility, building social capital (Al-Talib et al., 2020). Supply chain management (SCM) extends beyond the mere competencies involved in ordering components; it fundamentally encompasses the collaborative relationships established with suppliers within a defined governance framework (Essex et al., 2016; Mangan & Christopher, 2005). This feature will be discussed in detail in the section “key components of resilience” specific to the aviation industry in Section 2.3.2.
5. **Resilience capabilities** are situated within the wider organisational resilience (see item 3) (Scholten et al., 2019) and primarily focus on anticipation capabilities, coping capabilities, and adaptation capabilities (Munir et al., 2022; Bledy et al., 2018; Kamalahmadi & Parast, 2016). This study will examine the

three forms of resilience capabilities within SCs, specifically in the context of aviation. These dimensions include anticipation capabilities, coping capabilities, and adaptation capabilities. A more detailed exploration of these critical phases of resilience will be provided in Section 2.3.4.

Key attributes of SCR

The resilience of the SC within aircraft manufacturing focuses on cultivating essential attributes such as dynamic capabilities, skills and competencies, organisational agility, capacity management, process definition, and governance. (Ambulkar et al., 2015a; Tukamuhabwa et al., 2015a; Mckinnon, 2014). Each of these attributes will be succinctly presented in sequence to establish a foundational context for this research, with a more comprehensive discussion to follow in Chapter Two (Section 2.3 on SCR). The attributes under discussion are not independent of one another and frequently appear as recurring themes within the literature.

The first attribute of a SC is the possession of **dynamic capabilities**. This attribute can be interpreted as a systematic approach through which organisations deliberately reorganise their resource foundations to enhance their responsiveness to fluctuations within their operational environment (Brahmana et al., 2019; Masteika & Čepinskis, 2015; Teece & Augier, 2008). DCT originated from the understanding of wealth generation by private firms operating in rapidly evolving technological landscapes (Bleady et al., 2018; Teece, 2007). In recent years, this theory has been applied to SCs, particularly as the integration of technology, including digitisation and electronic connectivity among organisations, has become more prevalent (Felsberger et al., 2022; Teece et al., 2009).

Dynamic capabilities involve the evolution of existing operational capabilities through a transformative process characterised by sensing, seizing, and reconfiguring, ultimately leading to the development of reorganised capabilities (Laaksonen & Peltoniemi, 2018; Sadler et al., 2010; Teece, 2007; Eisenhardt & Martin, 2000). In contemporary scholarly discourse, the notion of integrating and coordinating learning has been introduced (Bleady et al., 2018; Lengnick-Hall et al., 2011). These dynamic capabilities are, amongst others, a firm's capability to reallocate resources in order to

evolve from a low degree of control over its SC to a higher degree of control (Pitelis, 2022; Kapoor & Aggarwal, 2020). When component quality issues and supplier performance decline occur, customer resources shift to quality management, involving SC audits and monitoring. Resilience, or the ability to recover, is measured by the time taken to return to normal operations, which can be improved through enhanced control mechanisms within cost, time, and quality constraints. Therefore, DCT is crucial for this research study.

The second attribute is the **skills and competences** that the SC consists of. Competences are context-independent knowledge that refers to experience-based and context-dependent knowledge (Santra, 2021; Mangan & Christopher, 2005; Larson & Gammelgaard, 2001). Competencies now extend beyond warehouse management to include skills that support transformation in a dynamic environment. Development is increasingly focused on cross-organisational skills rather than those limited to a single organisation. Key areas for skill enhancement include demand forecasting, SC planning, supplier relations, customer interaction management, production oversight, and the use of information systems for logistics and production management (Lorentz et al., 2013). A deficiency in essential skills has been recognised in the areas of supplier sourcing and supplier monitoring (Makarius & Srinivasan, 2017). The acquisition of these supplementary skills is essential for effective crisis management. For example, they enable the adjustment of warehouse conditions in response to shortages, enhance the management of demand and planning processes, facilitate the identification of alternative suppliers in the event of delivery failures, and promote the utilisation of digital tools for communicating demand effectively (Huo et al., 2015).

The third attribute is **organisational agility**. This attribute is particularly significant within a dynamic and technologically advanced context, as it is intricately linked to the principles of dynamic capabilities theory, which will be explored in greater detail in this research. The existing literature predominantly focuses on corporate social responsibility and environmental issues rather than on innovative methods for organising or reassessing the interdependencies of roles and processes (Dossou, 2018; Feng et al., 2017). A transition process is described as one in which an

organisation evolves gradually from coordinating and integrating duties and processes to accelerating and facilitating duties and processes (Dossou, 2018).

The fourth attribute, **capacities management** is the ability to meet demand with internal and external production means in order to avoid shortage (Hosseini et al., 2019; Kouvelis & Milner, 2002). The SC plays a crucial role in ensuring effective capacity management by executing the necessary activities. Understanding the attributes of capacity management, along with the rationale behind tactical and strategic decisions, can be enhanced through the lens of resilience.

A final attribute of SCR is **adequate governance**, which is about the collaborative dialogue between various stakeholders of the SC in order to facilitate the right information, at the right time, to the right stakeholder (Zimon et al., 2019; Attaran & Attaran, 2007). Effective governance is essential for fostering resilience, particularly through the lenses of communication, prioritisation, and operationalisation, which will be explored in greater detail in this subsequent research (Dolci et al., 2017).

These five attributes have been investigated in several studies (Haegele, 2022; Rajesh, 2022; Kamalahmadi & Parast, 2016) and identified by multiple sources (Kamalahmadi et al., 2022; Christopher & Peck, 2004) as being relevant for building resilience in the SC and to deliver a product or service from the SC to an OEM such as Airbus or Boeing. In addition, strategic decisions and long-term requirements shape SCR, which will be discussed next.

In summary, this sub-section 1.1.2 has discussed theme two by evoking an evolving technology that requires more SC collaboration, the increasing outsourcing ratio observed in OEMs as they focus on integration only, the concept of SCs by illustration of an example, the current status of SCs in a post COVID-19 world that is transitioning to a new equilibrium, five key topic areas and key attributes of SCs. The next section will introduce China's perspective in this research.

1.1.3. Theme 3: Introduction to the geographic focus of China

The previous section has explored the growth of the aviation industry, the importance of the SC in aviation, and the resilience within the SC. This section will take a specific view from the People's Republic of China's (China) lens about the resilience of the SC in the aviation industry by looking at China's economy, market access, air traffic development and the research gap in China.

China aviation growth

Since the 1990s, China's integration into global SCs has significantly propelled its economic activity (Choi, 2018; Jia et al., 2018; Albers & Chen, 2017; Mark, 2017). From the viewpoint of buyers, China presents an opportunity to leverage a labour force that is cost-effective, benefits from economies of scale, and is strategically located near major economic hubs, thereby enhancing market access (Wang-Lu & Valerio Mendoza, 2023; Fajgelbaum & Khandelwal, 2022; Fan et al., 2021). Conversely, for Chinese enterprises, this market access facilitates the internationalisation of their products and brands, promotes the transfer of technology, fosters innovation in processes, and may lead to increased profit margins and expanded global sales. Throughout the 2020s, China's significance as an exporter has been notable, with a trajectory of growth that positions it as the third-largest exporting nation (Kong et al., 2021; Li et al., 2021; Zhu et al., 2020).

Market access

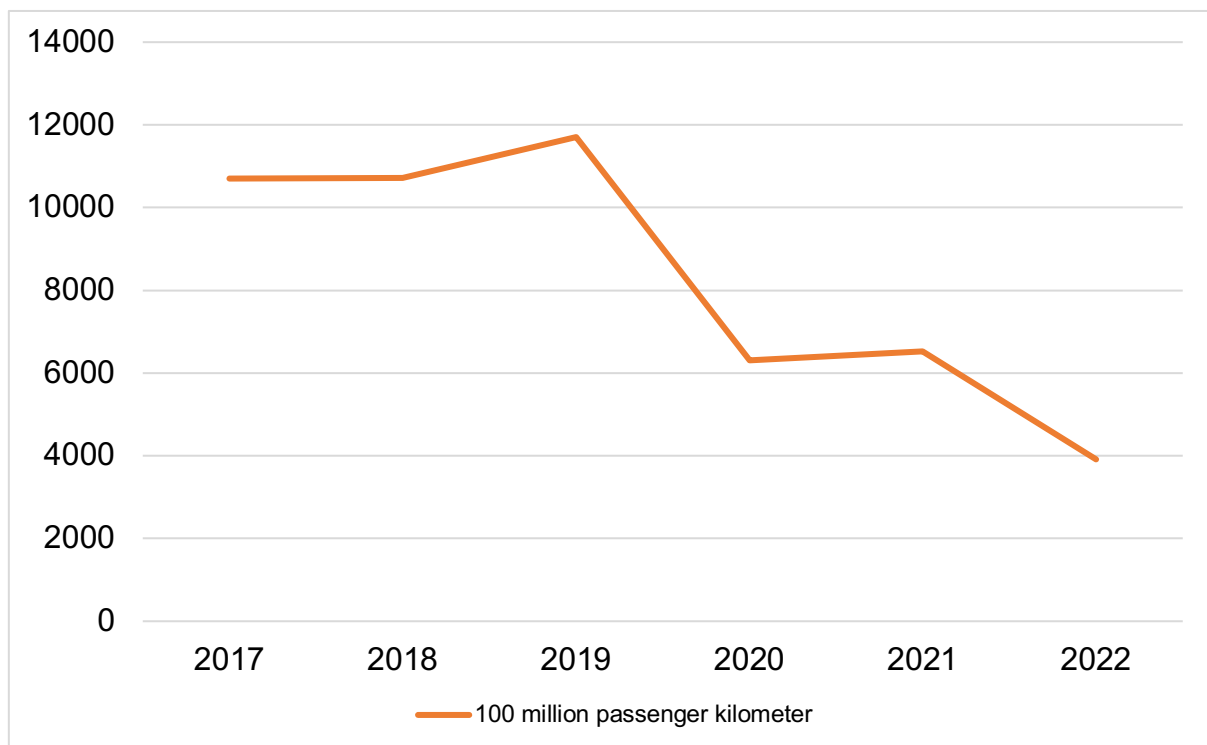
SCs for aviation in China have been growing since the 2000s (Gregson et al., 2015; Doerfler et al., 2012) due to increasing demand for aircraft, and this is evident by the significant order intake and the substantial delivery backlog. Enhancing production levels may alleviate immediate demand pressures; however, it is essential to establish long-term capacities. The growing intricacy of products, influenced by factors such as fuel efficiency, noise abatement, and other emission reduction mandates, necessitates the adoption of more sophisticated technologies. Specialised companies are equipped with advanced technologies, including automated tape laying for carbon fibre-reinforced plastic (CFRP), which offers weight advantages compared to metallic components, thereby decreasing the energy required for aircraft take-off and cruising (Banerjee et al., 2020; Ren et al., 2020). Additionally, alternative energy solutions,

such as hydrogen, eliminate carbon combustion and play a significant role in lowering carbon emissions (Zhao et al., 2022; Ren et al., 2021). China was able, through technology transfer programs, to access these technologies (Wübbeke et al., 2016). Market access opportunities and offset obligations require the OEM to allocate work packages to China that, in turn, commits itself to purchasing aircraft, such as the A320s, A350s or A380s (de la Tour et al., 2011). Therefore, technology transfer comes with application to an economic setting.

China traffic increase

According to the global RPK, China has grown significantly over the last decades to become a leading player in aviation traffic. China's RPK demand has grown at an average rate of 14.9% per annum from 1990 to 2010, outperforming global numbers significantly (Zhao & Wan, 2019; Fu et al., 2015), and this represented 0.230 trillion RPK in 2007 (Jia & Lamming, 2013a; Cliff et al., n.d.) and will reach 0.9 trillion RPK by 2022 (Scherer, 2019; Biermann et al., 2011). The COVID-19 pandemic, along with the grounding of aircraft, disrupted this trend, necessitating careful monitoring of the recovery to pre-pandemic levels, as illustrated in Figure 1.6.

Figure 1.6 Passenger turnover of Civil Aviation Industry in China 2018-2022



Source: Civil Aviation Authority of China, 2023

China's dependency and lacking open scholarly research

China's SC has become increasingly important in delivering parts, services, and designs in particular for cost-competitiveness or labour-intensive parts, such as for hand-layup CFRP parts or manual assemblies that cannot be automated (Goh & Chou, 2022; Miles & Snow, 2007). Nowadays, the SC in China is an integral part of delivering parts and components for any aircraft (Hart, 2022). Proximity to customer airlines makes the assembly of parts in China attractive from a cost and logistic perspective. The continued and further purchase of aircraft by China shows a continuous trend in this direction.

The growing importance of China in the global SC community is evident, but there is a lack of research on the topic (Golgeci et al., 2021). This lack of open and unbiased research may partially be due to the limited exposure of scholars, limited accessibility to information and possibly cultural and language barriers, as well as observed limited accessibility of the Internet from outside of China and some presumed central filtering (Piller et al., 2020).

In conclusion, Section 1.1 emphasises the increasing importance of global SCs, driven by technological advancements, economies of scale, market access, and strategic factors like risk distribution and the EU Green Deal. SCs are crucial for business operations, creating dependencies related to capacity, capability, and stakeholder goodwill. Thus, resilience in SCs is essential for managing deliverables effectively ensuring quality, timeliness, and cost-efficiency during uncertain times. In aviation, with its growth potential and global connections, resilience is not just beneficial but often necessary. *The thesis situates resilience within the frameworks of the Resource-Based View (RBV) and DCT. A discussion of these frameworks is conducted, focusing on the components and features, as well as the allocation of resources to enhance resilience in a dynamic environment. Recent findings pertaining to these components have surfaced in this heavily regulated industry, highlighting digitisation as a means to improve efficiency and transparency, particularly due to the industry's significant reliance on such advancements.* The emerging concept of resilience in China's aviation SC offers a valuable opportunity to explore its key components and their impact on SC dynamics, leading to the research problem and questions discussed in Section 1.2.

1.2 Research question, sub-questions, and objective of the research

This section will discuss the research question and sub-questions as well as their relationships to the overall objective of this research.

Since the COVID-19 pandemic, there has been significantly more research available about resilience in global SCs, working with redundancies and having capacities quickly deployed when demand emerges (Shishodia et al., 2023). Some research on resilience in the aviation industry is available that discusses important conceptual approaches such as SC strategies (Moosavi et al., 2022b; Gunasekaran et al., 2015), risk management (El-Baz & Ruel, 2021; Munir et al., 2020) and SC design (Browning et al., 2023). Recent research post-COVID-19 on aviation, however, focuses on the airline perspective, impacts on passenger traffic (Grimme et al., 2022; Piller et al., 2020) as well as auxiliary industries such as tourism (International Air Transport Association (IATA), 2023; Wang et al., 2019) and logistics (Dube et al., 2021; Abu-Rayash & Dincer, 2020).

A lack of research in the areas of SC, resilience, and aircraft manufacturing, especially in the context of China, is observed. Some pre-COVID-19 models and discussions on China SCs are noted (Li, 2018; Daniela, 2015; Wendt, 2015); however, they were deemed to be outdated due to the COVID-19 context. Nowadays, disruptions of SCs are no longer hypothetical but real-life threats that require an academic approach (Jia et al., 2020).

With respect to the **research focus**, it intends to discuss specifically the mentioned gaps in the literature by addressing the research question and sub-question of SCR in China's aircraft manufacturing industry with a detailed discussion on SCM (Section 2.2) and their approach to risk management in the SC (sub-section 2.2.1), SCM capabilities (Section 2.2.2), as well as resilience (Section 2.3), and the components of resilience (sub-section 2.3.2). Given the significant research gap that has been identified and the increasing importance of the context in China's aviation, the research question proposed is: ***"How and why does resilience affect SCs in the aviation manufacturing industry in China?"***

Research sub-questions

Two main research sub-questions (SQ) have been established to address the research question, which will be further illustrated below.

Sub-question 1

The **components contributing to resilience** in the SC of aircraft manufacturing require a more comprehensive understanding. These elements include inventory levels, quality performance metrics, the capacity to foresee and mitigate risks, ongoing improvement processes, and the incorporation of customer feedback (Feizabadi et al., 2021; Kamalahmadi & Parast, 2016). The literature proposes several themes related to other industries, which can help understand the problems related to China (Kovács & Falagara Sigala, 2021; Sprecher et al., 2015).

Risk management capability, contingency capacity management, availability of skills and knowledge management may all affect SCs (Abdallah et al., 2021; Goh & Loosemore, 2017). The SC characteristics may be delivery performance, stock levels, and quality defects (Hitt et al., 2016; Annarelli & Nonino, 2016). For example, a discussion around the impact of risk management capability and possible correlation to stable stock levels will be discussed in anticipation of shocks (Namdar et al., 2021). Therefore, the first research sub-question identified is:

SQ1: “What are the key components of resilience in the SC in the aviation manufacturing industry in China? How and why do these components influence SCs?”

Sub-question 2:

The second sub-question will explore the features of resilience that influence supply chains, either in a direct or indirect manner. A thorough examination of features of resilience in the literature review across various sectors, especially in energy production, identifies several critical traits, such as robustness, resourcefulness, rapid recovery, and adaptability. Nevertheless, the current body of literature does not offer a detailed investigation of resilience features specifically within the aviation manufacturing industry as discussed in section 2.3.2.

By acknowledging these features and their classifications, this study will propose targeted recommendations for organisations seeking to enhance the level of resilience levels within its supply chains.

SQ2: “What are the key features of resilience in the SC in the aviation manufacturing industry in China? How and why do these features influence SCs?” This sub-question is essential for addressing the overarching research inquiry: “ *How and why does resilience affect SCs in China's aviation manufacturing industry?*” This section has introduced the research question and how it is addressed by the research sub-questions SQ1 and SQ2. Next, Section 1.3 will justify this research.

1.3 Justification for the research

This section will justify the research based on three grounds: first, gaps in the current literature that this research aims to close; second, growing importance in the field of resilience in SCM; and third, relevance, contribution, and benefits to stakeholders. Each of these will be discussed in further detail below.

1.3.1 Gaps in the literature

There are three main themes identified in the literature that will be discussed further in Chapter Two and that will compose the gap in the literature (Section 2.4):

- SCM in China,
- Resilience in the aircraft manufacturing industry; and
- Resilience in the SC.

First, SCM literature predominantly addresses the subject from a logistics standpoint within the context of China, often overlooking the broader implications of operations management (Bednarski et al., 2023; Zhang et al., 2023). This research seeks to examine the entire value chain, encompassing the importation of raw materials, manufacturing processes, and the subsequent exportation to customers.

Second, discussions surrounding resilience in various industries tend to focus on sectors such as automotive, textiles, and semiconductors, which operate within a relatively low regulatory framework (Bednarski et al., 2023; Kamalahmadi & Parast, 2016). In contrast, there is a notable scarcity of literature addressing resilience in the aircraft manufacturing sector, particularly within the Chinese context (War et al., 2019). This research intends to bridge this gap by exploring the mechanisms of resilience specific to the aircraft manufacturing industry in China.

Third, the concept of resilience within SCs has gained prominence in the aftermath of the COVID-19 pandemic (Agrawal et al., 2023; Sharma et al., 2022). This research aims to investigate how minor disruptions can lead to significant consequences for businesses and to advocate for resilience strategies, recognising that economic dynamics have shifted in the post-COVID-19 landscape.

1.3.2. Growing importance of main themes: resilience, aviation and SCM

This sub-section will start by introducing the growing importance of the first parent discipline of resilience (sub-section 1.3.2.1), followed by an overview of the growing importance of aviation (sub-section 1.3.2.2), and the second parent disciplines of the research SCM (sub-section 1.3.2.3) will be discussed last.

1.3.2.1 Parent discipline 1: The growing importance of resilience

This sub-section will examine the rationale behind this research, emphasising the increasing significance of resilience, defined as the capacity to confront and navigate unforeseen circumstances. As the aviation sector undergoes a phase of internationalisation, its SCs are becoming progressively intricate, leading to the potential emergence of unexpected events from more distant regions, a phenomenon previously noted in other industries (Wied et al., 2020; Connelly et al., 2017; Tukamuhabwa et al., 2015c).

For instance, German automakers have assembled more vehicles outside of Germany than within their original facilities for a long time, and a complex SC system supports international operations (Boston, 2022). It is, therefore, of meticulous importance to understand how resilience can help manage unexpected events or prevent them from having impacts on the SCs, as has successfully been done in the automotive or food industry. The China context is of particular interest as it represents not only one of the main future growth engines of aviation but also due to its distinct context with SOEs, intervention from the State, planned economy set-up and several challenges related to emerging economies (including access to skilled labour, stabilising infrastructures, regulatory burden).

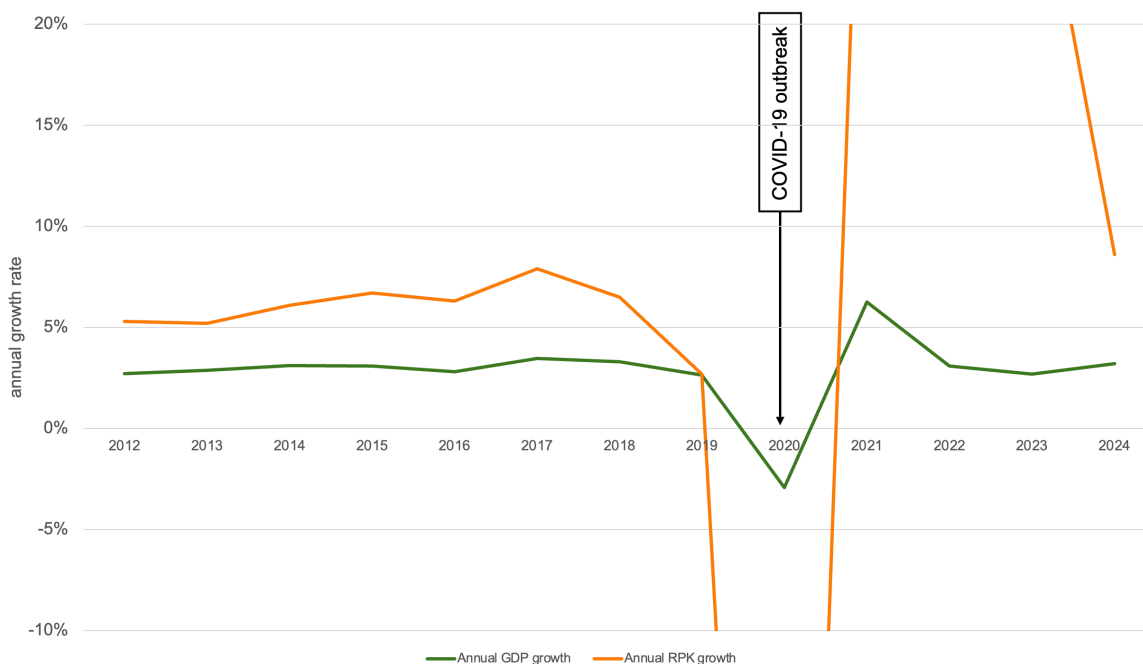
1.3.2.2. Growing importance of aviation and need for resilience

Aviation traffic has been growing at a rate of 4.8% per year, as illustrated in Figure 1.7 and is to double by the end of the next decade, fuelled by passenger demand for more distant travels (Yang et al., 2018; Boeing Commercial Airplanes, 2016). In Figure 1. 8, a long-term measure shows RPK (revenue passenger kilometres) growth in absolute numbers in which one billion RPK was reached in 1978, two billion RPK in 1990, three billion in the year 2000, four billion in 2007 and five billion RPK were surpassed in

2011 (ICAO). These numbers indicate the continuous as well as the exponential growth of RPK, meaning it took nearly 30 years to reach one billion RPK and the next billion was added within 12 years and yet an additional billion was added within ten years, then seven years, and four years (IATA 2024, Jin & Chen, 2019; Yao et al., 2014). Projecting this into the future, more and more RPK are added in a short timeframe, which is a signal of market need and business requirement and favourable for the aviation industry in creating more jobs (Lenaerts et al., 2021; Zhang et al., 2020) as more aircraft enter fleet operations and more aircraft are manufactured per year.

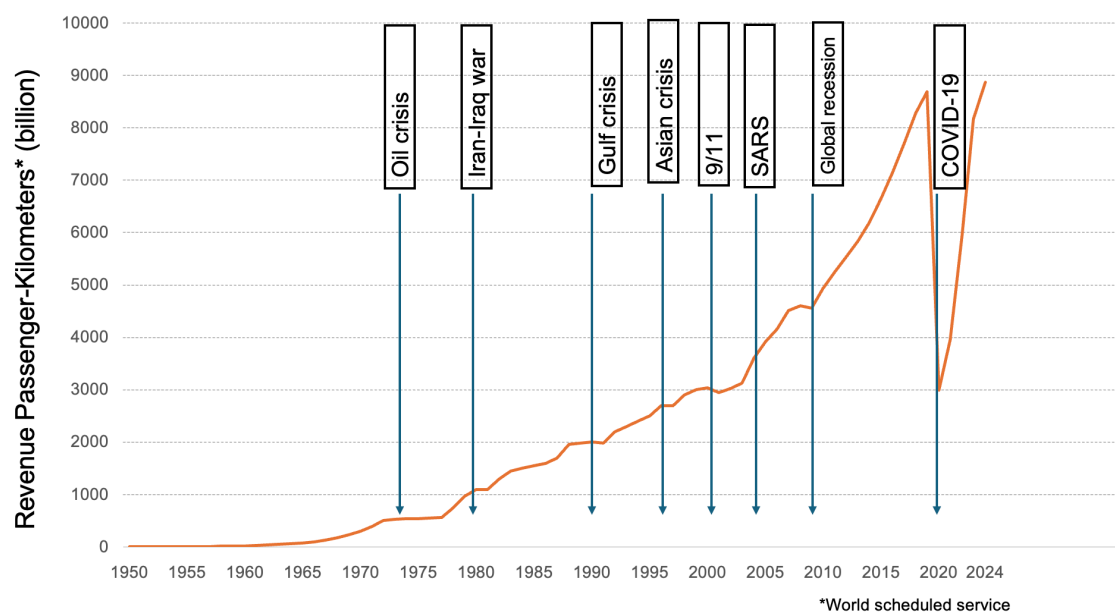
In summary, the significance of aviation for both business and the economy are emphasised by the observed pattern of rapid growth. Notwithstanding major geopolitical events such as the oil crisis, the Iran-Iraq war, the Gulf crisis, the Asian financial crisis, the September 11 attacks, the SARS outbreak, the global financial crisis, and the COVID-19 pandemic, the aviation sector has consistently demonstrated a capacity for recovery, with annual growth rates rebounding relatively quickly after these disruptions. This resilience is crucial for minimising potential delays in restoring operations to pre-impact levels (Sun et al., 2022).

Figure 1.7 World economic growth vs air traffic growth (passenger and freight)



Source: (International Civil Aviation Organisation, 2024; World Bank, 2024)

Figure 1.8 World aviation 1950 – 2023 in RPK and external shocks



Source: (International Civil Aviation Organisation, 2013; IATA website, 2024)

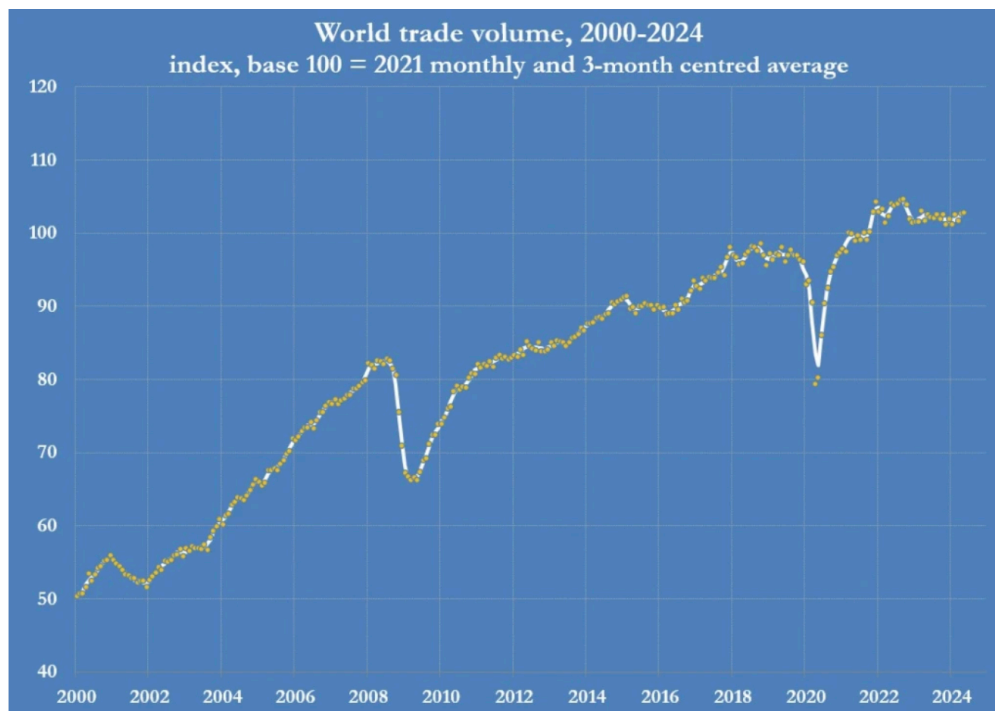
1.3.2.3 Parent discipline 2: SCM and importance of resilience

Global SCM is becoming progressively vital to the economy, characterised by three essential aspects that will be discussed in this section: the volume of trade, the availability of technology, and the accessibility of markets. More importantly, global SCs are becoming increasingly complex and intertwined, and this complexity needs to be managed, in particular with respect to the need for resilience (Iftikhar et al., 2022; Yin & Ran, 2022). This increasing complexity makes resilience even more important, and the augmented dependencies need to be adequately managed (Kamalahmadi et al., 2022). Themes such as collaboration and connectivity have become more and more important, even a prerequisite when managing global flows of material, production, and customer demand (Lotfi & Larmour, 2022; Al-Talib et al., 2020). This need for resilience has been shown in several other industries, such as automotive (Kamalahmadi et al., 2022; Balakrishnan & Ramanathan, 2021), textile (Kazancoglu et al., 2022; Xu et al., 2021) and agri-food business (Kaur & Singh, 2022). This research will discuss these themes for the aviation industry, specifically the manufacturing of aircraft, considering the high degree of regulation by airworthiness authorities and other quality requirements.

Trade volume importance for SC

The volume of trading in USD terms (international trade) is remarkably increasing. This trend of world merchandise trade is shown in Figure 1.9 below. Out of the global trade, which represents USD\$30.5 trillion, manufacturing output worldwide represents USD\$16 trillion in 2022 (World Bank 2023, World Trade Organisation, 2024).

Figure 1.9 World trade volume 2000-2024



Source: (Netherlands Bureau for Economic Policy Analysis, 2024; World Trade Organisation, 2024)

SCs play a crucial role in facilitating this growth trajectory, necessitating the establishment of a robust and resilient SC to sustain it. There exists a proportional relationship between trade volume and SC dynamics; as trade volume escalates—resulting in increased production within factories—the demand for components, raw materials, and semi-finished goods also rises. Furthermore, these products are subsequently distributed to other enterprises in business-to-business contexts or directly to end consumers. Effective distribution of these goods mandates comprehensive SCM and the implementation of appropriate logistical channels, including transportation and warehousing.

Access to technology and SC

Second, in terms of access to technology and knowledge, SCs connect global centres of competence with key companies (Phan et al., 2019; Goh & Loosemore, 2017; Mhlana, 2017). Technology clusters (hydrogen technology, battery technologies, autonomous flying, sustainability research) or ecosystems (access to venture capital, investment incentives) offer access to critical technologies, enablers or markets that otherwise would not be accessed. For example, the ‘LuFo’ initiative in Germany is

joining key players from various domains to jointly design and develop technologies that would lead to electrified aeroplanes: companies developing batteries, others working on engines, others on an airframe, others on wiring systems for high voltage (Lay et al., 2022). Consequently, SCs serve as an essential link in maintaining competitiveness and strategies for future developments. With foundational systems established in China, the government is now seeking to enhance its capabilities by acquiring more sophisticated technologies. This includes not only assembly and labour provision but also access to intricate technologies, assemblies, and advanced components such as systems, engines, and various other parts.

Access to markets and SCR

SCs are relocating closer to customers by establishing factories and distribution centres. Entering a new market requires careful consideration of customs regulations, infrastructure, and risk management. Recent developments in China, especially as certain sectors like aviation open, demand a more nuanced understanding.

In the context of market accessibility, SCs are increasingly relocating closer to their customer bases through the establishment of factories, distribution centres, and other economic activities. This expansion into new markets necessitates a thorough examination of its specific implications, including customs regulations, infrastructure considerations, and risk management strategies. The recent developments in China, particularly as the economy begins to open in select sectors such as aviation, warrant a deeper understanding.

Moreover, passengers and airline clients have heightened expectations regarding aircraft, demanding adherence to safety, quality, and environmental standards, as well as long-term economic viability. Given that up to 80% of aircraft components are sourced from suppliers and partners, effective SCM is crucial in meeting these expectations for enhanced safety, superior quality, and environmental responsibility (Doerfler et al., 2012). This means SCs must deliver more components, such as aircraft parts and components with at least the same level of quality, for a competitive price achieved through productivity and efficiency gains. This increased complexity in parts requires a higher level of resilience in the SC (Iftikhar et al., 2022).

1.3.3 Relevance and contribution on resilience in SC

The final rationale for this research pertains to its significance for various stakeholders, including aviation regulatory bodies such as EASA, FAA, and CAAC, as well as interest groups such as IATA and, ICAO and local governmental entities. These stakeholders stand to gain valuable insights into how resilience within SCs can influence aircraft safety, enhance capacity and economic prosperity, and improve the appeal of a region to investors and clients when a robust SC is in place. This understanding will empower policymakers to make informed decisions regarding safety regulations (such as airworthiness directives), implement tax incentives to foster capacity growth and stimulate job creation and tax revenue through the attraction of foreign direct investment (Adedoyin et al., 2020; Saidi et al., 2018). Such initiatives can be interpreted as a commitment to investing in resilience, encompassing aspects like capacity, workforce, and skill development. With the knowledge acquired, policymakers could formulate safety protocols that must be followed within the SC. Additionally, a comprehensive understanding of infrastructure requirements will enable policymakers to prioritise appropriate measures that support the advancement of SCs (Banerjee et al., 2020; Yang et al., 2020).

In conclusion, Section 1.3 has articulated the significance of the research on three fronts: the existing gaps in the literature, the critical role of aviation in the economy, and the perspective of stakeholders. The subsequent section will outline the research methodology.

1.4 Research methodology

This section outlines the qualitative research methodology, consisting of a two-phase design. The first phase involves semi-structured interviews with industry specialists, while the second phase includes case studies. A detailed discussion of these methods will be in Chapter Three, with objectives summarised in the following paragraphs.

The aim of stage one is to:

- Verify the relevance of the literature review key themes,
- Build a common understanding of definitions,
- Gain further insights about the relevant context; and
- Develop the most appropriate framework for conducting the case studies that will follow in stage two.

This aim was achieved by conducting approximately ten semi-structured, in-depth interviews with industry experts using open-ended questions (Rosenthal, 2016; Lewis, 2015; Creswell, 2013). This technique will be elaborated upon in sub-section 3.3.2. The interviews are evaluated by thematic analysis.

The aim of stage two is to:

- Answer the research question and sub-questions,
- Identify specific case-setting for novel knowledge gained; and
- Contrast variables of different cases, in particular components and features of resilience.

Stage two adopted a case study methodology because this research is exploratory in nature, and there are no prior research studies in this specific area. This methodology also supports exploring the complexity and dynamism of the background within the organisational settings and proceedings (Terluin, 2003; Capros et al., 1999). A multiple case study methodology was employed to ensure that the research conducted offered a comprehensive analysis of the observed phenomenon and accomplished both literal and theoretical replication. (Boulaksil et al., 2021; Perry, 1998a).

Stage two was based on nine cases with two interviewees in each case, leading to a total of 18 case study interviews (Song et al., 2016; Teegavarapu et al., 2008; Ghoris,

2007; Hinkin et al., 1997). This section has outlined the rationale for this research's two-stage qualitative methodology. A preliminary estimate of 10 interviews and nine case studies has been introduced and is being discussed in Sections 3.2 and 3.3 in detail. The next section will present an outline of the thesis structure.

1.5 Outline of the thesis structure

This section outlines the structure of the research and summarises the key elements of each chapter. The thesis is structured in six chapters with the following content (Perry, 1998b).

The introductory chapter presents the background of the research. The objective (Section 1.2) of the research is discussed, as well as the resulting research questions. Justifications for this research are presented in Section 1.3. In sequence, the methodology of the thesis is introduced in Section 1.4 before the structure is outlined in Section 1.5. The delimitations of this study are set out in Section 1.6. Chapter One is concluded in Section 1.7.

Chapter Two's literature review begins with an overview in Section 2.1, followed by discussions on SCM (Section 2.2) and resilience (Section 2.3). Section 2.4 highlights literature gaps, while Section 2.5 introduces a preliminary theoretical model, concluding with Section 2.6.

Chapter Three details the research methodology, starting with the chapter structure in Section 3.1. Section 3.2 explains the rationale for the research paradigm, and Section 3.3 outlines the research design, including in-depth interviews and case study research. Data analysis is covered in Section 3.4, limitations in Section 3.5, and concluding in Section 3.6.

Chapter Four focuses on the in-depth interviews and data analysis, beginning with contextual background in Section 4.1. Results, including participant profiles and insights, are presented in Section 4.2, followed by a revised theoretical model; in Section 4.3 and concluding in Section 4.4.

Chapter Five introduces case study findings in Section 5.1, discusses the case study organisation in Section 5.2, explores the research sub-question in Section 5.3, and concludes in Section 5.4.

Chapter Six synthesises an overall conclusion, starting with an introduction in Section 6.1. Section 6.2 discusses the conclusion related to the sub-questions, Section 6.3 addresses the main research question, Section 6.4 outlines implications for theory, Section 6.5 covers practical implications, Section 6.6 summarises research limitations, and Section 6.7 suggests future research directions whilst the conclusion is drawn in Section 6.8.

1.6 Delimitation of scope

This section discusses some delimitations of the scope of the research (Air Transport Action Group, 2018; Kar & Pani, 2014). As this research is bound by a limited number of samples, the conclusion and findings cannot be generalised. Furthermore, three delimitations are briefly considered hereafter: the geographic context of China, industry-specific: commercial aviation, business to business (B2B) supplier manufacturing specific view.

Geographic context: China

The initial limitation pertains to geography, specifically addressing China as it undergoes a transition from a planned economy to a market-oriented one. The research outlines, to a certain extent, the dynamics of this transition and its effects on both society and the manufacturing sector (Xu et al., 2018; Perkmann et al., 2013). Specifically, China is continuously growing economically (Xu et al., 2021; Li & Yu, 2018; Peterson Institute, 2008) despite global issues (trade, pandemic), thereby attracting international and domestic talents and skills and a growing manufacturing portfolio (Zhu et al., 2017). It is also to be noted that aviation is of strategic importance to the Chinese government and, therefore, attracts support from institutions, regulators and lawmakers in a privileged setting (Li, 2018). The status of the industry in the territories of Hong Kong and Macau's special administrative regions, as well as the island of Taiwan, is not within the scope of this research and will not be addressed whatsoever.

Industry-specific: Commercial aviation

The second limitation pertains to the manufacturing of commercial aircraft, which operates within a significantly more regulated framework than its military counterpart. This sector aims to achieve an optimal equilibrium in decision-making processes (Soshkin, 2016) concerning cost, scheduling, weight, and fuel efficiency. Moreover, the commercial aviation landscape is limited to a few players (essentially a duopoly between Airbus and Boeing). Furthermore, commercial aviation offers a context of shared information and communication and reporting where the visibility of information is deemed more reliable and transparent than in the military (Liao, 2015). Other industries do not share many of the characteristics such as (very) high development

costs and long cycles, high switching costs within the SC, rigorous regulatory burden, demanding testing requirements, continuous airworthiness, mandatory maintenance in approved stations by qualified staff, and a high degree of product complexity. It is therefore argued that the findings should not be compared to those of other industries, such as electronics, automotive, or pharma, as they are reasonably unique.

Supplier and manufacturing-specific

The third limitation of this study is its concentration on resilience within the context of SCM and manufacturing (Mckinnon, 2014). The research aims to provide a comprehensive understanding of the implications of resilience for both OEMs and their suppliers. While concepts such as inventory management, just-in-time (JIT) practices, single sourcing, quality control, globalisation, and productivity improvements are frequently discussed in the literature, there remains a significant gap in knowledge regarding the role of resilience as a mitigating factor during adverse events. This gap is particularly pronounced in emerging economies like China (Phan et al., 2019). The research will not investigate other domains such as design, customer services, or maintenance; moreover, it should not be generalised to areas other than SCM and resilience as key themes.

In summary, three delimitations have been identified that must be considered when contemplating the findings of this research: the geographic context of China, the commercial aviation sector, and the concept of resilience within SCM and manufacturing.

1.7 Conclusion

Chapter One established the foundational elements of the thesis. It commenced with an overview of the research topic in Section 1.1, highlighting the expansion of the aviation sector and the strategic significance and intricacies associated with China. In Section 1.2, the primary research question and its corresponding sub-question were articulated, drawing upon the limited existing literature. Section 1.3 provided a rationale for the research, grounded in three key areas: resilience, SCM within the aviation industry, and China's specific contributions. The research methodology was outlined in Section 1.4, which proposed a two-stage qualitative approach. Section 1.5 details the structure of the research. Section 1.6 delineated the scope of the study and concluded in Section 1.7. Consequently, the thesis will advance to the literature review in Chapter Two.

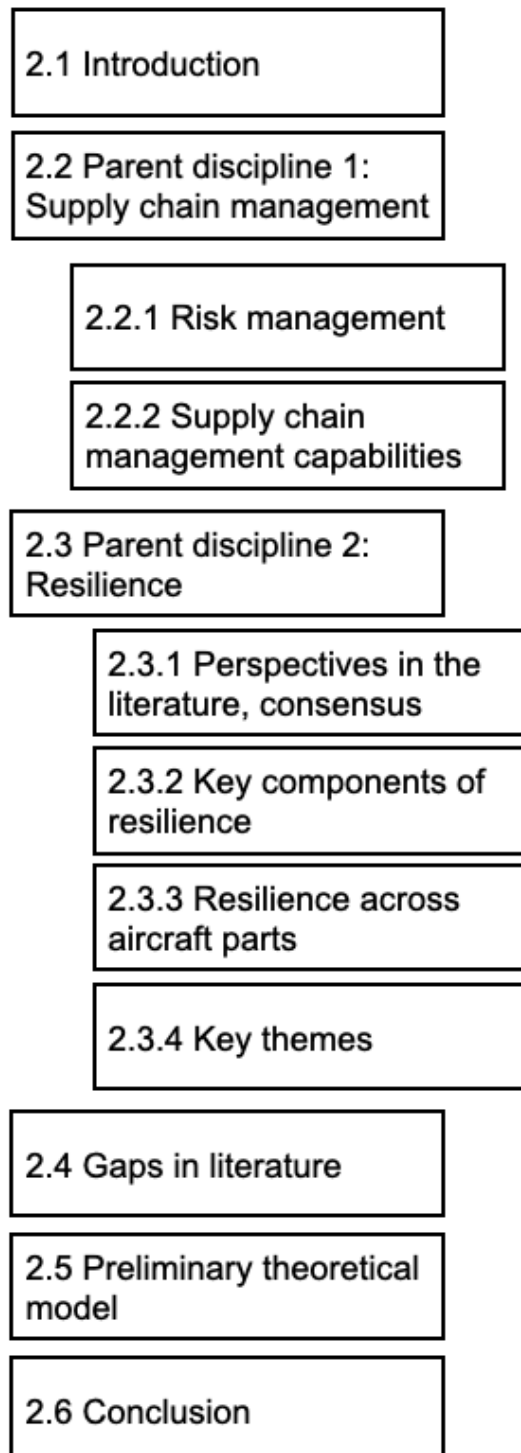
CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Chapter One introduced the research question relating to SCR in China's aviation industry and justified the research relevance. The objective of Chapter Two is to review the relevant literature (Belz, 2011a; Perry, 1998b) and to focus on the two key parent disciplines: SCM (Section 2.2) and resilience (Section 2.3).

This chapter is organised into six distinct sections, as illustrated in Figure 2.1. Section 2.1 provides a concise overview of the chapter's structure. In Section 2.2, the focus shifts to the primary parent discipline of SCM, encompassing aspects of risk management and the capabilities inherent to SCM. Section 2.3 delves into the second parent discipline concerning resilience in SCM, examining various perspectives found in the literature, achieving consensus, identifying key components, and offering insights into resilience across different categories of aircraft parts, alongside significant themes such as both direct and indirect influencing factors. Section 2.4 addresses the gaps identified within the existing literature and presents a preliminary theoretical model (Kaufman, 2015; Dupré, 2006; Perry, 1998c) to address the research gap put forward in Section 2.5 before drawing the conclusion in Section 2.6.

Figure 2.1 Outline of Chapter Two



Source: Prepared for this research

2.2 Parent discipline one: SCM

This section will discuss contemporary literature about SCM through a categorisation process and will elaborate upon two main themes: strategic risk management in SCM (sub-section 2.2.1) and operational SCM capabilities (sub-section 2.2.2).

Strategic risk management in SCM, the first theme, covers four topic areas derived from the literature:

- Strategic risk management capabilities (Dolgui et al., 2018b; He et al., 2017; Pettit et al., 2010),
- Organisational characteristics (Cruz-Cázares et al., 2013; Jia & Lamming, 2013a; Bhamra et al., 2011),
- Performance management (Kurth et al., 2019; Fahimnia et al., 2018; Dolgui et al., 2018b; Brown, 2017; Bowman Jr., 2015; Lockström et al., 2010); and
- Flexibility (in the SC) (Jain et al., 2017; Sreedevi & Saranga, 2017; Tukamuhabwa et al., 2015b; Falasca & Zobel, 2011; Ponomarov & Holcomb, 2009a).

As for operational SCM capabilities, the second theme, there were four topic areas as follow that derived from the literature:

- Stock and inventory management (Kovács & Falagara Sigala, 2021; Rezapour et al., 2017; Schmitt & Singh, 2012; Christopher & Holweg, 2011),
- Make or buy decision-making (Carr et al., 2012; Miles & Snow, 2007),
- Transportation and logistics (Chowdhury et al., 2021; Pečený et al., 2020; Feyissa et al., 2019; Monostori, 2018; Vinet & Zhedanov, 2011d; Galy & Germain, 2007); and
- Digitisation and dynamic planning (Ivanov, 2020; Vinet & Zhedanov, 2011e).

Once these two themes have been addressed, the second parent discipline on resilience will be discussed in Section 2.3 resilience.

Definition of SCM

McGaughey (2005, p.319) defines SCM as “the formal coordination and integration of business processes involving all partner organisations in the supply channel to measure, analyse and continually improve products, services, and processes to create

value and achieve the satisfaction of intermediate and final customers in the marketplace”. SCM is an essential factor in every firm in achieving competitive advantage and is, therefore, an important aspect that needs to be discussed in the context of this research and to address the research question “How and why does resilience affect SCs in the aviation manufacturing industry in China?” (Machado et al., 2020; Surbier et al., 2014; Li et al., 2003).

The definition adopted for this research is more suitable as it is more recent; it takes into consideration the management's responsibilities and actions and is not limited to a specific industry or geography. It is defined as “*the integration of members of a SC through management actions to enhance overall processes for strategic or operational purposes*” (Wieland & Durach, 2021; Kamalahmadi & Parast, 2016; Surbier et al., 2014; Vinet & Zhedanov, 2011b). This definition relates to the research adequately as it touches upon the SC community (suppliers) by referring to its members, it discusses the management actions which this research is doing during the interview of management, and the third element is the process enhancement that the research question is asking.

Literature categorisation

A comprehensive review of the SCM literature reveals that the identified subject areas can be categorised into two primary themes: strategic risk management within SCM (Gurtu & Johnny, 2021; Um & Han, 2021) and operational capabilities of the SC (Caiado et al., 2022; Farooq et al., 2021). Moreover, this category facilitates the practical implementation of theories and framework for decision-making within the business environment, as strategic risk management focuses on the 'what' and 'why', while operational SCM capabilities concentrate on the 'who', 'how', and 'when' (Kumar & Sharma, 2021; Luo et al., 2021). The categorisation is outlined in Table 2.1, which will be elaborated upon subsequently. These categories emerge from the literature, where risk management and SCM are frequently discussed in relation to the Supply Chain Operations Reference (SCOR) Model. The SCOR Model serves as a standardised framework for describing SC processes, performance metrics, best practices, and enabling technologies (Jamehshooran et al., 2015; Georgise et al., 2012).

Table 2.1 Themes and topic areas in the literature

Theme	Topic area	Example of Literature
Strategic Risk Management	Risk management capabilities	(Dolgui et al., 2018b; He et al., 2017; Pettit et al., 2010)
	Organisational characteristics	(Cruz-Cázares et al., 2013; Jia & Lamming, 2013b; Bhamra et al., 2011)
	Performance management	(Kurth et al., 2019; Fahimnia et al., 2018; Dolgui et al., 2018a; Brown, 2017; Bowman Jr., 2015; Lockström et al., 2010)
	Flexibility (in SC), i.e., changeover capability, adaptability	(Jain et al., 2017; Sreedevi & Saranga, 2017; Tukamuhabwa et al., 2015a; Christopher & Holweg, 2011; Ponomarov & Holcomb, 2009a)
Operational SCM capabilities	Stock and inventory management	(Kovács & Falagara Sigala, 2021; Rezapour et al., 2017; Schmitt & Singh, 2012; Christopher & Holweg, 2011)
	Make or buy decision-making	(Carr et al., 2012; Miles & Snow, 2007)
	Transport and logistics	(Feyissa et al., 2019; Monostori, 2018; Vinet & Zhedanov, 2011e; Peterson Institute, 2008; Galy & Germain, 2007)
	Digitisation and dynamic planning	(Ivanov, 2020; Vinet & Zhedanov, 2011e)

Source: Developed for this research

2.2.1 Key theme 1: Strategic risk management in SCM

This sub-section will discuss the first key theme of risk management in SCM and four topic areas:

- Risk management capabilities,
- Organisational characteristics,
- Performance management; and
- Flexibility in SCM.

Definition of risk management

“Risk can be understood as the potential for unwanted negative consequences that arise from an event or activity” (Ghadge et al. 2017, p. 313). Risk management is the process of how the SC deals with the risk, identifies, manages, controls and avoids negative consequences (Munir et al., 2020; Tummala & Schoenherr, 2011). Literature on risk management in SCM can be classified into four topic areas: (i.) risk management capabilities, (ii.) organisational characteristics, (iii.) performance management, and (iv.) flexibility in SCM. Each of these will be discussed in turn.

i. Risk management capabilities

The first topic area identified in the literature pertains to risk management capabilities, which underscore the proactive identification and strategic oversight of potential challenges from a process-oriented viewpoint. This perspective advocates for organised methodologies bolstered by a collaborative network of stakeholders alongside the essential condition of an organisation’s readiness to engage in risk-sharing (Sarkis, 2021; Lockamy, 2017; Sreedevi & Saranga, 2017; Zhao et al., 2013). Risk management capabilities involve detectability, which is the skills, knowledge, and management capabilities to identify a potential risk based, for instance, on data and information sharing (Qingyun Zhu et al., 2021). Skills, knowledge and management capabilities to support risk management capabilities are three fundamental components that are required to ensure adequate organisational readiness to face risk (Hock-Doepgen et al., 2021; Riley et al., 2016). Each of these capabilities will be discussed in turn.

First, **skills** are amply defined in literature as planning skills, negotiation skills, capability to develop a SC set-up and source parts and components from the market (Nazam et al., 2020; Bak et al., 2019). As such, soft skills required to cope with the challenges and opportunities of tomorrow have only recently been explored as these are new dimensions to the job of SC manager, such as concepts of industry 4.0 (Frederico et al., 2020; Dossou, 2018). The importance of soft skills in global SCs has recently gained recognition. Skills like persuasion, motivation, prioritisation, and trust-building are often not taught in traditional education but require personal feedback, role models, and emotional intelligence. Additionally, future competencies are increasingly tied to advancements in technologies such as data-driven reporting and tools that improve SC efficiency. As the aviation sector advances future products and concepts through digitisation, skill alignment is required to meet upcoming challenges. Key areas include innovative materials, streamlined regulations, enhanced aircraft electrification, augmented reality in manufacturing, and single-pilot cockpit operations.

Second, when talking about risk management capabilities, an adequate level of **knowledge** is required, which can be understood as the familiarity of the employee with processes tools and the capability of applying them on their job in a **knowledge management** culture (Ali et al., 2023; Marra et al., 2012; Samuel et al., 2011). Employee tenure is crucial, as it positively correlates with knowledge accumulation. Therefore, tracking the median years of service is essential for predicting the organisation's overall knowledge level (Nicolaescu et al., 2020). The second function of the level of knowledge is to determine to what extent the company formalises procedures (Centobelli et al., 2019; Oliva et al., 2019). For the aviation industry, these formalisations are governed by strict regulations, and procedures are standardised according to “standard operating procedures.” A high degree of formalisation can be deducted, and the level of knowledge is expected to be comparably higher than in industries without formalisation of procedures and where things are done out of habit (Maulini et al., 2022).

Third, **management capabilities** are the combination of skills, knowledge, tools, processes and behaviours in order to achieve a desired outcome (Saragih et al., 2020; Queiroz et al., 2019). These capabilities will need to evolve as the business reacts,

adapts or anticipates the business context of the future (Machado et al., 2020; Queiroz et al., 2019). The discourse on this topic has evolved significantly over the past decade. Initially, research focused on analytical models (Khan & Burnes, 2007), then shifted to quantitative models and phased methodologies (Tummala & Schoenherr, 2011; Tang & Nurmaya Musa, 2011), and later to conceptual frameworks on risks (Jüttner & Maklan, 2011). Recently, the effectiveness of these frameworks has been critically assessed (Cardona, 2013). Following the COVID-19 pandemic, there has been a heightened focus on SC disaster relief and managing complex global risks (Alicke et al., 2020; Junko et al., 2020). Understanding the integration of effective risk management strategies during crises is essential.

The existing literature of risk management capabilities. It is advisable to engage in further discourse fails to present a comprehensive model or a context-specific application concerning the three elements on this topic, which will be elaborated upon in sub-section 4.2.2 of this study, focusing on the components of risk management (Chopra et al., 2021; Kamalahmadi & Parast, 2016; Pettit et al., 2010). This is particularly pertinent as risk management is recognised as a fundamental aspect of resilience, as discussed in objective 3 of the in-depth interviews, and is also identified as a barrier to achieving resilience when it is lacking, as outlined in objective 4 of the in-depth interviews.

Within the theme of risk management, **data and information sharing emerge** as important elements. Information sharing within an organisation has the meaning of a cooperative approach to data and making this data accessible, understandable, transparent and accurate (Brönnimann, 2022). The higher the degree of complexity of a SC, the more data is generated on a continuous basis, such as delivery notes, quality non-conformities, payment data, etc. A decentralised approach can mean loss of data, poor decision making and potentially mediocre SC performance (Dubey et al., 2021). To successfully manage this data and utilise it for adequate risk management, a centralised Enterprise Resource Planning (ERP) system such as SAP or ORACLE with good data quality and shared data transmission will be critical and a pillar to the digitisation strategy of a company or even an ecosystem.

In the context of aviation, it is observed that companies operate complex databases that are highly specialised, however not accessible to different functions, not shared, and neither cooperative nor synchronised (Annarelli & Nonino, 2016; Fiala, 2005). Therefore, further discussion is required as to how the aviation industry plans to tackle this challenge of further integration (Lindkvist et al., 2013). The theme of digitisation as a key capability of SCM is discussed in sub-section 2.2.2.

ii. Organisational characteristics

The second topic area pertains to organisational characteristics, which encompass a wide-ranging concept that includes elements such as corporate strategy, governance, culture, and employee integration. Within the framework of risk management, organisational characteristics refer to the capacity and readiness of an organisation to incorporate innovation into its business model, thereby avoiding stagnation (Bak et al., 2019; Min, 2019; Ketchen et al., 2011).

Corporate strategy consists of two elements: the strategy formulation (shaped by authors such as Ansoff, 1965) and the strategy implementation (Engert & Baumgartner, 2016) in order to create a unique position for the company (Lanzolla & Markides, 2021; Islami et al., 2020; Porter, 1979) and create a competitive advantage (Galli-Debicella, 2021; Kiyabo & Isaga, 2020; Mintzberg, 1978). In the context of organisational characteristics, a linear relationship between the strategy and the performance is discussed (Oyewobi et al., 2016) that is influenced by the organisational characteristics such as organisational structure (Shuaib et al., 2021) and its ability to change and transform, management style which will determine the outcome (John-Eke & Eke, 2020) and decision-making style that only recently is acknowledged as being vital in determining results (Sinnaiah et al., 2023). The research will need to consider these recent changes in paradigm, in particular, the decision-making style importance on the outcome; for example, are decisions taken by executives and leaders in an intuitive way, is this intuition based on experience, feelings or on rational data and what is the speed of the decision making that is observed (Zhu et al., 2021). To what extent is this decision-making style distinct in the aviation industry, as it is subject to authority approvals, conservative by nature and changes must be substantiated with reports and data and possible testing strategies.

Under the umbrella of organisational characteristic, **corporate governance** refers to a firm's internal mechanisms, such as accountability mechanisms (shareholders, board), accounting mechanisms (reporting, auditing) and external mechanisms, such as direct stakeholders (regulators) and indirect stakeholders (activist) (Brennan et al., 2019). A survey on corporate governance in China found that the complexity is higher compared to Western corporations due to concentrated ownership (Jiang & Kim, 2020) and thus, one cannot apply Western assumptions in China, and further research on China is required, particularly in the context of governance in case of adverse economic situations (Chen et al., 2021).

Culture, another organisational characteristic, can have a multitude of facades, such as local culture, national culture, and culture linked to ethnicity and habit. In the context of organisational characteristics, the focus is on corporate culture, meaning the cultural elements that are shared, pervasive, enduring, and implicit in the corporation (Chapple et al., 2020). Furthermore, in recent publications, the question arises of how corporate culture accommodates a culture of home-office and remote working in the aviation industry (Deveci et al., 2022; Widodo et al., 2021; Sobieralski, 2020; Spicer, 2020). This research should discuss in further detail how the culture of a SOE, a private enterprise, and a foreign-owned company influences the organisational characteristics and to what extent the home office and remote working may influence these elements, if at all.

Integration of employees in the context of organisational characteristics is speaking of a multi-level integration with a focus on the recruiting process (Acikgoz, 2019). From an organisational perspective, a question that arises and that ought to be addressed is how employees are integrated into an organisational decision-making process. The literature has no profound recent articles, in particular in the post-COVID-19 context and in the context of the crisis of attracting qualified staff (Usanova & Géraudel, 2023). For the aviation industry, it means that a discussion around organisational characteristics is essential in order for a risk management culture to flourish and for structured governance to be operational, for instance, by defining the level of trust required, defining mechanisms for employees to be able to speak up without fear of

repercussions, defining and deploying common values that are shared and obeyed by (Sawyer & Harrison, 2020). This organisational requirement is also raised as a requirement by airworthiness authorities and focuses on the governance that is instated in a corporation: roles and responsibilities, escalation paths, and reporting.

Roles and responsibilities are, according to airworthiness regulators and the literature, the formalised responsibility to act in accordance with procedures in a specified perimeter of action. These are clearly defined by regulators within applicable policies, such as those relevant to EU regulation No 1321/2014 (Jones, 2023; Agustini et al., 2021; ICAO, n.d.). The escalation path is, according to regulators, the temporary abnormal condition in which a decision is taken outside regular reporting lines and authorities due to its complex nature (Oman, 2019). Reporting is, according to regulators of the aviation industry, any communication of an occurrence or of possible issues related to safety, and any organisation operating in the aviation industry must set up an independent monitoring system. Examples of such reports may include working conditions, product-related issues and design faults (Official Journal of the European Union, 2018).

iii. Performance management

The third topic that emerges in the literature is performance management, which relates to the performance management system that provides information required for strategic decision-making and to control the execution of a strategy and reports the performance to its stakeholders (Vegter et al., 2021), such as identifying measures, defining targets, planning, communicating, monitoring, reporting, acting and providing feedback (Badorf et al., 2019; Linkov et al., 2018). Performance measurement is essential in avoiding risk and ensuring a capable SC, and each item will be synthesised in turn (Munir et al., 2020).

Identifying **measures** in performance measurement or performance measures and metrics (PMM) proposes two non-mutually exclusive categories. A literature review on SC performance measurement systems reviewed 66 papers and found that 24 performance measures are used to evaluate PMM, and 130 measures are used for assessing the performance of processes (Kamble & Gunasekaran, 2020a). Practical

application and industry-specific discussion are required in light of digital SCs and big data (Lee et al., 2022; Fatorachian & Kazemi, 2021). Considering the large number of measures, the question of relevance emerges in the specific moment of resilience. This research shall discuss this further in sub-section 2.3.2 as a key component of resilience and in sub-section 4.2.2 as a key component of proactive resilience building.

Defining targets is the process by which service levels are formalised in accordance with strategic goals, for instance, the target inventory levels (Rozhkov et al., 2022) but in light of the COVID-19 pandemic, some of the strategic goals and associated targets needed to evolve, for instance, is JIT delivery possibly still the adequate target in light of the complex aviation SCs (Zimon & Madzík, 2020). How do sustainability goals integrate into the targets, such as reducing CO₂ emission from logistics (Zimon et al., 2019), as aviation aims towards carbon neutrality in the next decades (Sacchi et al., 2023; Vardon et al., 2022)?

Planning execution refers to operationalising the defined strategy and tactical and operational responses (Mantik et al., 2021). It is noted that the COVID-19 pandemic and digitisation efforts increase the level of focus and visibility of the execution process significantly, which could be beneficial for the outcome of this research, specifically for the aviation manufacturing industry (Ivanov, 2021b; Schniederjans et al., 2020).

Communicating the PMM to stakeholders is essential for its successful implementation, which has been demonstrated in cases (Kamble & Gunasekaran, 2020b). The relevant communication strategy is key to its successful implementation (Kamble & Gunasekaran, 2020b) and many times, organisations fail, not due to lacking PMM but due to lacking communication (Singh et al., 2019), as seen in cases such as the A380 wiring issues in which poor communication within a single company resulted in failing the conforming installation of 470 km of wiring on the large aircraft (Ramanatt et al., 2020). The best PMM can lead to failure if the communication strategy is inadequate. Recent practical evidence on this topic is to be collected.

Monitoring and reporting are essential to identify and address inefficiencies and identifying cost increases (Moons et al., 2019) that can lead to insolvency. This had

been observed in regional aviation in the early 2000s (Fairchild Dornier, Fokker) (Schniederjans et al., 2020b). Digitisation can support this through automated processes in an efficient manner (Singh, 2023), and this topic is to be looked at jointly with the digitisation strategy of SCs (Machado et al., 2020; Schniederjans et al., 2020a).

Acting and providing feedback is about taking relevant actions with adequate stakeholders to return to nominal performance levels. The process encompasses the identification of stakeholders and the proficient management of their expectations, the assessment of performance indicators, and the creation of strategic action plans. Furthermore, it requires the engagement of stakeholders in the formulation of the action plan, followed by the implementation of the actions while monitoring progress and providing ongoing feedback until the desired results are achieved. Recent examples from the aviation sector illustrate the obstacles faced by engine manufacturers in achieving production goals and maintaining quality benchmarks, alongside comparable challenges experienced by suppliers of cabin interiors (Hepher, 2017).

Performance issues are crucial in the aviation sector, which faces challenges in adjusting production rates, implementing modifications, maintaining long-term airworthiness, and meeting quality standards. Thus, the SCOR model is relevant here (Ayyildiz & Taskin Gumus, 2021; Bowman Jr., 2015; Huan et al., 2004).

iv. Flexibility in SCM

The fourth and final topic area the literature discusses is flexibility with respect to risk management capability that can be understood as the “extra margin”, “buffers”, or “room to manoeuvre” (Pettit et al., 2019; Stevenson & Spring, 2007) within the SC of an organisation. It is the ability to utilise resources to mitigate risks such as supply risk, manufacturing process risk and delivery risk (Reichardt et al., 2018; Sreedevi & Saranga, 2017). Three main perspectives on flexibility are discussed in the literature: supply flexibility, manufacturing flexibility, and distribution flexibility.

Supply flexibility answers to supply risk and addresses inputs such as components received from suppliers. The risk is that these components do not meet requirements such as specifications or other quality requirements that are not delivered when required (He, 2017). In the aviation context, flexibility can be addressed by material, components or semi-finished products that are, for example, multi-program, meaning that they have not been developed for one specific function, use or aircraft type. These supplies are flexible in usage. An example is passenger seatbelts, which are generic to many aircraft types.

Manufacturing flexibility responds to manufacturing process risks such as process deviation. For instance, missing quality inspection skills in the manufacturing of a product (Wan et al., 2019) may have a direct correlation to process stability. In the aviation context, manufacturing flexibility is often achieved by reducing production rates and thereby gaining flexibility on two fronts: firstly, by having more time to address quality concerns and work on technical solutions, and second, by being able to adjust the assembly sequence of the aircraft.

Distribution or logistics flexibility responds to the delivery risk of the finished goods or services to a customer (Zhao et al., 2013), for instance, a shortage in the supply of units due to incomplete planning. In the aviation context, continuous risk assessment performed by the OEMs aims to identify material that is subject to risk, such as shortages and relevant distribution changes are performed, such as advancing purchases and ensuring that raw materials are available to its suppliers. Therefore, this comparison in the literature shows a strong connection between the theme of flexibility and the theme of risk and the risk management process. Flexibility serves as a crucial supplementary factor in the management and response to risk in a reactive manner; however, its efficacy in the face of significant disruptions remains uncertain. A more in-depth exploration of flexibility is warranted.

This section has outlined the primary theme concerning risk management within SCs, emphasising the necessity for further examination of risk management capabilities, as well as the pertinent skills and organisational characteristics. The relevance of performance management has been discussed alongside the role of flexibility in SCM.

Additional research is essential to assess practical applications, particularly in the context of global SCs following the COVID-19 pandemic.

2.2.2 Key theme 2: Operational SCM capabilities

Within the parent discipline of SCM, the second key theme that emerges in SCM capabilities is the ability of a SC to adapt to its changing environment. Its four topics areas will be discussed in turn:

- Stock and inventory management (Ramos et al., 2020),
- Make or buy decision-making capability (Friedrich et al., 2022),
- Transportation and logistics management (Pečený et al., 2020; Hosseini et al., 2019); and
- Digitisation and dynamic planning (Ivanov, 2020).

Definition of SCM capabilities

SCM capabilities are the organisations' ability to exceed customer expectations and enhance performance (Tracey et al., 2005; Vonderembse & Tracey, 1999). These expectations are strongly associated with perception. Thus, the SCOR model (Fernandes et al., 2017; Lima-Junior & Carpinetti, 2016; Zhou et al., 2011) offers a standardised description of main processes, matrixes, best practices and enabling technologies that will help guide the organisation of the topic areas.

i. Stock and inventory management

The first topic area related to operational SCM capabilities is stock and inventory management, which is concerned with ensuring adequate stock and inventory of parts (raw material, semi-finished or finished parts) to meet customer demand at various locations. Furthermore, when defining stock levels, considerations include replenishment lead times, carrying cost of inventory, asset cost, inventory valuation, and quality levels (Ramos et al., 2020).

Strategic stock, alternatively called safety socks, is concerned with guaranteeing a service level to customers (Klosterhalfen et al., 2023). Disruptions are an indication that the strategic stock needs to be reconsidered. Some models of dual-sourcing and base-stock levels exist but have not been tested or validated in the context of expediting (Boulaksil et al., 2021; Dong & Transchel, 2020). Some literature suggests that digitisation and performance levels need rapid acceleration, and this perspective

is to be investigated further in the research when discussing stock-level policies and strategies (García-Reyes et al., 2022; Petroni et al., 2013).

In aviation, the complexity of products and extensive SCs necessitate diverse inventory strategies. SCM must adapt to ensure components are available throughout an aircraft's operational lifespan, which can exceed 30 years, including everything from basic fasteners to advanced avionics and engine parts.

ii. Make or buy decision-making

The second topic area in the literature related to SCM capabilities is the make-or-buy decision-making process and the capability to evaluate if a company is better off manufacturing the product or component internally or outsourcing it and buying it from a supplier (Friedrich et al., 2022; Medina-Serrano et al., 2020).

Besides the strategic decision-making of long-term capacity planning and other strategic considerations to contrast make or buy (Park, 2018), the consideration for a company is to find the most cost-competitive option. To perform this evaluation, the SCM will compare internal capabilities and external offers by comparing prices, lead times, and capabilities to find the most cost-competitive option.

In the aviation context, it has recently been observed that OEM's insource components, meaning what used to be a 'buy' part, become a 'make' part to meet operational requirements. It may be necessary to maintain some core capability in-house, while the large volume may continue as a "buy" (Bonner et al., 2023; Cruz-Cázares et al., 2013). These evaluations go well beyond the SC domain and require strategic, financial, and research & technology (R&T) perspectives (Xiang Zhang, 2019). Nevertheless, the notion of in-house capabilities is important for SCM when designing SCs. This recent trend, post-COVID-19 pandemic, has not yet been researched in the literature, and it has recently been observed that OEMs re-source work on the occasion of the collapse of SCs. Furthermore, in the aviation context, it is only recently observed that new technologies, such as 3-D printing, provide a new and important evaluation criterion as to whether a part or component should be purchased

from a supplier or if the OEM should invest in 3-D printing capabilities, to manufacture the part in-house (Meyer et al., 2021).

iii. Transportation and logistics management

The third topic area in the domain of operational SCM capabilities is transportation and logistics management to ensure day-to-day operations. By transport and logistics, one means the ability of the organisation to deliver a product from one location to another in the most efficient manner, using a portfolio of possible routes (Pečený et al., 2020; Hosseini et al., 2019).

Most recently, the notion of flexible transportation has been forwarded to the discussion of reviewing classical transportation systems and structures (Nagy & Foltin, 2022). For instance, the necessity to have a multi-medium transportation system using different means of transportation (sea, rail, air, road) on a multitude of mediums can be considered (including shared resources, dedicated resources, and modular approaches) (Musa Ardo et al., 2022; Zhao et al., 2013). During recovery phases, an organisation will be required to be capable of adapting to the transport that is available and not by the one that is desired in an optimal stage. This additional constraint had not been observed on a global scale prior to the COVID-19 pandemic (Ivanov, 2020; Hosseini et al., 2019; Tamvakis & Xenidis, 2012). The two large OEMs have the advantage of being able to use strategic air lifters such as the Airbus '*Beluga*' and the Boeing '*Dreamlifter*' to compensate for some of the limited shortcomings of traditional logistic capacity. However, these assets cannot compensate for an overall shortfall (Park, 2021). Key issues that are being faced are closure of routes, newly emerging bottlenecks and new strategic initiatives. Closure of routes, such as the port closure in China due to lock-down, the sanctions on seaports in Russia or the terrorist actions on vessels in the Gulf of Aden, have been observed during the last years due to the COVID-19 pandemic, the invasion of the Ukraine by Russia and the war in the Middle-East (Trif, 2023; Choi, 2021).

Furthermore, due to imbalances in the SC, new bottlenecks emerge, such as lack of customs clearance capacity, unavailability of containers or cargo freight capacity absence (Bombelli et al., 2020; McDonnell, 2020). Strategic initiatives previously

developed in multilateral dialogue are now prioritised by directive regimes such as the Silk Route project of China (Peters, 2021; Mishra, 2020). Recognising these geopolitical changes is essential for placing the findings of this research in context.

iv. Digitisation and dynamic planning

The final topic area encountered in literature is digitisation and dynamic planning to support operational goals. Digitisation is, in the domain of SCM, the degree of digital maturity and the adoption of digital tools (Zouari et al., 2021). It has been found that the positive correlation between SC performance and SCR is given and that more discussion is required about the adoption in the manufacturing industry (Yang et al., 2021). For instance, the degree of deployment has not yet been answered. How many firms use digitisation of their tools, and how advanced is the digital maturity in the SC in aviation? These questions may be worth addressing during the discussion on components of resilience and how digitisation is advancing the journey to more resilience levels in the aviation industry. Strong levels of digitisation are witnessed in airline operations, notable levels are seen in airport operations, and minor progress is seen in aircraft manufacturing SCs (Halpern et al., 2021).

With regard to SCM capabilities, dynamic planning is the ability to postpone or adjust production by means of an organisational control methodology (Ivanov, 2020; Lee et al., 2006). In times of crisis, the options linked to dynamic planning, such as postponing or rescheduling, are often called upon; however, due to the absence of forecasting, not a single model is valid. Therefore, scenario building is one possibility to prepare for (Fang et al., 2020). Due to the complexity of the aviation SC and limited synergies with other industries, dynamic planning is observed in airline operations and maintenance, rarely on the aircraft manufacturing side (Tracht et al., 2013). Therefore, further discussion as to common themes in planning in the aviation manufacturing industry would provide a further perspective on this topic area, which is discussed in sub-section 2.3.3. when comparing different models of supplier relationships with the OEM.

The concept of postponement, which dates back to the 1960s, still holds true in modern logistics in order to minimise risk linked to change and uncertainty of customer demand (Pagh & Cooper, 1998). If a SC has the capability to confirm the degree of maturity of the product, the relative risk linked to changes may be reduced to a quantifiable level (Al-Hakimi et al., 2022). In aviation development, maturity gates have this role, and postponement of manufacturing is a practice that is regularly seen (Cohen & Kouvelis, 2021). This capability is therefore required and common practice, and some further discussion of postponement in times of crisis, such as the COVID-19 pandemic, will complement the perspective of postponement as a topic area.

This section analysed SCM using current literature to explore SC risk management and its competencies. The increasing complexity of SCM necessitates developing organisational capabilities to effectively manage risks and enhance overall effectiveness. The next section will focus on the second foundational discipline: resilience.

2.3 Parent discipline two: Resilience

The previous section discusses the first parent discipline, SCM, and the key themes around risk management and SC capabilities and their characteristics (Pournader et al., 2020). This section will address the second parent discipline, 'resilience,' begin with definitions of resilience commonly found in the literature and summarise resilience from different perspectives in the current literature. Sub-section 2.3.1 will discuss the perspectives in the literature and propose a consensus on resilience, followed by a discussion of key components of resilience (sub-section 2.3.2). Sub-section 2.3.3 compares resilience on different components and parts of the aircraft, and sub-section 2.3.4 elaborates on direct and indirect factors influencing resilience.

- Perspectives in the literature (Kurth et al., 2019; Sangwan et al., 2018; Kaufman, 2015),
- Key components of resilience (Wieland & Durach, 2021; Umar et al., 2020; Linkov et al., 2018; Su & Linderman, 2016; Galvin et al., 2015; Folke et al., 2010),
- Comparison of approaches towards resilience depending on the different parts of the aircraft and respective model (Chinoperekweyi, 2019; Dong & Ryerson, 2019; Treuner et al., 2014),
- Direct and indirect factors influencing resilience (Um & Han, 2021; Khan et al., 2021; Zouari et al., 2021; Chunsheng et al., 2020; Fonseca & Azevedo, 2020; Iflaifel et al., 2020).

Once this second parent discipline has been elaborated upon, the gaps in the literature will be discussed in Section 2.4.

Definition of resilience

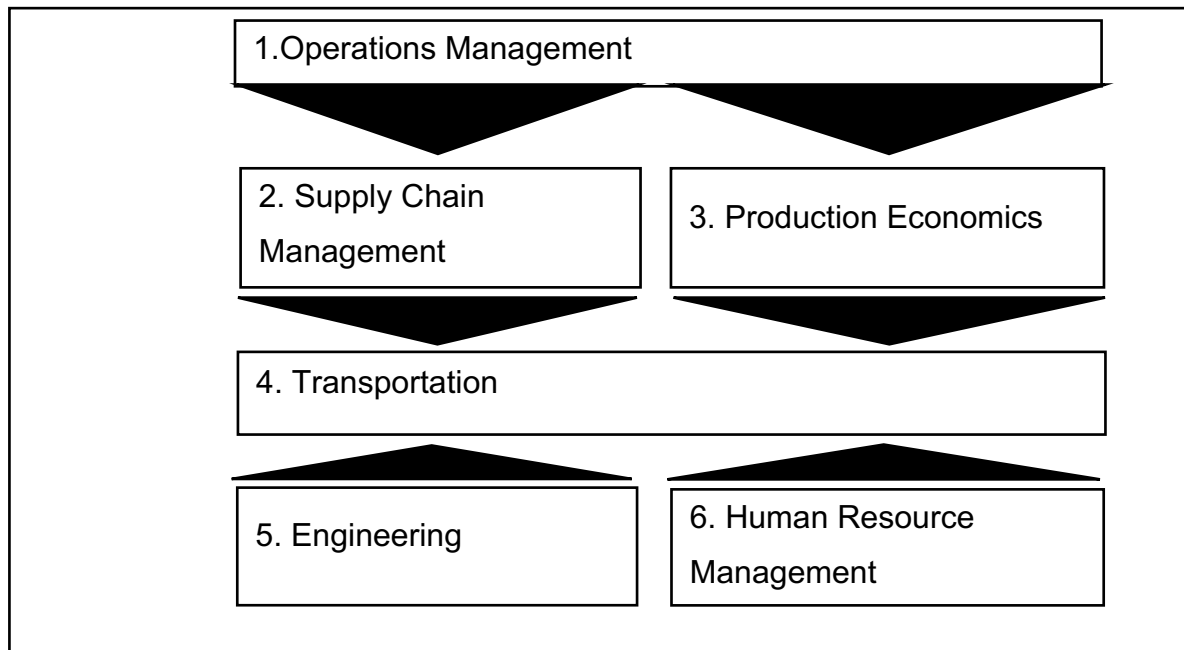
Resilience comes from the Latin word *resilire*, meaning to spring back or to rebound. “*The process of adapting well in the face of adversity*” (Brown & Abuatiq, 2020; Southwick et al., 2014; Mallak, 1998) and “*positive adaptation*” (Fletcher & Sarkar, 2013; Piercy, 2009) is adopted by the American Psychological Association. One of the most widely used definitions of resilience in the education context is the heightened likelihood of success despite environmental adversities (Goelgci et al., 2020; Waxman et al., 2003). In the technology context, resilience is used as a reactive approach to

avoid risk and uncertainty (Min, 2019; Pettit et al., 2019). Although the term resilience may be applied differently depending upon the context, resilience can be generally defined as *“the capability and ability to operate with adaptability, establish redundancies when advantageous, engage in collaboration among SC participants for shared benefit, and demonstrate agility in responding swiftly.”* (Ramaswami & Rungtusanatham, 2015; Bhamra et al., 2011; Ponomarov & Holcomb, 2009). This definition is adopted for this study as it is sufficiently broad to allow for open interview discussion during stages one and two but sufficiently explanatory to guide further discussion. Furthermore, this definition is applicable to the aviation industry and the post-COVID-19 context of SCM.

2.3.1 Perspectives in the literature and consensus

This sub-section will discuss the perspectives that different disciplines have on resilience and that have been highlighted by the literature review and summarised in Table 2.4 under *“examples of definitions of resilience in the literature”*. Six categories have been defined in accordance with the literature that refers to the higher-level parent discipline of operations management (Wieland & Durach, 2021), the broad areas of SCM (Sangwan et al., 2018), and production economics (Yoo et al., 2019). The application in the expertise of transportation (Musa Ardo et al., 2022), the perspective of engineering (Kurth et al., 2019) and finally, human resource management (Kaufman, 2015).

Figure 2.2 Hierarchy of the categories identified in the literature



Source: Prepared for this research

The hierarchy visualised in Figure 2.2 shows the overarching discipline of (1.) Operations Management, under which sit the broad areas of (2.) SCM and (3.) Production Economics. Transportation (4.) is then an application to the two broad areas, such as Transportation within the SC or transportation within production economics. Finally, both (5.) Engineering and (6.) Human Resource Management contribute with a distinct perspective and interpretation.

Table 2.2 Examples of definitions of resilience in the literature

Context	Definition	Authors
1. Operations management	Resilience is the capability for an enterprise to survive, adapt, and grow in the face of turbulent change . Proactive and reactive resilience: capabilities to increase the required level of readiness, collaboration and recovery ability during the pre-disaster and post-disaster phases. Develop resilience through resource reconfiguration or risk management infrastructure.	(Wieland & Durach, 2021; Bastas & Liyanage, 2018; Brusset & Teller, 2017; Chowdhury & Quaddus, 2016; Prajogo et al., 2016; Ambulkar et al., 2015a; Ebrahimi & Sadeghi, 2013)
2. SCM	Resilient SC means finding a balance of robustness and adaptability. Resilience consists of 13 enablers of capability, collaboration, trust, sharing, agility, visibility, etc. The ability to maintain, execute and respond swiftly (adapt) the planned execution along with the achievement of the planned (or adapted, but still acceptable) performance.	(Sangwan et al., 2018; Jain et al., 2017; Sokolov et al., 2016; Chou et al., 2012; Vinet & Zhedanov, 2011d; Krause et al., 2000)
3. Production economics	Resilience refers to the capability and ability of a system or component to bounce back from a setback. Cost-effectiveness SC recovers from a disruption to the same or a better state than before.	(Yoo et al., 2019; Mishra et al., 2016a; Tukamuhabwa et al., 2015a; Surbier et al., 2014)
4. Transportation	Resilience is the robustness of a supply network under the successive collapse of its transportation links. The capacity for an enterprise to maintain, adapt and grow in the face of turbulent change	(Musa Ardo et al., 2022; Fahimnia et al., 2018; Adenso-Díaz et al., 2018; Pettit et al., 2010)
5. Engineering	How well can a system handle disruptions and variations that fall outside of the base mechanisms/model for being adaptive as defined in that system.	(Kurth et al., 2019; Hosseini et al., 2019; Woods, 2015; Hollnagel et al., 2012; Vinet & Zhedanov, 2011d)
6. Human Resources Management	The organisation's capability and ability for resilience is developed through strategically managing human resources to create competencies among core employees that, when aggregated at the organisational level, make it possible for organisations to respond in a resilient manner when they experience severe shocks .	(Kaufman, 2015; Su et al., 2015; Lengnick-Hall et al., 2011; Vinet & Zhedanov, 2011d; Wilkinson et al., 2005)

Source: Prepared for this research

The six categories and perspectives are discussed at the same level because the overall concept of SCM and resilience is explored from different views, and it is strongly correlated to the specific perspective of engineering and human resources in the complex context of China (Cui et al., 2023; He et al., 2023). Each one of them will be discussed in turn.

1. **Operations management** covers all elements of a firm associated with and required by the manufacturing apparatus to fulfil customer orders and deliver parts (Helo & Hao, 2022). These elements include planning, resource allocation, production flow, and output management. (Chowdhury & Quaddus, 2017; Ambulkar et al., 2015a).

From a resilience perspective, it is observed that an organisation can respond to a disaster in multiple ways, for instance, by adjusting planning or by changing resource allocation and reconfiguring, for example, by adjusting the production flow (Morrish & Jones, 2020; Brusset & Teller, 2017; Chowdhury & Quaddus, 2017; Ambulkar et al., 2015a). With that respect, each element of an integrated operations management system plays a fundamental role in delivering a product on time, on quality and on cost. A fundamental question that is to be answered is how this reconfiguration will be characterised compared to the initial state, and in the context of aviation, where change is typically subject to authority approval, how will change be tackled from a communication, administration, and timing perspective? For instance, will an organisation decide to structure its operations to be leaner or rather operate with more inventory? The rationale for this decision-making will be investigated further in the context of Chinese suppliers, such as in sub-section 4.2.2 when discussing the findings of the in-depth interview and objective 5 of proactive resilience building on industrial operations.

2. **SCM** is concerned with ensuring the delivery of parts and products at the right time, at the right cost, and at the right quality to a customer. SCM discusses achieving a balance of flexibility and robustness when defining resilience (Shishodia et al., 2023; Dolgui et al., 2018b; Adenso-Díaz et al., 2018; Ambulkar et al., 2015b). This view is complemented by a scheme of 13 enablers (Jain et al., 2017) to achieve resilience

within an acceptable level of performance (Sokolov et al., 2016; Arzu Akyuz & Erman Erkan, 2010). Said enablers will need to be further discussed in this research regarding applicability in the context of aviation. These thirteen enablers are briefly illustrated as follow.

1. Adaptive capability is the ability of a SC to minimise the chance of unplanned disturbances, to resist the spread of disturbances by maintaining control over structures and functions, and to respond and to recover by immediate and effective plans to transcend the disturbance and to restore the SC to a nominal state of operations within the shortest possible time to reduce adverse effects (Yarosan et al., 2021; Sabahi & Parast, 2020a).
2. Collaboration amongst players in order to reach transparency, and that way, collaborations help SCs respond and recover from a disruption (Duong & Chong, 2020; Ghadge et al., 2017; Näslund & Hulthen, 2012).
3. Trust amongst players, in recent literature discussed the notion of deployment of blockchain, which is not observed in aerospace at all, is about the basic principle of honouring commitment, which is widely observed in a small and highly regulated industry such as aerospace (Alshurideh et al., 2022; Di Vaio & Varriale, 2020; Mishra et al., 2016a; Rebolledo & Nollet, 2011).
4. Sustainability in the SC discusses the long-term investment in partnerships that consider multiple elements in its priority of sustainability, such as equitable relationships, environmental impacts and investing in the employee and society's well-being (Beshara, 2023; Min et al., 2019; Fahimnia et al., 2018; International Civil Aviation Organisation, 2013).
5. Risk and revenue sharing are often discussed in large projects such as public infrastructure projects. The notion of profit sharing is not commonly discussed and not a basis of the contractual relationship in aerospace; however, the profit is often postponed to the aftermarket operations in which a successful program will generate a revenue stream for the life of the aircraft (Gupta & Ivanov, 2020; Yoo et al., 2019; Liu et al., 2017).
6. Information sharing is a basic principle in a bigger concept of integrating data from the SC to respond quicker and to predict trends of SC performance. It goes beyond the basics of exchanging purchase order data and much rather

about system connectivity and integration (Gaweł et al., 2023; Fatorachian & Kazemi, 2021; Fischer-Preßler et al., 2020; Roh et al., 2014).

7. SC structure examines the interconnectedness of SCs, which refers to the density and clustering of ties connecting a company's SC members, as well as the geographical and industrial differentiation among these SC actors (Gualandris et al., 2021; Yaroson et al., 2021).

8. Market sensitiveness is positively affected by collaboration, and in turn, market sensitiveness influences the risk management culture favourably (Jain et al., 2017). Suppliers and OEMs having cooperative contracts with each other show a higher degree of investment in SCR as an element of the risk management culture (Bakshi & Kleindorf, 2009).

9. SC agility is the ability to respond quickly to unpredictable changes in demand or supply by adapting operations and SC requirements (Kazancoglu et al., 2022; Gligor et al., 2020; Gligor et al., 2019; Christopher & Peck, 2004).

10. SC visibility is the end-to-end SC visibility for resilience management purposes by means of digital tools such as a digital twin of a physical SC as a step towards digitisation of SCs (Brun et al., 2020; Chen et al., 2014a).

11. Risk management culture is positively associated with firm SCR and consists of various elements such as a firm's environment that rewards employees to manage risks by using current knowledge and skills, including the subject of risk management as an important topic in new personnel training, collaborating with the SC in a transparent way and through open exchange of knowledge on potential threats and how to address and manage the risk and threats, and that risk management becomes an intrinsic part of business operations (Ali et al., 2023; Chapple et al., 2020; Chunsheng et al., 2020).

12. Minimising uncertainty by incorporating uncertainty of the future outcomes in business plans and when uncertainty is high, the SC can pursue either flexibility or redundancy strategies (Munir et al., 2020; Junko et al., 2020; Mensah & Merkuriev, 2014).

13. Technical capability in the organisation and SC through training and instruction programmes ensuring SC involvement in the development of the strategy using resource mapping and industry strategy tools (Yaroson et al., 2021; Orr & Jadhav, 2018).

Furthermore, the SC perspective emphasises the need for a holistic approach when evaluating and defining strategies for building resilience (Jain et al., 2017). Evaluating single elements of resilience would not ensure the sustainability of resilience for SCs, and therefore, a holistic approach is required.

3. For **production economics**, resilience means the ability to bounce back from a setback in a cost-effective manner (Lenjani et al., 2020; Tukamuhabwa et al., 2015a; Schmitt & Singh, 2012). This bounce back requires the implementation of a SCR strategy that will involve different SC partners to overcome the deformation that occurred. Strategies to do so may include the implementation of a JIT or lean management approach that covers awareness by all employees, quality assurance at each process step, level production where output matches demand and finally, JIT production (Kovács & Falagara Sigala, 2021; Mensah & Merkurjev, 2014). The unanswered element in production economics is the measurement of cost-effectiveness (Choi et al., 2023). The financial implications of implementing a new SCR strategy shall be less than the quantifiable direct benefits. Changes will need to consider implications with respect to cost-effectiveness, for example, incorporation of lost revenue, training staff for the changes ahead, recruiting the level of skills required, and accounting for changes in logistics. Discussing practical cases will help gauge the expectation of cost-effectiveness (Santra, 2021). For the aviation industry, limitations in the literature are observed regarding the approach to JIT production, how it is compatible with long development and production times and how lean production methods are relevant in a capital-intense industry.

4. In the context of **transportation**, resilience is concerned with the robustness and the capacity to survive the successive collapses of links and the adaptation and growth (Burgos & Ivanov, 2021; Pettit et al., 2019; Adenso-Díaz et al., 2018). Transportation systems are of specific interest due to their complexity of being multi-modal in terms of what they carry (freight, passengers, others), multi-faceted (impact on society such as positive and negative externalities) and multi-parametric (design, operations, management) (Ivanov, 2020; Tamvakis & Xenidis, 2012). These characteristics are shared largely in this research. Moreover, the extent to which

authorities are involved in designing transportation systems and ensuring their level of resilience (of the transportation system, of its services and the information available) is relevant because of similarities with aviation, as a type of transportation system in the sky (Tonn et al., 2021). Furthermore, it is noted that the OEMs have externalised the transportation capabilities in China due to regulatory requirements. Traditionally, OEMs manage the transportation network; however, it is novel in China that third-party suppliers perform this task on behalf of OEMs (Namcheol Moon, 2015). Further discussion is required to understand how the transport services suppliers can respond to resilience compared to traditionally vertically integrated internal solutions.

1. Resilience, from the perspective of **engineering**, is the capability of the system to handle disruptions (Wieland & Durach, 2021; Nemeth & Herrera, 2015; Raj et al., 2015). This is also referred to as resilience engineering (RE): the primary concern is designing and building systems that can circumvent accidents by anticipation, surviving disruption by recovery and growing through adaptation (Lundberg & Johansson, 2015; Madni & Jackson, 2011). Separately, the human and psychological element of coping with change is equally important when looking at sustainability (Madni & Jackson, 2011) in the context of disruption and adaptation. This notion of handling and anticipating disruption resembles the SC definition and approach to resilience.

2. The **human resource management** (HRM) perspective mentions that resilience is the ability of the organisation to strategically develop competencies in the workforce and to respond to shocks (Bonner et al., 2023; Polyviou et al., 2020; Hollnagel et al., 2012; Lengnick-Hall et al., 2011). Three dimensions are suggested as lenses to employee desire for contribution: (1) the cognitive lens, (2) the behavioural lens, and (3) the contextual lens. The **cognitive lens**, in which employees reflect on their experience, enables finding solutions to problems (Nikookar & Yanadori, 2022), while the **behavioural lens** assumes a careful consideration of contextual elements in order to determine desirable behaviour (Zakery & Saremi, 2021). The **contextual lens** emphasises the importance of environmental factors by including variables such as influences of social behaviour and other forces that have been underestimated in other perspectives (Craighead et al., 2020). Each lens ought to be supported by

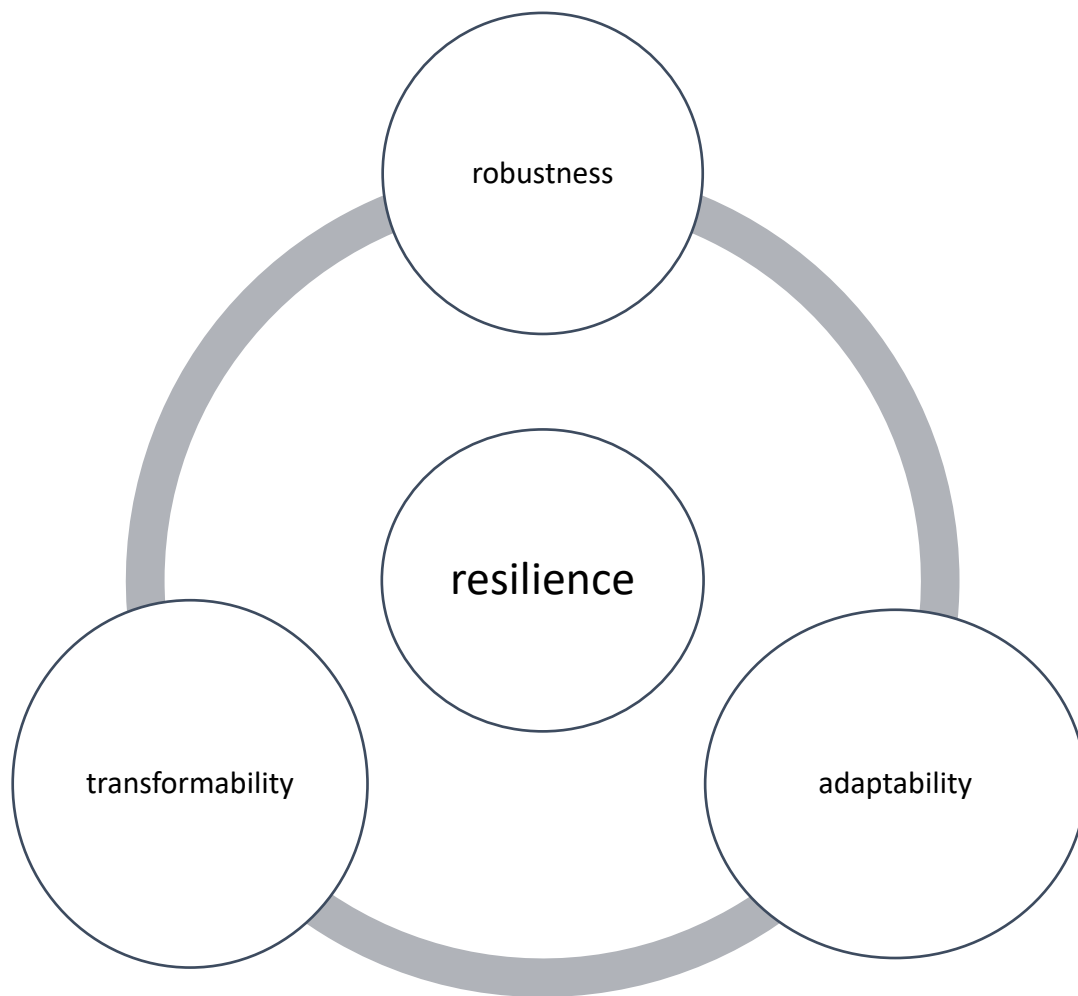
adequate HR principles and policies (Festing & Eidems, 2011; Lengnick-Hall et al., 2011). The notion of developing skills is aligned with a preventive approach to resilience building, meaning that the skills are developed prior to and with anticipation. Once an event happens, the skills can be deployed to respond to it, or the skills can be used in anticipation of an event to protect or postpone a possible impact.

This sub-section provided an overview of six perspectives on resilience, highlighting a consensus on themes across disciplines, with notable differences in responsiveness and proactive management. These viewpoints will be further explored in relation to the research question and literature validation during the initial in-depth interviews. The next sub-section will focus on the essential technical components of resilience and their interactions.

2.3.2 Key components of resilience

In this sub-section, the key components will be discussed to critically evaluate how they contribute to SCR. The literature was assessed and organised according to key components and their categories.

Figure 2.3 Categories of components of resilience of an organisation



Source: Prepared for this research

Components of resilience can be categorised into three categories (Wieland & Durach, 2021; Linkov et al., 2018; Hollnagel et al., 2012; Folke et al., 2010): robustness, adaptability, and transformability (Umar et al., 2020; Su & Linderman, 2016; Galvin et al., 2015; Galvin et al., 2014), and are presented in Figure 2.3.

Definition of components

A component of resilience is a part or element of a larger whole (Wieland & Durach, 2021; Tukamuhabwa et al., 2015a). Examples include logistics ability, quality assurance and knowledge management. These components can be allocated according to three main categories that describe the state of resilience. The specific components identified in the literature review will be discussed next.

Components belonging to **robustness** are defined as the ability of the SC to withstand a shock considering disruption propagation (Adenso-Díaz et al., 2018; Brown & Singh, 2018). In the context of the research, the robustness of manufacturing processes and manufacturing systems is investigated as how a company may overcome SC risks that are either demand-side (e.g. transportation problems, inadequate warehousing) or supply-side (capacity problems, quality issues) (Lockström et al., 2010).

Components of resilience in the category of robustness include:

- Logistics ability is the capability of the organisation, of its assets, resources, and processes to move parts and components from one location to another (Song et al., 2022),
- Inventory management is the ability to operate adequate systems and structures to ensure parts, considering constraints such as space and financial guidance (Fatorachian & Kazemi, 2021; Burgos & Ivanov, 2021; Lenjani et al., 2020),
- Financial capability such as cash availability, access to credit lines within acceptable conditions and credit rating (Beuren et al., 2022; Tsai & Lasminar, 2021; Dolci et al., 2017),
- Appropriate supplier selection supported by a multifunctional team selecting suppliers based upon a risk assessment, strong internal procedures, adequate governance and compliance adherence (Jessin et al., 2023; Mohammed, 2020; Lima-Junior & Carpinetti, 2016); and
- Security preparation refers to the ability to secure SC relevant resources, both intellectual and tangible, such as property (Santra, 2021; Hajda et al., 2021; Urciuoli et al., 2014).

The literature proposes to strengthen the manufacturing processes and the manufacturing system, for instance, by means of quality controls, flexibility, warehousing capability, and close monitoring of key performance indicators in industries such as pharmaceuticals (Arden et al., 2021). In addition to increasing the degree of robustness, the size of the impact from which the organisation would withstand needs to be measured to its magnitude. Is the impact a small, medium, or large incident, and how long will it last? Will it be short, medium, or long (Dong & Ryerson, 2019)? Equally so, an assessment of the impact is required: is the event targeted at a specific point of the organisation, such as a specific cyberattack, or does it spread throughout all elements of an organisation, such as a pandemic?

A second category of components of resilience discusses the components of **adaptability** of resilience and the capacity to change from the current state to another state (for example, from a low level of incoming quality controls to a systemic and 100% quality control strategy) (Elmqvist et al., 2019; Meuwissen et al., 2019; Zhang et al., 2011; Ponomarov & Holcomb, 2009a). Some simple examples are provided in the food industry related to changing tastes and how quickly the manufacturers are able to cater to changing demand (Hobbs, 2021). In more complex industries, many variables have to be added; for instance, in the aviation industry, changing from traditional Jet-A1 fuel to a type of sustainable aviation fuel requires testing components, changing tank structures, modifying the chemical composition of sealants and so on. Therefore, the level of adaptability will depend on how quickly an organisation can change, how profoundly it can change, and if the change can be sustained across the SC.

- Quality assurance is ensuring that the systems are compliant to manufacture a product in line with requirements every time (Singamneni et al., 2019; Zhang et al., 2011). Specifically considering resilience, it means that the quality assurance system is robust to ensure a ramp-up in production and stable quality output, regardless of the skills of operators,
- SC collaboration is the interaction between various actors of the SC in an effort to achieve a common goal, such as the recovery in case of an event that impacts production (Shi et al., 2023; Zouari et al., 2021),

- SC network structure means the degree of complexity and visibility and the degree to which this structure is known and transparent to the different actors of the SC (Akerman et al., 2020; Fiala, 2005); and
- Visibility in the SC across all tiers upstream and downstream is needed for the SC to identify risks and act upon resolving them (Brun et al., 2020; Mandal et al., 2016).

Components belonging to **transformability** are the capacity to significantly change internal systems and processes and to respond to several shocks or enduring stress to the existing system (Meuwissen et al., 2019; Folke et al., 2010). These components do not necessarily refer to specific components of resilience but rather to enablers of transformability, such as managerial vision, corporate foresight, and financial ability to support transformation in sectors such as farming and agriculture (Nicholas-Davies, 2021).

- Knowledge management is the capability of using available and applicable knowledge and experiences in the business context to solve issues, run operations and innovate (Zeng et al., 2011; Russo et al., 2012; Essuman et al., 2020),
- Innovation is the capability of the organisation to ensure the willingness across the organisation to adapt to changes in product or process with an expected benefit to the customer or other stakeholders (Do et al., 2022; Sabahi & Parast, 2020a); and
- Sustainability means the capability of managing further constraints, such as reducing CO2 emission and energy consumption in a long-term approach with stakeholders, the SC and customers (Di Vaio & Varriale, 2020; Brun et al., 2020; Orr & Jadhav, 2018).

In conclusion, sub-section 2.3.2 has summarised the categories of key components and proposes some areas of further consideration when exploring the level of resilience during in-depth interviews. The interaction between robustness, adaptability and transformability has been discussed. These three categories (each consists of a multitude of elements) will be considered when evaluating the level of resilience of a SC. This leads to the research sub-question two: “what are the key components of

resilience that affect SCs?”, which will be answered through in-depth interviews and case studies that will be further illustrated in sub-section 3.3.2.1.

Definition of feature of resilience

A feature of resilience represents a unique quality or dimension of resilience (Connelly et al., 2017). Examples include team capability, rate flexibility, and redundancies. By contrast to the component of resilience that is a part of a whole, the feature is a descriptive attribute of resilience. The literature distinguishes four categories of features, namely critical functions, threshold, time (and scale), and memory / adaptive management.

- The **critical functions** category includes features that respond to an event. This category belongs to the ‘*readiness phase*’ of resilience (see sub-section 2.3.4). The study focuses on how a system maintains essential functions during stress from adverse events. Assessing resilience requires identifying critical functions, with stakeholders playing a key role in defining what is being made resilient, against which threats, and for whom. The system's boundaries, determined by the scale of interest and temporal factors, also influence resilience. Stakeholders shape resilience assessments by defining critical functions and the system's scale. For example stakeholder groups may be encouraged to conceptualise systems, potential disturbances, and vulnerabilities. Stakeholder questionnaires are commonly used to evaluate resilience in both psychological and organisational contexts, making the identification of critical functions more subjective than in environmental or engineering systems (Connelly et al., 2017b). Nonetheless, stakeholder-driven identification of critical functions is crucial for understanding system resilience. An example includes the infrastructure and access to services.
- The **threshold** category includes features of resilience that are linked to the organisational adaptive capacity. Generally, resilience refers to the stable states a system maintains before a disruptive event. Systems can absorb changes to a degree, but if a shock exceeds a certain threshold, they may shift to a new regime with altered structure or function. Positive and negative

feedback can push a system beyond this threshold, leading to decreased performance and potential collapse (Fath et al., 2015). Identifying resilience thresholds is crucial, especially in organisations, as they relate to adaptive capacity and management strategies. Research continues on recognising these thresholds before they are crossed (Mohammed, 2020; Angeler & Allen, 2016). Once crossed, recovery is difficult, particularly with hysteresis. If a threshold is not breached, resilience remains relevant, with return time metrics becoming more applicable. As resilience limits are approached, return time may increase, a phenomenon known as critical slowing (Sarkis, 2021; Woods, 2015). A simple example includes the threshold linked to the logistic capacity. Once the threshold is reached, the disruption occurs. This category belongs to the '*response phase*' of resilience.

- **Time (and scale)** in the category under which features enable returning to a stage of equilibrium within a certain time. These features belong to the '*recovery phase*' of resilience. As resilience is often assessed by the time taken to recover from a disruptive event and the spatial dimensions of the affected system (Cheng et al., 2022). It's crucial to understand the interplay between spatial and temporal scales, as changes in critical functions are often linked in both aspects. However, studies frequently focus on one scale at the expense of the other, which is a significant oversight (Connelly et al., 2017). The emphasis is often on minimising recovery time to restore services, particularly in engineering resilience, which prioritises a quick return to equilibrium. This approach overlooks the existence of multiple stable states and the concept of non-stationarity. Nonetheless, returning to equilibrium can provide insights into a system's resilience against disturbances that don't exceed critical thresholds. The timing of disturbances relative to the system's state can greatly affect performance outcomes (Seidl & Turner, 2022). Understanding resilience also requires examining system dynamics across space and time, with key variables changing at different rates. Interdependent systems often display a diverse array of functionalities and capacities across various contexts. An example includes the ability to deploy alternatives.

- **The memory/ adaptive management** category includes resilience features that enable change and modification to the system. This category belongs to the '*renewal phase*' of resilience. Recalling past disruptions and system responses can enhance adaptability and resilience. The importance of ecological memory in reorganisation after disruptions is discussed (Angeler & Allen, 2016). Systems with high modularity or diversity tend to retain memory more effectively (Fath et al., 2015). While the relevance of memory varies with system boundaries, it is particularly significant in human systems. Short-term memory of events can improve safety and resilience by enhancing anticipation of future shocks, though this memory may fade over time (Rowland, 2013). Comprehensive monitoring is essential for detecting changes in critical conditions, and analysing sensory data helps form memories and identify causal relationships. Understanding system behaviour over time is vital for predicting responses to stressors. In human physiology, repeated stress exposure leads to long-term changes in affected systems. Generally, past shocks reliably indicate how a system will respond to future uncertainties, although memories can sometimes have negative effects (Wieland, 2021; Connelly et al., 2017). An example includes the empowerment of the workforce.

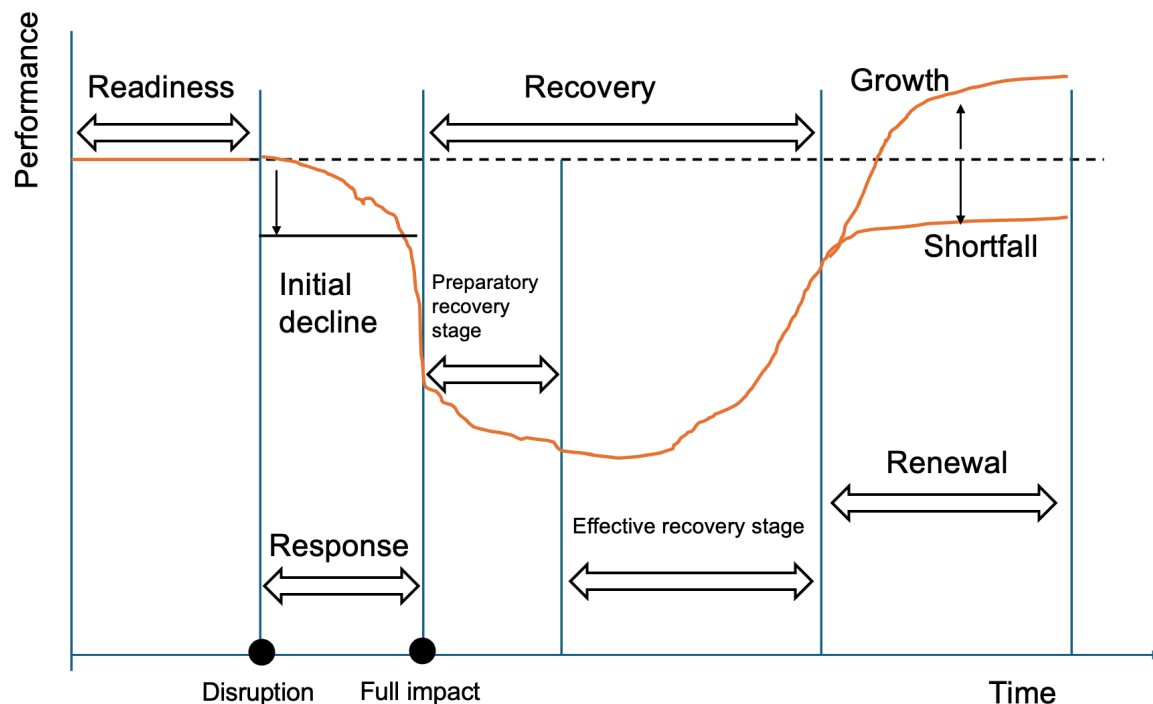
The literature does not explore a detailed analysis of features of resilience in the aviation manufacturing industry. A discussion of features of resilience in various sectors, including energy production, identifies several categories: robustness, resourcefulness, rapid recovery, and adaptability (Afzal et al., 2020; Berkeley Iii et al. 2010). Similar features are also observed in other infrastructure projects, encompassing redundancy, adaptation, efficiency, robustness, interdependence, preparedness, flexibility, and rapidity (Gonçalves & Ribeiro, 2020). Additionally, the literature predominantly emphasises the types of impacts, such as those resulting from weather events or climate change, rather than the specific features themselves (Jasiūnas et al., 2021), which is not a primary focus for the aviation sector. Further discussion on the features related to the SC within the aviation industry will be provided in the findings section of this study. The next sub-section will examine the key phases of resilience from a temporal perspective.

Key phases of resilience

Four key phases of resilience in SCs (as shown in Figure 2.4) are distinguished in the literature review (Kamalahmadi & Parast, 2016), namely:

- Readiness, the phase of anticipation, ante-disruption,
- Response, the type of resistance or coping, the phase after the disruption and prior to the full impact,
- Recovery, the response, the phase post full impact; and
- Renewal, the phase that will characterise a growth or a shortfall in performance.

Figure 2.4 Key phases of resilience during SC disruption



Adapted from: Song et al., 2022

By the notion of **readiness** or **anticipation**, one understands anticipatory thinking such as scenario elaboration, risk mitigation strategy and “what if” considerations and dealing with the “unknown unknown” (Olivares-Aguila & Vital-Soto, 2021). Furthermore, anticipation by data capturing and early data analysis provides a further valuable source of information in order to make educated decisions before an impact (Munir et al., 2022). In anticipation, it was found that SCs are quick in increasing

inventories (Rozhkov et al., 2022), and further discussion is needed on understanding how this will help avoid an impact. This phase concludes once a disruption occurs.

Then, the second stage occurs at disruption, where the organisation moves to a phase of **response** that is **resistance** by **coping** with the disruption, for instance, by consuming inventories and other means put in place during the anticipation phase (Alikhani et al., 2021). This phase goes on until the full impact is reached. During the response phase, certain recovery means are already being elaborated (Song et al., 2022).

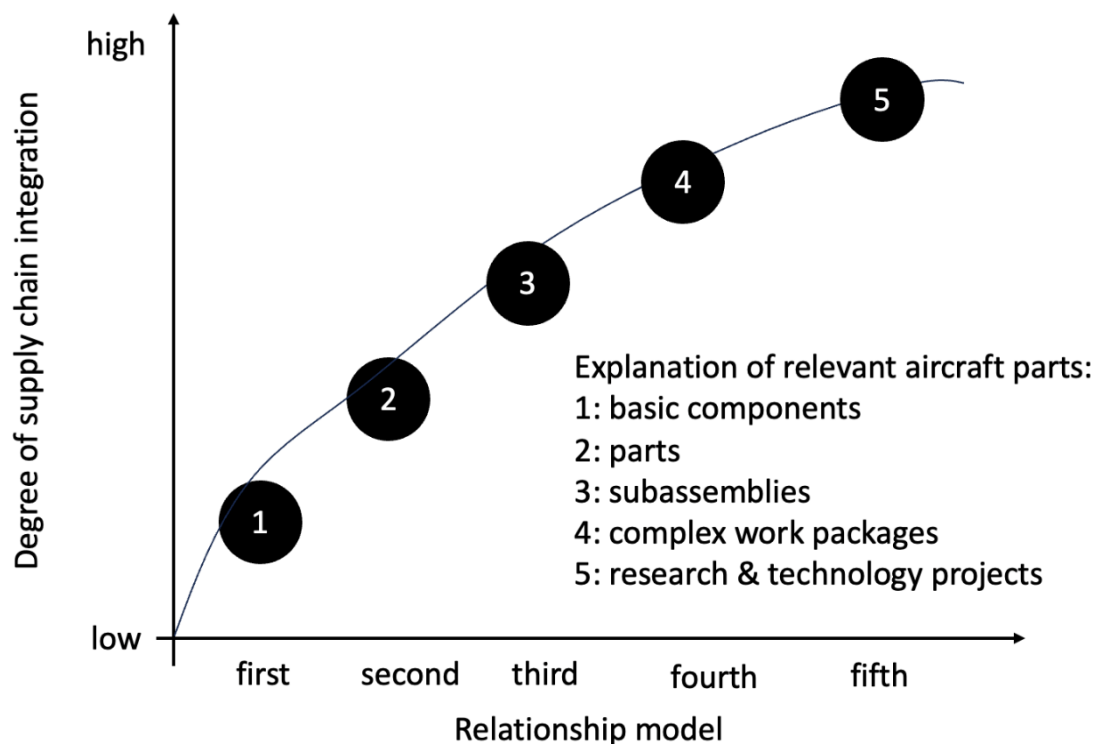
Once the full impact is reached and the performance levels are stabilised, the phase of **recovery** starts (Behzadi et al., 2020; Ivanov, 2020). During this phase, a specific focus is given to the organisation to improve performance levels. The duration of the recovery phase will depend on the ability of the organisation to redirect resources (dynamic capability theory). Finally, the **renewal**, which is the fourth phase, will determine if the organisation is able to renew itself by means of new business practices that yield a higher level of performance and thereby achieve some growth (Adobor, 2020; Sá et al., 2020).

A leitmotiv across the literature is that resilience-building is analysed post-event, meaning that mechanisms are enacted to return to the state before the adverse event happens (Wieland & Durach, 2021; Lenjani et al., 2020; Sá et al., 2020). The opposite approach, meaning defending the current state by utilising proactive deployment of resources, is rarely discussed (Echefaj et al., 2022; Kaur & Singh, 2022; Elluru et al., 2019). In the educational context, a randomised controlled trial has evaluated the effects of resilience building to prevent burnout in teachers (Jennings et al., 2013) and concludes significant positive effects on well-being, efficacy, burnout/time pressure and mindfulness. How and why components and features of resilience influence SCs is covered by SQ1 and SQ2 and its objectives will be discussed in detail in sub-section 3.3.2.1. The subsequent sub-section 2.3.3 examines various resilience models as they pertain to distinct components of the aircraft. It will also explore the evolution of these models over time, influenced by the diverse industries to which they are associated.

2.3.3 Resilience across different categories of the aircraft

This sub-section explores strategic methodologies for resilience, highlighting different aircraft components—such as engines, systems, cabins, consumables, and standard parts—require distinct models due to variations in product maturity, supplier capabilities, and technology. It covers categories like raw materials (aluminium, steel), advanced materials (paints, coatings), specified components (fasteners, cabin interiors), and capital-intensive parts (aerostructures, systems, powerplants). A multi-generation model in Figure 2.5 illustrates these characteristics, with examples provided in Table 2.3. This multi-generation model summarises five generations of models of SC relationship: classical or market exchange, collaboration approach, partnership approach, risk sharing approach and strategic partnership or integration approach (Chinoperekweyi, 2019; Dong & Ryerson, 2019; Treuner et al., 2014). The multi-generation model is discussed from different perspectives of resilience maturity, complexity, and context.

Figure 2.5 Supplier relationship model: Degree of SC integration over time



Source: Prepared for this research

The lowest degree of integration is visible in the first-generation supplier relationship model represented by basic components (Wasti et al., 2006) such as raw materials (including aluminium, steel). In this model, not only the product itself but also the dependence of the organisation on suppliers is minimal (Schiele, 2010; Çebi & Bayraktar, 2003).

The second-generation model, with a basic degree of collaboration and forecasting, includes more advanced (processed) materials such as paints, coatings, and sealants (Simatupang & Sridharan, 2002; García-Flores & Xue, 1998). These products are standardised and rarely aircraft specific. The third-generation model operates in a partnership between the supplier and the customer with aligned objectives (Shi et al., 2023; Piercy, 2009; Wasti et al., 2006). This model is applicable to components such as fasteners, detailed parts or cabin interiors, all of which require specific aircraft drawings and designs.

The fourth-generation model has a higher degree of SC integration and may be characterised as strategic integration (Santra, 2021; Stratton & Warburton, 2003). Long-term contracts are of the essence. This is applicable to advanced components such as aerostructure parts with specific aircraft-related design, fit and function. Finally, the highest degree of integration is observed in R&T.

Each model requires its own appropriate approach towards resilience (Kaur & Singh, 2022; Namdar et al., 2021; Adenso-Díaz et al., 2018). This strategic partnership is observed in advanced and complex products that require a high degree of integration and mutual dependencies. A typical example is aircraft engines or systems such as the landing gear.

Table 2.3 Multiple-generation supplier relationship model

Generation	Name of model	Characteristics of resilience	Example of aircraft part
1 st	Classic/ market exchange	No special investment, opportunistic, standardised product, transaction- related	Raw materials such as aluminium, steel
2 nd	Collaboration	Share information: collaborative planning and forecasting	Advanced materials such as paintings, coatings, sealants
3 rd	Partnership	Share knowledge, highly dedicated and contractual framework	Specified parts such as fasteners or cabin interiors
4 th	Risk sharing	Power and dependency relationship, cooperation on long-term	Aerostructure and other high-capital investment parts
5 th	Strategic partnership/ integration	Objective alignment, effective relationship. Lean SC integration, cost efficiencies, time to market	Most advanced systems, such as engines, equipment

Source: Prepared for this research

The literature proposes overarching supplier relationship models such as an integrative framework of supplier relationship (Park et al., 2010; Forkmann et al., 2016) that rely on strategic supplier segmentation (Kraljic, 1983; Dyre et al., 1998). As identified in the literature (Sharma et al., 2022; Remko, 2020), these models may be

outdated, and the recent context of COVID-19 poses a research gap in the relevance and applicability of said models. Its applicability to the aviation SC is not discussed in the literature.

The first-generation model, **classic or market exchange**, is typically observed in highly standardised products and services, such as commodities, and based on simple and matured technology and/or processes. The market is competitive, and alternatives are available (Wasti et al., 2006). The relationship is characterised by a buyer's market where the most competitive price gets "a deal". SCM is limited to its simplest form of offer and demand management, using simple and short-term forecasting. Levels of resilience are not captured or transaction-specific, and the applicability to the aviation industry is limited (Queiroz et al., 2022). Even basic commodities such as raw materials or fuel must come from qualified sources, meaning high switching costs are observed (Dogu et al., 2021). Further research has discussed how this type of commodity is available in China only in a few SOEs, such as aluminium suppliers (Gulley et al., 2019).

In the second-generation model, the **collaborative SC** is characterised by an approach of resilience of collaborative planning and forecasting (Simatupang & Sridharan, 2002). This allows the supplier to adapt capacities and plan resources such as material and labour. SC planning uses some planning tools such as electronic data capturing, and levels of resilience are seldom measured (Zouari et al., 2021). In aviation, some applications involve supplying components like paints, sealants, and coatings that require no detailed schematics and are characterised by high volume and low complexity. Data exchange on rate changes, vendor-managed inventory, and real-time consumption analysis aids in forecasting, demonstrating resilience. Additionally, emerging trends like rising demand can be incorporated into planning models. (Nikookar & Yanadori, 2022). A shared data exchange strategy requires trusting transparent data exchange and the use of confidential data for business purposes. This research will discuss how some foreign-owned enterprises provide these commodities in China through distribution centres (Zavala-Alcívar et al., 2020; Meuwissen et al., 2019) in the case studies. As raw materials are critical and prove to

be a repetitive and fundamental issue in SCM stability in aerospace, a specific focus will be given when investigating case studies.

In the third-generation model, the **partnership** is characterised by the seamless alignment of long-term objectives between the buyer and the seller (Shi et al., 2023; Piercy, 2009; Wasti et al., 2006) whereas the second generation focuses on collaborating on planning and forecasting only. Both organisations are highly dedicated to enhancing the use of mutual resources and assets to achieve joint objectives (Tarigan et al., 2021), whereas the first and second generations do not elaborate on the commonality, a strong sign of resilience compared to the second generation. An adequate level of efficiency in the relationship is achieved and characterised by the length of the relationship and the supply volume (Yoo et al., 2019; Simatupang & Sridharan, 2002). Levels of resilience depend on mutual planning and feedback loops, such as forecasting, resources and material availability, and prioritisation is mutually agreed upon (Manyena et al., 2019). The third generation, compared to the second-generation model, where collaboration is observed, i.e. working together, emphasises the common long-term objectives. In the aviation sector, this collaborative strategy is seen in smaller work packages, such as subassemblies and specialised fastener systems. Research shows that domestic private suppliers often enter the industry at this stage to familiarise themselves with the necessary standards and requirements (Zakery & Saremi, 2021).

The fourth-generation model refers to **risk sharing** and is characterised by a degree of dependency (Azimli, 2020; Ghadge et al., 2017) that is not observed in the third-generation model, and cooperation between the buyer and the seller is at a higher degree compared to the second or third generation model. The contractual modality of risk-sharing partnership reduces investment risk (for example, in specialised tooling, engineering and infrastructure) (Fischer-Preßler et al., 2020; Figueiredo et al., 2008) and remains transaction-related on the first generation, with an objective focused on the second generation and mutual goals focused on the third generation. Requirements such as performance criteria for a product, technical limitations of operations and limiting interfaces are jointly discussed and optimised. Degrees of resilience are elevated as data exchange and common planning take place, and this

mutual exchange fosters cooperation on risk mitigation plans. This approach is often used in subcontracting aircraft work packages, shifting some risk to suppliers. For instance, design-to-specification packages for components like fairings or movable parts made from aluminium or CFRP are commonly assigned to SOEs in China, which have the financial resources to invest in new technologies and manage development risks, including potential delays and revenue impacts.

The fifth-generation model is referred to as **strategic partnership or strategic integration** of SCs and is portrayed by optimisation in the SC performance (such as process variation and batch size), cost efficiencies and response time (Santra, 2021; Stratton & Warburton, 2003). These characteristics go beyond the risk sharing observed in the fourth generation, as the fifth generation talks about the true integration of organisations. Levels of resilience are at their highest, with a clear forecast, planning and risk management outlook, and performance is stable and robust (Domnina et al., 2022). In the aviation industry, this approach of strategic partnership is observed in future R&T projects, where strategic goals are discussed and aligned, such as future engine concepts, future energy sources or new materials (Wieland & Durach, 2021; Remko, 2020). Regarding the China context for commercial aviation manufacturing, this strategic approach is not yet observed and will be further investigated in this study, including, for instance, technology transfer risk and the overall industrial system maturity (Chow, 2023; Xu et al., 2021).

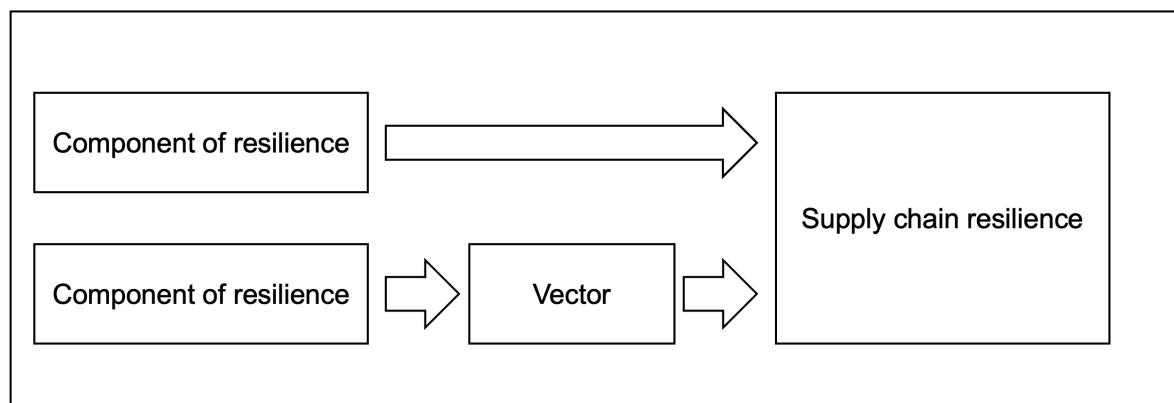
In conclusion, it can be observed that the degree of integration increases from the first generation (visualised by 1 in Figure 2.5) (Ervits, 2023; Ferreira & Critelli, 2022), to the fifth generation of the supplier relationship model (visualised by 5 in Figure 2.5) (Ramzy et al., 2022). Equally so, the level of inter-dependency and resilience increases towards the fifth-generation model (Feizabadi et al., 2021). This research analyses the current state of China's aviation industry, focusing on the maturity and evolution of partnerships, particularly between suppliers and OEMs. It will investigate if Chinese suppliers are delivering complex, integrated work packages and whether these are mainly assigned to SOEs or privately-owned enterprises. Additionally, the research will assess the domestic sourcing of raw materials, noting a basic level of

integration and low resilience, highlighting the need for OEMs to identify alternative suppliers during disruptions.

2.3.4 Key themes

The literature review on the parental influence of resilience revealed the need to elaborate on several additional key themes and their integration into the research objectives. Initially, the discussion will focus on the elements of resilience that impact the SC, examining both direct and indirect effects (Um & Han, 2021; Chunsheng et al., 2020; Ilaifel et al., 2020). Second, the key phases of resilience will be synthesised, meaning how resilience evolves in a company over time (Linkov et al., 2020; Punzo et al., 2020). When looking at components of resilience that influence the SC, the classification of directly affecting and indirectly influencing is plausible and will be discussed next (Khan et al., 2021; Zouari et al., 2021; Fonseca & Azevedo, 2020) as visualised in Figure 2.6.

Figure 2.6 Component of resilience affecting SCs



Source: Prepared for this research

Components of resilience with direct effects on SCs

A component of resilience with a direct effect on the SC can be defined and measured by holding constant all intermediate variables between the two (Queiroz et al., 2022; Zhu & Wu, 2022; Vinet & Zhedanov, 2011a). The component of resilience has a direct effect on the SC, and an adjustment in its ability will increase or decrease SC performance, i.e. resulting in a favourable or unfavourable effect (Gurtu & Johny, 2021). For instance, reducing logistics availability (fewer vessels, waiting time for

planes, longer routes by trains, the bottleneck on truck drivers, reduced container availability or longer customs clearance) has a direct effect on the speed at which materials can be delivered to customers, as observed from the literature in other industries (Singh et al., 2021; Attaran & Attaran, 2007) and as a result the level of SC performance dropped. This component is illustrated in the upper section of Figure 2.6, demonstrating its impact on SCR. The literature is hesitant to provide a detailed classification of components that directly influence resilience as the components are context dependent. Surveys are used (Brusset & Teller, 2017) to compare perspectives and to provide conceptual variance-based models (Alikhani et al., 2023).

This fundamental question, however, is to be answered: what are the components with a direct effect on SCR that can be affected? This element is of fundamental importance in addressing the main research question and sub-question “**How and why are key components of resilience affected?**” and will be discussed with priority over the “indirect factors”. Three main categories are proposed: firm internal component, SC-specific component and system-related component (Brusset & Teller, 2017).

Firm internal components are those that a firm can internally influence, such as resources, assets, and skills. Examples include the availability of a temporary workforce to take over a task, the set-up of warehouse space to accommodate inventory, and the skills required to outsource work that had previously been conducted by a supplier (Matysiak et al., 2018; Paulraj, 2011). **SC component** factors are those influenced by the suppliers, such as the cooperation with customers, the degree of quality robustness, and the agility in execution orders (Dogu et al., 2021; Mohammed, 2020; Fiala, 2005). **System-related components** relate to the agility of the system set-up to cope with resilience, such as the deployment of effective integrated ERP systems, the robustness of local infrastructure, such as stability in independent electricity supply, access to ports to receive and ship goods, and the risk management culture (Chowdhury & Quaddus, 2016; Wieland & Wallenburg, 2013). Besides the direct component that a firm may have a direct impact on influencing, the indirect component will be discussed next.

Components with indirect effects

Indirect effects present conceptional difficulties because they cannot be isolated (Xu et al., 2021; Iflaifel et al., 2020). This indirect effect is transmitted through a vector, which, in turn, will affect SCs favourably or unfavourably. This is visualised in Figure 2.6 in the lower part, where a component influences a vector.

For instance, a policy that is set by authorities may affect how quickly customs process imports and exports (Grassia et al., 2022; Kowalska et al., 2022). This change in the ability of customs to process goods will, in turn, affect the lead time at which goods are customs cleared and will add hours or days to the order-fulfilment-lead-time and to delivering the product to the customer (Pretorius et al., 2022; Nazam et al., 2020). Another example is the rate at which newly hired employees become effective on the job (Gu et al., 2023). New employees will require training, and new employees tend not to observe all quality rules (Beuren et al., 2022; Santra, 2021). Therefore, quality levels may temporarily drop, for example, due to reworking parts, scrapping, or issuing non-conformity reports or concessions (Annarelli et al., 2020). These components then affect the overall delivery to customers. One can speak of an indirect impact of employee hiring on customer delivery (Annarelli et al., 2020; Jang et al., 2020). Indirectly affecting components is more difficult to evaluate, and the correlation may be more challenging to prove. Nevertheless, when trying to increase levels of SC performance, the company management, being aware of these components, shall take a holistic approach by evaluating the entire environment of the SC (Fatorachian & Kazemi, 2021).

Some discussion in the literature proposes mathematical models for quantifying the multiplying coefficient between direct and indirect effects on SCs (Namdar et al., 2021). Some field data research has been applied in specific contexts outside of aviation, i.e. textiles or commodities (Karimi et al., 2022; Jia et al., 2020). Some considerations for this research will be explored through the theoretical model of Section 2.5 of this chapter.

A recent discourse has arisen concerning the impact of various resilience strategies and the potential indirect influence one strategy may exert on another (Alikhani et al.,

2023). A relevant example is seen in the differing strategies of two OEMs: one may use JIT production approach, while another, like a SOE, may focus on inventory accumulation. These contrasting SCM strategies can lead to challenges in resource planning, forecasting, and production management, though these issues are not the main focus of this research. The chosen strategy significantly influences how resilience factors impact SCs.

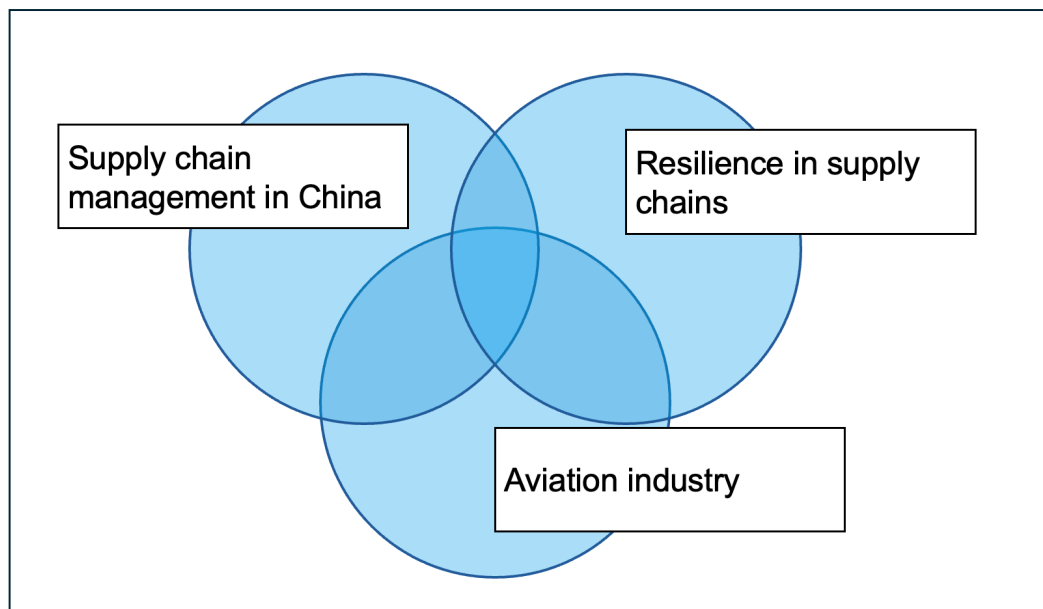
In summary, this sub-section categorises components influencing SCs, distinguishing between those that directly affect operations—manageable through SC strategies—and those that indirectly impact them through stakeholder behaviours. Future research should explore the components further.

2.4 Gaps in the literature

The previous sections have integrated SCM and resilience. This section will address literature gaps, especially regarding China, and guide the research question. While there is a consensus on the definition of resilience across disciplines, as noted in sub-section 2.3.1, literature on its development and implementation in SCs, particularly in aviation, is notably scarce, as discussed in sub-section 2.3.3.

These parent disciplines are visualised in the Venn diagram, Figure 2.7, in which the two parent disciplines are identified, together with the context of aviation that this research focuses on. SCM in China is a first circle (upper left), resilience in SCs is visualised as a second circle (upper right), and the aviation context is visualised in the third circle (lower middle).

Figure 2.7 Research gap by categories and focus of research



Source: Prepared for this research

In addition, the four overlapping areas (intersections) will be discussed. SCM in China intersects with resilience in SCs. SCM in China intersects with the context of the aviation industry. Furthermore, resilience in SCs intersects with the context of the aviation industry. Finally, the two parent disciplines, SCM in China and resilience in

SC, intersect with the aviation industry context, which is the research focus. Each one will be discussed in turn.

SCM in China (discussed in Section 2.2). It was found during the literature review that the topic is discussed in great detail as a growing number of international companies operate in China (Lau & Tovstiga, 2015; Philipsen & Littrell, 2011) in industries such as automotive, food production or industrial appliances. Distinct findings include that China, despite its WTO accession, still restricts operations to foreign-owned companies (Tan & Davis, 2023). In addition, the strong involvement of the State in regulation is making China distinct from other economies (Fan & Fang, 2020). Research on SCM specific to China is therefore relatively well described, even though not very accessible and often from a foreign perspective, as it focuses on foreign-owned enterprises. A gap exists specifically in China's SOEs and in a general understanding of China's SCs that are becoming increasingly complex, for instance, by needing to coordinate logistic flows of incoming and outgoing materials (Tan & Davis, 2023).

Resilience in SCs that had been introduced in Section 2.3: first, further empirical research is required to understand how resilience-building occurs as described in sub-section 2.3.1 (Sawyer & Harrison, 2020; Remko, 2020; Denning, 2013) as it is rarely investigated (Shishodia et al., 2023; Dolgui et al., 2018b; Gunasekaran et al., 2015). Second, more research on sustainability, meaning the long-term level of sustained performance (Dolgui et al., 2018b) and successful anticipation (Pettit et al., 2010) is needed. For example, building a buffer stock before a surge in demand is happening. Third, practical research on managerial tools (Um & Han, 2021; Pettit et al., 2010) and practical policies (Schmitt & Singh, 2012) are recommended, as well as guidelines for managers on how to build a resilient organisation (He et al., 2023; Elluru et al., 2019; Vinet & Zhedanov, 2011a; Mallak, 1998). Since the outbreak of the COVID-19 pandemic the shortcomings of SC capabilities (sub-section 2.3.2 and 2.3.4) have been noted throughout the global economy. Fundamental rethinking and redesign of SCs may be required and will be discussed further with the latest industry interviews, such as the development of redundancies. These questions lead to the research sub-question one (SQ1): "what are the key components of resilience in the SC in the

aviation manufacturing industry in China? How and why do these components influence SCs?”

The aviation industry, which is well-researched, is described in sub-section 2.3.3. The aviation industry in China is changing profoundly as more technology is adapted in China (transfer of technology) and as more complex products are manufactured in China (previously assembly of parts, today design and manufacturing of parts). Furthermore, the volume of procurement from China has drastically increased, which requires more profound procedural securities. Moreover, the dependency of Western economies on China has increased, which in turn requires a more detailed understanding of China’s sustainability of production capability.

The four intersections in Figure 2.7 reveal limitations in the availability of research. The COVID-19 pandemic has spurred research on SCR in the aviation sector, focusing mainly on airline operations due to limited information on aircraft manufacturers. To fill this gap, in-depth discussions and interviews will be conducted in Chapter Four. Although some studies have examined SCM in aviation, the sector has seen little change in the past decade, resulting in a lack of recent literature on industry developments, such as the rise of private enterprises and their increasing complexity. The intersection of resilience in the SC and SCM in China is discussed in Section 2.3 and sub-section 2.3.3, and that different products require different levels of resilience and a multi-generation model, which will be elaborated on further in a practical case-study setting, which this research intends to do in Chapter Five. The visualisation of the centre of the three overlaying circles is SCM in China’s aviation industry, that is the focus of the research.

These three areas of further research (interactions in Figure 2.7) offer the opportunity of a logical argument of firstly discussing practical tools and policies during interviews and then understanding, during case studies, cases of sustainability and anticipation and finally, looking at specific examples in the context of China, as an emerging and developing economy. In summary, the key areas for further research have been discussed, and a base is offered to formulate questions for the interviews and case studies of this research.

2.5 Preliminary theoretical model

This section will initially outline the pertinent theoretical model and subsequently examine two significant theories: the RBV of the firm and DCT, which are encapsulated in Table 2.4. Following this analysis, a preliminary model will be visually represented, as depicted in Figure 2.8.

Table 2.4 Theoretical models investigated

Theoretical models	Key references investigated
Control theory	Kegenbekov & Jackson, 2021; Brusset & Teller, 2017; Chowdhury & Quaddus, 2017
Systems theory	Adobor, 2020; Ismail et al., 2011; Vinet & Zhedanov, 2011a
Relational view	Patrucco et al., 2022; Chowdhury & Quaddus, 2016; Wieland & Wallenburg, 2013
Contingency theory	Yang & Jiang, 2023; Remko, 2020; Skilton, 2014; Grötsch et al., 2013
Dynamic capabilities theory *	Nikookar & Yanadori, 2022; Kapoor & Aggarwal, 2020
Resource-based view of the firm *	El Baz & Ruel, 2021; Freeman et al., 2021; Barney, 2012a; Carnahan et al., 2010; Barney, 1991

*Theories relevant and applicable to this research used to elaborate the theoretical model

Source: Prepared for this research

The SC has the systemic ability to coordinate a network of partners to achieve final customer satisfaction (Asamoah et al., 2021; Diaye et al., 2014). A variety of theoretical models have been applied to the study of SCR over the past two decades. In a systematic literature review by (Shishodia et al. 2023; Meuwissen et al., 2019 Kochan & Nowicki, 2018), they discussed seven key theories:

Control theory (Kegenbekov & Jackson, 2021; Brusset & Teller, 2017; Chowdhury & Quaddus, 2017) suggests that dynamic modelling is used to develop path-dependent

processes that enable SCs to go through a process of adaptation (Papanagnou, 2022; Galvin et al., 2014). The adaptation of the firm is neither the research question nor suitable for addressing the information regarding the internal state of the system that is being researched.

Systems theory (ST) is concerned with modelling recovery functions in complex networks (Adobor, 2020; Ismail et al., 2011; Vinet & Zhedanov, 2011a). ST utilises quantitative measurements of resilience, amongst others, to predict a recovery point (Raj et al., 2015) and, therefore are not suitable for this descriptive research.

Relational view (RV) explores the relationship between elements of the SC and resilience (Patrucco et al., 2022; Chowdhury & Quaddus, 2016; Wieland & Wallenburg, 2013) and is a supplement that builds RBV (Kobayashi, 2014). Some elements of this theory will be applied opportunistically to answer the research question, such as how resilience affects SCs.

Contingency theory suggests that there is not a single best way to manage processes, people or leadership in an organisation and argues that existing circumstances, such as leadership acceptance level, explain proactive resilience building (Yang & Jiang, 2023; Remko, 2020; Skilton, 2014; Grötsch et al., 2013). Despite leadership capabilities being of interest, the research must consider all elements of resilience building that could impact the SC. Since the researcher will not limit the possible outcome of the research to managerial practices, leadership and human resource capabilities, the contingency theory does not apply to this study.

Dynamic capabilities theory (DCT) and **resource-based view** (RBV) will be elaborated upon next. Other theories have been applied in the literature on limited occasions, but because of the rarity of their appearance, they are not of interest for further consideration.

RBV of the firm and DCT and a preliminary model

The research question focuses on the operational attainability and the strategic significance of resilience. Consequently, the theoretical model must encompass both the mid-term and long-term effects of resilience on the organisation. To fulfil the objectives of this research, the RBV of the firm and DCT will be employed, as both frameworks significantly contribute to the study: the RBV focuses on a firm's capacity to sustain its competitive advantage through the effective management of resources, while the DCT addresses the strategic reallocation of resources. These concepts are particularly pertinent to the discourse on resilience building.

Firstly, the **RBV** (Barney, 1991) describes how a firm uses resources to gain sustained competitive advantage through four empirical indicators: the value of the resources, rareness, imitability and sustainability (El Baz & Ruel, 2021; Freeman et al., 2021; Barney, 2012a; Carnahan et al., 2010). RBV explains how a company gains and sustains competitive advantages and optimal SC performance by strategically accumulating internal resources and capabilities that enhance SCR (Phan et al., 2019; Ponomarov & Holcomb, 2009b) which is highly relevant for the case of the aviation industry which constitutes of complex SCs. The focus is on firms' distinctive capabilities, which are a blend of skills and knowledge used in organisational processes. This allows firms to leverage their assets effectively, improving outcomes like SCR (Bonner et al., 2023; Laaksonen & Peltoniemi, 2018; Zhu et al., 2017; Man, 2009; Morash & Lynch, 2002). This model will assist in exploring how the aviation industry can utilise its unique competencies, such as technological advancements, logistical capabilities, and SCM practices, to enhance resilience within its SCs. (Queiroz et al., 2022; Chae et al., 2014).

Organisational knowledge is the ability of the organisation to capture and formalise knowledge, also referred to as knowledge management (Schniederjans et al., 2020a). Several papers concur that knowledge management, together with the opportunities of digitisation and technology are affecting SC performance massively and that further research on the topic is required (Wieland & Durach, 2021; Sabahi & Parast, 2020a; Schniederjans et al., 2020a).

Managerial skills are the ability to manage SC operationally and strategically. The literature points out a shortage of managerial skills (Ellinger & Ellinger, 2014) and that managerial skills shall evolve into entrepreneurial skills (Kump et al., 2019; Hohenstein et al., 2015) as the SC's importance on the business is growing and reaching up to 80% on new aircraft. This view is also supported by the DCT (Teece, 2016).

Technology refers to the integration of technology in the context of SCM, for instance, by the deployment of digital tools. This technology aims to increase the efficiency and performance of SCs (García-Reyes et al., 2022; Helo & Hao, 2022; Ansari, 2019). SCM practices are the application of theoretical models such as the viable SC model to real-life context (Ivanov, 2022) which is relevant to this research that will contribute with practical cases.

In the context of SCM which this research focuses on, this means the ability of a firm to maintain a competitive advantage through the uniqueness of its SCM capabilities and the access to enterprise resources, skills and knowledge by its staff to achieve efficient processes (such as risk management). Three main categories are referred to in the RBV:

- Financial resources such as cash, access to credits and credit rating of the firm (Goh & Loosemore, 2017),
- Tangible resources such as logistics and the ability of warehousing, infrastructure and the ability to have access to electricity and water as well as roads and technology such as access to the internet (Eisenhardt & Martin, 2000); and
- Intangible resources such as the ability to collaboration, access to resources with adequate skills and appropriate relationships with key stakeholders (Freeman et al., 2021; Morash & Lynch, 2002).

Secondly, **DCT** complements the notion of development and redevelopment of capabilities to address rapidly changing environments (Nikookar & Yanadori, 2022; Kapoor & Aggarwal, 2020), such as the one of the dynamic SCs that this research focuses on. For example, SCs need to be developed to support the sale of aircraft to new client (Hajami & Chinoperekweyi, 2019). The DCT provides the framework for

sensing, seizing, and transforming distinct capabilities to where the organisation needs them most (Sabahi, 2019). Another example identified is the ability to redeploy SCs when needed, in the case of disruptions, temporary suspension, or capacity issues as is discussed in this research in the context of severe disruption (Mishra et al., 2022; Aliche et al., 2020).

This research will specifically look at how sensing opportunities, seizing a strategy and transforming the business structure influence the strategic management framework (Khan et al., 2021). There is a general consensus that no hard-evidence data is in place to quantify dynamic capabilities, however, a multitude of indicative and comparative scales exist (Kump et al., 2019) and this qualitative research fits with the consensus. These three main pillars, sensing, seizing, transforming, of dynamic capabilities, are discussed next.

Sensing, or sensing opportunities (and threats) based on an application of a resource-based view of the firm, is applied to the international aviation business context: competitive advantages, country-specific advantages, and location-bound firm-specific advantages that positively control the effect of sensing processes (Vardon et al., 2022; Khan et al., 2021; Matysiak et al., 2018). These opportunities should align with the company's overall strategy and involve identifying, developing, and evaluating technological prospects based on customer needs (Teece, 2014). Sensing refers to an organisation's ongoing ability to monitor its environment, especially the SC, to identify technological changes and shifts in customer preferences (Pavlou & El Sawy, 2011). This process is proactive rather than reactive, especially in the aviation sector, where it becomes complex before launching new products or significant modifications, challenging the idea of "continuous scanning."

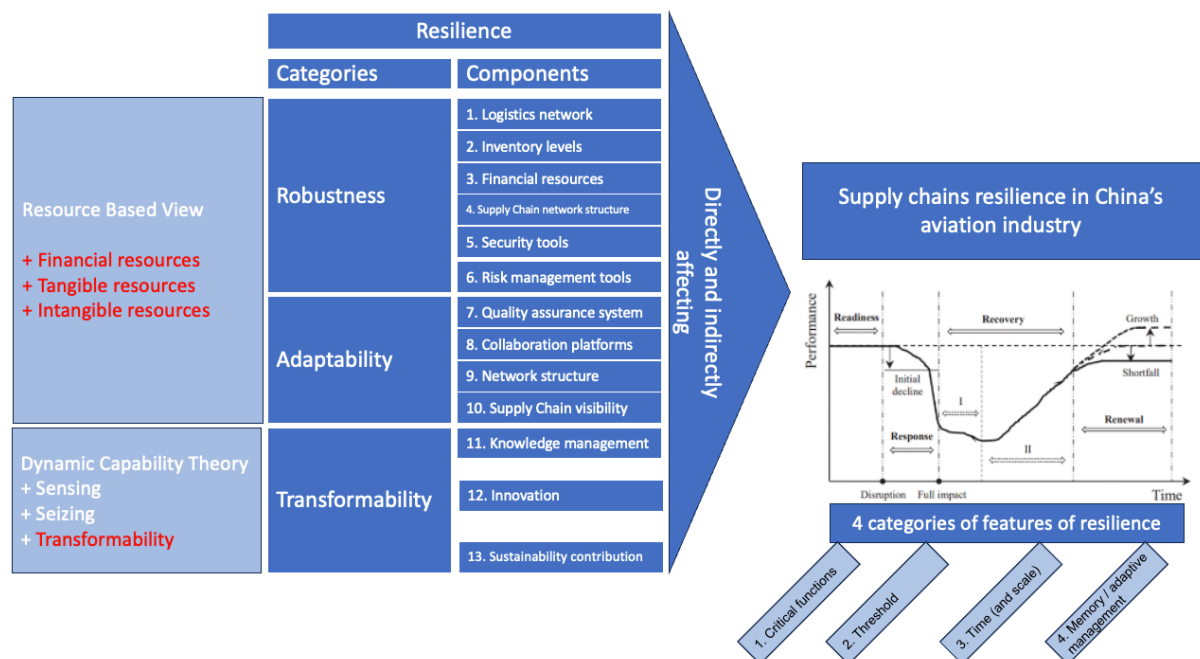
Seizing (or neutralising) needs and opportunities is defined as the mobilisation of resources to address needs and opportunities and to capture value from doing so (Teece, 2014). This mobilisation is plausible from both the DCT and RBV of the firm in which resources may be reallocated according to the development and the selection of business opportunities that fit with the organisation's environment, its strengths and weaknesses and strategy (Kazancoglu et al., 2022; Song et al., 2022; Kump et al.,

2019). Seizing involves effectively utilising SC opportunities, such as establishing a new facility within a redundancy framework, while mitigating threats like facility shutdowns that could reduce production capacity. This process integrates external and internal information and is closely linked to strategic decision-making, particularly in investment choices related to sales forecasting and long-term SC capacity (Makkonen et al., 2014). In the aviation sector, where product development takes about ten years and production and operation can last an additional twenty to thirty years, long-term capacity planning is crucial for enhancing production capabilities.

Transforming the firm through means of its resources and capabilities according to a formulated plan means nothing less than “continued renewal” (Teece, 2014) and includes the enhancement, combination and reconfiguration of the tangible and intangible assets of the SC to meet the reformulated objectives: new business models, products, or processes (Kazancoglu et al., 2022). The reorganisation of resources requires the firm to adapt its structure and management methods while leveraging new technological insights from the SC for innovation. This transformation poses a challenge in the aviation sector, which is resistant to change and subject to strict regulations. New frameworks and process changes must undergo airworthiness assessments and thorough testing, resulting in a slower pace of transformation compared to other industries.

This research will contribute to the theoretical model by examining case studies that demonstrate how resources enhance resilience as a competitive advantage, enriching the RBV and DCT. In the context of this study the research will focus on the capabilities-creation process, particularly proactive measures taken before adverse events, such as developing crisis management skills for timely deployment. It will also emphasise the role of knowledge and managerial competencies required for SCs within the RBV, providing insights into strategic decision-making for resource adjustments in response to production fluctuations. Finally, the research will explore the deployment and redeployment of resources such as logistics and inventories to further strengthen resilience in the SC.

Figure 2.8 Preliminary model of factors influencing SCR



Source: Adapted from RBV and DCT and prepared for this research

Definition of key terms:

SCR refers to the ability of a SC to endure fluctuations from its steady-state conditions and either return to its original state or transition to a new, more favourable state. (Shi et al., 2023; Pournader et al., 2020).

Capabilities can be understood as collections of interconnected, yet separate, routines. (e.g. Hult et al., 2003; Henderson and Cockburn, 1994; Amit and Schoemaker, 1993; Stalk et al., 1992; Prahalad and Hamel, 1990). This approach, centred on routines, facilitates the deconstruction of capabilities into distinct and recognisable routines, thus delineating potential avenues for the enhancement of capabilities..” (Peng et al. 2008). The sustainability performance of an organisation is shaped by its capabilities, including skills, resources, and competencies, which subsequently impact the performance of its entire SC. (Chari et al. 2022)

Robustness occurs when a process consistently upholds its acceptable performance at a predetermined level, despite the presence of considerable fluctuations in input variables and noise parameters over a specified timeframe or planning horizon. In this

context, the importance of process monitoring and adaptive control becomes particularly pronounced (Monostori 2023, Dogu et al. 2021).

Collaboration encompasses a wide array of activities, concepts, and frameworks, such as cross-functional teams, a grassroots approach to enhancement, early engagement of suppliers and customers, strategic coherence around shared goals, servant leadership, agile management, among others. While certain collaborative initiatives are directly linked to innovation, others focus more on operational aspects (Sudusinghe & Seuring, 2022; Lee et al., 2006).

The visualisation of the preliminary model (as shown in Figure 2.8) outlining the components that impact SCR has been enhanced by integrating relevant theories pertinent to this context. This model will allow for an in-depth examination of the interactions among the components of resilience within SCs and the associated theoretical models.

Central to the model are 13 components of resilience, which are classified into three categories: robustness, adaptability, and transformability. These components of resilience significantly influence SCs. The categories of robustness and adaptability are associated with the RBV, and the components can be categorised into financial, tangible, and intangible resources of the organisation (Erboz et al., 2022; Yuan et al., 2022). Furthermore, the category of transformability is linked to the DCT. However, the other two elements of the DCT—sensing and seizing—are excluded from this research as they do not pertain to the research questions and sub-questions.

2.6 Conclusion

In conclusion, this chapter commenced with an exploration of the foundational disciplines of SCM and resilience. Subsequently, it delved into the essential components of resilience, examining its impact on SCs and the strategies organisations employ to enhance their resilience. The identified gaps within the existing literature were also highlighted. Consequently, the subsequent research sub-questions that arise are outlined below.

SQ1: “What are the key components of resilience in the SC in the aviation manufacturing industry in China? How and why do these components influence SCs?”

SQ2: “What are the key features of resilience in the SC in the aviation manufacturing industry in China? How and why do these features influence SCs?”

A preliminary model outlining the factors that contribute to SCR was developed to respond to the research question “how and why does resilience affect SCs in China's aviation manufacturing industry?”

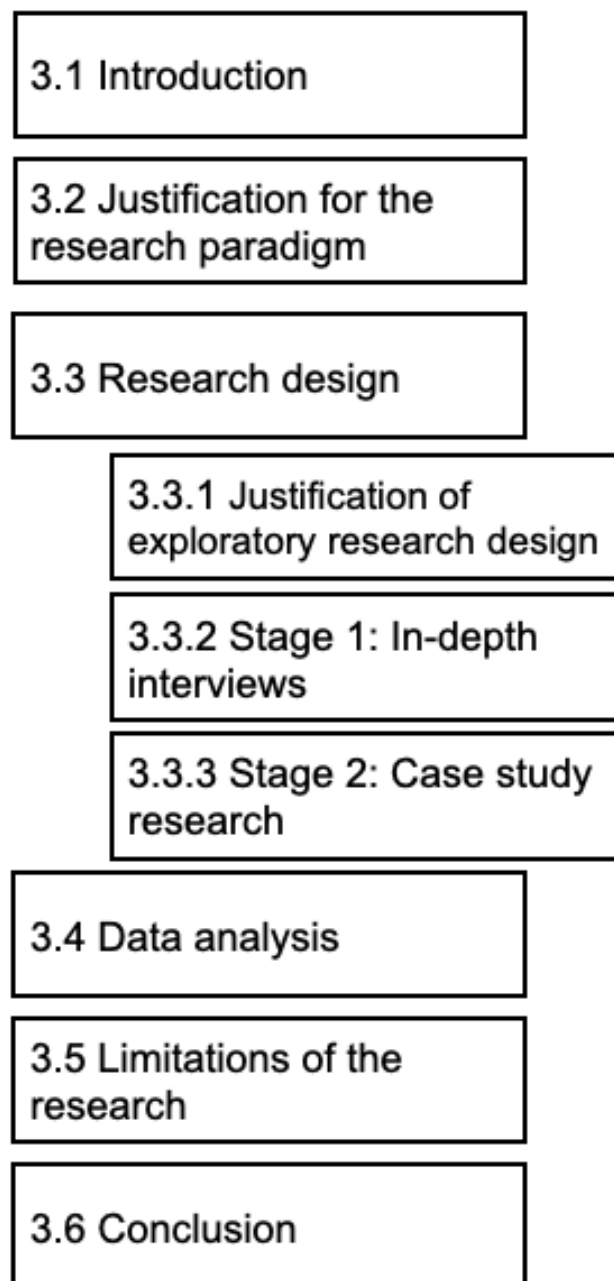
CHAPTER 3: METHODOLOGY

3.1 Introduction

Chapter Two examined the existing literature and introduced a preliminary model aimed at addressing the research question and its sub-questions. The purpose of Chapter Three is to elaborate on and rationalise the chosen research paradigm, as well as the two-stage research methodology implemented in this study.

Chapter Three consists of six sections, as illustrated in Figure 3.1. Research paradigms are discussed in Section 3.2, where the critical realism paradigm will be justified as the most suitable, followed by a justification of an exploratory research design in Section 3.3. This research design consists of two parts: stage one, in-depth interviews, and stage two, case study research. Section 3.4 discusses data analysis for both the in-depth interviews and the case study research. Section 3.5 attempts to discuss the limitations of this research and to point out ethical considerations. Finally, the conclusion is drawn in Section 3.6.

Figure 3.1 Outline of Chapter Three



Source: Prepared for this research

3.2 Justification of the research paradigm

This section first discusses the importance of a paradigm and then justifies why the critical realism paradigm has been chosen over competing paradigms (Collins & Stockton, 2018; Reed, 2017; Halkier, 2011), namely, positivism, critical theory, constructivism, critical realism, and as summarised in Table 3.1.

Importance of a paradigm

A paradigm is an interpretive framework in which an investigator works, and it is an essential collection of beliefs (Collins & Stockton, 2018; Rahi & Reiter, 2017; Antwi & Kasim, 2015; Creswell & Tashakkori, 2007). Thus, the paradigm guides the inquiries for particular research such as this research (Rahi & Reiter, 2017). This guidance is important for the research to have a clear path of investigation and methodology. Furthermore, it allows the research, interview, and conclusion to be independent of the researcher and to be a paradigm orientation. Four principal paradigms that are used across different research and specifically in the field of SCM are discussed hereafter (Eriksson & Engström, 2021; Mahajan, 2010; Linkov et al., 2018; Perry, 1998b).

Table 3.1 Summary of paradigms in SCM

Paradigm / Assumption	Positivism	Critical theory	Constructivism	Post positivism/ Critical realism
Sources	(Ilan, 2018; Schrag, 1992)	(Collins & Stockton, 2018; Roberts, 2014)	(Rowland, 2013; Antwi & Kasim, 2015)	(McAvoy & Butler, 2018; Reed, 2017; Halkier, 2011)
Ontology	Reduces people to mechanic systems, naïve realism	Historical realism, virtual reality are shaped by cultural and other values	Relativism – specific constructed and co-constructed realities	Reality is imperfectly apprehensible
Epistemology	Dualist/objectivist findings are true	Value-mediated findings	Subjectivist, creating findings	Findings probably true, observed with some level of involvement
Methodology	Empirical testing, sampling, questionnaires	Action research/ dialogic	Hermeneutical / dialectical	Case studies / convergent interviews
Suitable to this research	Not suitable because the relationship between an independent variable and one or more dependent variables will be discovered by causal inferences as the results of experimental designs	Not suitable as historical studies omitted	Not suitable as there is no underlying belief or value system. Constructed realities	Suitable as it allows mapping out a theory of causality, which is compatible with qualitative research methods

Source: Adapted from (Chun Tie et al., 2019; Yoo et al., 2019; Lan, 2018; Crotty, 1998; Perry, 1998a)

Table 3.1, presented above, delineates four main research paradigms: positivism, critical theory, constructivism, and post-positivism, also referred to as critical realism. The key characteristics of each paradigm are summarised in terms of their ontology, epistemology, methodology, and appropriateness. A detailed discussion of each paradigm will follow, culminating in an examination of the most pertinent and selected paradigm: **critical realism**.

Positivism has an ontology whereby people and subjects are reduced to mechanical systems that act and react in a naïve way (Lan, 2018; Schrag, 1992). Weaknesses include detaching oneself from the hypothesis. It is almost impossible to detach oneself from the research topic, which undermines the ability to interpret the findings. The methodology consists of surveys, experiments, and questionnaires. A general understanding would remain broad, and the knowledge produced may be too abstract and far-reaching for direct application in this research context (Harris, 2019; Johnson et al., 2013). Positivism is not suitable because the research does not aim to test a hypothesis. Furthermore, positivism fails to address the causal relationships between variables, and it is, therefore, impossible to interpret findings as they would remain both too broad and too abstract to explain specific questions that this research aims to answer.

Critical theory has an ontology of a virtual reality shaped by cultural and other values, such as social values. It is focused on inequalities and aims at a positive change through its epistemology (Collins & Stockton, 2018; Roberts, 2014). Furthermore, critical theory is characterised by the main limitation of lacking standards, references and baseline, which is of notable concern for this research (Roberts, 2014). Findings are value-mediated, making them subjective. The methodology is action research and forward-looking at 'what could' and 'what should'. Its suitability and application to this research, which aims at openly discussing ways of resilience building, would be influenced by the subjectivity of a critical theory paradigm. The critical theory is, therefore, not suitable as references are missing, and it is mostly forward-looking. This research is not action research, and historical experience is not considered, by contrast, a pillar of this research.

Constructivism is limited by ontology, which states that multiple realities exist that are constructed and co-constructed by people (Antwi & Kasim, 2015; Rowland, 2013). The epistemology is characterised by passionate participants who may be subjective about findings that would be created during the research. The methodology is phenomenological, again, neither objective nor data-driven or fact-based. This paradigm is, therefore, not suitable for this research as it has no underlying belief system, and realities are constructed. It, therefore, fails to provide a neutral, objective

or accurate account of findings that are critical to this research (Roberts, 2014; Creswell & Tashakkori, 2007). Furthermore, consistency would not be met by this paradigm.

For **critical realism**, the universe is multifaceted and hierarchically structured into layers (Peter & Park, 2018; Bhaskar, 1978). To build an understanding of a layer, the researcher needs to explain the mechanisms of underlying layers. In natural science, these mechanisms include tangible elements such as gravity or air pressure. In social sciences, however, it may not be possible to see or physically touch the elements such as norms, roles, personality or attitude (Danermark, 2002).

In the business research setting, these mechanisms exist independently of their investigation and are both transformed and reproduced by humans (Hedström & Ylikoski, 2010). For example, some interviewees are expatriates who temporarily live in China. They may be unaware of cultural norms, they may not fully comprehend the political context of China, and they have certainly not grown up in China's values and educational system. Therefore, a certain disconnect may be expected. An examination of these mechanisms, of the level of seniority of the individual, for instance, is the interviewee able to critically evaluate the context or cultural background. To what extent the interviewee is culturally sensitive is therefore essential in applied business research methodology, which is the focus of this study.

The critical realist believes that reality occurs in the domain of the actual (McAvoy & Butler, 2018; Halkier, 2011). Experienced events reside in the domain of the empirical. Mechanisms can lead to events and are independent of them, while events can occur independently of our experience of those events. As such, the domains can be “out of phase” with each other (Peter & Park, 2018; Bhaskar, 1978). This is typically investigated in business research, as opposed to closed laboratory settings. Critical realism is, out of the four paradigms, the most appropriate for this research (Reed, 2017; Danermark, 2002) as it allows us to delineate the phenomena of resilience building. Reasons for the suitability of this paradigm will be further discussed next.

Reasons for the application of critical realism

There are four main reasons to justify the application of a critical realism paradigm: (1) relationship between the entities, (2) contextual framework, (3) triangulation of sources, and (4) knowledge capturing.

First, the **relationship between different entities**, such as the manager, the supplier, and the authorities, can be assessed by means of interviews in a comparative and comparable manner (Brönnimann, 2022; Edwards et al., 2014). For instance, it may be answered which factors make the manager decide to adjust quality levels in a supplier to achieve resilience in its SC. Specifically in the aviation industry, the relationship between the industry and airworthiness regulators may be elaborated upon, such as the needs of airworthiness regulators in terms of safety requirements. The industry will need to provide evidence to meet the requirements, such as safety data substantiation.

Second, critical realism provides a **conceptual framework** under which organisational phenomena that evolve can be observed, such as resilience building that changes over time (Frederiksen & Kringelum, 2021). The transformation of processes, such as digitisation, can be assessed. A company may decide to digitise its processes to enhance transparency and increase collaboration. The conceptual framework permits an analysis of the phenomenon.

A third rationale is that the application of **triangulation** can yield explanatory value. Data-gathering in this research is based on interviews and case studies, which may be interlinked. To capture the complexity of resilience-building in SCs, a pluralistic view may yield a novel understanding of a particular combination of factors and elements in a triangulation process of various data sources (Frederiksen & Kringelum, 2021). Different interviews may provide different perspectives that, in combination with different case studies, may reveal novel knowledge on how and why resilience is developed in SCs. For instance, different suppliers may decide to independently implement ERP software. In isolation, these events seem plausible; in the overall context, it will become evident that the deployment of ERP in the SC facilitates the

cooperation of raw-material allocation, increases traceability of stock and enhances capacity and demand planning of the industry on limited aviation-grade raw material.

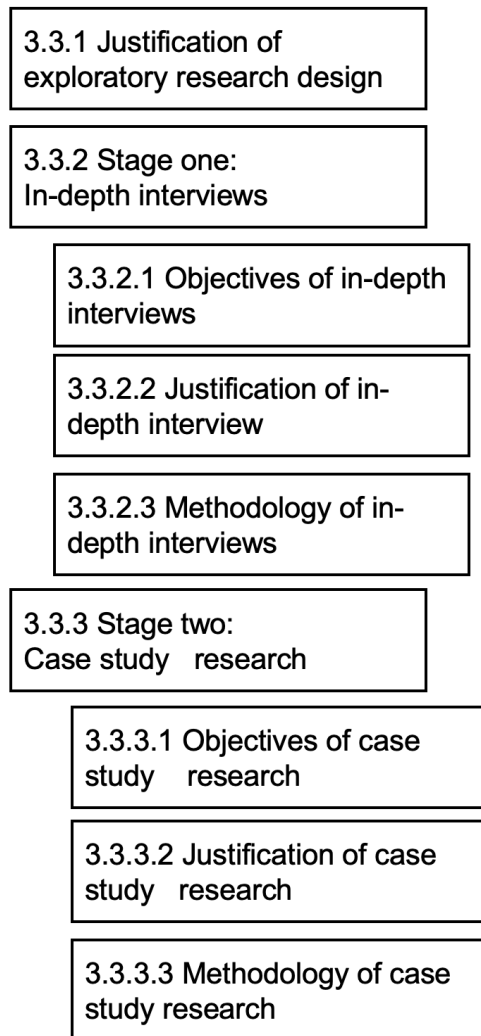
Lastly, the critical realism paradigm is well suited to support the intention of this research to **obtain deep knowledge of phenomena** through in-depth interviews and case studies. Companies in the aviation manufacturing industry and their suppliers manage their SCs in China and build resilience while adding to the theoretical development of the field such as by a model that identifies some of the principal factors pertinent to resilience building (Brönnimann, 2022; Sá et al., 2020). This is achieved by an analytical assessment of findings. For instance, the interviewee will have the opportunity to critically discuss views on SCR, express opinions on the sub-question, and propose specific case studies for an investigation to generate further knowledge, which the critical realism paradigm tries to do.

In summary, Section 3.2 discusses four paradigms that are principally used and applied in the field of business studies and provides the rationale for critical realism over competing paradigms whilst justifications are made. Section 3.3 will discuss the research design, and its sub-sections will justify exploratory in-depth interviews and case studies.

3.3 Research design

This section comprises three parts. Sub-section 3.3.1 provides justification for the exploratory research; sub-section 3.3.2 elaborates on stage one, in-depth interviews, and sub-section 3.3.3 discusses stage two, case study research as illustrated in Figure 3.2.

Figure 3.2: Research design content



Source: Prepared for this research

A two-stage exploratory research process is appropriate and will be discussed by evaluating its suitability, followed by the justification of this research design. This study involves in-depth interviews (stage one) and case studies (stage two) as a two-stage research process that offers a rounded research approach (Yin, 2017; Healy & Perry, 2000). The two-stage approach is appropriate for this research as it allows for

discussion of the macro perspective on the researched topic at first, including definitions and validity of the literature review (Falasca et al., 2008).

Stage one will confirm the validity of the literature review in the context of China's aviation industry SC, and stage two will build on that knowledge by discussing specific cases in China's aviation industry. This discussion will critically evaluate the applicability to specific cases, their exceptions, and the general context of SCR in China's aviation industry. Furthermore, limited research has been identified on the research topic in Chapter Two, which is pointed out through the literature gap in 2.4. Calls for more research on SCR in China's aircraft manufacturing industry by means of case study research (Halpern et al., 2021; Sangwan et al., 2018).

Research design definition: the research design refers to the overall strategy that is chosen to incorporate all components of the research in a coherent and plausible structure in order to address the research question and sub-questions comprehensibly (Tomlinson & Fai, 2016; Drost, 2011; Robinson & Malhotra, 2005). Furthermore, it supports the research question with methods to gain empirical evidence about the research question and sub-question (Harris, 2019; Cabral et al., 2012; Greene et al., 2004). There are two main types of research design, exploratory and confirmatory, which are discussed in sub-section 3.3.1 (Drost, 2011).

3.3.1 Justification of exploratory research design

Confirmatory research, also called hypothesis testing, which is not the objective of this research, allows for the formulation of a theory that is to be tested in its application, as opposed to exploratory research. The formulation is commonly done through hypotheses, which allows for structuring a research process by building theories and related hypotheses and developing a research design. Methodological tools are best suited to address the research question, which is also formulated up front in this research (Rahi & Reiter, 2017; Popper, 1993).

By contrast, **exploratory and inductive research** focuses not on outcomes, results or consequences of human behaviour but directly on the **causal mechanisms** that underlie and produce social phenomena and novel knowledge (Peter & Park, 2018; Blos et al., 2009; Jones, 2008). This research will be exploratory in nature, and it aims to explore novel knowledge that will address a specific set of questions (research question and sub-questions) about factors that influence resilience in SCs. In addition, this research seeks to obtain evidence from actual SCs on the relevance and applicability of theory to SCs in the aviation industry. Furthermore, it investigates industry case studies and obtains insights from experts in a real-world setting.

The adoption of exploratory research is justified based on two principal arguments inherent to this research: the nature of the research and the limited research available on the topic. First, the nature of the research question “How and why does resilience affect SCs in the aviation manufacturing industry in China?” is about gaining insights into how resilience is being built. This means the study seeks to understand different perspectives and consider exploring different opinions, for instance, by comparing and contrasting different supplier approaches, such as SOEs and privately held companies, to resilience building. The research will compare strategic vision, such as building redundancies in the SC, with operative tactics, such as adjusting schedules and prioritisation of demand. The researcher does not test a hypothesis or a theory of how resilience is built; therefore, exploratory research is suitable.

Second, limited research on the specific topic of resilience building in the domain of SC, specifically the aviation industry in China, is available to address the research

question comprehensively. That is why exploratory research is appropriate for this study to gain further insights into the context of why resilience is built, the reasons for its importance, and why companies decide to proceed in a certain way and allocate resources or redeploy resources accordingly (under the theoretical umbrella of the resource-based view of the firm). In addition, this study seeks to support a theory-building process for a relevant and appropriate structure for future research in the field of resilience building in the aircraft manufacturing industry and its SC.

Factors that influence SCR

The research will attempt to explore factors for resilience building that would strengthen further studies in this domain of research. For instance, factors that directly affect resilience in the SC (quality levels, inventory policy, financial capability) or indirectly affect resilience in the SC (education, technology readiness, supplier relationship). A preliminary model will be built based on the findings of the literature review. In-depth interviews will then contribute to further enhancing the factors identified and confirming them with the case studies. The next sub-section, 3.3.2, will discuss the in-depth interviews followed by case study research in sub-section 3.3.3.

3.3.2 Stage one: In-depth interviews

This sub-section begins by proposing the definition of in-depth interviews, followed by the objectives of in-depth interviews (sub-section 3.3.2.1). The justification for in-depth interviews is discussed in sub-section 3.3.2.2. The methodology follows in sub-section 3.3.2.3, which includes a discussion of the interview protocol, selection of participants, and interview administration.

Definition of in-depth interview

An in-depth interview or unstructured interview is a formalised process of interviewing an individual using a set of questions, in this case semi-structured, by a well-versed interviewer, usually conducted in a face-to-face setting (Lucas, 2014). Due to the naturalistic appearance, the conversation-like dialogue will reveal various original perspectives (Rosenthal, 2016). In-depth interviews are qualitative in nature and are usually conducted with individuals. Furthermore, the interviewer tries to understand the interviewees' standpoints, which may be situational, as well as the interviewees' practical experiences that are described using the respective contextual words (Purvanova, 2014).

3.3.2.1 Objectives of in-depth interviews

To meet the purpose of verifying the literature and addressing the research question and sub-questions, there are **seven objectives** that emerge:

Objective 1: to gain an understanding of the definition of resilience in the context of China's aviation industry SC; its applicability to cases will be discussed in stage two,

Objective 2: to map out an initial aviation supplier landscape in China; these will be correlated with the cases of stage two,

Objective 3: to identify a list of key features and components of resilience in the aviation industry in China; stage two will then confirm applicability in real-life cases,

Objective 4: to gain an understanding of the level of importance of resilience in the short-term and long-term and why it is difficult to achieve; stage two will then elaborate on why certain choices are made,

Objective 5: to gain an understanding of proactive and reactive approaches to resilience capabilities building and why it occurs; stage two will provide real-life examples,

Objective 6: to identify the key characteristics of the phases of resilience building; this will be supported by case study discussions of stage two; and finally,

Objective 7: to identify a list of potential case studies for stage two of the research.

Table 3.2 below outlines how the objectives are linked to the interview questions. This correlation is done to ensure that the questions asked during the interview process address the in-depth interview objectives. Furthermore, the interview questions have

been correlated to the research sub questions 1 and 2 There is a risk of limited time for the interview; therefore, this focus is important and required. These seven objectives will be discussed in more detail next.

Table 3.2 Correlation of objective with interview question

Objective	Interview question	RQ1	RQ2
1	Q1: “What is your definition of SCR in China, and could you illustrate it in context?”	x	x
2	Q2: “What type of company ownership is observed in China?”		
	and follow-up question Q3: “What tier status do the companies belong to?”		
3	Q4: “What are the key features of a resilient SC in China’s aviation industry?”	x	x
	and Q5: “What are the key components of resilience that affect SCs in China’s aviation industry?”	x	
4	Q6: “What level of importance of resilience from a short-term and from a long-term perspective do you observe?”	x	x
	and Q7: “Why is it difficult to achieve resilience in the SC, and how do companies overcome this?”	x	x
5	Q8: “How do companies respond to external shocks: rather proactively or rather reactively: in preparation and anticipation or in a responsive mode of recovering and damage control?”	x	x
	and Q9: “Could you elaborate on an example?”	x	x
6	Q10: “What are the key characteristics of resilience prior to an event and what about during a crisis?”		x

	and Q11: “What are the key characteristics of resilience after a crisis?”		x
7	Q12: “Are there specific cases of resilience building in China’s aviation industry that would be relevant to investigate further?”	x	x
	and Q13: “Who could discuss the cases?”	x	x

Source: Prepared for this research

Objective 1: To gain an understanding of the definition of resilience in the context of China's aviation SC.

The first objective is to develop a common understanding of the terminology of resilience. Finding a common understanding is important for any further discussions, as different industries may have different interpretations of resilience and resilience levels. In addition, this objective validates the definition of resilience according to the literature as a desirable feature or capability of the SC. This definition emerges as an outcome of the literature reviewed in Section 2.2 and refers to the scope of this research. Stage two will build on this by asking for applicability in real-life cases.

Objective 2: To map out an initial aviation supplier landscape in China.

The second objective aims to map out an initial aviation supplier landscape and to understand the type of suppliers that operate in China. For instance, what is the ownership structure? Are China's Tier-1s privately-owned or foreign-owned? A further type of perimeter is the size of the company, meaning it is a small enterprise or a large corporation, and finally, the tier-status, i.e. a direct supplier to the customer (OEM) or a tier-2, tier-3, tier-n supplier. Stage two of the research will use this knowledge to correlate the cases discussed with those identified in stage one.

Objective 3: To identify a list of key features and components of resilience in the aviation industry in China.

The third objective aims to identify a list of key features and components of resilience through a process of categorisation of the interview answers. By this means, the researcher will be able to critically evaluate the gaps identified in the literature as to what features and components are covered in the literature and which ones are not. The applicability and relevance to the aviation industry SC in China will also be discussed. The stage two case study research will then discuss how the features and components of resilience function in real-life cases.

Objective 4: To gain an understanding of the importance of resilience in the short and long term and why it is difficult to achieve it.

This objective aims to address the importance of resilience from short-term and long-term perspectives. It will also discuss why it is difficult to achieve in the SC. Stage two

will use this knowledge to discuss the case study setting and how companies make choices on resilience in the short-term and in the long term.

Objective 5: To gain an understanding of proactive and reactive approaches to resilience capabilities building and why they occur.

This objective will discuss if resilience is developed proactively, i.e. by conviction that benefits outweigh cost, or as a response to an issue, i.e. out of necessity. This objective refers to the research problem and aims to contrast the effort and benefit of the two approaches based on the context of different enterprises. Stage two of the research will discuss how companies make the choices around resilience capabilities building.

Objective 6: To identify the key characteristics of the phases of resilience building.

This objective will discuss key phases of resilience building and how enterprises behave prior to, during and after the occurrence of an adverse event, as each phase may observe a different set of components of resilience (or effectiveness) of component that had been discussed in sub-section 2.3.4 “*key themes*”. The purpose of this objective is to contrast each phase and to contextualise key components of the different phases to one another. Stage two of the research aims to provide examples of how these key characteristics operationalise.

Objective 7: To identify a list of potential case studies for stage two of the research.

The rationale of the last objective is to identify leads of potential case studies to investigate foreign-owned companies, local private enterprises, and SOEs. The purpose is to ensure the representativeness of cases.

In summary, this section addressed the seven objectives of the in-depth interview, providing a rationale for each and linking them to stage two's interconnectivity. The insights gained will be contextualised within real-life case study interviews. The discussion will then shift to the correlation between the interview questions and the overarching research question.

3.3.2.2 *Justification of in-depth interview*

The adoption of in-depth interviews can be justified on four grounds: (1) the gathering of inductive data; (2) the participation of experts; (3) the requirement for a detailed understanding of the research topic and of the research objective; and (4) the necessity for suppleness and openness to gather novel knowledge. Each of these elements will be elaborated upon in turn.

In-depth interviews are amongst the most appropriate techniques in **exploratory research** for gathering inductive data, as knowledge and understanding in this research area are limited. Therefore, this technique is deemed appropriate (Tonn et al., 2021; Dolci et al., 2017; Rosenthal, 2016) and allows the researcher to generate preliminary and background data in the area of resilience building in SCM in the aviation industry in China, and to gain insights and understanding regarding the research question and sub-questions such as key features and components of resilience influencing resilience (Brusset & Teller, 2017; Mann, 2011).

Second, this research comprises **experts from areas** of SCM, procurement, and strategic areas of the business, directly or indirectly dealing with the aviation industry in China and having had significant exposure to resilience in the SC. Identifying operational challenges in the context of sending highly skilled expatriates to China. These insights will further confirm the validity of the literature or identify differences based on the real-world setting of the in-depth interviews. Both will support contextual settings. Therefore, the in-depth interview method is justified.

Third, in-depth interviews permit the researcher to **acquire a comprehensive understanding** of the issue that is being investigated. The interviews allow us to discuss further topics that are complex or may be of a certain degree of confidentiality that would otherwise not have been exposed (Sá et al., 2020; Fidler & Kleinknecht, 1977). Complexity is given by the nature of the aviation industry: a global supply base, long qualification cycles, high barriers to entry, capital intensity for investments, and long product lifecycles. Confidentiality relates to companies wanting and needing to maintain a competitive advantage; therefore, exposing names may infringe on this confidentiality. Furthermore, the confidentiality of responses from the interviewees is

ensured. This encourages the interviewees to freely discuss their attitudes, experiences and perspectives towards the research topic (Alam, 2021; MacDonald, 2012). This is particularly relevant to this research because the findings from the in-depth interviews should clarify the objective of issues such as the types of resilience models in use and the factors that influence SCs, specifically to determine the appropriateness of influencing factors manifested utilising the literature review. Furthermore, the in-depth interview will help identify **potential case studies** for stage two – case study of this research. For instance, by asking which private or SOE could be interested in participating in this research and by asking if there are specific cases that would be of contribution to the research.

Finally, in-depth interviews also provide the **flexibility** to allow the researcher to adjust, drop or add propositions in response to evidence from the interviewees, particularly concerning factors that influence SCR and its components (Wilson et al., 2016). Consequently, the interviewer may gain a more dynamic and beneficial research outcome by applying an in-depth interview in a semi-structured manner.

It proves a big challenge to organise group interviews or focus groups that suit professionals since they have busy schedules to follow and may hold competing and confidential information (O.Nyumba et al., 2018). Therefore, in-depth interviews were considered to be appropriate as they allow the researcher and the interviewee a relative degree of flexibility to arrange suitable interview appointments (Von Soest, 2023; Rowley, 2012).

3.3.2.3 Methodology of in-depth interviews

Sub-section 3.3.2.2 justified the use of in-depth interviews based on the objectives of the research. This sub-section will discuss the methodology of in-depth interviews, i.e., how the research is being operationalised. First, the interview protocol will be discussed, including the type of questions and how they relate to address the objective of the in-depth interviews. Second, the participation in the in-depth interviews will be discussed, including the selection strategy and the categorisation. Third, the interview administration will be discussed, as well as what steps will take place and when. Data capturing and data analysis will be discussed in Section 3.4.

Interview protocol

An interview protocol (Appendix I, III) helps collect required data in a structured, systematic and reliable manner (Castillo-Montoya, 2016; Ibrahim, 2003; Booth et al., 1991). The interview protocol and script aim to guide the research towards answering the research question.

Interview questionnaire

The interview questionnaire consists of four sections (Castillo-Montoya, 2016):

- Introductory question,
- Transition question,
- Key question; and
- Closing question.

The two introductory questions consisted of neutral questions eliciting general and nonintrusive information. The key purpose is to provide background information, such as the definition of resilience and ensure a relevant understanding of the research objective. This section also highlights the ethical guidelines of this research to the interviewee and confirms their understanding of the risk. Furthermore, this helped to calibrate the general understanding of the research and key definitions of resilience. For instance, the research is about the resilience of the SC and not about airlines having resilience in capacity for passengers. These questions matched objectives one and two of stage one, *“to gain an understanding of the definition of resilience in the context of China’s aviation SC”* and *“to map out an initial aviation supplier landscape in China”*.

Introductory questions work as an “ice breaker” and help establish a connection between the interviewee and interviewer. For instance, *“what is your definition of SCR in China, and could you illustrate it in context?”* (Q1) and *“what type of company ownership is observed in China?”* (Q2), and *“what tier status do the companies belong to?”* (Q3).

The transition questions (question four and question five) are linked to objective three and ask: *“what are the key features of a resilient SC in China’s aviation industry?”* (Q4)

and “what are the key components of resilience that affect SCs in China’s aviation industry” (Q5).

The key questions (questions six through 11) then addressed objectives four, five and six of stage one. These questions included: “*what level of importance of resilience from a short-term and from a long-term perspective do you observe?*” (Q6) and “*why is it or is it not desirable and is it or is it not difficult to achieve it?*” (Q7) and “*how do companies respond to external shocks: rather proactively or rather reactively: in preparation and anticipation or in a responsive mode of recovering and damage control?*” (Q8) and “*could you elaborate on an example?*” (Q9) and “*what are the key characteristics of resilience prior to an event and what about during a crisis?*” (Q10) and “*what are the key characteristic of resilience after a crisis?*” (Q11).

The final closing questions (questions 12 and 13) allowed any remarks by the interviewee to propose specific cases and contacts for further interviews, which is part of objective seven) to define cases for stage 2 by asking, “*are there specific cases of resilience building in China’s aviation industry that would be relevant to investigate further?*” (Q12) and “*who could discuss the cases?*” (Q13).

Participants

This sub-section will address the process of identifying and selecting participants for the in-depth interviews. Initially, the strategy for selection will be outlined, including the total number of participants involved. Subsequently, the specific criteria for participant selection and their categorisation will be examined, followed by a discussion on the administration of the interviews.

Selection strategy

Aviation industry managers, senior managers, directors, and executives were deemed as having the relevant and required experience, knowledge, and expertise in the researched domain to contribute towards the stage one objectives. The interviewees were selected based on convenience judgement sampling, where interviewees were approached through personal contact and references from peers and colleagues. Moreover, the snowball sampling strategy (Sadler et al., 2010) was applied, increasing

the number of potential participants. Furthermore, during meetings with senior industry experts at specialised trade fairs, further contacts and recommendations for interviews took place, including Farnborough 2022 and 2024, ILA (*Internationale Luftschiffahrt-Ausstellung* meaning the international aircraft exhibition) in Berlin in 2022, and Le Bourget, 2023.

To develop meaningful themes and interpretations, an approximate number of 15 to 20 interviewees should be identified (Rahi & Reiter, 2017; Mason, 2010; Man, 2009). Although the actual number of interviews was smaller than the targeted number, a state of theoretical saturation occurred (Mason, 2010; Vissak, 2010). In this stage of the research, saturation occurred after nine in-depth interviews, at which stage no novel knowledge was generated; therefore, the in-depth interviews were concluded without further interviews.

Selection of participants

The selection of participants will be based on several primary criteria, which include:

- Aviation industry experience length of a minimum of five years,
- Knowledge of international SC, quality management and manufacturing; and
- Minimum of five years of exposure to China's aviation industry.

To meet the aviation industry experience criterion, outreach was conducted to senior managers and executives from commercial aircraft manufacturers and suppliers. This ensures interviewees have relevant knowledge of this highly regulated sector, as insights from other industries may oversimplify aviation complexities. Interviewee identities and companies will remain confidential. Their qualifications were verified through LinkedIn and other public sources, and no issues were encountered.

Criterion two highlights the importance of knowledge in international SCM, quality assurance, and manufacturing, especially in the complex aviation sector. Candidates should understand qualification processes and approval mechanisms for supplier partnerships, ensuring that products are sourced only from vetted suppliers with ongoing surveillance. They are also expected to be familiar with the AS 9100 Series Norms for aviation quality standards or their equivalents. Candidate qualifications

were verified through LinkedIn profiles, business cards, or published works, and all participants met the necessary criteria.

Criterion three, which pertains to exposure to China, holds significant relevance for this study, as it investigates the functions of suppliers within both the private and public sectors in China. The dynamics of the Chinese economy diverge from those of other economies, and thus, drawing a conclusion based on these differences may lead to erroneous implications for future research (Mhalla, 2020; Vinet & Zhedanov, 2011d; Zeng et al., 2011). It is, therefore, important for the interviewee to know how China works from a business perspective. To confirm this criterion, the interviewee's experience was captured during the introduction of the interview as they briefly introduced themselves. This occurred during a short introduction, during which the researcher presented himself, and the interviewee was asked to do the same. All interviewees qualified.

Participant categorisation

As part of the interviewee selection criteria, the interviewees have been profiled into three categories. First, technical experts second executives and third local managers. This is done to ensure a balanced approach between the strategic views of the executive, the technical view of the experts and a Chinese view from local managers. A mixture of interviewees who can provide different perspectives from their respective domains of expertise is noted (Adeoye-Olatunde & Olenik, 2021).

The use of public and privileged information allowed the researcher to successfully ensure that participants qualified. The LinkedIn profile was used to associate the interviewee with the categories below. Where no LinkedIn profile was available, a peer confirmation was received. To ensure a balanced distribution of participants, the researcher successfully targeted participants specifically through the interviewees' network and through the LinkedIn platform.

Technical experts are individuals who have over 15 years of experience in the domain of resilience, quality, and SCM and manufacturing. The interviewees were expected to be able to contribute to key elements of the technical subject matter (Pfadenhauer, 2009).

Executives are categorised as individuals who are ranked as vice president or above; for example, a chief executive or general manager would fall into this category. Executives are characterised by having a strategic business view and can contextualise situations rather than being able to contribute to detailed technical components (Yrjölä et al., 2018).

Local experts are categorised as individuals native to China who work in the domains of SCM, resilience, quality, and manufacturing. These individuals are not executives. Local experts are expected to have an applied local perspective on SCs, which was confirmed during the interview (Akkermans et al., 2011).

Interview administration

This section will walk through the steps of how interviews for stage one was administered. They were divided into three phases: preparatory, execution, follow-up, and post-interview, which will be discussed in turn (Adhabi & Christina, 2017).

Preparatory phase

The preparatory phase consists of the organisation, the logistics and the ethical clearance. Interviewees were selected based on the selection strategy, first contact was made, the research was explained, and ethical considerations and ethics clearance were processed.

The interviewee introduction was done by personal contact or by email. During this introduction, the research context was introduced. Upon confirmation of willingness to participate, the participant information sheet and ethical consent form were sent (available in Appendix II and Appendix IV, respectively). The interview protocol was sent to the interviewees, making their preparation easier, assisting with the flow of the interview and offering an overview of the research.

Execution phase

The execution phase is the conduct of the interview itself. The questions that have been asked were outlined in sub-section 3.3.2.1. and in Table 3.1.

The second step was the interview execution, which took place on the agreed day and time using ZOOM, given the global COVID-19 pandemic, government restrictions, and social-distancing policies. Where consent was given, the interview was recorded using the ZOOM feature. The defined interview protocol (Appendix I) was followed. Each interview lasted for approximately one hour and was conducted in English language.

Follow-up phase (post-interview)

The follow-up phase shall ensure the accuracy of transcription, acknowledge the support received, and value the inputs by presenting the conclusion and findings of the overall research once they are completed.

The third step in the interview administration was the transcription and its confirmation by the interviewee. The interview was transcribed using the Otter APP, which has a 95% accuracy rate. The researcher reviewed and corrected the transcription before sending it to the interviewee for approval, who raised no objections, confirming its accuracy. The audio data was uploaded solely for transcription and is not retained by the Otter APP, ensuring data privacy compliance. The final data is stored digitally per the University of Southern Queensland's policies on data storage and retention. Upon successful completion of the research and examination, the key summary findings will be shared with the participants who expressed an interest in learning about it. This concludes the stage one case study research.

3.3.3 Stage two: Case study research

This sub-section is structured in three parts. It begins by qualifying the adoption of case study research and sets forth the objectives thereof in sub-section 3.3.3.1. The justification of case study research is given in sub-section 3.3.3.2. The methodology and administration (sub-section 3.3.3.3) are discussed, including case selection and literal and theoretical replications.

Definition of case study research

Case study research centres on an industry, sector, institution or organisation to methodically explore and study experienced events whilst retaining real-life annotations and interpretations within the events (Burgos & Ivanov, 2021; Yin, 2017). Furthermore, case study research provides descriptive data on management situations within a particular setting (Arora et al., 2020; Schoch, 2009). Once this data is analysed adequately, it may lead to general observations and plausible recommendations, such as best-in-class cases and benchmark levels (Pimentel, 2018; Schoch, 2009).

3.3.3.1 Objectives of case study research

The objectives of stage two, case study research, are initially identified in Chapter One, Section 1.2, “Objectives of the research and research question and sub-questions”. These objectives include the following sub-questions (SQ1 and SQ2) of this research:

SQ1: “What are the key components of resilience in the SC in the aviation manufacturing industry in China? How and why do these components influence SCs?”

SQ2: “What are the key features of resilience in the SC in the aviation manufacturing industry in China? How and why do these features influence SCs?”

The objectives for each sub-question will be discussed next. The primary objective is to address the research sub-questions (SQ1 and SQ2). Furthermore, the research will reveal specific case settings, practical information, and knowledge from real-life examples in the context of resilience in China’s aviation SC. For example, an interviewee will have explained their observations on features and components of resilience within a supplier in China (objective 3 of stage one). The case study will then explore these in further detail throughout the SQs.

The objective of SQ1 is to examine the key components of resilience that emerged from the interviews. Q2 will inquire what the key components of resilience had been observed in the SC. Following this, Q3 asks to contrast the components of SOEs, foreign-owned enterprises, and domestic privately-owned enterprises. Lastly, Q4 will

investigate “how” and “why” the components affect SCR and to discuss example. An overview of the questions and their relationship to the SQ is provided in Table 3.3.

The objective of SQ2 is to discern the features of resilience that influence SCs in real-world contexts. Q5 will inquire about the key features of resilience that affect SCs. Subsequently, Q6 will explore “how” and “why” these features influence SCs.

Table 3.3 Extract of case study interview questions

Objective	Extract of Case study interview questions
SQ1 “What are the key components of resilience in the SC in the aviation manufacturing industry in China? How and why do these components influence SC?”	Q2: “What are the key components of resilience that you have observed in the SC?”
	Q3: “How and why do the key components affect SCR and could you elaborate on specific components of resilience in a specific example within your organisation?”
	Q4: “Could you contrast components of SOEs, foreign-owned enterprises, and domestic privately-owned enterprises?”
SQ2 “What are the key features of resilience in the SC in the aviation manufacturing industry in China? How and why do these features influence SCs?”	Q5: “What are the key features of resilience that affect SCs?”
	Q6: “How and why do these features influence SCs?”

Source: Prepared for this research

This sub-section has succinctly delineated the primary aims of stage two of this research, which include addressing the research sub-questions SQ1 and SQ2, as well as providing contextual illustrations through real-life examples from various cases. This approach facilitates the acquisition of new insights and enables the comparison of variables across different scenarios.

3.3.3.2 Justification of case study research

The justification for the use of case study research for stage two is given by the nature of this research. It is based on three primary reasons: real-life accounts, experience of experts and non-perfection of the real world (Elmore et al., 2024).

First, the research discusses in-depth the factors that influence resilience building, utilising illustrations in a case study setting (Liu et al., 2021). Case study research is most suitable as they are a real-life account of an organisational setting, for example, by discussing why a company was able to successfully use data to predict change and why another company may have failed due to resistance to change (Stanton & Roelich, 2021). Actual-lived experience will be discussed as compared to theoretical or hypothetical theories. This experience will provide a holistic view of the topic (Basias & Pollalis, 2018). For example, by contrasting components of resilience according to variables such as between the SOEs and the domestic privately-owned companies.

Second, the case study enables the researcher to examine the experiences of experts that will have elaborated upon how resilience is being developed and how it impacts the SC in the cases discussed (Pacho, 2015): case study research is interactive and not static, interaction is possible between the researcher and the interviewee.

Third, case study research reflects the non-perfection of the real world (Sá et al., 2020). For example, detailing the relevance of logistics and strong infrastructure ensures consistency in deliveries and thereby builds reliability in a systemic approach that can ultimately be characterised as resilience in SCs.

The case study is therefore suitable for theory building and the case for this research as it is novel, testable and empirically validated based on a rich and in-depth real-life dynamic account; the application of case study research is deemed appropriate (Eisenhardt 1989).

3.3.3.3 Methodology of case study research

This sub-section addresses the methodology associated with case study research, including the case study protocol and the three distinct phases of the research

process: the preparatory phase, the execution phase, and the follow-up phase. Following this, the discussion will shift to the pilot cases, providing a rationale for the number of cases included and detailing the criteria used for case selection.

Case study protocol

The case study research questions are divided into three parts: the introductory question (Q1) that presents the case study setting and guides the discussion; key questions (Q2-Q6) that aim to elaborate on the case study; and closure questions to address any remaining element of the research. The protocol for the case study (Appendix III) is guided by open-ended questions, and the actual questions relevant to the objectives are provided in Table 3.3.

Case study administration

Similar to stage one, the in-depth interview, the case study administration consists of three phases (Baškarada, 2014):

- Preparatory phase,
- Execution phase; and
- Follow-up phase.

The three phases will now be discussed in sequence.

Preparatory phase

This section aims at confirming relevant cases initially identified in stage one. Relevant people have been contacted in order to engage them to participate in the interviews using the researcher's contacts as well as the referrals from interviewees during stage one of the research study (Luna et al., 2018; Baškarada, 2014). Potential interviewees were contacted by personal phone call or email, during which the research context was introduced; upon confirmation of willingness to participate in the case study research, the participant information sheet and ethical consent form were sent (available in Appendix II and IV, respectively). The case study protocol was then sent to the interviewees, making their preparation easier, assisting with the flow of the interview and offering an overview of the research and how their contribution would contribute to this research.

Execution phase

The second step is the case study execution, which took place on the agreed day and time using ZOOM, given the global COVID-19 pandemic and governmental restrictions and social-distancing policies (Oliffe et al., 2021; Halkier, 2011). Where consent was given, the case study interview was recorded using the ZOOM feature. The defined case study interview protocol was followed (Appendix III). Some definitions of SC and the context of resilience were given during the introductory questions that had been elaborated upon during stage one of the research. Each case study interview lasted approximately one hour and was conducted in English language.

Follow-up phase

The third step in the administration was the transcription of the case-study interviews and the confirmation by the interviewee. The interview was, with interviewee acceptance, automatically recorded by “the Otter APP”, and simulations were available in a Word file (Wollin-Giering & Hoffmann, 2023; Rosenthal, 2016). Second, the text was confirmed and, where pertinent, amended by the researcher. Third, the Word file was sent by email to the interviewee for their validation. No objections had been received regarding the accuracy of the transcription, validating its accuracy. The data generated is being stored digitally in line with UniSQ policy for data storage and data retention.

Pilot case

Two pilot cases have been performed to pre-test the suitability of the case study protocol and to determine if changes were required (Baškarada, 2014). One pilot is on a SOE, and the other pilot is on a foreign-owned enterprise. Some minor changes to the protocol were performed, such as precision in the wording, the fact that the research was not looking at airline resilience but SCR, an emphasis on the Chinese context, and the removal of lengthy introductions.

The findings of the two pilot interviews confirmed the validity of the case study interview protocol (Appendix III). As the questions discussed contributed to the research, the interview protocol went well, and the processes and methods used

needed no refinement. The remaining cases were conducted without changing the interview protocol, and the data generated in the pilot case was included in the data analysis in Chapter Five.

Case selection

Appropriate case selection is of fundamental importance to ensure the success of the research in addressing the objectives (Mehrad, 2019; Yin, 2017). This section will discuss the selection criteria as well as the minimum quantity of cases to be investigated. The selection of cases relies on purposeful sampling drawn from the complete supplier landscape in China (Yin, 2017). This data is public and available from the two main aircraft manufacturers (with over 80% of the market share) with significant operations in China. The samples drawn meet the given primary selection criteria enumerated in this section (Asiamah et al., 2017).

As an outcome of stage one, the interviewees contributed with recommendations of relevant cases as well as recommended points of contact for further investigation that significantly influenced the case selection (Mohsin, 2021). For instance, it was recommended to investigate the case of a supplier in Sichuan province, as the case of manufacturing a complex structural aircraft assembly could provide interesting insights into resilience in the SC. It was also recommended that a senior manager who had been working on this case for several years be contacted as the person was well-positioned to address the research interest. A second interviewee had also been found. Interviewee selection criteria for the case study research included:

- Existing and established aviation industry suppliers in China to address the research gap that looks at China aviation suppliers specifically,
- The tier-x status (direct supplier or supplier to a supplier) to provide a diverse and critical view of the phenomenon investigated; and
- Background information collected included categories such as company size, structure and ownership, i.e. SOEs, privately-held enterprises, foreign-owned enterprises, product type and location and proximity of the SC.

To ensure a balanced approach, specifically with reference to SOEs and private enterprises, the researcher ensured that potential case study participants were approached in an adequate manner.

Selection criteria and background information

The outcome of the analysis will be used to verify the findings of stage one and of the literature review in which these variables appeared to influence the subject investigated (Oliva et al., 2019; Tellis, 1997). These selection criteria and background information would later enable a cross-case analysis and validation of similarities and/or differences. Cases were selected through purposeful sampling, guided by insights from initial interviewees and the researchers' industry expertise in China.

The preliminary list includes four SOEs, three of which have over 500 employees, and four foreign-owned enterprises, two of which also employ more than 500 individuals. Additionally, there is one privately held Chinese company with fewer than 500 employees. Table 3.4 summarises the cases to be examined in the second stage of the research, with each case study analysed using input from two interviewees. The methodology will be detailed in Chapter Four.

Table 3.4 Schematic view of cases investigated

Size of enterprise	Types of ownership			Product complexity
	SOEs	Foreign-owned enterprise	Domestic privately-owned enterprises	
Large enterprise (>500 employees)	3 cases (1pilot)	2 cases	n.a.	Higher complexity (work packages) 5
SME (<500 employees)	1 case	2 cases (1 pilot)	1 case	Lower complexity (material, parts) 4
Total	4 cases (8 interviews)	4 cases (8 interviews)	1 case (2 interviews)	

Source: Prepared for this research

Literal and theoretical replications

In the case of literal replication, cases are selected to predict similar results (Schmidt, 2009). In the case of theoretical replication, cases are selected to predict contrasting results but for theoretical reasons (Schmidt, 2009). In this research, the cross-case analysis between different cases is conducted to determine differences and similarities (Wang, 2020). Themes are identified during the case analysis and include:

- **Ownership:** SOEs, privately-owned enterprises and foreign-owned enterprises commonalities and differences,
- **Company size:** large corporations vs small and medium-sized enterprises (SME); and
- **Product complexity:** commonalities and differences in companies manufacturing simple products versus highly complex products.

The applied cross-case analysis will help to determine the validity of individual cases as commonalities and differences emerge. Furthermore, commonalities will provide

strong evidence in support of generalisable observations to link them to theory and discuss findings.

Range of cases

A single case would investigate a phenomenon in detail; however, this would not allow the examination of a holistic perspective of the research matter (Yin, 2017). Furthermore, the variables in the cases are multiple and will need cross-case validation (Elmore et al., 2024; Baškarada, 2014). Therefore, the number of cases must be adequate for the outcome of the analysis to be meaningful and to comply with a research strategy (Alam, 2021; Popenoe et al., 2021; Yin, 1981). Despite there not being predetermined rules to govern the sample size or the minimum acceptable number of cases for a case study research, the selection of cases should be based on their richness and ability to contribute in a meaningful way to the research (Yin, 2017; Israelsson, 2016). It was proposed to use a range between four (4) and fifteen (15) cases to meet the minimum requirements of data content and to avoid problems arising from too much data (Eisenhardt, 2021; Eisenhardt, 1989). Where possible, financial reports and investor guidance documents (such as metrics on profitability, workforce size, and financial turnover) were utilised (especially for publicly traded companies) to further triangulate the results. Given these guidelines and recommendations and considering constraints with respect to accessibility of interviewees and time constraints to perform the interviews, a total of nine cases was conducted, which fell into the acceptable range and offered a wide range of knowledge to look at (Harrison et al., 2017; Chen et al., 2014b). A total of nine case studies were chosen to illustrate the varied landscape of China's aviation SC. These cases encompass a range of geographical regions, including Southern, Northern, and Coastal China, as well as Central China. They also reflect a spectrum of operational sizes, from small and medium-sized enterprises (SMEs) to large corporations, and include different ownership types, such as SOEs, private companies, and foreign firms. According to industry experts, these cases collectively represent a significant portion of China's SC.

Selection of interviewees for case study

It had been proposed that nine cases would be investigated. To avoid a single opinion and to enhance the detailed view of cases, two interviews were conducted per each case study. This brought the number of case study interviews to a total of 18, including two pilot case interviews. This also falls into the recommended range between fifteen (15) and twenty (20) interviews (Mouatasim & Hadid, 2020; Song et al., 2016; Teegavarapu et al., 2008; Ghoris, 2007; Hinkin et al., 1997).

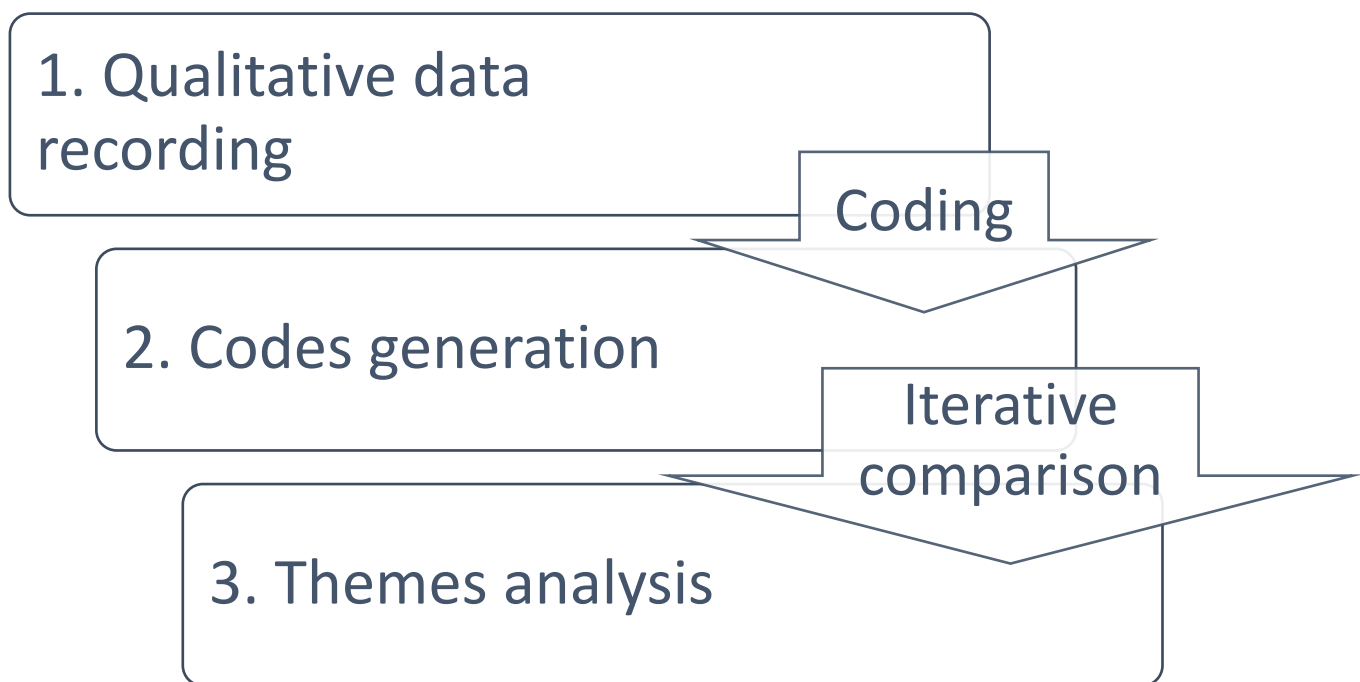
The selection of interview participants for case study interviews is based on the criteria of ability to contribute to the research from respective angles of the business. Therefore, one interviewee will provide an operational perspective, whilst the second interviewee will provide a strategic perspective. One interviewee would be the vice president, chief executive officer or equivalent, and the second would be a program manager, general manager or equivalent. The criterion is checked and confirmed by the title of the interviewee using public information such as LinkedIn or the company website. No further selection criteria were required.

Sub-section 3.3.3 outlined the case study research methodology, detailing the case study protocol and the three research phases: preparatory, execution, and follow-up. It discussed pilot cases, the rationale for the number of interviews, case selection criteria, and the diversity of cases. The next section will address data analysis from the in-depth interviews and the overall case study research.

3.4 Data analysis

Data analysis is critical to understanding the information recorded (Collins & Stockton, 2018; Skilton, 2014; de la Tour et al., 2011). Data analysis is the process by which the data generated is organised, analysed, and structured in order to draw a meaningful conclusion (Von Soest, 2023; Saragih et al., 2020; Mezmir, 2020; Vinet & Zhedanov, 2011f). This section will discuss data reduction, data display and data analysis techniques and reporting that this research intends to apply. This approach is applicable to both stage one, in-depth interviews, and to stage two, case study research.

Figure 3.3 Visualisation of the analysis process



Source: Prepared for this research

Data recording

Step one, presented in Figure 3.3, was the recording of qualitative data that had been transcribed during the interviews. The data had been organised through thematic analysis, converting the data into manageable and quicker access information (Bazeley et al., 2013) and through content analysis (Lindgren et al., 2020). The transcription of the interviews was analysed using NVIVO computer software. NVIVO is a computer-assisted qualitative data analysis software (CAQDAS) that is used to collect, organise, analyse, visualise and report data (Westby, 2021).

Data reduction

Data reduction is the process by which captured qualitative information is reduced to make it presentable, to summarise it and to edit it in a meaningful way (Mezmir, 2020). Data coding is a method by which the captured data is organised to explain its meaning (Charmaz, 2006).

A coding process was used leading to step two (as shown in Figure 3.3), and categories were set up. Content analysis has been used as a descriptive approach in both the coding of the data and its interpretation of quantitative counts of the codes (Morgan, 1993; Downe-Wamboldt, 1992). The data will then be organised and analysed according to the categories that it would build. Several cycles will be used in the coding process to best capture the themes and concepts. Categories were then set up, including SC policies, tools, methods, processes and procedures, behaviour and ethics, and skills and capabilities. For instance, objective three of the in-depth interviews aims to confirm the key features and components of resilience in China's aviation SC. These components and features are captured during the interview (e.g. logistic capabilities, redundancies, digitisation). Codes are then generated; for example, interviewees one, two and three believe that logistic capabilities are a key component. Then, the iterative comparison takes place, explaining why each interviewee contributed the data. Tables and diagrams are then populated with the data to visually illustrate the answers to the interview, and the analysis then addresses the individual objective. As this research is exploratory in nature, the researcher will use a conceptual model to guide the research. The process of data reduction is likely

influenced by the conceptual framework chosen for the research (Huberman et al., 1994).

Data display is used, such as findings that will be summarised and supported by quotes from the interview in italics alongside narrative text from the interview. Furthermore, visual displays such as diagrams will be used to visually represent segments of the data that address the concepts of interest. This visualisation will be done using NVIVO and Excel to draw diagrams. To continue with the example discussed, a Pareto diagram will be used to illustrate the features and components most mentioned all the way to those least mentioned in a visual diagram.

Data analysis interpretation technique

This final step consists of drawing meaningful statements about how the captured data illustrates the topic of research (Huberman & Miles, 1994). The researcher will contrast cases and provide contextual reasons to interpret why the findings occur.

Reporting strategies

The findings will be presented using the categories identified in a neutral voice without interpretation. Furthermore, results will be interpreted and compared to previous studies published in the relevant literature (Ebrahimi & Sadeghi, 2013; Franca et al., 2010) and theories (Zu & Kaynak, 2012; Arzu Akyuz & Erman Erkan, 2010) such as dynamic capabilities theory and resource-based view of the firm. The reporting is done twofold, where interviews from stage one is reported in Section 4.2.2 and for case study research of stage two in Sections 6.3 for the research question and 5.3 for the sub-questions, respectively.

The described data analysis methodology will be applied to both stage one and stage two in the respective chapter of this research. Stage one data collection is based on nine interviews, and stage two data collection is based on a total of 18 case study interviews (Song et al., 2016; Teegavarapu et al., 2008; Hinkin et al., 1997).

3.5 Limits of this research and ethical considerations

This section will begin by discussing the research limitations that prevail, and sub-section 3.5.2 will address ethical considerations.

3.5.1 Limitations

This sub-section will discuss the limitations related to stage one in-depth interviews, followed by the limitations of stage two in the case study.

Limitations of in-depth interview

Even though the adoption of in-depth interviews has been justified in Section 3.3.1, certain limitations exist. For instance, the interviewer needs to be qualified to conduct the interview; there may be interviewer bias, and some findings may not be trivial enough to generalise (Wilson et al., 2016). The researcher should be aware of these limitations and try to minimise the impact, for example, by not generalising. Some techniques are described next.

Primarily, the researcher had previous professional experience conducting interviews using open-ended questions when assessing SCR. The researcher knows the technical content very well. Furthermore, the researcher was conscious of maintaining a non-biased approach by not providing any personal opinions that could influence the interviewee's answers (Anyan, 2013). In addition, the researcher prepared before the interviews took place as described in the section 'in-depth interview methodology'.

A further limitation identified generalising results, i.e., deducting. As the research is exploratory in nature and seeks to build on existing theories, the findings are not generalisable to the population at large. It is solely relevant to the specific case discussed and needs to be acknowledged as such.

Limitations of case study research

Even though the adoption of case study research has been discussed and justified, two key limitations are identified and will be further elaborated as follows.

Firstly, representation of cases, i.e., to what extent are the selected cases adequately representing the China landscape? This concern is overcome by using multiple cases

to capture, until saturation, different perspectives and experiences. A representative sample is proposed based on the selection criteria. Furthermore, it should be noted that China has limited cases to investigate as the market is strongly controlled by the State.

A further limitation is the generalisation of results. It is to be acknowledged that individual cases and their findings may not be generalisable to all suppliers in China and are only to be applied to specific cases in a specific situation or context. This will provide the groundwork for further studies in the domain of resilience in China's aviation SC.

3.5.2 Ethical considerations

Ethical considerations are important not only to adhere to legislation and rules of the University but also to ensure the safety of the researcher and of the interviewees (Rodríguez, 2023). The resulting risk shall be managed in line with guidance pertinent to this research. This section discusses the measures put in place to minimise any potential risk to interviewees and to the overall research.

The qualitative research component consists of interviews; therefore, research ethics approval had to be obtained from the University of Southern Queensland before any interviews could start. The relevant framework, guidelines and standards have been incorporated (Australian Government: National Health and Medical Research Council, 2018; Cabello et al., 2015) and regulations relevant and specific to China (Xinqing et al., 2016). To minimise the risk to interviewees, a participation information sheet and consent form were issued (including a request to record the voice and to store and process it until completion of transcription). The researcher emphasised that participation was voluntary, that potential interviewees were under no obligation to participate, and that they could freely withdraw at any time, including the removal of any data previously provided, nor to complete all elements of the research if they deem it a risk to them.

A further ethical consideration is that **confidentiality** was pointed out prior to the interview and the case study and that the researcher had guaranteed the participants'

confidentiality. This allowed the interviewee to freely express their point of view on the research question. To guarantee confidentiality, both the transcripts and this thesis have made the interviewee's name and case study references (company name and city) anonymous. Case anonymity is important to ensure that individuals cannot be traced back and not to expose industrial secrets to the public domain. At no stage did any potential risk materialise. The defined procedure was applied consistently throughout the interview process.

3.6 Conclusion

In conclusion, Chapter Three, has examined the critical realism paradigm employed in this research and articulated the underlying rationale. Following the introduction in Section 3.1, the rationale for the research paradigm was articulated in Section 3.2. Section 3.3 outlined the research procedure and design, characterising it as exploratory in nature. The objectives and methodologies of the in-depth interviews were elaborated upon in sub-section 3.3.2, which set the foundation for the interview protocol and the data collection strategy. A detailed discussion of the stage two case study approach was presented in sub-section 3.3.3, emphasising its aim to acquire comprehensive insights. The methodology was further elaborated, addressing aspects such as piloting, criteria for case selection, and the number of cases involved. Section 3.4 addressed the data analysis process, which will ensure anonymity for data privacy purposes. The limitations of the methodology were examined in Section 3.5, culminating in the conclusion drawn in Section 3.6.

Chapter Four will focus on the findings derived from the in-depth interviews, including a discussion of the participants and the insights gained from the interviews. The results will provide an analysis of participation and findings, along with proposed revisions to the model.

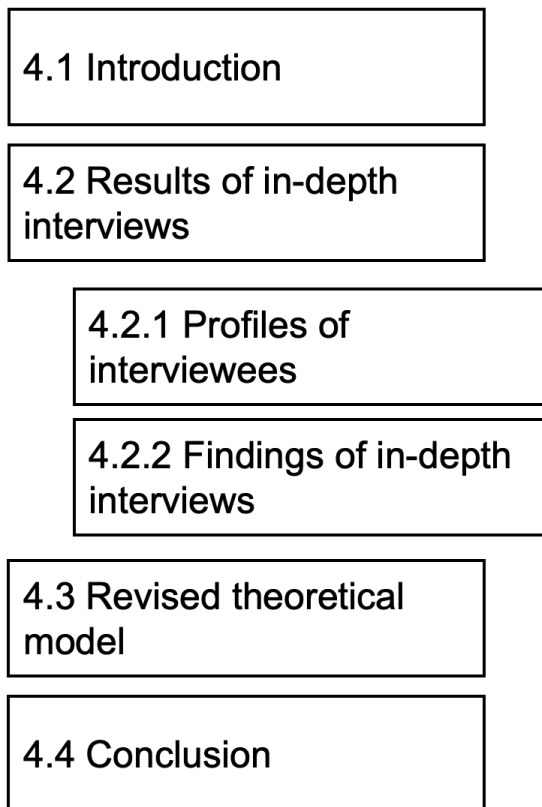
CHAPTER 4: IN-DEPTH INTERVIEW FINDINGS

4.1 Introduction

The objective of Chapter Four is to discuss the findings of the in-depth interviews and to analyse the findings from the in-depth interviews as well as their implications for the stage two research (case study research).

This chapter has four sections, as outlined in Figure 4.1. Section 4.1 introduces this chapter, and Section 4.2 discusses the results of the in-depth interviews, first the interviewee profiles and then the findings. Section 4.3 presents a revised theoretical model that will be used for the stage-two case study interviews. The conclusion is then drawn in Section 4.4.

Figure 4.1 Outline of Chapter Four



Source: Developed for this research

4.2 Results of in-depth interviews

This section begins with a description of the interviewees involved in the in-depth interviews. Profiles of the interviewees are presented in sub-section 4.2.1, and the findings of the nine in-depth interviews will be discussed in accordance with the objectives outlined in sub-section 4.2.2.

4.2.1 Profiles of interviewees

The interviewees included technical experts, executives and local experts with vast knowledge and years of experience in the aviation industry in China, as summarised in Table 4.1. In-depth interviews were conducted with nine interviewees, two of which were pilot interviews that were included in the research findings, as no further refinements were required in the interview protocol. Interviewees have been allocated an individual code (i.e. S1A, S1B, S1C, S1D, S1E, S1F, S1G, S1H, S1I) to ensure their anonymity. The profiles of interviewees are summarised in Table 4.1. Each of these interviewees will be described in turn.

Table 4.1 Profiles of interviewees

Interviewee	Position	Years of service in the aviation industry	Area of expertise	Location: technical expert (TE), executive (E), local expert (LE)
S1A	Senior Manager	10	SCM	Beijing (LE)
S1B	Senior Manager	15	Quality Control	Tianjin (LE)
S1C	Senior Manager	20	SCM	Beijing (LE)
S1D	Executive	20	SCM	Shanghai (E)
S1E	Director	35	General Management	Shanghai/Canada (TE)
S1F	Senior Manager	40	Quality Assurance	Beijing/Xi'an/UK (TE)
S1G	Senior Manager	20	SCM	Beijing (TE)
S1H	Senior Manager	15	SCM / Program Management	Beijing/ Chengdu/ Germany (E)
S1I	Executive	35	General Management	Tianjin/France (E)

Source: Field data collected for this research

Interviewee **S1A** is a senior manager in the procurement department of a large OEM based in Beijing. The interviewee is a native Chinese with ten years of experience in the aviation industry. During this time, the interviewee visited many suppliers across China and performed assessments of supplier industrial capabilities and ability to meet SC requirements. In the current role, the interviewee is responsible for the performance of suppliers, i.e., the SC's ability to deliver components on time and of the best quality to the OEM.

Interviewee **S1B** has 15 years of experience in the aviation industry, mainly in aircraft manufacturing, from the perspective of quality, manufacturing, and SC. This interviewee is responsible for leading teams in quality performance and SC coordination and has an end-to-end view of aircraft manufacturing. Other activities the interviewee was involved in included working on the daily management of suppliers for the OEM and tracking on-time and on-quality deliveries. In addition, this individual is a qualified auditor of aviation quality systems according to regulatory requirements, thus capable of identifying gaps in the quality system of suppliers that could potentially lead to quality defects and safety issues.

Interviewee **S1C** is a native Chinese and holds 20 years of experience in the domain of procurement and SC in the aviation industry. This individual's role includes the strategic procurement view of suppliers and is responsible for negotiating long-term agreements with strategic suppliers and considering their performance levels when deciding to allocate work to them. The interviewee has a view of long-term supplier commitment and strategic supplier planning, such as investment in capital expenditures, including machines, land, and buildings.

Interviewee **S1D** is a native of the Shanghai region and has over 20 years of SC experience in aviation from both the OEM and the supplier perspective. The individual has a high level of responsibility across China by managing suppliers that have significant performance issues such as late deliveries or quality issues. The interviewee has the responsibility to allocate teams to recover the performance and, therefore, has real-life experience in contributing to the view of what gaps of resilience lead to and how suppliers can recover.

Interviewee **S1E** recently retired from over 35 years of aviation life. The interviewee is a native of North America and has spent numerous years as an expatriate in China, building there the presence of a large OEM, including various aspects of resilience related to supplier networks, customer support, and logistics. During the last assignment, this interviewee was responsible for signing contracts with suppliers and for ensuring the operational performance of the China business. Therefore, the individual was exposed to various business areas, including the responsibility to

ensure business continuity in case of supply issues, transportation of parts, coordination with customs, and so on.

Interviewee **S1F** has over 40 years of aviation experience and has worked for many years in the production of aeroplane wings and has an eye for production quality detail and is, for instance, able to evaluate how employee behaviour impacts product quality. This interviewee was an expatriate in China during the industrial ramp-up of production and oversaw large teams, and during these ramp-ups, experienced multiple cases of resilience such as capacity adaption, hiring and quality issues. Interviewee S1F had the responsibility to ensure that suppliers could cope with the industrial ramp-up of production by ensuring planning, recruiting, qualifications, quality, and deliveries. The interviewee is a native of the United Kingdom and has been retired for a few years.

Interviewee **S1G** has 20 years of aviation experience in the domain of procurement and SC, is a native of China and has worked with many different suppliers during their tenure at a large OEM. This interviewee is responsible for the supplier quality and delivery performance in multiple procurement commodities such as materials, structures, and equipment. This interviewee is also an auditor of supplier capacity and can calculate supplier production efficiency, a key element of resilience.

Interviewee **S1H** is a German national with over 15 years of work experience and was an expatriate to China for more than five years whilst working for a large OEM located in situ at a supplier. Interviewee S1H oversaw all aspects of resilience in this supplier with responsibilities across all domains of production, SC, quality, and logistics. The interviewee also held senior strategic positions in an aviation OEM and currently holds an executive position in aircraft manufacturing in China.

Interviewee **S1I** is a French executive with over 35 years of aviation experience. This interviewee has been dealing with China for the past 20 years and can testify to the evolution over time. The interviewee held numerous strategic positions dealing with China, including as an expatriate for over five years in northern China with the responsibility of setting up a factory with over six hundred direct and indirect employees.

4.2.2 Findings of in-depth interviews

This sub-section will discuss the findings of the in-depth interviews per the objectives with interview quotes. Tables and other visualisations are used to illustrate and analyse the findings based on data collected.

Objective 1: to gain an understanding of the definition of resilience in the context of China's aviation SC,

Objective 2: to map out an initial aviation supplier landscape in China,

Objective 3: to identify a list of key features and components of resilience in the aviation industry in China,

Objective 4: to gain an understanding of the level of importance of resilience in the short-term and long-term and why it is difficult to achieve,

Objective 5: to gain an understanding of proactive and reactive approaches to resilience capabilities building and why it occurs,

Objective 6: to identify the key characteristics of the phases of resilience building, and

Objective 7: to identify a list of potential cases for stage two case study research.

Each objective will be addressed in turn, referring to the context of the relevant literature setting, and findings will be summarised and supported by quotes from the interview in italics. Key differences will be highlighted with reasoning, and an explanation will be provided.

Objective 1 is to gain an understanding of the definition of resilience in the context of China's aviation SC. This is done largely by the introductory question one, *"What is your definition of SC resilience in China, and could you illustrate it in context?"*

Findings revealed that all nine interviewees agreed that resilience was about the ability to bounce back to a stage before an adverse event happened. This was supported by Interviewee S1C, commenting: *"Resilience is the capability or the ability of an element to return to a stable state after a disruption."* Examples include the ability to recover shortly after the 2008 financial crisis or after the H1N1 epidemic in 2010 by means of specific government intervention, respectively, through capitalisation of banks or tracing and controlling the spread of the virus. Another interviewee (S1F) mentioned: *"My understanding is exactly this, it is the ability to be able to recover quickly from an issue or an unplanned disruption or difficulty."*

Resilience was also regarded as the ability to withstand failure and ensure sustainable success. Interviewee S1D agreed with this perspective and commented: *"Resilience is also a kind of the energy that you can absorb, to absorb a failure"*. Interviewee S1E remarked: *"Our ability to be able to do that, to make it, to make things work, because, in the end, we want them to succeed and provide us parts on time and, you know, to a quality of an acceptable degree that we can continue to build"*.

Furthermore, it has been acknowledged that not all events are the same, and resilience ought to be seen with respect to the depth and duration of the event (such as economic downturn). For instance, the COVID-19 pandemic had a global and years-long impact that went deep into the global SC equilibrium as compared to the H1N1 swine flu in 2010, which had a localised impact lasting a few weeks without knock-on effects. Interviewee S1H illustrated this by commenting: *"So how deep does the pain go? And how long will it persist? Is it short and deep pain, is it a long but low pain, but it takes longer, or is it a deep pain like COVID? So, for me, those elements this is, first, the key to understanding the single strategy or whatever elements you need to trigger. The second one is keeping for me the ability how, out, of where you are, no matter how deep or how low you are, how quickly do you get back to track."* This was also supported by Interviewee S1I's comment: *"To be able to recover economically and efficiently as quickly as possible."* Understanding the intensity is key

to determining the necessary activation strategies. It's also important to evaluate recovery capacity and how quickly one can return to normalcy, aiming for efficient and timely economic recovery.

In summary, the concept of resilience has been validated within the Chinese context, with additional insights gained from examining both the intensity and duration of disruptive events. As consensus the following definition of resilience in the aviation industry in China is proposed: Resilience refers to the ability of the system to recover swiftly from disruptions, contingent upon the severity and length of the event. This resilience enables the system to return to its pre-adverse event state or to withstand setbacks while maintaining a trajectory of sustainable success.

Objective 2 is to map out an initial aviation supplier landscape by asking questions such as “*What type of company ownership is observed in China?*” and as a follow-up question “*What tier status do the companies belong to?*” This mapping will be performed on two grounds: firstly, the categorisation of Chinese suppliers according to SOEs, privately held enterprises, or foreign-owned enterprises. Secondly, by the tier status: is it a tier-1 to the OEM, a direct supplier, a tier-2 status, a supplier to a supplier, or even further away in the value chain?

Table 4.2 Supplier landscape in China

	SOEs	Domestic privately-owned enterprises	Foreign-owned enterprises
OEM	n.a.	n.a.	8 (S1A, S1B, S1C, S1D, S1E, S1F, S1H, S1I)
Tier-1 (supplier to OEM)	5 (S1B, S1C, S1D, S1E, S1F)	n.a.	5 (S1B, S1C, S1D, S1G, S1I)
Tier-2 (supplier to Tier-1)	n.a.	2 (S1D, S1F)	3 (S1B, S1C, S1I)
Tier-n (supplier to Tier-2)	4 (S1A, S1B, S1D, S1F)	1 (S1F)	2 (S1C, S1G)

Source: Field data, analysis of in-depth interview data

Note: n.a.: not applicable, meaning there is no mention by any interviewees about such type of set-up. Each number refers to the total number of interviewees mentioned in the respective category. The interviewee is referred to in parenthesis.

As shown in Table 4.2, the most common (supported by eight out of nine interviewees) supplier landscape in China in terms of ownership was foreign-owned OEMs that have strong support from the Chinese authorities to establish in China with a possible intention of technology transfer. This technology transfer is characterised by its technical complexity and by the ability to integrate components, quality requirements across all products and processes, safety standards and its overall industrial setup. Interviewee S1H said: *“The OEM is really with a perfect strategy, with a strong local support, an impeccable quality standard, robustness in processes, tools and methods and the SC strategy.”* S1A commented: *“The biggest project since 2008 is the foreign-owned FAL (Final Assembly Line) in China with the requirement to set up all elements of an FAL including the SC, to meet strict quality and SC requirements. Today, China has no similar serial-run projects with SOE.”* It is noted that no SOE OEM is in place, as strict quality standards, safety requirements and a SC set-up are required.

China has no globally recognised airworthiness authority, quality standards such as standard ISO9100 are not yet robust and consistent, and SCs are not vertically

integrated. Interviewee S1C said: *"It will still take a long time for China OEM to be recognised internationally. ... Certification and recognition at the level of EASA and FAA is still a long way out."* Possibly, with time, this may change as China is building the required capabilities and reputation. The interviewees supported the view that China is not yet ready to have a State-owned OEM. This is because the requirements of regulators are very strict to meet the highest quality levels, and the reputation in the market for China's quality levels is not convincing, while the complexity of being an OEM is high and takes time to establish. S1H added: *"The SOE are not yet there to have the OEM status, but soon there may be a change; it is about the reputation, and today it's not the strong point of China."*

Similarly, there is no privately-owned OEM in China. Interviewee S1C provided some insight: *"SOE are not at the level yet; the foreign-owned assembly line is here (in China) already. Now, for a private project, it's not in the category of large aircraft."* This absence of a privately-owned OEM may be due to the capital intensity and the long payback period (for instance, it takes USD\$ 1 billion for small new aircraft development and over 20 years to pay back the investment (Norris & Wagner, 2005) that favour other industries over aviation in terms of profitability and attracting private capital. S1I adds: *"In China, the quality level is gradually increasing, but even for the aircraft when they have the choice, they prefer the foreign assembly. Slowly, we see a change, as patriotism creates a local perception of must-buy-Chinese, but not on an international level."* This stresses the perspective for change in China's aviation context.

In Tier-1 ownership, there is an equal distribution of five responses between SOEs and foreign-owned companies, but their circumstances differ. SOEs primarily engage with customers, the OEMs, based on non-commercial factors like offset agreements and market access. S1B said: *"AVIC are our direct suppliers on many of the older contracts or where we try to fill off-set, that's to say aircraft sales support. Often, we cannot freely choose the supplier, and we have to select the AVIC in order to achieve a turnover target. We had a plan to achieve an amount of one billion of China sourcing."* This means SOEs are selected for their commitment to selling aircraft to China rather than their capabilities or competitiveness. S1B added: *"So, we can achieve this plan when we select the AVIC companies. That's how this works, with the*

problems it brings.” S1C said: “A lot of the contracts are older with complex set-ups like material we provide to the supplier or managing the SC for them... It’s really managing for AVIC the SC. We have some projects to improve this set-up, but it takes time for AVIC to build the capabilities to do this.”

Foreign-owned enterprises in China thrive mainly due to lower labour costs. Comparisons of European hourly wages with those in China reveal advantages from China's strong infrastructure and favourable tax incentives for new manufacturing. Additionally, the growing domestic market and rising consumer demand play a significant role. S1D said: *“There is a good amount of foreign-owned enterprises here in China operating as Tier1, and we use them for the cost improvement projects where work is transferred, for example, from Spain to Harbin with a lower hourly rate. We also have some technology transfer going on, and the Chinese stakeholders like to see that.”* S1I further supported this by commenting: *“The cost and market potential attracted large foreign players in China, and the infrastructure is good, the workforce is available and cheap, and the growth to have more customers in China is likely to occur soon.”* China's strong financial prospects and market opportunities have attracted substantial foreign investment, supported by robust infrastructure, an affordable labour force, and potential for rapid customer base growth.

Regarding the foreign-owned tier-2 status, three interviewees (S1B, S1C and S1I) commented about its role in the China supplier landscape where benefits of China seem inherent to the country, namely lower-cost hourly rates, municipal support, and a good infrastructure. In supporting this, interviewee S1B commented: *“The foreign tier-2 benefit from low cost and then ship parts to Europe. The tier-2 set up a joint venture with a local partner and benefitted from low-cost labour. They train people here and implement their processes.”* Foreign tier-2 suppliers capitalise on cost advantages by manufacturing components cheaply and exporting. They form joint ventures with local partners to leverage affordable labour, invest in staff training, and adapt operations, often in smaller cities with lower labour costs and good transportation. S1I added: *“The foreign companies will use China as a source for high manual parts and then ship to final inspection to Europe. It is not on the high value-added components like engine parts or systems, this we don’t have in China; the*

labour is used for small assemblies like brackets or on rails; also, we can see on composite parts where all the layup of the part is manual, ply after ply is added manually.” Foreign companies source manual components like brackets and rails from China, which are then sent to Europe for final inspection. Manufacturing composite parts in China is also cost-effective.

Furthermore, China’s private enterprises were referred to by two interviewees (S1D and S1F) as entering the aviation industry from other industries, i.e. diversification strategy. These new players enter the market with industrial standards and capabilities, including managerial. That way, tier-2 enterprises can benefit from offering competitiveness and capabilities to their customers. S1D said: *“This is a unique example of a private company in China, and they supply to the Tier 1 mostly.”* S1F added: *“It took me a lot of effort to develop them, and we succeeded. This company originates from another industry, and they wanted to diversify in aviation. It means that I took their existing capabilities and adapted them to aviation standards; for example, the skills matrix was set up for employees and key capabilities tracked, traceability standards and systems were put in place and the monitoring of the SC with much stricter requirements than in their other divisions.”* This demonstrates how a domestic private enterprise serving the OEM, invested significant resources to succeed in diversifying into aviation. The company leveraged its strengths while adhering to aviation standards by developing a skills matrix, tracking competencies, establishing traceability systems, and enhancing SC standards.

Finally, when it comes to tier-n ownership, four interviewees (S1A, S1B, S1D and S1F) suggested that the SOE has a strategic approach. The material suppliers for aluminium, titanium, and steel are SOEs that secure access to qualified raw materials to control the capacity of the state. The SOE will become a supplier for the OEM that must qualify the facilities to the latest standards and thereby significantly improve the infrastructure; quality standards of the product will be strictly controlled, and some industrial performance management principles will be implemented. S1B commented: *“The SOE also tried securing the raw material in China because they need good quality material for the domestic (military) products. The OEM will help the SOE to qualify the mills with quality standards, improvement of efficiency and further*

requirements.” The SOE, therefore, benefits from the improvements and secures long-term capacity. S1D also mentioned: *“The raw material from China today we have Steel, Aluminium and Titanium, and all of these are existing mills on really important products; we don’t talk about the set-up of new facilities.”*

By contrast, two interviewees (S1C, S1G) revealed that foreign-owned tier-n were to provide material such as sealants, paint, or consumables as they were neither strategic nor crucial for the industry but were convenient to have these capabilities in China, though considered redundant in the system. S1G commented: *“The foreign-owned company will not be the owners of material production or manufacturing in China, but they can make, for example, the fasteners or other processing of material like cutting it, distributing, storing and importing it.”* Furthermore, S1C commented: *“The supply of chemicals and consumables comes often from the foreign-owned and in China they will distribute and maybe repackage it.”* Foreign-owned tier-n suppliers provide non-strategic materials. While having these capabilities in China is beneficial, it's not essential. Foreign firms may not own production facilities in China but can produce fasteners and manage material processing, distribution, and importation. Chemicals and consumables often come from foreign companies that handle their distribution and repackaging in the Chinese market.

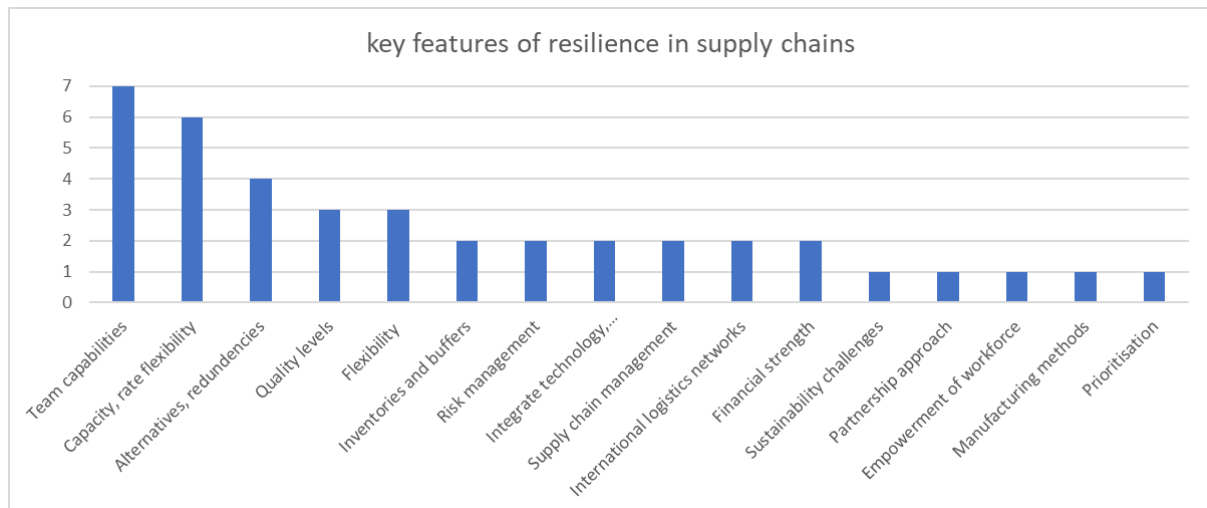
One interviewee (S1F) noted that domestic privately-owned enterprises supplying semi-finished parts are evolving by manufacturing more complex components and expanding into assemblies, surface treatments, and other value-added services. Their goal is to achieve tier-2 and eventually tier-1 status in the aviation sector. S1F supported this observation with a comment: *“The private company in China started with some detailed parts and can be considered as a material supplier, and with time, they got into more complex assemblies and secured tier two contracts with suppliers, so we can say some tier-n suppliers with time grow to become the tier-2.”*

In summary, the Chinese supplier landscape has been mapped to include SOEs mainly operating as tier-1 tier-n suppliers. This is due to their strong position on offset support or as a strategic material supplier. At the same time, foreign-owned companies benefit from lower hourly rates, incentives, and good infrastructure as tier-1, 2 or tier-

n. The private enterprises in China have grown in the aviation domain and increased their capabilities to be tier-2 or tier-n.

Objective 3 aims to identify a list of key features and components of resilience in the aviation industry SC in China. To achieve this objective, two questions from the interview protocol were posed to the participants: “*What are the key features of a resilience?*” and “*What are the key components of resilience that affect SCs in China’s aviation industry?*” Findings on the key features will be discussed next.

Figure 4.2 Key features of resilience in the SC



Source: Analysis of in-depth interview data

The findings identified 16 key features, as illustrated in Figure 4.2. Among these, team capabilities, capacity and rate flexibility, and alternatives and redundancies emerged as the most frequently cited features. In contrast, sustainability challenges, partnership approach, workforce empowerment, manufacturing methods, and prioritisation were noted the least, sharing equal mention. The subsequent section will categorise and elaborate on these 16 key features of resilience.

Categorisation of key features:

The 16 key features identified in Table 4.3 can be classified into four categories, as outlined below (Connelly et al., 2017).

- Critical functions,
- Threshold,
- Time (and scale); and
- Memory/ adaptive management.

Table 4.3 Interviewees response to the key features

Category/Key feature	S1A	S1B	S1C	S1D	S1E	S1F	S1G	S1H	S1I	Total count
Critical functions										
Risk management			x	x						2
SCM				x			x			2
Thresholds										
Financial capability	x						x			2
Inventories and buffers				x			x			2
Time (and scale)										
Capacity, rate flexibility		x		x	x	x	x	x		6
Alternatives, redundancies	x		x	x	x					4
(Behavioural) flexibility				x		x	x			3
Quality levels	x		x	x						3
International logistics network				x		x				2
Integrated technology		x			x					2
Empowerment of workforce					x					1
Prioritisation							x			1
Memory / adaptive management										
Team capability	x	x	x	x	x	x		x		7
Manufacturing methods					x					1
Sustainability challenges				x						1
Partnership approach						x				1

Source: Field data prepared for this research

The categories will be examined sequentially based on their significance to resilience stages. First, critical features will be addressed, followed by thresholds. Next, temporal and scale-related features will be discussed, and an analysis of memory and adaptive management features will be concluded.

Key features in the category critical functions

The critical functions category comprises two main features of resilience. One is the risk management feature, and the second is the features related to SCM. Each of these will be discussed in detail next.

Risk management was mentioned by two interviewees (S1C, S1D) as having the ability to detect risk and manage it adequately to avoid a major issue in a corporation. Risk management refers to the ability to define effective actions to confine the risk and avoid an issue (Abdel-Basset et al., 2019). These measures may not produce immediate results; their effectiveness should be evaluated over time. For instance, if a machine frequently breaks down, the maintenance strategy should be revised, such as by increasing lubrication frequency. Interviewee S1D stated: *“Risk management is an adequate approach for dealing with a crisis or the shock, so you need to put in the action plan and make sure these are permanently closed with an effective action closure. The validation will need some time and then we are back into a stable state.”* The benefits of these changes may take months to appear, ultimately reducing breakdowns and improving machine stability and resilience.

Risk identification involves recognising potential deviations, often through audits. This process relies on established expectations to identify gaps, discrepancies, or non-compliance issues. Interviewee S1C commented: *“We have highly trained auditors that go to the suppliers and continuously audit and assess capabilities, adherence to processes, industry best practice benchmarking and so on. The important thing is regular communication, listening to the supplier, and having sharp eyes on potential issues.”* Documented in a risk register, these factors form the basis for risk management, ensuring suppliers are prepared for significant SC disruptions.

SCM was mentioned by two interviewees (S1D and S1G) as a key feature of resilience. SCM in the context of SC flexibility is understood as the managerial ability to coordinate the SC in order to achieve flexibility in meeting customer demand and a high level of responsiveness (Stevenson & Spring, 2007). S1G commented: *“The SC manager and organisation need to take the right decision at the right time on critical elements of the SC. Not every risk will be managed and the suppliers with little*

experience need more focus and follow-up because they don't know full repercussions and they don't have the full picture. The more mature and traditional suppliers are generally running well." It was noted that adequate tools, methods, and data must be available for the SC managers to focus on the key issues in the SC.

To enhance recovery, resilience, and business continuity in global aviation, data-driven decision-making is essential. Interviewee S1D mentioned: *"SC managers are the interface to the suppliers, and suppliers are critical for the Program, so this means the SC manager needs to have the full view of requirements and risk and actuate the necessary means to resolve risk and issues, not alone, but in a multi-functional team."* SC managers must time actions like developing alternative sourcing, assessing capacity, auditing suppliers, implementing quality improvements, holding strategic meetings, and escalating issues. This requires experience, a learning process, effective communication, and clear objectives.

Key features in the category thresholds

The category thresholds include two key features of resilience. The feature of financial capability and of inventories and buffers will be discussed next.

Financial capability was mentioned twice by interviewees S1A and S1G. The financial capability of suppliers (which has been identified as a strategic component of resilience) refers to the ability to sustain a shock with an adequate financial position, such as a strong credit rating (Martin & Hofmann, 2019). A solid financial capability is important to ensure continuity concerning payment for material and labour and thereby ensure a continuous material flow and the employment of skilled workers as an element of resilience. Interviewee S1G mentioned: *"A key feature of resilience is the financial capability of the supplier and of the supplier of the supplier, so the tier-2. We need minimum levels of availability, for instance, to keep producing for a few months autonomously, as a contributor to the system."*

Financial robustness includes liquidity, payment frequency, and factors influencing the perception of financial strength, such as management culture. It's essential to evaluate a supplier's ability to consistently meet obligations like salaries, rent, and raw materials

over time. A strong financial position, whether through cash reserves or effective management, enhances resilience. For instance, China's SOEs benefit from government budget allocations, allowing them to maintain inventories, sustain production, and keep employee salaries, unlike private companies that may face downsizing. S1A highlights the advantages of SOEs in China: *"The SOEs are funded by the State Council of China, so the funding is almost unlimited, and China's Defence spending has never been so high and grows."*

Inventories and buffers were another key feature of resilience mentioned by two interviewees (S1D, S1G). By inventories one understands the inventory, raw material, work in progress and finished goods that are considered a business' assets that are ready for sale. Inventories are one of the most important assets of a business (Moons et al., 2019; Singh & Verma, 2018; Vinet & Zhedanov, 2011a). Buffers, more precisely capacity buffers, are commonly referred to as a mechanism by which the average demand is set higher in order to avoid shortages during peak demand (Christopher & Holweg, 2011; Vinet & Zhedanov, 2011a). The JIT had previously been adopted across different industries, including aviation and its suppliers, but its risk, in times of disruption, is high, and inventories at strategic locations on critical components are a feature of resilience. S1D commented: *"We need some critical parts deep inside the SC, such as the forging in the engines. It's not the engine that is the problem but the components in its assembly. These buffers at critical locations are to be increased."* Therefore, to ensure resilience, it's vital to keep essential component inventories at strategic locations. S1G added: *"A particular difficulty is in the SOEs, because there, military programs have priority and very quickly the competent workforce is pulled to the National Program, and then our priority becomes second priority – no negotiation possible."* As part of inventory management is the management at the right locations. As SCs spread globally, the centralised approach is not always useful, as disruption in border closure and transport breakdown add obstacles. Warehouses containing inventory should be located within a range of 20 to 30 kilometres from the production facility, and this is perceived as a key feature of resilience.

Key features in the category time (and scale)

The category contains by far most features of resilience. The interviews revealed eight key features that will be discussed next. These include capacity / rate flexibility, alternatives / redundancies, flexibility, quality levels, international logistics network, integrated technology, empowerment of workforce, and prioritisation.

Capacity and rate flexibility were mentioned by six interviewees (S1B, S1D, S1E, S1F, S1G, S1H), which relate to how quickly suppliers could increase or adjust production rates to the demand. By capacity, in the context of SC flexibility, is understood the ability to adjust output to meet customer demand. This results in rate flexibility (Kouvelis & Milner 2002). Capacity requirements need to be frequently communicated to the supplier using procurement plans and these plans need to be compared to the previous plan. In supporting this, interviewee S1D commented: *“The revised plans are prepared by Program and then the SC needs to confirm it, but in reality, this is often a one-way communication. Maybe a consideration needs to be what can be done realistically and what are the repercussions in the SC.”* For instance, in case of a significant adjustment of deliveries, a delay or an anticipation, the actions need to be deployed to ensure adherence to the new plan and to provide an adequate level of SCR. The supplier then needs to provide the feedback to the OEM with an acknowledgment of feasibility or with an alert and action plan if the revised procurement plan cannot be implemented for reasons of capacity, capability or for other industrial reasons

Rate flexibility relates to the extent of which the supplier can ramp up or ramp down to meet rate (i.e. to increase or decrease output) and requires a holistic view of capacity including the suppliers of tier-2 or tier-n to ensure resilience levels across the entire SC. Interviewee S1F commented about the CCP (Capacity Contingency Planning): *“We need to run the CCP assessment not just on the tier 1 and its critical processes, but even to the tier-n where the critical processes take place. Ideally, we train the tier-1 to perform the exercise at the tier-n. Key is that the full demand from all customers be captured in the rate simulation, to have the real utilisation that will be cumulative across the various customers.”* To attain rate flexibility, timely and accurate data is required to identify bottlenecks and to adequately implement action plans to ensure sufficient capacity. For instance, if a machine is at a 95% load factor, the supplier may

either decide to add another machine, to outsource some capacity to another company or to enhance efficiently, such as reducing set-up times or improve nesting for the part if applicable. Either of these requires resources and time to be effectively implemented by the supplier. Interviewee S1C further supported this by commenting: *“You can go up and down in rate, not always up and up. So, we need regular feedback with suppliers and simulation. Also, this is feedback to the regular sales and operations planning. You see, an airline can place orders let’s say for 100 aircraft, but we cannot deliver right away, depends on cumulated demand and output capacity. And maybe an airline goes bust, then we need to cancel and reduce capacity.”*

Alternatives and **redundancies** as a key feature of resilience were mentioned by four interviewees (S1A, S1C, S1D, S1E). *Redundancies involve the strategic establishment of buffer capacities, multiple suppliers, safety stock, overcapacity, and backup suppliers available as well as the fortification of general facilities to mitigate the risk of disruptions (Kamalahmadi et al., 2022; Riccardo et al., 2021).* By alternatives are understood the option of choosing another supplier. These alternatives were considered as a back-up plan, another available and capable supplier, in order not to be without business continuity in case of default or production halt. However, this choice must be attainable either from a time, quality, or financial perspective. As such, investing resources in an alternative could be correlated with anticipation, for instance, qualifying a second supplier for a special process being approved and therefore having a redundancy in the system, or providing another logistic route or setting up a twin factory. This was supported by interviewee S1A who said: *“The alternative needs some time to be ready, for instance to have another supplier qualified, we need several months or even years if we talk about material, with testing and samples that need analysis and destructive testing; it is quicker to have an alternative logistic route than a real supplier alternative.”* In addition, interviewee S1C stated: *“We can consider with higher production volumes approaches of redundancies in our system. For instance, with a final assembly line in Asia, several in Europe and one in the Americas, we have redundancies and will always be able to deliver. However, this comes at a cost, and absorbing the lost capacity, for instance of America, in the other redundancies, would be a major challenge.”*

Flexibility was mentioned by three interviewees (S1D, S1F, S1G) as a key feature of resilience. By flexibility is understood the penalty-free change (Delic & Eysers 2020) and in the context of operations, it can be understood as the change in the production sequence, product mix, product rates and prioritisation without impacting further operations.

Flexibility could be arranged by the OEM by shifting the integration of a component from one station to another, for instance, the empennage or vertical stabiliser can be incorporated to the fuselage prior to fuselage closure or after fuselage closure. The final assembly function usually has a very strict and regulated assembly process in which each production step needs quality sign-off, inspection and functional testing. Significant inconvenience could be observed in case of temporary change in the process, and it needs to be reasonable and most importantly production will need to continue. S1D commented: *“In production there is a logical flow in the build sequence where the engines are mounted at the end of assembly and wings go on a completed fuselage and not vice-versa, we have some flexibility. For example, we can paint the stabiliser and mount it on afterwards.”*

Furthermore, the option to be flexible could be very limited as the constraints in aircraft assembly dominate, namely: customer delivery schedule, product quality and assembly lead times. The aircraft delivery to the airline cannot shift, as the airline needs capacity of additional seats for its route network, for example new routes are inaugurated and an aircraft needs to carry it out, this planning is done years in advance, furthermore, severe penalties for late delivery may be imposed by the customer airline for each day of delay. Regarding product quality there will be no compromise and therefore there is no flexibility on quality; some possibility of installing parts with concessions suffix “R” for restrictive, may be an unpleasant option as these parts reduce the operational performance such as life limited parts. Last, the assembly lead-time, measured in hours of production workers may be adjusted a little bit but no significant gain of flexibility can be expected. Interviewee S1F confirmed this by commenting: *“Flexibility in production is there but it is minor. You see if we need to put more effort on production due to outstanding work or late delivery of parts, all the open workorders will accumulate at the final production station. I can put more workers*

for this; however, the space in the aircraft is limited; to add more workers I will get more damaged parts due to accidents, health and safety concerns and overcrowded. It is not as easy as it sounds and if we are late, we get the huge penalty from the airline if the aircraft is delivered late, and we never know if there could be some surprises during the first flight, so we need to keep some buffer.”

Quality levels and the underlining system quality had been mentioned by three interviewees (S1A, S1C and S1D) as a key feature of resilience since this is a mandatory function that must be ensured consistently across processes, products, and people’s capabilities. By quality levels is understood the ability of the organisation, through its systems quality, to meet or exceed customer expectations (Oschman 2019). Necessary attributes include auditing skills, regular specific training, and surveillance alongside the verification by safety and quality management system audits. Quality levels of the product affect resilience in the way that steady output without quality concerns, meaning consistently reaching predicted quality levels, ensures meeting customer demand. A loss of quality level adversely affects resilience as parts will be scrapped, reworked, or sold with restrictive use. Interviewee S1A stated: *“Quality is a must in our industry, there is no compromise, and it can impact the safety, airworthiness, and reputation of the company and of the people. We must have the robust process with continuous auditing, we have the product inspection that always takes place, and the skills matrix of our people. When we lose quality levels, it means scrapping part and reducing output.”*

During times of shock or recovery, the employees, in particular on the shop floor, may decide to change, or additional hiring is required which creates a resource gap. Either way, skills drop or even disappear. It is therefore fundamental to ensure skills levels (through training, on-the-job training, mentoring or detailed recording) are adequately present. However, it may be expected that quality levels drop (temporarily) as people get acquainted with machines and processes. Parts may be scrapped which means output is further reduced, therefore it is advisable that quality controls are increased whenever the staff turnover reaches an abnormally high level. Interviewee S1C mentioned: *“When new people join a company, they need time to get used to the machine; on assembly job they need to develop craftsmanship, need to understand*

work instruction and so on. It just takes time and good supervision. No blaming for wrong work but dedication. Sometimes, we see no time for training and supervision, so worker does not know what is right or wrong. For example, in the curing of sealant, they don't observe the time and then we have to scrap the part and start again."

International logistics network was mentioned by two interviewees (S1D and S1F) as key feature of resilience in the SC. By international logistics network is understood the structured configuration of logistics and transport modes in order to transport goods across national borders (Creazza et al. 2010). Nowadays, through digitalisation and increasing transparency and cooperation, a mix of logistics means can be applied for transporting products on international routes and increasing resilience levels, for instance, adding parts on a container that is not full and where a single truck would not have been available at the desired location or route. Furthermore, through digitalisation the demand may be anticipated depending on where and what SCs are being demanded to deliver due to anticipated demand and thereby providing adequate resilience at the right location and the right time. In addition, a mix of transportation means may be desirable, meaning not just by ship but possibly adding rail as a viable alternative, in particular between China and Europe: flexibility, i.e. resilience, is created by means of choice. This "*Silk Road*" is a recent addition to the logistics network. Interviewee S1D commented: "*Logistics is changing here, where before it was all by ship from China to Europe, we now can look at rail or truck as road alternative thanks to the China Silk Road strategy. We have to evaluate and digitalisation of capacity of the operators of networks help us compare lead-time and cost of sending products to France and to Germany.*"

Moreover, logistics ought to look at the end-to-end process, meaning the mapping of each step of the value chain, that includes for instance the availability of operators to load containers with the parts, the availability of a container, the disposition and lead-time to clear customs at exporting stage, the availability of customs on the receiving site such as the European Union. This end-to-end process approach ensures resilience across the value chain, as the weakest link may jeopardise resilience levels until the product delivery, for example by missing customs clearance steps. S1F said: "*The Brexit really was a huge impact for us, where before there were no customs, now*

we need all the paperwork and customs declaration and the UK is not prepared to clear as quickly as we need, huge backlog is observed. And the other issue we see currently is that no container is available, they are all stuck in the port in Shanghai and our products cannot be shipped, even if we are ready, and our raw material is also stuck there, so it's like domino effect here."

Integrated technology was mentioned by two interviewees (S1B, S1E) and refers to the system availability such as an enterprise resource planning e.g. Oracle or SAP. By integrated technology or integrated production planning and control is understood a systemic approach through an ERP System (Enterprise Resource Planning), thorough a push-pull approach and handoff between planning and execution (Stevenson & Spring 2007). The minimum technological levels of deployment are mandatory, such as an ERP system, to achieve levels of resilience. Besides the benefits of such a system (resource planning, demand planning, production planning, financial controlling), it also offers consistency in the ways of working. A company is becoming more dependent on a running system with predictable resilience levels and not on the behaviour and the ways people work. This key feature of resilience had been touched upon as the information technology capability. Interviewee S1B said that: *"Technology is nowadays integrated everywhere: the procedures, the machines, the databases, it's all connected and integrated. This system becomes failure-proof."* Interviewee S1E also added that: *"Technology is the basic level, and it is everywhere, and the same platforms are used for instance in Germany and China."*

Empowerment of workforce was only mentioned by interviewee S1E as a key feature of resilience. It is understood as the process by which management provides tools, budgets, and other resources in order to achieve the objectives defined, for instance of recovery of a supplier (Yin et al. 2019). Employees must have the right tools at hand, such as a line of balance set-up to track progress, the budgets required to recovery secured such as to switch from a sea transport to air transport, and the resources secured including a quality inspector with the necessary skills to approve quality documents. Interviewee S1E said: *"When we recover in the supplier, the first is assessing the situation and then we scope what is required to come to nominal levels. Often its more about the right skills and securing resources, budget is usually*

not a constraint but needs to be monitored, and finally the nominated team engages to execute the plan and achieve the recovery to nominal or desired levels.”

In addition to the resource perspective, the workforce empowerment requires an adequate governance and dialogue between teams and leadership. With this respect the target-setting together with employees is more fruitful and sustainable than top-down task management and directives. This was supported by S1E who commented: *“When recovery is starting the first task is to set-up the adequate governance and forecast a recovery time. This is a complex task that the operational teams will deploy early on, it may take several weeks to set-up the governance and manage the multiple variables and stakeholders.”*

Prioritisation was another key feature of resilience mentioned by one interviewee (S1G) and had been understood as the adequate consolidation of demand across the SC and the relevant and consistent prioritisation in accordance with top-level customer needs. For instance, customer demand being the delivery of twenty single-aisle aircraft over the duration of six months (hypothetically). This customer demand of twenty aircraft then needs to be cascaded across the value-chain from the final assembly line to the main components of the aircraft, such as 40 engines and its subcomponents. However, at subcomponent level, the relevant casting parts need to be prioritised between a single aisle aircraft and a large aircraft. There, arbitrary prioritisation leads to confusion and inconsistency. In addition, it is observed that a risk is present in SOEs, that defence projects will be prioritised over commercial programs: it's an inherent risk. Interviewee S1G affirmed this by commenting: *“The supplier tier-1 is often not the problem as there we have clear demand flow-in, but then it's the tier-2 where the demand from two customers or two OEMs accumulate. The tier-2 or tier-n needs then a good system to ensure consistency and the required capacity surge to meet the cumulative demand and to prioritise accordingly. This is delicate and rarely achieved. A particular difficulty is in the SOEs, because there, military programs have priority and very quickly the competent workforce is pulled to the National Program, and then our priority becomes second priority – no negotiation possible.”*

Key features in the category memory / adaptive management

The category memory / adaptive management includes four key features of resilience: team capability, manufacturing methods, sustainability challenges and partnership approach. Each of them will be discussed in sequence.

The most frequently mentioned feature of resilience was **team capability**, which was supported by seven (S1A, S1B, S1C, S1D, S1E, S1F, S1H) of the nine interviewees. By team capability, the interviewees understood that the OEM and the suppliers should work together in a transparent way to achieve a common goal of resilience in corporations. Interviewee S1H commented: *“The way of working and the way of working together, such as having common inspection criteria, is important. To simplify, it doesn’t help if one party measures in centimetres and the other in inches”*. Interviewee S1E added: *“To build it together (the parts), we must build it together (the people) across functions and with the suppliers as part of the solution. It is too complex and so much interconnected that we need knowledge and inputs from everyone to find an acceptable and workable solution.”* This cooperative approach is required to solve problems together and eliminate obstacles in a stage of recovery or other disruption.

In addition, tools, processes, and methods need to be aligned to commonly reduce interfaces. Interview participants noted that team capability includes both readiness and capacity for effective collaboration. This was supported by interviewee S1H: *“We work together (to recover), and it is needed that management supports a common goal: OEM wants the right parts, and the supplier must provide the right parts; there were cases where the supplier was delivering parts but the wrong parts – they achieved quantity, but not the right ones, they focused on the more profitable parts.”* The emphasis is on the need for management to support teamwork and cultivate a cooperative culture; without this, team members may focus only on their individual goals. For example, the recovery due to a quality issue needs to ensure process capability and process adherence across all value steps. Individuals will ensure each step but must look at inputs and outputs to ensure consistency. The ability of the team to work together is a management responsibility, including fostering the team's capability to perform.

Manufacturing methods were the least mentioned (only by interviewee S1E), a key feature of resilience, and it is understood as the ability of the OEM or the supplier to adjust the method of manufacturing to fit the circumstances and capabilities. S1E said: *“So we wait for a subassembly, and this impacts the SC downstream. An alternative I have seen is to make this subassembly instead of sheet metal parts composed together with rivets to machine the part out of a metal block. We reduce part count, subprocess steps and multiple first articles, and often gain weight benefits.”* The manufacturing method involves systematic procedures to transform raw materials into finished products through operations like machining, assembly, and finishing. The goal is to improve production processes, ensuring high-quality products while minimising costs and meeting deadlines (Singamneni et al., 2019). As technology advances, aircraft designs from two or three decades ago may lack modern manufacturing techniques like advanced materials and 3D printing. OEMs or suppliers may suggest enhancements to components that align with current practices if airworthiness regulations deem the modifications minor, considering form, fit, function, and weight.

Sustainability challenges were mentioned by only one interviewee (S1D) as a key feature. It was discussed as a reflection on current practices and how to develop towards sustainability goals such as a decent work environment, responsible consumption, climate action, and partnerships for the future (Brandao & Godinho-Filho, 2022). Interviewee S1D commented: *“I just want to add that consistency to sustainability policy is going to be more and more important. We cannot airship a part and claim that there is a zero CO₂ emission on the part; the whole lifecycle should be looked at, maybe there is not necessary a trade-off between sustainability and resilience, but we need to assess the perspectives.”*

The discussion about adequate consideration of key topics is given, such as extensive night shifts that may impact social components, air shipping instead of rail, recycling and repair instead of scrapping and how these considerations impact resilience. For instance, by adding air shipment, the CO₂ footprint increases significantly; however, the speed of delivery to the customer is higher, and resilience is observed; by scrapping a part, the waste is increased, and by adding overtime or a nightshirt, the social component is impacted however a higher degree of resilience is observed. This

consideration should be given some consideration in the evaluation of choices to ensure a company's sustainability guidelines.

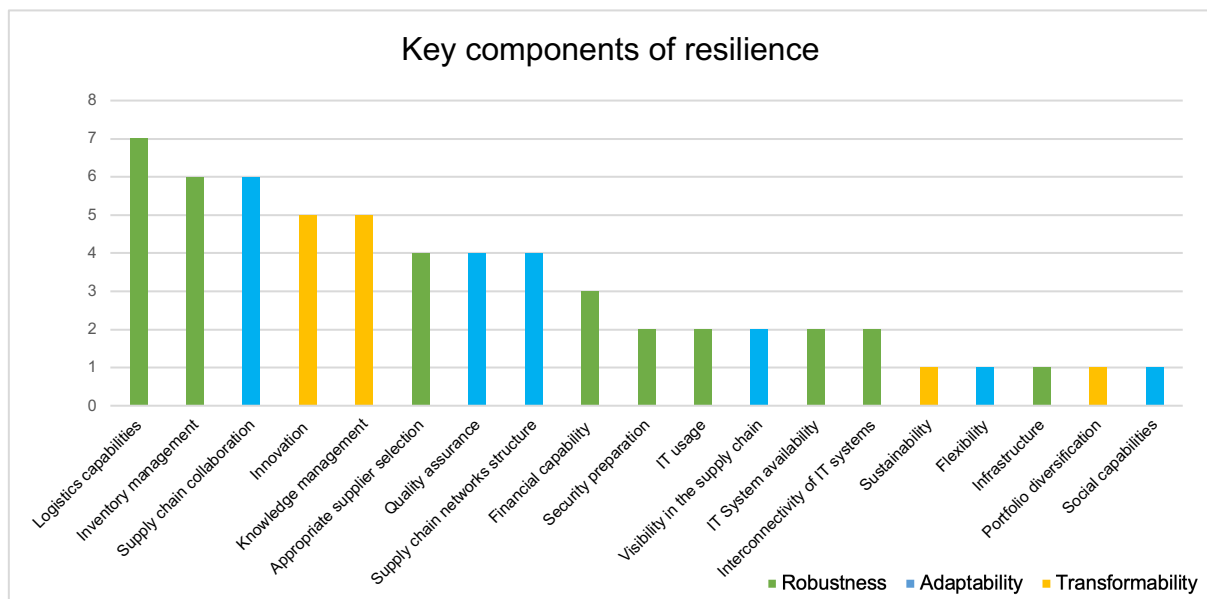
Partnership approach was mentioned by one interviewee (S1F) and was discussed in the context of alignment of objectives: maximise output and optimise the cooperation with the OEM. By partnership approach is understood as the upstream or downstream relationship with business partners that is characterised by contractual and relational mechanisms (Trunk & Birkel, 2022). On the one hand, there is the contractual setup to supply parts on a price basis, which will initiate a competition on prices (e.g. who pays the highest price for aluminium receives deliveries. On the other hand, there is the objective of sharing, where the contract foresees that the supplier profitability is linked to the maximisation of sales. Interviewee S1F said: *"We need to ask and remind ourselves if it is just a contract for deliveries of parts or is it a risk-sharing partnership where the supplier has a vested interest in the success of the program."* In addition, in a partnership, the partner needs to contribute toward innovation and pioneer new technologies in the interest of increased efficiencies, risk management and time-to-market purpose. The benefit of the innovation and pioneering of technologies must be observed from a financial perspective too, for partners to be willing to invest in innovation and technologies. Public funding programs might be a suitable vehicle to do that. Interviewee S1F supported said: *"Using new processes, for example, to manufacture a part out of a block (machining) instead of assembling out of multiple sheet metal parts will reduce complexity, reduce weight, eliminate subprocesses that have long lead times and reduce individual first article inspections to one per part only."*

In summary, 16 key features of resilience in a SC have been identified under four categories. The respective phases to which the features belong are discussed in objective 6.

Key components of resilience

This section focuses on the key components of resilience. The components have been organised according to their frequency, as illustrated in Figure 4.3, with a detailed discussion to follow. A total of 19 components have been identified, among which seven—namely flexibility, IT usage, IT system availability, interconnectivity of IT systems, portfolio diversification, infrastructure, and social capabilities—are considered novel, as they have not been previously addressed in the existing literature.

Figure 4.3 Key components of resilience



Source: Prepared for this research

The categories proposed in Figure 4.3 encompass robustness (green colour), adaptability (blue colour), and transformability (yellow colour). Said categories of components of resilience originate from the literature review of Chapter Two, in which robustness, adaptability and transformability had been identified as categories of resilience in an organisation (Wieland & Durach, 2021; Linkov et al., 2018; Folke et al., 2010) and will be looked at in turn starting robustness and followed by adaptability and transformability. Table 4.4 summarises the key components of resilience from the in-depth interviews that will be discussed in detail.

Table 4.4 Summary of key components of resilience

Category and Components	S1A	S1B	S1C	S1D	S1E	S1F	S1G	S1H	S1I	Total count
Robustness										
Logistics capabilities	X	X	X	X	X	X		X		7
Inventory management	X	X				X	X	X	X	6
Appropriate supplier selection	X				X	X		X		4
Financial capability	X						X		X	3
Security preparation		X			X					2
IT usage				X	X					2
IT System availability		X			X					2
Interconnectivity of IT systems					X			X		2
Infrastructure					X					1
Adaptability										
SC collaboration	X	X	X	X		X		X		6
Quality assurance		X		X		X		X		4
SC network structure	X	X		X				X		4
Visibility in the SC	X							X		2
Flexibility			X							1
Social capabilities								X		1
Transformability										
Innovation	X	X		X				X	X	5
Knowledge management	X	X		X		X		X		5
Sustainability								X		1
Portfolio diversification (referred to the Mergers & Acquisitions)									X	1

Note: x in each column represents the affirmation

Source: Field data, analysis of in-depth interview data

Each component will now be discussed in turn according to the categories that have been proposed during the analytical data processing. Further to the category, the components are ranked according to the order of highest to lowest number of counts by category (robustness, adaptability, transformability).

1. *Robustness*

The robustness category includes nine key components, five of which are validated by a literature review: logistics capability, inventory management, financial capability, supplier selection, and security preparedness. The other four components are the use of information technology, availability of IT systems, interconnectivity of IT systems, and supporting infrastructure. A detailed discussion of each will follow.

Logistics capabilities were the most frequently mentioned component of resilience by seven interviewees (i.e. S1A, S1B, S1C, S1D, S1E, S1F, S1H). Logistics capabilities are an essential component to ensure that the produced parts are delivered to customers. An absence of logistics capabilities leads to parts not reaching the point of requirement on time, and consequently, the supplier would not get paid by the customer and possibly incur penalties for the delay. Interviewee S1A stated that: *“Finished parts are sitting in the port of Shanghai. Nothing has been getting in and out for weeks due to the lockdown. We need raw material, but it’s blocked in the port. Without it, we don’t produce and shut down.”* Repetition of failure to deliver could potentially lead to a terminal situation, as well as the inbound situation of missing raw material or semi-finished products for processing in the production line. Interviewee S1D said: *“We activated the option of sending parts by rail to Europe, as the shipping routes were not moving.”*

Maintaining the logistic capabilities is, therefore, a key component of resilience in terms of reacting quickly to demand from the customer in terms of delivering finished parts and from the supplier in terms of delivering raw material and semi-finished parts. Logistics capability is basic in SCM, even crucial and not having it simply blocks the system, stops SC flows, and stops payments to suppliers. Interviewee S1E added: *“No containers are available, so we cannot send finished parts to the customer, and without finished parts shipped, the supplier will not get paid.”* The point of financial

implications will be further discussed in financial capability (of this section). The importance of logistics capabilities as a component of resilience is to ensure the adequate timely movement of material either to the customer (finished parts) or to the factory (raw material or semi-finished parts).

Inventory management is the ability to provide products (raw materials, semi-finished products, final products) with the right levels of quantity in line with the demand. Six interviewees (S1A, S1B, S1F, S1G, S1H, S1I) mentioned this component of resilience. Poor inventory management means delays and high indirect adjustment costs such as rebalancing the final assembly line stations, taking an aircraft out of the production line, or even halting deliveries of the aircraft and occurring financial penalties for late delivery to the airline. Interviewee S1F supported this by commenting: *“The smallest missing component can block the production line; for example, a missing rivet on the wing production will halt its progress into the next higher assembly, and at some stage, maybe days or a couple of weeks, the final assembly of the aircraft will be impacted”*. For these reasons it is fundamental for each part to be on time, on quality, always. Two important consequences of poor inventory management are a direct impact on delays and a huge cost linked to adjustments in production, both of which adversely affect resilience. In addition, interviewee S1H added: *“Missing parts are already an issue, but this will create a huge mess in production, changing work orders, assembly locations, workers will run everywhere to adjust to a new set-up, special processes need to adjust, painting, and so on and so on.”*

Appropriate supplier selection was another component of resilience mentioned by four interviewees (S1A, S1E, S1F, S1H), which relates to how well the suppliers are selected during a call for the tender phase of development. Interviewee S1A said: *“The supplier must not depend too much on the customer but must put the financial means to resolve issues.”* The supplier selection must be based on the ability of the supplier to meet desired levels of resilience on specified components and, foremost, the strategic fit between OEM and supplier. For instance, when selecting a supplier for a special process such as surface treatment, the capacity and industrial capability to deliver to customer requirements shall be considered. Interviewee S1E mentioned: *“The suppliers must meet all quality requirements. No compromise. This is not so*

plausible.” Interviewee S1F added: “*The sub-tier, such as special processes, must be in a strategic alliance, to be synchronised with the needs and be willing to support in case of urgent or unplanned requirements.*” Data such as the processing capacity of a number of parts per labour shift is an important factor to consider. The process steps shall all be monitored to meet the customer's capacity requirement. In addition, holistic criteria shall be applied and verified, such as the financial capability of the supplier to meet customer demands.

Financial capability was a key component of resilience, as indicated by three interviewees (S1A, S1G and S1I). Financial capability is fundamental for SCR post-global financial crisis and even more so post-COVID-19 pandemic (Shi et al., 2023; Jüttner & Maklan, 2011). The reason is that this financial capability enables the supplier to access sufficient funds (either existing capital or access to fresh capital) to sustain business operations during periods of disruption. This ability then allows for the sustaining of business activity, maintaining material flows, paying salaries, rent, energy costs, and facilities.

A nuance of the component of financial capability is profitability targets that are particularly different between private enterprises and SOEs, which will be discussed in sequence. As parts manufactured by suppliers are not being delivered to paying customers in times of disruption in accordance with the business plan, the financial repercussions to the supplier may be high as they do not get paid, salaries may be impacted, sub-tier suppliers also, payment of rent, interests, etc. This could aggravate the financial capability of a supplier. It is, therefore, important that the entire value chain, including all intermitting steps, maintain a solid financial position and financial solvency in times of disruption. The longer this financial solvency is maintained, the higher the degree of resilience that can be achieved. Interviewee S1G said that: “*The finance ability on the customer side and on the supplier side are crucial for the smooth delivery, even of the ones in the middle as they also have a share in it: warehouse, logistics, banks, and so on.*”

For instance, to what extent is the supplier able to continue paying salaries, rent, cost of capital (interest rates), raw materials and work in progress? This ability can be

measured on a timescale. The better the financial capability (either as a cash position or by using financial engineering capabilities), the longer the supplier can sustain itself and the higher the level of resilience. Interviewee S1G mentioned: *“A key feature of resilience is the financial capability of the supplier and of the supplier of the supplier. We need minimum levels of availability, for instance, to keep producing for a few months autonomously, as a contributor to the system.”*

Of particular interest to this research is the view of interviewees S1A and S1G that SOEs are in a financially more stable position than privately held enterprises. Interviewee S1G mentioned: *“The good cash position of SOE allows to keep inventory levels and continue to produce and keep a good financial cashflow.”* According to interviewee S1A: *“The operators stay in the company as it is difficult for SOE to terminate contracts for political reasons, so the operators receive salary and can continue to work, make parts, and get training; with no financial support, it’s not possible.”* Interviewee S1A added: *“The buyer may change supplier in the private enterprise due to price reasons, but that’s certainly not the case if the supplier is a SOEs. The SOE produces at a price; even if a bad batch of products needs to be scraped, the contract stays, and so does the price. The supplier cannot go bankrupt because of this. The SOE continues production.”* SOEs are, according to interviewees, in a financially strong position, as budgets are allocated by ministries to support them. SOEs are therefore able to purchase inventories and maintain production and business operations. As this component has not been previously identified in the literature and has not been adapted to the theoretical model, it will be discussed in Section 4.3, ‘revised theoretical model.

Profitability targets are less of a concern for SOEs as these are more driven by prestige and by the technologies that they can manage and integrate as opposed to profit and margins for private enterprises, according to interviewees S1D and S1H. Interviewee S1D illustrated this: *“SOEs don’t have profitability target, they care for the reputation, the capability and the technology. Foreign companies want to be present, and local companies want growth.”* For example, China has no industrial capabilities on commercial engines or avionics due to strategic considerations. These types of systems are managed by the private enterprise (outside of China). The profitability

target is understood as the profitability of a customer. For instance, the OEM-A has a profitability of 5%, and the OEM-B has a profitability of 20%; in this case, the supplier is more likely to prioritise deliveries for OEM-B, as this will provide a higher margin of profitability to their financial bottom-line. Interviewee S1H said: *“The private enterprise will stop working on a project if the profitability targets are not met, or they will suggest a transfer of work to a low-cost place. It is important to ensure a fair level of profitability and to keep a partnership approach with the supplier.”* Therefore, it is important for the OEM to benchmark profitability levels and to stay competitive by not over-demanding, as this may lead to delays over more profitable OEMs. This nuance of the component had previously not been identified in the literature and will therefore be added to the revised theoretical model of Section 4.3

Security preparation is the readiness in case of a security breach on-premises or from cyberattacks (Hajda et al., 2021; Bhamare et al., 2020). Two interviewees (S1B and S1E) mentioned this key component. A company must do what is necessary to ensure that both physical assets and data (either virtual or physical) are secured from potential intruders. Interviewee S1B supported this with a comment: *“We need to do everything required for the security of the company. In turbulent times, we face the risk of theft and intrusion, and as the world polarises, we observe increasing cyber-attacks. Every employee and supplier must do their share. Especially in the cyber world, we need to prevent intrusions and put security measures in place.”* A breach in premises or digital networks may be a fatal incident for the company. A company must ensure that premises are secured through security, firewalls, and appropriate software and that networks are protected from intruders.

The preparation of these security measures is a key component of resilience as it will ensure operational continuity and facing adverse conditions and threats alike. Interviewee S1E said: *“We spent a lot of time and money to simulate scenarios of a cyber security breach, and it was required to quickly deploy required assets if a breach occurs; it is a question of time, and minutes can make a difference to ensure system compliance. Consequences can be fatal for the company; all operations could be stopped: no orders to suppliers, no internal production, and no deliveries to customers.”* Security preparation requires the company to prepare adequately in case

of an intrusion. The level of resilience is higher when the time required to fix the intrusion is lower, the time to free assets is lower, and the time of immobilisation is lowest.

Information technology (IT) usage means that data is available online and can be shared, transmitted instantaneously, and collaborated with in an effort to reach a lean and agile SC (Chae et al. 2014). This was a key component of resilience mentioned by two interviewees (S1D and S1E). The lean SC is resilient because less interference and quicker throughput are expected, and IT accelerates this with instantaneous data transmission. Interviewee S1D commented: *"It's about the time required to find the data, the search for paper will take longer, but with digital it's right available, for everyone, everywhere. We can check parts status, work in progress, and material and inventory levels."* On the other hand, the agile SC will be able to adapt quicker to circumstances such as disruption by means of cooperation and data sharing between stakeholders, which leads to a higher degree of resilience. Interviewee S1E said: *"Technology and the internet make it so much faster than in the past, it really accelerates the business"*. Interviewee S1D added: *"Full automation using IT is the future because then the machine is independent of operators."*

IT System availability refers to an ERP availability such as Oracle or SAP. Interviewees S1B and S1E comment on it as a component of resilience. The finding is that technological minimum levels of deployment are mandatory, such as an ERP system, to achieve levels of resilience. Interviewee S1E stated: *"Technology is the basic level, and it is everywhere, and the same platforms are used for instance in Germany and China."* Besides the benefits of such a system (resource planning and demand planning), it also offers consistency in the ways of working. The company is becoming dependent on a running system and not on the behaviour and ways of working of people. Interviewee S1B said: *"Technology is nowadays integrated everywhere: the procedures, the machines, the databases, it's all connected and integrated. This system becomes failure-proof."* This key component of resilience has been touched upon as the information technology capability, but this component is more specific in another area of IT.

Interconnectivity of system and data availability refers to the degree of transparency and connectivity between the OEM and the supplier and within the suppliers. Interviewees S1H and S1E elaborate on this. Interviewee S1E stated: *"Systems should be agile and able to answer many questions quickly with accurate data. For this, the systems should be compatible with SAP or similar. That way, it's easy comparison and simulation."* Interviewee S1H added: *"Systems need to be connected for us to be able to anticipate, or at least react with the correct data. For example, to what extent is the demand from our customer adequately communicated to the suppliers and their suppliers?"* Three important elements for achieving resilience are identified. Firstly, it is essential that systems are interoperable, which can be accomplished by utilising uniform software platforms like SAP or Oracle. This approach mitigates potential compatibility challenges. Secondly, it is vital that interfaces are properly integrated; for instance, employing a cloud-based solution that facilitates established interfaces ensures that data remains intact. Lastly, regular data exchange is imperative, occurring either immediately following any changes or on a daily schedule. Such data transfers should be automated rather than initiated manually or on an irregular basis.

Infrastructure was mentioned by one interviewee (S1E) as a key component of resilience covering the quality of brick-and-mortar facilities as well as access to energy, water, and high-speed internet. Interviewee S1E mentioned that: *"Infrastructure is so critical to responding to the business. You need the right tools, structure, and reliability on energy and water."* Stable infrastructure is crucial for manufacturing aircraft components, involving not just buildings but also essential utilities like water, gas, energy, and high-speed internet. Shortages in these resources can disrupt production, affect quality, and lead to costly restarts or disposal of defective parts. Continuous assessment of resource availability, including utility maintenance and bandwidth evaluation, is vital. Energy and water supply reliability can fluctuate, especially during peak demand, and water quality may pose challenges. Infrastructure standards vary, necessitating redundancies, such as multiple electricity grids and backup generators, to ensure resilience in case of supply failures.

2. Adaptability

The second category, adaptability, includes four key components from the literature—SC collaboration, quality assurance, network structure, and visibility—along with two additional elements: flexibility and social capabilities.

SC collaboration relates to how different suppliers or partners within the SC interact, communicate, and share data. Six interviewees (S1A, S1B, S1C, S1D, S1F, S1H) agreed that this was a component of resilience. Interviewee S1D commented: *"The SC is an integral part of our system where everyone needs to openly collaborate"* S1A affirmed that: *"The collaboration is required operationally to ensure planning and production is secured with suppliers."* Using SC collaboration and digital exchange on data, material location, quantity, specification, expected recovery time, and so on, is a key component of resilience for day-to-day operational problem-solving. Interviewee S1H added: *"We need to collaborate data between supplier and OEM to make sure mid and long-term capacity and deliveries are secured."* Furthermore, this component ensures a structured and controlled prioritisation when matching customer demand and supplier capacity, which is critical for planning purposes. A lack of collaboration can mean a rush to resources, arbitrary prioritisation and poor communication between customers and suppliers. Interviewee S1F added: *"Collaboration between supplier and OEM is mandatory, at all levels of the company; only then can we succeed in solving problems."*

Quality assurance was another key component of resilience identified by four interviewees (S1B, S1D, S1F, S1H) and is related to the ability of a system to perform and meet customer expectations consistently. Interviewee S1F said: *"There is no compromise on quality due to the safety requirements and the regulation of airworthy agencies across the world. The operator needs to have this awareness and culture. You see an issue, you tell it; don't hide or close an eye on it."* The system runs however qualified staff is required, processes are robust, and quality checks occur at regular intervals, in the right place, using adequate means. Interviewee S1H also commented: *"Mandatory when we select suppliers is for the supplier to be qualified according to ISO9100 to ensure quality systems, and this should to some extent cascade across the SC in order to raise overall quality standards So, the supplier should invest in*

this in order to be able to attract business." Standards such as ISO9100 certification regulate quality levels to ensure that parts meet quality requirements and guarantee that quality will support steady and resilient production. OEMs require this certification in their supplier selection rationale.

The SC network structure is a component of resilience, and it is about finding solutions within the network, as mentioned by four interviewees (S1A, S1B, S1D, S1H). Existing networks, such as within the client and customer relationship, are vested to commonly succeed and, therefore, have aligned objectives. An important component of resilience is the ability of the network to innovate and develop solutions through dialogue. Interviewee S1H supported this with a comment: *"The network means you can rely on the professionals that work on commonly delivering the product. The solution will be found within the network, such as an indirect inventory for a critical part or a resource that can be made available temporarily to solve the issue. The network is very important and powerful."* Furthermore, this network is most familiar with the product and processes and will, therefore, be able to propose solutions using a problem-solving approach. To the network, a permanent stage of disruption is not desirable. Interviewee S1D commented: *"We can find common solutions within our network of direct and indirect suppliers, and in a partnership, we find solutions that are a temporary relief or a permanent adjustment and change to stabilise performance. It's a natural process."*

Visibility in the SC refers to bringing transparency to decision-makers so that they can make educated, data-driven decisions. Two interviewees (S1A and S1H) supported this component of resilience. There were three aspects of visibility that the findings revealed, namely:

- Cumulated demand,
- Visibility on all means and monitoring; and
- Control feedback loop.

First is the cumulative demand, i.e. consolidating customer requirements: what is needed when and whereby the entire SC. The consolidation and prioritisation need to be managed by the OEM for the suppliers and sub-tiers to avoid errors and consolidate

planning. Interviewee S1H supported this by commenting: *"The planning and visibility of demand allow capacity to be simulated and planned properly. At the end of the day, a crisis is about priority management, so we need to make decisions based on facts, and the transparency of the SC is important. How many parts do we need, and when do we need it?"*

Second, to provide visibility on all capabilities such as material, semi-finished products, and resources to address the fundamental question of what demand can be absorbed by the supply. Interviewee S1A also added that: *"The mindset of transparency is important, solve problem together, to share information and to keep for yourself."* Third, to continuously monitor the progress of matching demand with capacity and providing the feedback. Interviewee S1A commented that: *"Then the execution and the validation will close the loop. Adjustments will always take place, and it can be done in the dialogue with the SC and material providers. Just agreed plans should not change without agreement and understanding consequences."*

Flexibility is another component of resilience mentioned by one interviewee (S1C), which was not previously identified in the literature. Flexibility is a generic term used to describe the ability of an organisation to have a margin of manoeuvre from strict processes; for example, a procedure dictates the use of a specific carrier on a logistics route. However, another carrier may be willing to pick up a part outside the typical schedule. The organisation would then be flexible and choose the better solution despite a strict procedure. This is supported by interviewee S1C: *"Rate flexibility being able to ramp-up and ramp down as required"* and adds that: *"From a financial perspective flexibility is a cost, it means spare capacity on a machine that is not used productively, it means having workers on training instead of direct contribution, flexibility is extra space in a warehouse that cost insurance, heating and space."* Flexibility was seen as a component of resilience as it offers a degree of manoeuvrability; however, it is difficult to capture the exact implications, such as rate flexibility, logistics flexibility, workforce flexibility, and financial flexibility are all very different features. A general remark is that a certain margin of flexibility, for example, a 5% capacity buffer, is an important component of resilience, despite the cost it might have on the business for not fully using capacity.

Social capabilities refer to the moderating variable between relationships, creativity, research and development and intellectual property (IP) (Muñoz-Pascual & Galende, 2020) and was mentioned by one interviewee (S1H). The skill of communicating the appropriate information in an adequate way to the right level of the organisation and initiating the right action is a key component of resilience. Interviewee S1H mentioned that: *"One of the critical skills required and often overlooked is the ability to communicate adequately with stakeholders. Not just the technical solution but how it is communicated and how they interact with colleagues, customers, authorities and so on."* This means, for instance, if the sales department is informed of a production stop, the decision can be taken to temporarily suspend sales or adjust sales deliveries to a later point to avoid penalties for late deliveries.

3. Transformability

The third category, transformability, validates three elements from the literature review: innovation, knowledge management, and sustainability while introducing a fourth element, portfolio diversification.

Firstly, five interviewees (S1A, S1B, S1D, S1H, and S1I) mentioned **innovation** as an important component related to resilience in the SC. Innovation may be understood as the disruptive way of doing things with ideas, skills, methods, and knowledge; applying innovation could have a more favourable outcome than a traditional process or finding new solutions to problems (Sabahi & Parast, 2020a). Research has found that companies with a high degree of embracing innovation are more resilient to disruption and that innovation helps firms fortify capabilities that positively affect risk management capability and resilience levels (Sabahi & Parast, 2020b). Interviewee S1D commented: *"Doing things differently when everything fails is some type of innovation for me. Some areas in the company are really expert and prepared to provide innovation for products or processes; we just need to let them have the chance"*. This is due to innovative firms paying more attention to customer requirements, handling problems better, responding better to environmental uncertainty and being more capable of dealing with volatility in demand. S1H added: *"Are we prepared to get out of our comfort zone? I mean, we used to follow procedures. But when this does not work, and everything is stopped, the option that*

we have is to do everything differently and expect another result. Too long we were stuck and kept improving the existing; this is the chance to do it differently."

Radical innovation pertains to the adaptation of new technologies to create a demand for a product not yet acknowledged by the market and by customers (Sabahi & Parast, 2020a). Due to strict regulation in the aviation industry, radical innovation is rarely observed. It requires a lot of time and approval from airworthiness authorities to approve significant changes and radical innovation. Interviewee S1D mentioned: *"As there were no flights or boats available, we used the rail as a new and innovative transport solution from China to Germany. It took longer, but it was reliable. It's like we jumped the queue with this approach, as everyone else was waiting for the ship."* However, it is noted that from an organisational perspective, radical innovation can be fostered with respect to how to do things and how to get organised to do things. Interviewee S1H added: *"To tackle the issues, we need another way of thinking; it's what I would call resilience; it's to come up with new methods or ideas. This will lead to resilience for me."*

On the other hand, **incremental innovation** refers to slight changes in existing technologies involving configuration, function, price, quantity, and features to address the needs of existing customers (Sabahi & Parast, 2020a). An organisation aims at incremental innovation and improvements by continuously evolving on various parameters such as product, process, function, and performance trade-offs. S1A said: *"With small improvements and a little innovation, we can reduce our assembly time and deliver the product faster. The same goes for the SC; with continuous improvements, we can get better, faster and more cost-efficient. It will take some time, a project approach, and resources, and we will deliver results."* Less adverse effects and risk is involved as the platform, and the ecosystem is stable. Incremental improvements will reach 3-5% improvements and take less effort in time, resources, and cost. S1B added to this: *"Innovation is in our everyday work. No matter what we do, we ask how we can do it better. Be more customer-focused. It's important to keep our ears and eyes open to see what is happening in the market, and then we adjust and adapt. It's a continuous process, and its resilience is resilience with innovation."*

Both the radical and the incremental innovation are observed to occur in the aviation industry but at different levels of speed. Radical innovation takes more time to occur due to regulatory limitations. Incremental innovation is observed to take place thoroughly as improvements are continuously searched for.

Knowledge management refers to how informal knowledge and experience is captured. It is of particular importance in times of disturbance as employees may leave their job and the organisation struggles to maintain knowledge and key skills (Belz, 2011b; Teece et al., 2009). In total, five interviewees (S1A, S1B, S1D, S1F and S1H) mentioned knowledge management as a key component of resilience.

Essential skills can diminish over time due to employee turnover, making it crucial for organisations to protect their knowledge base. Implementing a knowledge management system—through training programs, standard operating procedures, documentation, and best practices—ensures that knowledge is retained and can be effectively transferred when needed. Interviewee S1D supported this by commenting: *“When newcomers start, we will have quality problems because they are unaware of quality standards and standard operating procedures. This quality will impact the output negatively, and the output volume will drop because we scrap parts or have to rework them.”* Interviewee S1H also added: *“The knowledge is generated as we industrialise the product, and the capturing through work instructions, guidelines, best practices are important to ensure continuous quality standards...Employees will depart, but quality and product stay.”* Interviewee S1F commented: *“We saw this in the last months as the quality suddenly dropped. When we investigate, it is understood that key skilled employees in the company shop floor have disappeared.”* Regular adjustments are required as production evolves over time with improvements such as semi-automatic process steps.

Sustainability was mentioned as a key component of resilience by one interviewee (S1H), which involves a multitude of topics, such as reduction of waste, energy efficiency, equality, access to education, etc., that are indirectly linked to the resilience of SCs. Interviewee S1H commented: *“When you have time, resources, and interest, the topic of sustainability is really preparing the future; however, in times of crisis, it's*

about surviving. Sustainability, I see, is not so directly related to resilience in the SC, except maybe the long-term energy stability through renewables.” Sustainability adds complexity to SCs by requiring the integration of economic, environmental, and social dimensions into their strategies (Negri et al., 2021; Gupta et al., 2020; Zavala-Alcívar et al., 2020). Achieving this management and cooperation ensures that a company is prepared for the future and designing its SC strategy with sustainability in mind whilst maintaining the appropriate level of resilience.

Portfolio diversification is referred to by one interviewee (S1I) as a key component of resilience. A diversification strategy may be an element to consider reducing risk and dependency on one industry. If a supplier operates in more than one industry, through balancing and shifting resources, a certain additional degree of resilience may be achieved due to the portfolio strategy. Interviewee S1I supported this by commenting: *"Through mergers and acquisitions, we can see that the portfolio of capabilities of the supplier grows. However, very little is observed concerning true diversification through a portfolio of capabilities."*

In conclusion, the discussion identified 19 resilience components organised into three categories, including seven new components: flexibility, information technology utilisation, portfolio diversification, infrastructure, IT system availability, IT system interconnectivity, and social capabilities. These will enhance the revised theoretical model in Chapter Four.

Objective 4: Gain an understanding of the importance of resilience in the short and long term and why it is difficult to achieve it.

This objective consists of two elements: first, to comprehend the **level of importance of resilience** from a short-term and from a long-term perspective by means of interview question Q6: *“What level of importance of resilience from a short-term and from a long-term perspective do you observe?”*. Second, to grasp the **difficulty of achieving it**, consider three main challenges: skills, processes, and cultures by asking the question Q7, *“Why is it difficult to achieve resilience in the SC, and how do companies overcome this?”*

By importance, one understands that effects have a positive and favourable impact and that they are, therefore, desirable to achieve (Walker, 2020). This importance of resilience could be viewed both from a long-term, strategic perspective and from a short-term, tactical perspective (Belhadi et al., 2021; Zighan & Ruel, 2023). In both perspectives, the benefits exceed the cost, but a certain investment in building and creating these capabilities is required (Chopra et al., 2021; Gligor et al., 2020). Four interviewees (S1D, S1G, S1H, S1I) supported the long-term strategic view, whereas the remaining five interviewees (S1A, S1B, S1C, S1E, S1F) had a pragmatic, short-term view, as summarised in Table 4.5. Short-term is understood as the short-lived benefit that resilience provides to SCM, such as pragmatic solutions. A long-term strategic approach means a systemic and fundamental strength that is supported by resilience. Regardless of a short-term or long-term view, resilience is a desirable state and somehow complex to achieve. This different view may be due to the specific role of individuals, where half are strongly involved in day-to-day business, and the other half has more strategic and corporate views of the business.

Table 4.5 Temporal view on appeal of resilience

Short-term pragmatic view	Long-term strategic view
S1A	S1D
S1B	S1G
S1C	S1H
S1E	S1I
S1F	

Source: Field research

Importance of short-term benefits of resilience

Three key findings about the importance of short-term benefits of resilience will be discussed: benefits of inventories, flexibility through redundancies, and alternatives in logistics.

Resilience in the short term is important, for instance, in setting up **inventories** in strategic locations: it increases flexibility, enhances reactive capabilities to defend against a temporary adverse condition, allows rapid deployment of alternatives, and provides for parts availability. Interviewee S1B commented: *"So we have inventories, alternative sources, and we can activate alternative suppliers quickly; that's a benefit of local sourcing."* S1C added: *"The short-term benefits are required to defend when we have a shock such as logistic issue overseas, so we can have inventory nearby to support a few weeks that suppliers need to manage, we care only for the final delivery."* These benefits can be activated within a couple of days and therefore classified as short-term benefits; they may also be quickly exhausted, such as inventories or strategic stock due to consumption, and therefore do not offer permanent protection against adversity.

Furthermore, a second qualified supplier can partially or entirely absorb the demand and allocate the demand to another geographic region: the strategic development of **redundancies** for commodities such as aluminium, titanium, or steel will then support a level of resilience. Interviewee S1E said: *"With the additional FAL, we can ensure customer delivery even when there are major events; of course, we have to keep redundancies and also maintain strategic stocks on specific materials such as*

titanium. It's a cost, but missing delivery is a huge cost and loss of reputation in the market. What's the price of that?" All these options have some cost associated with them, such as the cost of maintaining an additional supplier (audit, assess, continuous safety control) or the cost of carrying inventory (balance sheet adversely affected, cost of insurance, land, and building, and administration), which should be offset by the benefits of this resilience gained.

A further finding on the importance of short-term resilience includes logistics such as **alternative** routes that permit the overcoming of logistic challenges and maintaining deliveries of parts and material to factories and of finished products to customers. Interviewee S1D commented: *"Having the logistic network to support customer deliveries and provide our SC is mandatory; we use a combination of rail, sea, and air, and each is an alternative route".* Nowadays, airfreight, sea shipment, rail and truck complement each other on the route from China to Europe and vice-versa, and the State invests in growth through strategic projects such as the "Silk Route" initiative. Interviewee S1F said: *"China is now developing the new silk road, which connects China with the world, in particular with Europe, the Middle East, and Africa. This is by road, rail, and sea. New ports open, and additional airports are being built. The Chinese State invests so much in infrastructure and transportation systems."* These alternatives may avoid a region in case of a conflict, a natural disaster, or sanctions.

Importance of long-term benefits of resilience

The long-term benefits of resilience could be attributed to the strategic predictability of growth. In the long term, suppliers and partners are more willing to invest in growth, capacity, and new technology to ensure a common trajectory of increased output. Partners will be prepared to make required investments and to forego short-term profits for long-term, mutually beneficial gains. Interviewee S1I commented: *"Partnerships are engagements with all partners to cooperate and to find solutions. It reflects the willingness and capability of the organisation to come back to nominal performance levels The aviation industry is very small, and a supplier, manager and executive cannot jeopardise the reputation. There are only two main OEMs in the world, and they are aware of each other's supplier performance."* Interviewee S1I added: *"We are in it for the long-term, not a quick fix or response but the long-term*

capability of people and the system, and it's always a strong sign when considering future business opportunities such as the launch of a new program."

Three specific findings will illustrate the benefit of resilience from a long-term perspective: strategic predictability and partnership, namely performance to deliver, financial means to sustain the business, and benefits associated to capabilities such as knowledge related to technology. Each one of three key aspects will be discussed in detail and supported by the evidence from the interviewees.

Three interviewees mentioned **performance benefits** (S1E, S1H, S1I). Resilience levels have increased over time, and this has led to a more stable quality performance and deliveries on a day-to-day basis. This increased level of resilience is observed to have developed over time and can be attributed to the investment of the OEM into the supplier, for example, through supplier development initiatives and quality improvement plans that have increased the robustness of the quality system. Interviewee S1E commented: *"Resilience in the SC is desirable, and the level used to be much lower than what is observed today; previously, the supplier did not do capacity planning; now, we observe active and regular capacity simulation."*

It has also been acknowledged that traditionally, SOEs had a lower level of performance, but this has changed, and SOEs are improving and having a more stable performance. In supporting this, interviewee S1E commented: *"SOEs are traditionally with a lower level of SC performance compared to multinationals, delivery issues, low response to change, SC disruption, but it is changing, and the SOEs want to enhance their performance."*

The financial benefit was supported by four interviewees (S1C, S1E, S1F, S1I) as an element of long-term resilience. From a financial perspective, the consideration was given that businesses must be profitable and that short-term costs, such as investments, must be outweighed by long-term benefits. Interviewee S1E commented: *"Resilience can be achieved or supported by means of redundancies. However, we cannot have redundancies everywhere as they are intense from a resource perspective when setting up additional suppliers. Also, the financial considerations are*

mandatory because each additional supplier is a cost and an opportunity because they will be in competition against one another, in particular, true on single-aisle aircraft.”

For instance, having two suppliers approved and qualified means, in turn, double the effort on supplier follow-up, management, and surveillance. Instead of sending one purchase order for a full rate, this case would require two purchase orders at half a rate. An indirect benefit is that the two suppliers are in competition, and they may compete in terms of cost, innovation, and quality against one another. So, this benefit needs to outweigh the cost incurred that may be justified on aircraft production at a high rate (such as single-aisle aircraft, as compared to the relatively lower rate of twin-aisle / long-range aircraft).

At a high production rate, it is well justified to invest in redundancies and ensure resilience, whereas, in the case of low production rates, such as long-range engines versus short-range engines that are produced in the hundreds per month, it might not be viable. It means that the consideration must have a cost-benefit. Therefore, the potential benefit or the benefit of avoiding disruption in deliveries or customer dissatisfaction shall outweigh the cost of putting in place capabilities of resilience. S1F states: *“The goal of resilience must be financial, and we must be better off with the resilience”*. S1F said: *“The financial consequences of an impact are huge, and the consequences of a supplier shutdown are fatal. Resilience is about maintaining resources and the business running.”* S1I adds: *“The question is always what happens if we lose a supplier, what's the cost of qualifying a new one, not just the financial cost of capital expenditure like tools and qualifying but also the cost of lost deliveries and maintaining a facility idle; so we need to keep monitoring our SC for the potential risk and propose a de-risking strategy, for example through redundancies, second sources and so on.”*

Capabilities benefits have been mentioned by two interviewees (S1I, S1F). Obtaining the technical capabilities such as to build resilience across the SC is a further limiting factor to achieving the desire for more resilience. An entire ecosystem consists of suppliers, partners, and training institutions such as technical colleges. Communities and politics need to be willing and capable of supporting the journey to more resilience. For instance, technical colleges shall support the industry with the required skills, such

as programming machines. Is the local community prepared to accept a growing factory in its jurisdiction to meet growing rates and a need for flexibility? Interviewee S1I commented: *"Resilience levels depend on the overall capability of the system. You need the people, the processes, the structure, the political will, and capability."* S1F commented: *"It took us something like 20 years to build up the capabilities of some suppliers; in the 1990s and 2000s, there were not the same levels of technology we had today- limited calls to China, no internet. So, it's really much faster today."* It is important to note that the attribute of capabilities is a complex element that requires long-term planning and development.

Challenges in achieving resilience in the SC

To understand the difficulties and obstacles to achieving resilience, which is the second part of objective 4, its benefits will be contrasted with its cost, risk, and negative implications. Interview question Q7 asked, *"Why is it difficult to achieve resilience in the SC, and how do companies overcome this?"* All nine interviewees had consistently responded that resilience is difficult to attain. Regardless of short-term or long-term views of the benefits of resilience, significant challenges in achieving resilience in the SC are noted. The findings captured to the question why resilience is difficult to be achieved were sorted according to three categories: skills, adherence to processes and a risk management culture that had been identified in the literature (Shi, 2023; Cohen et al., 2020).

The level of **skills required** was mentioned by four interviewees (S1B, S1E, S1F, S1I) as an impediment to achieving resilience as it takes time for the skills to be developed and available within an organisation to manage a complex SC, to provide adequate forecasting, to manage material flows. Interviewee S1E said: *"We have been here for years now to put in place capabilities: qualify workforce, provide English training, technical training and so on. Then we train staff, and they move on to new opportunities when they are paid more elsewhere."* Interviewee S1I supported this by commenting: *"The skilled ones stay because of non-financial reasons. Others will go after 2 -3 years."* Possessing the technical expertise for auditing suppliers requires proficiency in interpreting technical drawings, being a certified auditor, and using modern ERP systems like SAP. This is crucial in a multilingual environment involving

English and the local language in commercial aircraft manufacturing. While training programs, language courses, and IT solutions can be quickly implemented, their strategic integration is a lengthy process that eventually becomes routine for employees and operators.

Implementing process was mentioned by three interviewees (S1C, S1F, S1H) as an obstacle in reaching resilience as it takes time to deploy, and the implementation, in particular strategically, cannot follow a single standard plan as a high level of customisation is required and people need to be convinced and supported during the journey of implementation. S1F commented: *"Implementing change takes time, and it's mostly about convincing people of the benefits. When people are in the routine, this change does not happen; we need an external impact to weaken us and make the change required."* As such, regular training and coaching are required. For instance, when implementing a process of regular auditing, the process owners must confirm sustainability by developing annual audit plans, warranting process efficiency, and ensuring that audit findings are adequately managed or escalated. In addition, the process must be integrated in the entire process chain from a strategic angle and in the Quality Management Handbook of the company. In supporting this, interviewee S1H commented: *"All processes can be in place, but it's the people that make them alive and operationalise them. We can have the greatest processes but if they are not interpreted or not respected, it is useless."*

Three interviewees (S1G, S1F, S1H) mentioned that another obstacle in the implementation of resilience in the SC was the **risk management culture** in organisations, departments, and cells. Besides procedural approaches, organisations are slow at detecting risk from a strategic perspective, even slower at raising awareness of what the risk could do in terms of disruption and slowest at implementing action plans to mitigate the risk effectively. This was supported by interviewee S1F: *"We have cases where we detect the risk in the supplier, but then it is not raised to the right level in the organisation so that we cannot raise it and control it."*

It is also important to acknowledge that more discipline in closing action plans to confine the risk effectively is required across various levels of the organisation. S1E

commented: *“There are many action plans regarding audit findings, regarding capacity action and quality actions, but the action plans are not adequately managed, so problems are becoming concrete risk and issues that impact. We need more discipline in that area”*.

Furthermore, the cultural aspect is significant in deploying a risk management culture, particularly in a strategic setting. Interviewee S1H said that: *“The cultural aspect of risk management is very difficult to implement. People are not speaking up or willing to contradict their management.”* To what extent is the national culture, for instance, in the Chinese context, compatible with the corporate culture of willingness to support a risk management culture of transparency, speaking up, and challenging the managerial hierarchies and authority (Dong et al., 2019; Wu et al., 2013; Bhaskaran & Sukumaran, 2007).

In summary, organisations must navigate unique challenges to build resilience during transformation. Identifying key competencies and aligning them with future needs is essential. A structured workforce strategy, supported by training, governance, coaching, and clear communication, is crucial. Fostering a risk management culture requires ongoing assessment of business risks and market conditions. Ultimately, resilience improves quality, delivery, and business continuity, offering benefits that surpass financial investments. Achieving resilience necessitates specific skills, a risk management culture, and strict adherence to protocols.

Objective 5 is to gain an understanding of proactive and reactive approaches to resilience capabilities building, and why it occurs.

To address this objective the following questions had been asked during the interviews Q8 and Q9: “How do companies respond to external shocks: rather proactively or rather reactively: in preparation and anticipation or in a responsive mode of recovering and damage control?” and “Could you elaborate on an example?”

According to the literature (Tsai & Lasminar, 2021; Elluru et al., 2019) the tipping point between proactive versus reactive is the actual event in itself. By building capability proactively, one understands the intellectual and capital means deployed to reduce or to alleviate the impact of the event (Jia, 2020). In contrast, reactivity means the containment actions, intellectual or material are deployed to return to nominal level (Cui, 2023). As shown in Table 4.6, both proactive (S1A, S1B, S1D, S1F, S1G and S1H) and reactive (S1C, S1D, S1E, S1F, S1H, S1I) approaches were equally supported by six interviewees each.

Table 4.6 Proactive vs reactive capability building

	S1A	S1B	S1C	S1D	S1E	S1F	S1G	S1H	S1I
Proactive	X	X		X		X	X	X	
Reactive			X	X	X	X		X	X

Note: x in each column represents an affirmation

Source: Analysis of in-depth interview data

Table 4.7 Comparative resilience building approaches

Type of approach	SOEs	Private (foreign-owned and domestic privately-owned)
Proactive	1 (S1B)	5 (S1B, S1C, S1D, S1E, S1F)
Reactive	5 (S1D, S1E, S1F, S1H, S1I)	1 (S1G)

Source: Analysis of in-depth interview data

Proactive approach

A total of five respondents noted that a proactive strategy was evident within the private sector, as demonstrated in Table 4.7. In this context, companies are evaluated based on their performance, financial outcomes, and levels of customer satisfaction. Organisations are making initial investments in various capabilities, including capacity management, skill development, performance management, industrial optimisation, and the ongoing enhancement of industrial systems, such as improvements to machine maintenance plans. Each of these aspects will be examined in detail.

Capacity management in China's private enterprises is characterised by a willingness to monitor and track capacity across all critical manufacturing steps, including in critical sub-tiers, to ensure sufficient industrial means and qualified operators are available, as mentioned by four interviewees (S1B, S1C, S1D, S1F). This capacity management is crucial to adapt capacity to the consequences of an event and thereby demonstrate resilience. Interviewee S1D said: *"The OEM goes and performs some critical CCP assessments (Capacity Contingency Planning) based on the latest Program simulation and a 3-year capacity horizon. The private enterprise usually is prepared. In a second assessment step, the supplier can deploy the CCP in the tier-2 or tier-n suppliers."* Not only are the assessments of simulating capacity performed, but action plans are also in place to monitor progress on a regular basis.

In addition, and for the sake of sustainability and business continuity, a methodology is deployed, which refers to the supplier's quality management system. S1F commented: *"The OEM will assess based on the latest program plan (and simulate the rate of 70 aircraft production per month, for example) and then the supplier must report the actions. Private enterprises take it to a high level of importance, and all management is involved. Furthermore, the supplier will use the latest program data to continuously re-assess sub-tiers so that capacities can be optimised and risk anticipated."* Capacity simulations are regularly evaluated with action plans to monitor progress. A methodology aligned with the supplier's quality management system ensures sustainability. The OEM assesses performance based on the latest program plan, while the supplier updates their initiatives. Private enterprises stress strong

management involvement in this process. The supplier will leverage current program data to enhance sub-tier capacities and proactively identify risks.

Skills management is another key element mentioned by three interviewees (S1A, S1C, S1H) that private enterprises proactively develop. Key capabilities required for resilience include training and monitoring of skills and capabilities despite the challenge of fluctuation and attrition in the workforce. Interviewee S1A said: *"Yes, it is really challenging to find good people in China that are willing to stay, especially with young people. There are so many opportunities in the tier 1 and tier 2 cities nowadays. There are many ramp-ups in industries such as automotive, technology and infrastructure. Sometimes, employees stay for 2 or 3 years and get training, and then go to another company because of the cost of a few yuan more per hour. It can be frustrating."* The initial phase involves recruiting personnel who can read, write, and communicate in English, especially in aviation. A commitment to quality and relevant skills, like painting, is essential. Operators will then undergo comprehensive training and certification. As they gain experience, their qualifications will progress from beginner to advanced, eventually allowing them to train new employees. This process ensures sustainability through resilience and proactive skill development.

Furthermore, the challenge for private enterprises in China is that workforce turnover is elevated, and the Human Resources Department has a challenge in keeping staff. Interviewee S1H: *"It is really not the salary; the people want a better canteen, a nicer shuttle bus, other benefits. SOEs are very good at providing benefits. You know, in the big cities like Beijing or Shanghai or the tier 2 like Tianjin or Suzhou, the workforce is almost saturated, so we have to get people from other provinces. There, the hukou may limit legal permanent employment, so it's a more complex process. Or we put factories elsewhere."* Adequate policies are required that may go beyond salary only (provision of benefits, additional training, canteen services, shuttle bus, sponsoring the Hukou – a cross-province type of green card).

Performance management was raised by two interviewees (S1F, S1H) as an element of a proactive approach to resilience and refers to the notion that key performance indicators are measured, monitored, and controlled in line with business

targets, including delivery performance, quality targets, concessions, non-conformities, and cost targets. The private enterprises have implemented visual management tools to monitor performance on the factory floor (with strong involvement of operators in the bottom-line targets) and the setting of targets such as a 95% on-time delivery target or a continuous concession reduction plan. Interviewee S1F said: *"We deployed the SQCDP approach in the suppliers, and they took it right away into their management practice because it is such a useful and simple tool. It creates visibility. There is no need to blame; just understand the cause and offer support. Together, we cascade the targets from the program, for example, 95% OTD to the individual workstations."*

The visual management, broken down at workstations, feeds into the overall performance of the supplier. It makes it evident to management as to which section, department or station is performing in line with business targets and which one is not and requires specific help such as SQCDP (a methodology of visual management categorising issues according to the acronyms: Safety, Quality, Cost, Deliveries and People). All the performance indicators and performance management tools enable preventative actions, risk management and an anticipative view towards resilience. In addition, S1H offered the complementary view: *"With the SQCDP, we can measure the deliver performance from one station to the next, so we can focus where the issue happens, for example, if a problem with the paint like a paint peel (orange peel) we go to the upfront to process such as surface treatment and we check there if we have consistency. The key performance indicator just must focus on the key indicator, not any measure that's not useful. That requires experience to monitor the right numbers. The daily SQCDP then feeds into the monthly and annual data, so we can see trends in how quality improves over the months and years, and the private enterprise is so good at it."* The SQCDP evaluates daily metrics, including safety, by comparing the occurrence of work-related accidents against a target of zero incidents. In the event of any discrepancies, the 5-Why methodology is employed to identify the underlying causes of the issue, which may include insufficient personal protective equipment, inadequate training, potential hazards, distractions, or fatigue. As a result, appropriate corrective measures are initiated.

Industrial optimisation was mentioned by two interviewees (S1A, S1G) as the ability of a supplier to continuously optimise to reduce cost, enhance safety, and increase quality. The willingness to invest in these improvements requires a strong management conviction as well as a degree of competition between suppliers. If there is no competition, the supplier will be content with the status quo. Industrial optimisation is, for example, the investment of the supplier in additional tooling to meet the tolerances of a part in the Nanometre range or the reengineering of the industrial processes to reduce the number of workstations and become leaner in the individual work steps or to reduce complexities and to gain weight. S1G commented: *"We have foreign-owned enterprises in China proposing improvements, usually together with their overseas headquarters, where small improvements are proposed, like additional tools for quality improvements, some lean initiative to reduce waste or lead-time reduction."* S1A added: *"It's a small improvement, but to be resilient in proposing is important; keep making small improvements will add to big gains. Nowadays, for example, airlines will be satisfied with a 1% fuel efficiency increase or a 10 kg weight reduction."*

The supplier may propose a cost reduction strategy to the OEM by switching from aluminium to aluminium-lithium alloy, enhancing resilience through reduced complexity, costs, weight savings, and improved quality. S1A said: *"Vertical integration has the potential in China to reduce logistics complexity, source locally, become more agile, and increase response time and flexibility. We can switch to local sources and avoid complex importation or look at vertical integration with local alternatives."* A key strategy is vertical integration of the SC, sourcing raw materials and components locally instead of relying on costly imports. This approach speeds up ordering, shortens response times, and can save costs by eliminating import duties while promoting local value creation.

Continuous improvement was mentioned by S1A as a proactive component towards resilience and can be understood as the mindset by which, across the whole organisation, employees proactively propose enhancements such as improvements to the work environment, operational organisation, or sequence to the instructions. For instance, the 5S approach (a workplace organisation method) (Gapp et al., 2008) will

not only enhance the day-to-day work but will also benefit cost, quality, deliveries of products and operator safety. Interviewee S1A said: *"The continuous improvement is not a top-down instruction, but it is a mindset of management and operators, where ideas are received and then investigated. For example, in the maintenance of machines by the supplier, do they follow the protocol of planned maintenance cycles, do they have the spare parts available when required, or do they go a step further from preventive maintenance to predictive maintenance that way the cycles for maintenance are optimised, reduce cost, or reduce machine failure?"* This contributes to a state of resilience as the workplace is leaner, simplified and follows a 5S approach.

Reactive approach

A reactive approach towards resilience was observed by six interviewees (S1D, S1E, S1F, S1H, S1I) in SOEs and by S1G in private enterprises as summarised in Table 4.7. In these case resources and financial means are abundant and a focus on expansion rather than performance is observed. Both approaches will be discussed in turn with the relevant interview evidence.

A post ante strategy is a reactive approach that responds to a disturbance with collaboration amongst players, resource availability and agility and flexibility in responding to an issue (Ali, 2021). This approach was mainly observed in SOEs where resources and financial means are abundant, and the focus is primarily on expansion rather than on performance.

An observation is made about **collaboration** through inventory levels that are strongly related to levels of resilience, which were mentioned by three interviewees (S1B, S1G, S1D). It is observed that SOEs can stock material in large quantities and are encouraged to do so. S1B stated: *"The State has many resources to fix the problem; they get the people that they need and also buy a large stock of material; they have vertical integration within their own group of companies"*. Interviewee S1G suggests: *"The more material the State buys, the better it looks for their importance to the economy. It's not efficiency; it's about size only. You know it's not a market economy here."* The inventory can therefore, in collaboration with production and suppliers, be allocated to the right supplier to maintain the production of parts and semi-finished

products. This way, production is not stopped; production can be adjusted in line with requirements and reactively demonstrate resilience through the collaboration of suppliers to optimise the utilisation of inventory. This is in sharp contrast to the private enterprise, which financially would not allow for a large inventory pile-up.

Two interviewees (S1B, S1G) emphasised that providing **human resources** reactively to address disturbances is crucial for event response. SOEs typically have abundant resources, as their primary goal is expansion. For instance, when additional personnel are needed to expedite a process, the SOE's large workforce can be temporarily reassigned. S1B noted: *"SOE really have a different approach (to the foreign-owned) and they employ people and then deploy them as required, usually with priority on National and defence projects. It's then a question of negotiation at the highest level to get the required resources, but once it is agreed upon, the staff will be allocated quickly and usually at a good level."* However, such decisions require top management approval, as consensus at lower levels is rare. This ability to mobilise resources in response to challenges illustrates the reactive nature of resilience.

The SOE is also able to attract a workforce due to generous benefits such as housing, pensions, stable working hours and access to personal credits. S1G, said: *"Compared to the foreign-owned, the SOE attract a different profile of people; they look for stability, to grow gradually, and have security. There is a low rate of turnover."* It's a huge apparatus compared to foreign-owned enterprises operating in China. Thus, the larger the SOE, the more benefits are expected, which in turn attracts more workforce and a higher level of resilience.

Addressing **agility**, as noted by interviewee S1G, adds to the SC's reactivity, differing from proactive risk identification. In an agile framework, suppliers respond quickly to challenges, reducing bureaucratic delays and enhancing resilience. For instance, if a component is found deformed during inspection, an investigation may reveal inconsistent temperature control at the facility, causing significant seasonal fluctuations. This led to the components expanding beyond tolerance levels. The supplier would then adjust conditions, like improving HVAC¹ systems, but would not

¹ HVAC is an acronym that stands for Heating, Ventilation, and Air Conditioning

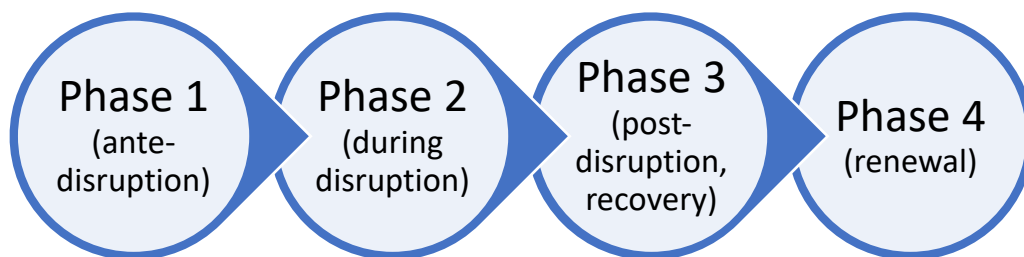
tighten tolerances beyond established limits. S1G supported this view with a specific case example: *“One case we had was complex to investigate where parts at the component level were all in accordance with drawings but at higher assembly tolerances were not met. The investigation found that environmental control was not respected. Doors were kept open; heating was too hot, or air conditioning was out of service in the summer due to some restrictions.”*

In summary, objective five has discussed that proactive resilience building is observed predominantly in privately-owned enterprises, including both domestic privately-owned enterprises and foreign-owned enterprises. This proactivity is characterised by skills development, performance management, industrial optimisation, and continuous improvement. The reactive capabilities building post-event is mostly observed in SOEs and consists of allocating resources, fixing an issue, or consuming inventories.

Objective 6 is to identify the key characteristics of the phases of resilience building. Objective six aims to verify the literature about the key characteristics of the four key phases of resilience building. The interviewer asked: *“What are the key characteristics of resilience prior to an event, and what about during a crisis?”* and *“What are the key characteristics of resilience after a crisis?”*

The findings aim to outline the characteristics of resilience for each of the four phases (Scholten et al., 2019; Nguyen & Akerkar, 2020; Sangwan et al., 2018). Phase 1 is ante-disruption or readiness, phase 2 is during the disruption or responding to the disruption, phase 3 is post-event in recovery mode, and phase 4 is the renewal phase, as illustrated in Figure 4.4.

Figure 4.4 Visualisation of phases of resilience building



Source: Prepared for this research

Phase 1: Characteristics of resilience ante-disruption - readiness

This phase is characterised by two specific characteristics: the risk-based approach to resilience and the efficiency of the risk management system. Both will be discussed in turn in this section.

An organisation may decide to prepare itself for a potential disruption happening using a risk-based approach, evaluate potential scenarios, and decide to implement reactive or preventive measures as mentioned. The organisation may use a risk assessment in a proactive manner, and action plans will ensure compliance with requirements by proactively building resilience into processes and systems. This approach had been mentioned by three interviewees (S1E, S1I, S1D). S1E stated: *“The business continuity plan is continuously reviewed with the management where we assess all elements of the business and what could go wrong or occur. It is a very structured approach that looks at how we can sustain production for the longest possible duration and not impact the customer, particularly in China.”* The deployment of a business continuity plan will ensure that potential risk is assessed and that action plans are ready to be deployed as and when required, such as a logistics backup by another route or a power generator if an energy shortage occurs. These business continuity plans are common practice in business; however, in China, these business continuity plans may be activated more frequently.

In addition, the effectiveness of the risk management system can respond either by containing or by preventing the risk in an assessment. Depending on detectability, possible magnitude of the impact, and probability of occupancy, the decision to take action will be made. According to interviewee S1I, the risk management system is applied: *“The organisation may decide to perform a risk assessment based on various criteria: quantify the risk based on the likelihood of occurring (probability), possible damage (impact) as well as the degree to which it may be identified (detectability) and rank the risk.”* If a supplier faces capacity risks, the auditor will document the issue and request an action plan to address it. This may include optimising current capacity, acquiring more machinery, or outsourcing to an external firm. This risk-based approach has proven effective for ensuring compliance, as noted by interviewee S1D: *“Audits and assessments take place regularly to survey suppliers, and we perform the*

audits to verify compliance with requirements, best practices, and capacity. The findings then go into an action plan, and we ensure that the findings are closed.”

Phase 2: characteristics of resilience during a disruption – response to disruption

This phase is characterised by two specific characteristics that will be discussed in this section: the level of resilience as a function of the intensity of the event and the transparency and ability to communicate effectively with stakeholders.

Once an event happens, the **level of resilience** and the intensity of the event may counterbalance. The more intensive the event and the longer it lasts, the more resilience levels will be required. For instance, if an event such as a war, a natural disaster, or a political disturbance cuts the supply of critical raw material, it will depend on the level of resilience of the inventory to temporarily overcome the supply shortage. Interviewee S1B commented: *“The level of resilience will depend on the length of the event; for example, the short-term event will be overcome much quicker, and the long event will take more time to overcome.”* Having two weeks' worth of inventory suggests that the event can continue without major SC disruptions. However, if it lasts beyond two weeks, current resilience may not suffice, requiring alternative strategies to avoid disruptions. This has been previously noted by four interviewees (S1A, S1B, S1H, S1D). Interviewee S1H stated with this respect: *“Resilience and response to it will depend on the intensity of the event and how resources are allocated. The deeper the event, the harder the response must be. Is it the labour shortage, the material shortage, a pandemic, a war, each requires a different response, and some may be quick and easy, others will impact deliveries.”*

A further characteristic of resilience during the stage of disruption is the **transparency and ability to communicate**. Not all stakeholders may be aware of the consequences, limitations, and constraints in the SC, and it is the role of the SC manager to provide this visibility. According to interviewee S1A: *“At the stage of the event is happening, it is all about creating visibility.”* This visibility necessitates a clear understanding of specific shortages, affected components, dates, quantities, repercussions, and recovery timelines through a structured action plan. With this insight, stakeholders can make informed adjustments to mitigate potential impacts, as

noted by interviewee S1D: *“Communicating to the stakeholders the right level of accurate and time-critical information is essential”*. In addition, time criticality in communication is important, meaning that the relevant information is available at the right time to the relevant stakeholders.

Phase 3: characteristics of resilience post-disruption – Recovery

This stage is typified by three specific characteristics, namely, capacity and capability to deploy or redeploy resources, demand management and the continuous management of bottlenecks.

The level of **capacity and capability** deployment will determine the recovery point: the quicker machines, people and material can be directed or redirected to cover bottlenecks, the quicker the production will come back to nominal levels. Interviewee S1B stated: *“It depends on the availability of human resources that are skilled to do the job first time right. Otherwise, there will be quality losses in the output. Each required resource needs to be there and ready to start or continue the work.”* For example, if a milling factory has several available machines but misses the workers to operate them (programming, loading, unloading), the recovery will depend on how quickly more workers can be recruited and trained to operate the machines.

A further component of resilience post-disruption is **demand management** and creating visibility in the SC. This characteristic permits adequate capacity management. Interviewee S1D commented in the response that the most critical step is the: *“Demand management and visibility of provision of material from tier 2 suppliers.”* That way, the supplier does not reserve or sell capacity to the customer or to the OEM, which they don't have. This logic is applicable across the value chain, going across the tier-1, tier-2 and tier-n suppliers.

In addition, the continuous **management of bottlenecks** is a key characteristic due to its ability to solve capacity issues. A frequently observed example is the case of an autoclave, which represents a critical bottleneck in recovering capacity. The point in time when the supplier recovers to nominal levels will depend on the time that the new autoclave is operational (delivered, installed, commissioned, and qualified). Once the

bottleneck is under control, the next one needs to be managed and so on. This is an iterative process that is alimented by customer demand for rates and output. Interviewee S1F suggested: *“The speed of recovery will depend on how quickly capital goods and bottlenecks are recovered, in particular tier-2 suppliers and critical processes controlled such as surface treatments.”*

Phase 4 - Renewal

A fourth and final phase of renewal discusses the ability of the firm, post-recovery, to attain the initial performance levels, to exceed them through growth or to notice a shortfall.

Only the interviewee described the characteristics of this stage as the ability of the firm to do things differently and to **challenge its organisation** and thereby revise its position in the market. New partnerships, revised processes and improvements are some of the characteristics. S1C suggested: *“After we are back to nominal levels, it is also an opportunity for the company to do things differently. We can challenge the way we operate, we can improve our processes, we can rebuild the supplier network, we can look for new partners.”* It was also added by S1C: *“Some companies also will not make it; their performance will not be back to normal levels, and that could mean a competitive advantage for the others. So, really, it’s all going to be different.”*

In summary, objective six identified the key characteristics of the four phases of resilience building that were met, where ante-disruption, during-disruption, and post-disruption and renewal characteristics were discussed. Ante-disruption is characterised by a continuous risk assessment and risk management phase, while disruption is characterised by the level of resilience and the ability to communicate effectively and efficiently with stakeholders. Post-event is characterised by the deployment or redeployment of resources and the continuous management of bottlenecks. The renewal phase is characterised by partnerships and new business approaches.

Objective 7 is to identify a list of potential cases for stage two case study research. In preparation for stage two case study research, the interviewee has been asked, “Are there specific cases of resilience building in China’s aviation industry that would be relevant to investigate further?” and “Who could discuss the cases?”.

Several recommendations were given that have been clustered according to the SOEs, the domestic privately-owned enterprises, and foreign-owned enterprises. In total, 11 companies have been provided as a reference for further research. Of these, there were five SOEs, five foreign-owned and one domestic privately-owned enterprises. This list of companies has been consolidated and used as a part of the selection process during the stage two case study investigation. To ensure the anonymity of participants and the confidentiality of companies, the list is not published.

Summary key findings of in-depth interviews

This section summarises the key findings from the stage one in-depth interviews, confirming a strong alignment with the literature review. All seven objectives were fully met, along with the overall goal of this stage.

The first objective clarified the concept of resilience in China's aviation SC, which is defined as the ability to recover from unexpected adverse events and return to normal operations within a set timeframe. The second objective is to map the landscape of aviation suppliers in China. The interviews revealed that SOEs primarily serve as tier-1 or tier-n suppliers, benefiting from their strategic positions. Foreign-owned firms, with competitive rates and strong infrastructure, operate as tier-1, tier-2, or tier-n suppliers. The private sector is also growing, increasingly participating as tier-2 or tier-n suppliers.

Objective three aimed to create a comprehensive list of essential features of resilience in China's aviation sector, identified through interviews that also validated these components. The features were categorised into four groups: critical function, threshold, time, and memory. The top three features included team capabilities, flexibility in capacity and rate, and SC redundancies, with no discrepancies noted in the literature. Components of resilience were further classified by robustness, adaptability, and transformability, with logistics capabilities, inventory management, and SC collaboration receiving the highest evaluations. Novel components identified included flexibility, information technology utilisation, portfolio diversification, infrastructure, IT system availability, interconnectivity, and social capabilities.

Objective four explored the perceived significance of resilience in both short-term and long-term contexts, along with the challenges to achieving it. Participants recognised the benefits of resilience in both timeframes, with short-term advantages including optimised inventory and flexible supply arrangements, as well as long-term benefits linked to collaborative partnerships. Key concerns regarding feasibility included the capacity to implement plans, availability of necessary capabilities, and financial limitations.

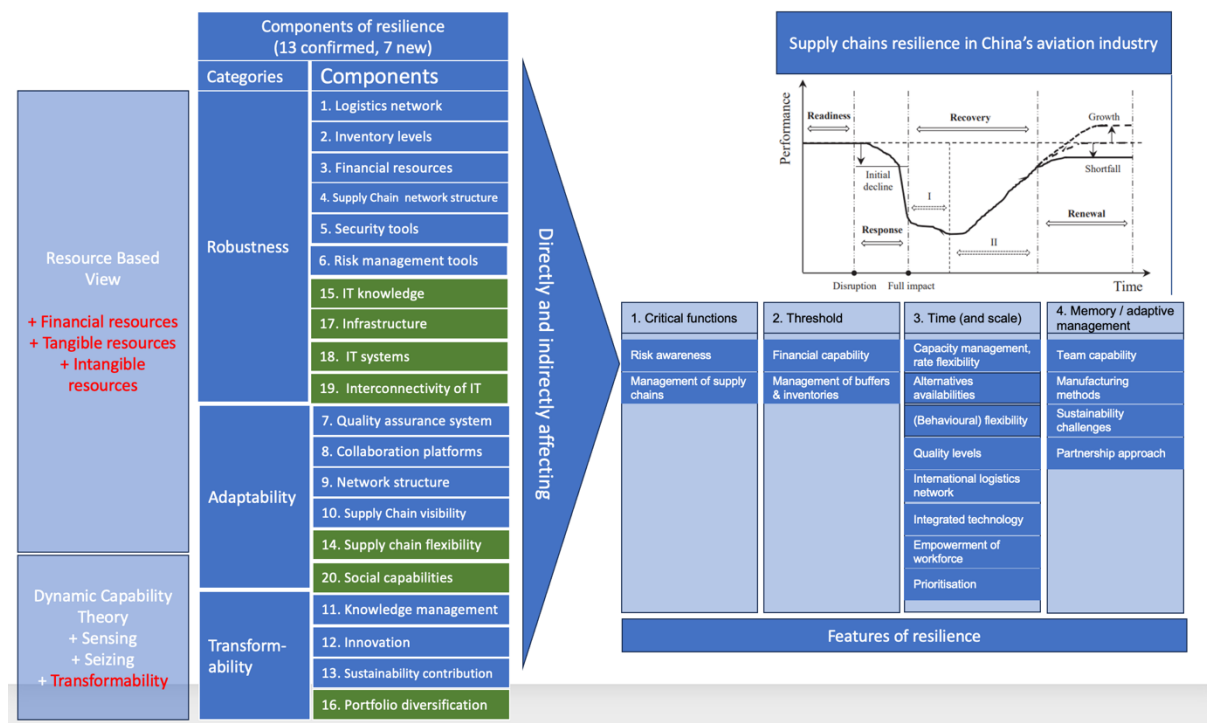
Objective five examined proactive and reactive strategies for building resilience, noting that SOEs tend to be reactive despite their resource investments due to their financial capacity and ability to attract talent. In contrast, private enterprises adopt a proactive approach to retain knowledge and ensure efficiency and profitability.

Objective six outlined the four phases of resilience building: the ante-event phase focuses on risk management; the during-event phase emphasises resilience, transparency, and communication; the post-event phase involves resource availability and demand management; and the renewal phase encourages new partnerships and innovative processes. Objective seven aimed to identify potential case study subjects, with interviewees providing relevant examples and personal contacts for further connections.

4.3 Revised theoretical model

Based on insights from the in-depth interviews and literature review, the initial model of SCR (see Figure 2.8) has been revised. It now incorporates both a resource-based view of the firm and dynamic capabilities theory. Established categories have been reaffirmed, and new components have been added. In the robustness category, IT components such as IT usage, systems, and interconnectivity have been included, along with infrastructure. The adaptability category now components flexibility, social capabilities, and portfolio diversification. Features of resilience are classified into four literature-identified categories with connections to resilience phases. New factors are highlighted in green in Figure 4.5.

Figure 4.5 Revised theoretical model



Legend:

	Component, feature of resilience
	Newly identified components of resilience

Source: Based on field research, prepared for this research.

In summary, some adjustments to the preliminary theoretical model have been made, as illustrated in Figure 4.5. First, seven components of resilience have been added and identified in green. The link between the features of resilience and the phases of resilience has been made. Second, the four categories of resilience are populated with 16 features of resilience.

4.4 Conclusion

In conclusion, this chapter commenced with a rationale for employing in-depth interviews as the initial phase of the research. Section 4.2 presented the outcomes of the in-depth interviews, detailing the profiles of the participants and the findings aligned with the research objectives. Subsequently, a modified theoretical model was introduced in Section 4.3, culminating in the conclusion drawn in Section 4.4.

CHAPTER 5: CASE STUDY FINDINGS

5.1 Introduction

Chapter Four discusses the in-depth interviews, includes an initial analysis of findings, and proposes a revised theoretical model. The aim of Chapter Five is to present the findings of stage two, case study. The real-life cases will be used to discuss resilience in China's aviation industry SC and to address the research sub-questions.

Chapter Five comprises of five sections, as shown in Figure 5.1. Section 5.1 introduces this chapter and its structure. Section 5.2 describes the case study organisation as well as each of the nine cases investigated (CSA, CSB, CSC, ...). Section 5.3 then discusses the findings of SQ1, the components of resilience, first by addressing each case, followed by a cross-case analysis. Section 5.4 then focuses on the findings of SQ2, the features of resilience. Finally, the conclusion is drawn in Section 5.5.

Figure 5.1 Outline of Chapter Five

5.1 Introduction
5.2 Case study organisation
5.3 Findings SQ1
5.4 Findings SQ2
5.5 Conclusion

Source: Developed for this research

5.2 Case study organisation

This section describes the organisation of the case study research by elaborating on the companies and the respondents that participated in the case study research. A total of nine companies were investigated by means of two interviews each. This brings the total number of interviews to 18, as outlined in Chapter Three, sub-section 3.3.3, methodology. For the purpose of anonymity, codes were allocated to the cases (e.g. CSA, CSB, CSC), and each case study was supported by two interviewees. Interviewee 1 (e.g. CSA01, CSB01, CSC01) had a strategic business view, whereas Interviewee 2 (e.g. CSA02, CSB02, CSC02) had an operational perspective. The two different perspectives allow the research to be explored from the strategic and operational levels to determine any similarities and differences. A brief description of the cases and interviewees is summarised in Table 5.1 below. The background of the cases is presented in sub-section 5.2.1.

Table 5.1 Description of case study organisation and interviewees

Company investigated	Description of product; attribute (low complexity, high complexity)	SOE/ foreign-owned/ domestic privately-owned	Company background information	Interviewee	
				1 (Strategic view)	2 (Operational view)
CSA	Structures; high complexity	SOE	Over 20 000 employees; revenue: USD\$ 50b – 100b; gross margin: 15 – 20 %*	CSA01	CSA02
CSB	Structures; high complexity	SOE	Over 20 000 employees; sales: USD\$ 5b – 10b *; gross margin: 5 -10% *	CSB01	CSB02
CSC	Assemblies; high complexity	Foreign-owned	500 -1000 employees; revenue: n/a; margin: n/a	CSC01	CSC02
CSD	Structures; high complexity	Foreign-owned	500-1000 employees; revenue not published; margin: n/a	CSD01	CSD03
CSE	Interiors; low complexity	SOE	100-500 employees; revenue not disclosed	CSE01	CSE02
CSF	Material; low complexity	domestic privately-owned	At Group** level between 10 000 -15 000 employees; revenue: USD\$ 5b-10b*	CSF01	CSF02
CSG	Parts; low complexity	Foreign-owned	At Group** level 15 000-20 000 employees; sales: USD 1b-5b	CSG01	CSG02
CSH	Assemblies; low complexity	SOE	10 000 -15 000 employees; sales: USD\$ 5b -10b*; gross margin: 10 - 15%*	CSH01	CSH02
CSI	Material; low complexity	Foreign-owned	At Group** level over 50,000 employees; revenue: USD\$ 10b-50b*	CSI01	CSI02

Source: Field data collected for this research

*Fiscal year 2022

** At Group level signifies that company CSF, CSG and CSI, respectively belong to a larger Group of companies. The respective case study investigates one company; however, background, such as employee number and turnover, are not segregated for the single company.

5.2.1 Description of cases

Case CSA. The first case investigated a supplier in southern China. A SOE specialising in defence aircraft design, production, and maintenance reported 2022 revenues of USD\$50 billion to USD\$100 billion, with a gross margin of 15% to 20%. Employing over 20,000 people, it manufactures complex components like passenger doors and empennage from advanced carbon-fibre reinforced plastics (CFRP). The SOE manages a complex global SC and uses temperature-sensitive materials, requiring careful planning for component customisation, production capacity, and demand management. It has strategically positioned itself near suppliers worldwide to enhance SCR. Management has focused on improving resilience strategies over the past decade. Two interviewees provided insights: CSA01, an executive manager with 20 years of experience in strategic procurement, and CSA02, an operations manager with over 15 years overseeing a specific work package's industrialisation.

Case study CSB. The second case study looked at a large SOE located in central China that has approximately 20,000 employees. In 2022, annual sales were between USD\$5 billion and USD\$10 billion, with profit margins of 5% to 10%. The company produces military aircraft and components for commercial aircraft, such as wing structures, and has seen significant growth over the past twenty years. Its resilience strategy focuses on maximising output, sustaining high production rates, creating jobs, and maintaining substantial inventory. The past decade has brought an expanding customer base and improved performance, driven by enhanced quality assurance. The commercial sector's role has grown, introducing complexities like parts procurement. The first interviewee (CSB01) is a senior manager with over ten years in strategic SC development, while the second (CSB02) has over thirty years of experience in SC and operations management.

Case study CSC. The third case focused on a coastal joint venture in China involving SOEs and a foreign entity with a 51% controlling interest. The company employed 500 to 1,000 local workers and specialised in assembling single and long-range aircraft, primarily for a delivery centre that transferred the aircraft to airlines. SCR was managed by a local organisation with a robust logistics network for direct component delivery. About 70% of parts were imported, while 30% were sourced locally. The first

interviewee (CSC01) was a senior executive with over 35 years of industry experience, while the second (CSC02) was a quality and SC manager with over 15 years of experience in business operations.

Case study CSD. The fourth case involved a joint venture between a Chinese SOE and a 25% foreign-controlled interest, operating a manufacturing facility in northern China with 500 to 1,000 employees. Initially reliant on expatriates, the company transitioned to a local workforce after extensive training. It focused on producing carbon fibre-reinforced polymer (CFRP) components, though its financial performance was not publicly disclosed. Key leadership roles, including the CEO and heads of various functions, are occupied by foreign nationals. Additionally, as its customer base consists entirely of commercial businesses, there is an absence of conventional SOEs interventions. The 75% ownership by the SOE is primarily non-executive and strategic in nature. To enhance resilience, the company implemented a systematic SCM approach, emphasising procedural efficiency and material flow management. It also aimed to improve its employer appeal to retain staff in a competitive market. The first interviewee (CSD01), an executive with over 20 years of experience, managed business operations and SCM, while the second interviewee (CSD02), a senior manager with over 15 years in the industry, oversaw SC flows.

Case study CSE. This fifth case involves a SOE in a coastal Chinese city, focused on cabin systems and furnishings, including seats. The company employs 100 to 500 people, with undisclosed revenue. Over the past decade, it has improved SCR through investments in skill development and expatriate knowledge, establishing strong capabilities in planning, skills management, capacity oversight, and quality assurance. The organisation has also engaged in international mergers to enhance its skills and capabilities. The first interviewee (CSE01) is an executive with over 20 years of experience, while the second (CSE02) is a senior SC manager with over 15 years in the industry.

Case study CSF. The sixth entity is a domestic privately-owned firm in southern China, rooted in a different sector but with a strong industrial foundation. It benefits from a vibrant industrial hub that is close to suppliers, educational institutions, and

essential infrastructure. Initially focused on machining components from aluminium, steel, and titanium, the company has expanded to include assemblies and sub-assemblies. Its SC relies on a local network of suppliers evolving alongside CSF in aerospace capabilities. The company employs 10,000 to 15,000 people and generated USD\$5 billion to USD\$10 billion in revenue in 2022. The first interviewee (CSF01) is a strategic business development executive with over 20 years of experience, while the second (CSF02) is a senior manager in SCM with more than 30 years in the industry.

Case study CSG. The seventh case study examined pertains to a foreign-owned enterprise that is part of a European conglomerate which operates a manufacturing facility in northern China. At the group level, the organisation employed between 15,000 and 20,000 individuals across three continents. In 2022, its global annual revenue ranged from USD\$1 billion to USD\$5 billion. The supplier primarily focused on the production of specialised electrical harnesses tailored to customer specifications. Its operations in China commenced in 1996. The strategies related to resilience, SCM, and capability development were predominantly influenced by the leadership from its international headquarters. The first interviewee (CSG01) held a senior managerial position in strategic business development and possessed over a decade of industry experience, with responsibilities encompassing business operations. The second interviewee (CSG02) was a SC specialist with more than 15 years of industry experience tasked with overseeing SCM.

Case study CSH. The eighth case involves a SOE in northern China with 10,000 to 20,000 employees. In 2022, it reported annual sales of USD\$5 billion to USD\$10 billion and a gross margin of 10% to 15%. The company focuses on fuselage structures for OEMs in Europe and North America. Historically reliant on expatriates, skill transfer was minimal until recent incentives improved capability development. This led to stronger quality and SCM processes, enhancing delivery and quality metrics. However, the company still shows significant reliance on expatriates and external entities, with limited ability to manage complex SCs and develop risk mitigation strategies. The first interviewee (CSH01), a vice president of strategic procurement,

and the second (CSH02), a senior procurement manager, both have over 20 years of industry experience.

Case study CSI. The final case study focused on a foreign-owned enterprise that supplies materials to various suppliers, like in previous cases. Based in a major Chinese port, the company manages a global network of suppliers, including aluminium and titanium mills, employing over 50,000 people and generating revenues between USD\$10 billion and USD\$50 billion in 2022. This organisation centralises its material demand and aligns it with supply over a 3 to 5-year planning horizon. It has exceptional visibility into OEM and supplier stock and demand, enabling it to share insights on planning, forecasting, and resilience strategies, including inventory policies. The SCR strategy emphasises data management for effective supply and demand planning and logistics across multiple transportation modes. The company can also provide alternative materials during supply disruptions and offers local value-added services in China, such as vendor-managed inventory and material cutting. The first interviewee (CSI01) was a senior manager with over 25 years of experience, while the second (CSI02) was a program manager with over 15 years of experience in SC operations.

In summary, Section 5.2 discusses the composition of the cases and the background of companies, such as their geographic location, their employee number, and their financial position. A brief description on each of the 18 interviewees has also been outlined. Section 5.3 and 5.4 will examine the results pertinent to the research questions SQ1 and SQ2.

5.3 Findings of sub-question SQ1

In this section, the findings and patterns of data for sub-questions SQ1 will be discussed, which focuses on key components of resilience and how and why they influence resilience. The findings will first be discussed for each individual case by a within-case analysis. In the second step, the cross-case analysis will compare and contrast cases based on previously defined attributes. Attributes include the company type (SOE, foreign-owned enterprises or domestic privately-owned) by organisational size (below or above 1000 employees) and by-product attribute (low complexity versus high complexity) with equal representation in the categories.

The SQ1 is: “What are the key components of resilience in the SC in the aviation manufacturing industry in China? How and why do these components influence SCs?” To address this sub-question three key questions were asked. First: “What are key components of resilience that you have observed in the SC?” Second: “Could you contrast components of SOEs, foreign-owned enterprises, and domestic privately-owned enterprises?” Third: “How and why do the components affect SCR, and could you elaborate on specific components of resilience in a specific example within your organisation?”

Overall summary of findings on SQ1

The cases discussed several examples of how resilience is observed in the SC, including capability and capacity development in the SC. Several common key components were identified by the case organisations including those summarised below: logistics network, financial resources, political support, inventory levels, quality assurance system (CSA), SC flexibility, redundancies, financial resources, knowledge management, SC network structure, quality assurance system, inventory level and political support (CSB), knowledge management, quality assurance system, redundancies, risk management tools, financial resources, political support, SC network structure (CSC), quality assurance system, knowledge management, inventory level, logistics network (CSD), SC network structure, redundancies, innovation, quality assurance system, inventory level, IT systems and knowledge management (CSE), quality assurance level, SC flexibility, redundancies, knowledge management, political support, risk management, IT system and SC network structure (CSF), redundancies, inventory levels, knowledge management, political support, risk management, IT systems (CSG), financial resources, quality assurance system, knowledge management, risk management tools, IT systems (CSH) and knowledge management, redundancies, political support, IT systems, SC visibility (CSI).

It was found that the components of resilience for SOE include a strong financial resource, a prioritisation mechanism in favour of non-civil projects, knowledge of key processes and a loyal, abundant and knowledgeable workforce. The SOE also tend to be more reactive as planning may fluctuate. Meanwhile, foreign-owned enterprises tend to have a relatively flexible, robust process, including problem-solving. Furthermore, communication is more lucid, and decision-making is faster. Some of these components are shared by the domestic privately-owned enterprise case study.

Discussion of each case study on the findings related to SQ1

Within-case analysis CSA

In the case of CSA, the interviewees described resilience conform with the definition, as the ability to bounce back to a nominal level. CSA01 commented: *“Resilience is to maintain in the face of adversity. At our company, we have seen that ability.”* CSA02 voiced the view that was affirmative: *“Resilience is exactly this. The ability to bounce back after an event.”* This was illustrated in the context of a specific work package that was assembled in the factory. Resilience was composed of adequate team capabilities, financial capabilities, and quality levels. CSA01 proposed a transfer of work case and illustrated resilience: *“For example, the project of transfer of work that was awarded to us, meaning a new work package, relatively complex. There, the OEM transferred this significant work package to our company. The development required skilled resources on the development side. After the development, adequate resources were required for industrialising and producing the parts... We were resilient in delivering despite obstacles.”* The capability of the workforce was also mentioned by CSA02: *“The technical skills that our operators have are really impressive.”* Consequently, the capacity to endure challenges is crucial, necessitating the appropriate allocation of resources to the project. The specific resources needed may vary based on the project's phase or the prevailing circumstances.

During the interview concerning CSA, the participants identified five distinct elements contributing to resilience: logistics network, financial resources, political support (a newly identified element), as well as inventory levels, and quality assurance systems. During the conversations with CSA01 and CSA02 about what the components are and how and why they affect SCs, a shared element of resilience emerged: the logistics network, which will be examined in the subsequent section. Initially, the components recognised in common will be addressed, followed by an exploration of the specific components associated with CSA01 and then those related to CSA02.

Logistics network

Both interviewees concurred that the logistics network constitutes a vital aspect of resilience. In addition to having a robust network of logistics partners capable of global reach and a transportation system encompassing maritime, aerial, rail, and road routes, a crucial factor in resilience is the cultivation of relationships with the authorities at both departure and arrival ports. Sustaining these relationships facilitates alignment with the priorities of suppliers and customers, thereby directly affecting delivery processes. Consequently, these deliveries play a significant role in determining customer satisfaction and performance metrics. CSA02 commented: *“Logistics is a strong component we have. Not just the best shipping companies and sending parts by plane or ship. But the most important is that we have an established relationship with authorities at ports of arrival and departure to fast-track any parts. That way, we are sure to get priority.”* The view of CSA02 was complemented by CSA01 that the logistics network is well established from a strategic view. This means that long-term contracts are in place, systems are robust, and capacity is available to cover customer needs. No unforeseen surprises ought to happen. CSA01 said: *“Our logistics network is well established. Both inbound and outbound are covered by our dedicated providers.”* The presence of a robust local supplier network offers significant advantages, as it eliminates the necessity to import or export components internationally. This arrangement allows for enhanced oversight and management of domestic suppliers. CSA02 added to the view: *“The local SC is a strong benefit; we don’t need to import or send parts overseas. That way we have a good control on local suppliers.”*

Consequently, the logistics network is a crucial component of resilience as it establishes a global network of partners capable of delivering sufficient services in the face of unexpected events, while also contributing valuable knowledge and agility.

CSA01 addressed two key components: financial resources and political support. The latter, a newly identified component will be incorporated into the theoretical model in Section 6.4, *“implications for theory”*, which will be elaborated upon in due course.

Financial resources

CSA01 had a distinct opinion regarding financial resources and their role on SCR. Financially CSA has the access to capital to maintain the SC going both from a parts perspective and from an employee perspective. That means paying for material and parts from its suppliers, even in times when liquidity might be an issue. Interviewee CSA01 commented: *“We benefit from a high level of financial ability to withstand. This means, we can invest further during the pandemic in inventory.”*

Furthermore, employment levels are stable, and no significant layoffs are anticipated. The expertise remains with the supplier while tasks are carried out. As a direct result, the shortage of parts is minimised, and the issue of workforce scarcity is prevented. Interviewee CSA01 added: *“Despite the pandemic, we are continuing the production and paying salaries to employees and bills of our suppliers. That way we meet customer orders and keep the system going, despite the pandemic.”* The view of CSA01 was more strategic when discussing the financial capability and how it impacts the SC. By means of financial resources, the SC was maintained by paying bills and ensuring material availability. In addition, the financial resources allowed the maintenance of employment by continuing to pay salaries. CSA01 commented: *“As SOE, the financial capability is strong. During the pandemic we kept up the production. The suppliers were paid. Employment too. We have a strong commitment to our customers. The stronger financial is, the longer with can withstand a pandemic and keep the SC going and fulfil customer orders.”*

Respondents noted that key components directly influence SCs. Inventory management ensures continuous production replenishment, preventing disruptions. Logistics is vital for maintaining delivery flow, avoiding delays from goods stranded at sea or in ports. Financial resources offer necessary capital during uncertainties and interruptions. Interviewee CSA01 added that these components also indirectly impact SCs strategically, as financial stability fosters trust. CSA01 mentioned: *“The financial strength provides indirectly security to our SC. We have financial power to pay the bills, to keep employees and to offer credit to suppliers. This is a strong signal to the supplier to continue production for us. Even in case of a pandemic or other issues, we are there like a rock. So, this gives trust, and we can count on our SC to deliver to us.”*

The workforce is readily available, and they possess the capacity to undertake overtime as required. From a financial standpoint, CSA is robust and capable of investing in inventory for parts and materials. CSA01 commented that: *“We have, of course, the workers available, and they can give overtime when needed. Financially, our company is strong and can invest in the parts and material stock.”* Consequently, the capacity to navigate challenging financial limitations through the availability of essential financial resources plays a significant role in fostering resilience within the SC, alongside the establishment of trust and confidence.

Political support

This newly revealed component of resilience was first raised by interviewee CSA01 as it facilitates making things happen. This component is new and has been raised by several interviewees. CSA01 said: *“...the support from local authorities is important to make things happen...”* Significant influence is exercised by local authorities to enable business actions such as licensing, permits or access to infrastructure. CSA01 added: *“It’s like an umbrella for us.”* The execution of these policies and support mechanisms is in harmony with the requirements of businesses while protecting suppliers from various potential adversities, such as energy deficits, license cancellations, or other operational limitations. When government officials and institutions champion the interests of businesses, they create a conducive framework that fosters investment, innovation, and growth. This supportive political climate can lead to the establishment of regulations and incentives that cater to business needs, including tax breaks, streamlined permitting processes, and reduced bureaucratic hurdles. In conclusion, political support is crucial for nurturing an environment that facilitates the development and implementation of policies advantageous to businesses, thereby raising resilience in the SC.

Inventory levels

On the other hand, Interviewee CSA02 emphasised the importance of maintaining optimal inventory levels to enhance operational resilience. Ensuring adequate component quantities in the warehouse helps prevent shortages, supports continuous production, boosts employee engagement, and improves logistics management. Sufficient inventory also enables organisations to effectively address temporary shortages as needed. CSA02 commented: *“The inventory we have available helps us*

overcome temporary shortages. We have invested in large inventories and warehouses where we keep several months of stock available. Our storing conditions are excellent and comply with the norms and quality standards. So, when we have a SC disruption, for example, the earthquake in 2008 or COVID in 2020/21, the stock will support us for several weeks.” But how exactly does this component of resilience influence the SCs of CSA?

Interviewee CSA02 illustrated the impact of components of resilience on SCs through the aerostructures assembly process. They emphasised that these components are crucial for timely deliveries and overall SC functionality. A well-defined inventory and stock management policy can help maintain appropriate inventory levels, reducing the risk of shortages by ensuring sufficient parts are available. CSA02: *“We are managing a complex SC with parts coming from all over the world. For instance, rods are highly specific, and we have only one approved supplier. So, we order large batches to ensure stock levels. Our inventory policy provides the ordering points. Therefore, the inventory capability influences the SC strategy. The more inventory we have, the more autonomy we gain from SC performance.”* Therefore, maintaining appropriate inventory levels is essential for building a resilient SC. It enables businesses to navigate uncertainties, respond to market dynamics, and maintain a competitive edge, all of which are vital for long-term success in an increasingly complex and interconnected global marketplace.

Quality assurance system

The significance of a quality assurance system was also underscored by CSA02, which emphasised the importance of adhering to standard procedures in the procurement of parts and components. CSA02 articulated that *“Procurement manages the purchase orders, dates, and deliveries,”* highlighting the critical role that procurement plays in ensuring that the right materials are acquired in a timely manner and in accordance with established specifications. This systematic approach to procurement not only facilitates the smooth operation of SC activities but also serves as a foundational element for maintaining quality throughout the entire process. Thus, the insights provided by CSA02 regarding the management of procurement processes underscore the critical importance of a quality assurance system. By establishing and

adhering to standard procedures, organisations can enhance the resilience of their SCs, mitigate risks, and ensure the consistent delivery of products and services.

In conclusion of the case CSA discussion, five components of resilience had been observed. Both interviewees provided insights into the logistics network as an essential component of resilience. CSA01 highlighted two components: financial resources and political support. The latter, identified as a new component, will be integrated into the theoretical model in Chapter Six. CSA02 emphasised the importance of inventory levels and the quality assurance system as key component of resilience in the case study.

The interviewees were asked in Q4 to discuss specific components of resilience, between the privately-owned enterprises compared to SOE. CSA01 and CSA02 commented that an SOE is shaped by its prime objective to serve the State, to fulfil customer orders and to defend its reputation by demonstrating innovation as a component of resilience as well as collaboration. CSA01 said: *“The SOE has the objective to serve the State. Having said this, there are customer orders that must be fulfilled, and the SOE must stand by its word for its reputation. In my view, the SOE, when it supplies to private customers, has a similar level like other suppliers.”* Interviewees commented that the SOE would not use its flexibility to accommodate customer needs, instead, in case of arbitration, the SOE will prioritise non-civil projects and follow orders from the State. CSA02 added to this: *“I have seen many times that the SOE, that also works on non-civil projects, will arbitrate, when required, quickly away from civil projects. I have seen it on key resources, I have seen it on capacity, and I have seen it on facilities such as the paint shop that suddenly is no longer available.... So, I would say yes, the SOE has another approach towards resilience that unfavourably impacts commercial products.”* CSA01 added: *“The flexibility is relative and needs to be seen from a context of size. For the SOE, the private customer is part of the business; the largest is the State that orders. So why should we be flexible for the small customer?”*

In summary, SOEs exhibit a pronounced commitment to serving governmental interests, prioritising the fulfilment of customer demands, and fostering innovation as

a means of enhancing their prestige and reputation, particularly in contrast to privately-owned companies.

Within-case analysis CSB

In the context of resilience at CSB, both interview participants highlighted that it involves bouncing back from challenges while maintaining essential operations. They provided several examples, including the organisation's recovery during a pandemic and the restoration of operations after a SC disruption that halted deliveries for weeks. CSB collaborated with customers to establish new delivery timelines and prioritise tasks. Another example involved addressing quality issues from a supplier, necessitating a comprehensive rework of production and a re-evaluation of production planning in partnership with customers to prioritise tasks and allocate workforce effectively. Interviewee CSB01 stated: *"Resilience is the ability to bounce back in case of issues or a crisis, and this is what we have seen here: during the pandemic, we continued to work but at a reduced pace. SCs were not working adequately, transport was inefficient, parts were blocked, and business travel was suspended. We kept minimum operations."*

In addition to the ability to bounce back, resilience is supported by SCs, logistics, a general willingness to support and a quality assurance system. CSB02 discussed an additional perspective of operational willingness to support and solve problems reactively. A high degree of flexibility and speed are observed when putting teams together. CSB02 said: *"There is a strong willingness to support in case of issues such as a shock from the SC or a quality defect.... There is quick action in responding to issues. Also, some big projects on improvement took place that eradicated quality concessions."* This commitment may partially be due to the investment by the company in its employees. Long term development plans indicate a willingness to grow employees and to keep them in the company for good. That way employees are motivated to make everything a success. CSB02 said: *"For the operators, we are planning with long-term development to qualify them and to keep them."*

The subsequent discussion will focus on case CSB, emphasising the shared components of resilience identified by interviewees CSB01 and CSB02 and how and why they occur. Following this, an analysis of the differing perspectives regarding the components of resilience will be presented for CSB02, leading to a conclusion for case CSB on SQ1. In the dialogue involving CSB01 and CSB02, four shared components

of resilience were identified: flexibility within the SC, local sourcing, and the availability of financial resources alongside the structure of the SC network.

SC flexibility

Both interviewees, CSB01 and CSB02, emphasised that SC flexibility is vital for resilience. They discussed factors affecting resilience and how they operate. Notably, SC flexibility has improved due to reduced reliance on global suppliers, particularly those in remote areas. The supplier now produces specialised products internally, such as sheet metal components. CSB01 said: *“We have vertically integrated the core processes to keep our knowledge under control.”* Internal capabilities, such as sheet metal production of parts, can, therefore, be better controlled as no other customer demand needs to be managed. CSB01 said: *“Our SC exposure is limited to only a few strategic suppliers; the remaining is vertically integrated due to historical and strategic reasons.”*

Internal prioritisation is shaped by production needs and customer demand, leading to improved response times, optimised logistics, simplified inspections, and adjusted capacity, all of which enhance SCR. CSB01 notes that CSB’s historical roots as a SOE focused on integrated processes and reduced external dependencies contribute to this resilience. However, rising cost pressures and supplier specialisation may prompt a strategic shift in the future. Currently, the financial benefits of vertically integrating the SC—from raw materials to assembly—are significant, but this approach may not be sustainable long-term in an era of specialisation. CSB02 suggests that market dynamics could shift the focus from traditional vertical integration to a more market-oriented strategy. CSB02 commented: *“Nowadays, we only have about fifteen to twenty key suppliers that pose challenges. Probably in the future, that number increases due to market demand.”* SC flexibility offers more suppleness and is, therefore, a component of resilience even though strategic changes may occur in the future.

Local sourcing

The second component of resilience highlighted by both CSB01 and CSB02 was local sourcing. The initiatives aimed at local sourcing suggest the presence of alternative options, redundancies, or secondary sources that are available within the local context, as opposed to dependence on international suppliers. CSB02 stated: “Thanks to local sourcing, we could use raw material locally produced.” Local sourcing decreases dependence on overseas suppliers, streamlining imports and logistics. By validating a local supplier, CSB can enhance SC redundancy, boost competitiveness, and reduce lead times. A new production facility increases overall capacity and eliminates import and shipping costs, improving resilience and efficiency. However, creating redundancies for some components may be impractical due to high setup costs and technology transfer challenges, and the limitations of economies of scale should be considered before adopting local sourcing strategies. CSB01 said: “*Local sourcing allows us to plan our capacity accordingly. Dependency on SCs is reduced, particularly on global SCs.*” Redundancies are due to its ability to reduce lead times, increase efficiency, and reduce SC risk exposure, which are valuable components of resilience.

Financial resources

A third component that both interviewees mentioned was the component of financial resources available to withstand a shock. By this, the interviewees meant that CSB could continue paying for salaries and supplies despite ramp down, frozen orders, and economic concerns. CSB02: “*Our company has, of course, the financial ability to sustain and maintain operations.*” This aspect of resilience manifests when CSB, a SOE, secures financial resources to sustain its operations. The funding originates from the State, enabling the continuation of activities and the retention of the workforce, thereby preventing layoffs. This retention ensures that the organisation’s knowledge and expertise remain intact. Consequently, there is no necessity for extensive recruitment following any disruptive events.

Furthermore, the stability of sub-suppliers is preserved, which mitigates the risk of insolvency. The financial support from the State aims to uphold a diverse customer portfolio. In the face of economic fluctuations, maintaining such a balanced portfolio

serves as an automatic hedge against potential risks. This was complemented with the ability to continue with a diversified portfolio of customers; CSB01 said: *“Thanks to our diversified portfolio, we have many commercial customers and others. That way, we maintain a stable revenue despite some turbulence.”* Access to financial resources is essential for resilience, enabling the support needed to overcome challenges and maintain operations. Financial revenue sustains production and employment, while a strong SC with reliable orders and timely payments minimises disruption risks, further enhancing resilience.

While interviewee CSB01 added no further point on components of resilience, interviewee CSB02 added four further components of resilience to the interview: knowledge management, SC network structure, quality assurance system, political support, and inventory levels. Each one will be discussed in turn.

Knowledge management

According to CSB02, knowledge serves as a crucial component of resilience. *“For the operators we are planning with long-term development to qualify them and to keep them.”* Skills develop progressively, enhancing productivity and quality. Improved employee retention fosters lasting relationships and aligns skills with business needs, promoting growth. Training programs boost knowledge management and reduce errors. CSB prioritises workforce investment to safeguard institutional knowledge and build essential skills, likely decreasing turnover and enhancing employee belonging. A knowledgeable workforce is vital for SCR, while ongoing recruitment ensures a steady influx of skilled workers, strengthening overall resilience.

SC network structure

The SC network structure as a component of resilience was raised by CSB02. It embraces the mutual dependencies between the customer and the supplier. *“We are not alone to solve the problems; it’s a partnership in China of mutual dependency”*, said CSB02. This relationship encompasses local suppliers, service providers, and authorities and should be regarded as a partnership characterised by a common goal and reciprocal advantages. Both parties are collaboratively engaged in the pursuit of this shared objective, as articulated by CSB02. *“For reasons of reputation or political*

importance, we made it together." The contractual responsibilities aside, this component of resilience revealed that partners come together to solve issues in a constructive manner with the common interest in mind. CSB02 referred to the practical experience of the past: *"For instance, during the 2008 earthquake, we all came together to help each other, to rebuild this city, to come back to school and to work and to return to normal. It took some time, but we made it together."* This case highlights the interconnectedness of the SC and its benefits during disasters. Building this resilient network requires time and collaboration beyond contracts, as shared goals are essential for overcoming challenges in restoring normal operations.

Quality assurance system

The interviewee CSB02 emphasised that a quality adherence system is a crucial component in fostering resilience. CSB02 said: *"For resilience, the process is important as it is the point of reference for the product and serves as process reference."* During periods of uncertainty, the importance of a quality assurance system becomes evident in maintaining the integrity of processes and service standards. Adherence to established processes is facilitated through comprehensive documentation, well-defined procedures, systematic approaches, and thoughtful process design. CSB02 said: *"Through documentation and formalisation and to make the system error-proof."* Formalised procedures empower operators and clerks to manage delays, quality issues, and shortages effectively. Compliance enhances resilience by ensuring predictable task execution, reducing delivery uncertainty, mitigating quality defects, and improving planning. Therefore, the quality assurance system is crucial for SCR.

Political support

Governmental backing was identified as an additional factor that bolstered, for example, local sourcing initiatives. CSB02 said: *"Once top-level decisions are taken, we will perform the task given to us. For example, to deliver the program that has government priority. We can allocate the resources."* The support was initiated because of the government's objective to enhance the involvement of the local SC within the aviation sector. Additionally, the potential for increased employment, business revenue, and tax contributions presented an attractive proposition. This support was realised through the provision of credits, the alleviation of regulatory

obstacles, and political commitments. In summary, political backing plays a crucial role in fostering resilience within the SC.

Inventory levels

Effective inventory management is crucial for preventing shortages. By keeping sufficient stock of essential products like composite materials and aerospace-grade metals, organisations can reduce the risk of shortages. If a supplier fails to deliver due to unforeseen events, existing inventory can provide a temporary solution. CSB02 said: *“We try to keep it high to absorb fluctuations from our suppliers.”* The higher the inventory level, the longer the disruption period may last without impacting production. CSB02 said: *“CSB inventory is like an extension of suppliers.”* The level of inventory is consequently a fundamental component of resilience, which, depending on its magnitude, can endure disruptions within the SC.

In summary, the case study conducted on CSB identified seven elements of resilience. Among these, interviewees highlighted three components: SC flexibility, local sourcing, and financial resources. Additionally, CSB02 introduced four components from an operational viewpoint: knowledge management, SC network structure, quality assurance systems, political support, and inventory levels.

Q4 asked to contrast CSB, as a SOE, with the private sector. It was voiced by both interviewees that the SOE is more capable of defending itself due to its financial capability. CSB01: *“The capability of the SOE to absorb a shock is very high compared to the private sector. The SOE has the financial backing of the State, so the financial constraint is very limited.”* In more detail, it was commented that the SOE is more vertically integrated (fewer sub-suppliers, special processes in-house, and engineering capabilities within departments), which reduces exposure and financial volatility. CSB01 stated: *“The SOE is vertically integrated, so the dependency on external suppliers is lower.”*

In addition to the financial perspective, the labour availability and team capability at the SOE are higher, and this provides flexibility and almost immediate capacity for internal deployment when and where needed, as CSB01 commented: *“Our employee*

number is high, we can allocate them according to the priority that we have.” Finally, the customer relationship was mentioned to be of a special nature. It is not necessarily customer-focused, as in other industries or regions, but rather described by CSB02 as a partnership approach of mutual dependency: “Well, we have our frame contracts with our customers. They depend on us, so when we have a problem, they will support to solve the issue. We are not alone to solve the problems, it’s a partnership in China of mutual dependency.”

Within-case analysis CSC

In the context of resilience for case CSC, both interview participants agreed that it involves returning to normal operations after a crisis. They cited workforce recovery through maintaining essential operations and strategically reallocating personnel. This concept also applies to suppliers and their components, as noted by CSC01: *“Resilience is the ability to bounce back. We see that in our case, where we need to keep our skills and resources on standby and available for when the demand comes back. We increase competencies; we offer rotation on the job. That way, we are stronger when the demand comes back.”* A complementary view was offered by CSC02 that the supplier is contributing significantly towards resilience by the ability to support ramp-up back to nominal levels: *“The suppliers have a big responsibility and contribution to support a ramp-up after the crisis...To mitigate this, we need to be creative with our partners and commonly find solutions. For example, whether we find a local alternative that is available. We define together equivalences; we prioritise together and improve the lead-times. Its together with the supplier that we can solve the issue. It’s not perfect but we need to be creative in finding new solutions.”* The staff availability and team capability were pointed out as an important element of resilience in order to avoid the loss of critical skills by CSC01 as they had to ramp down: *“During this crisis, it was clear that we had to ramp down all our activity. However, we used the time to train our staff on another task. Also, we decided not to stop but to slow down. That way we don’t lose any key skill such as NDT.”*

Next, case CSC will be discussed and will highlight commonalities between interviewees CSC01 and CSC02 of the components and how and why they affect SCs. Subsequently, the different points of view about components of resilience will be discussed before concluding case CSC. Both interviewees discussed the following three components of resilience: knowledge management, quality assurance system, SC network structure.

Knowledge management

The initial component of resilience addressed by both CSC01 and CSC02 was knowledge management. The case examined the workforce’s expertise, competencies, and timely availability in appropriate quantities. This indicates that

having knowledgeable and well-trained personnel on hand is essential to satisfy demand and to prevent prolonged training or recruitment processes, which can extend over months or even years. CSC01 deliberated: *“We see that in our case, we need to keep our skills and resources on standby and available for when the demand comes back.”* Understanding operational processes, machine functionality, and the dynamics of the SC is a vital aspect of organisational resilience. It is imperative to ensure that the necessary personnel are present in adequate numbers to meet operational demands. This proactive approach prevents the need to initiate recruitment in response to rising demand, a process that can take between three to six months. Obtaining certain qualifications, such as NDT² may even take years. CSC01 said: *“We used the time to train our staff on another task. Also, we decided not to stop but to slow down, that way, we don’t lose any key skills such as NDT.”* The manufacturing of aircraft necessitates the acquisition of certain skills that require extensive time to master, primarily due to the intricate nature of the product, in contrast to the more straightforward serial mass production processes found in the automotive industry or other sectors. Ongoing training is essential for enhancing workers’ knowledge and improving their efficiency and quality-oriented mindset. This approach minimises the likelihood of errors and quality defects, particularly as production stabilises. CSC02 stated: *“During the pandemic, we used the time to train our staff.”* Knowledge management with the reference to skilled and qualified workers is, therefore, a component of resilience.

Quality assurance system

The quality assurance system represents an additional element of resilience identified as significant by both CSC01 and CSC02. This system implies that processes are integral to operational practices and are underpinned by a robust control framework, exemplified by the AS/EN9100 quality assurance system. Regular audits of these processes are conducted through the quality assurance system, allowing for the identification and rectification of deviations. In times of uncertainty, employees may prioritise immediate action over adherence to established protocols, which increases

² NDT stands for Non-Destructive Testing. It is a collection of testing techniques used to evaluate the properties of a material, component, or system without causing any damage. NDT is commonly used in various industries, including manufacturing, aerospace, automotive, construction, and maintenance, to ensure the integrity and reliability of structures and components.

the likelihood of lapses in quality standards, including non-compliance with curing times, torque specifications, or procedural sequences. CSC02 said: *“The strong process helps to ensure quality.”*

By regularly reviewing fundamental processes, operators can prevent neglecting steps and ensure essential tasks are completed, thereby enhancing work integrity. Implementing a quality assurance system within SCR ensures that product output meets established standards despite challenges like delivery delays or personnel changes. Consequently, the focus has been on how CSC has maintained process robustness. In summary, the quality assurance system emphasises product quality and compliance, strengthening SCR.

SC network structure

Interviewees CSC01 and CSC02 added the SC network structure as a further component. CSC01 said: “Local services were used as a redundancy in the system, on some special processes.” Redundancies enabled specialised local processes, like surface treatments, reducing the need to transport components to distant suppliers. This strategy of utilising the SC network proved especially beneficial during the COVID-19 pandemic by cutting transportation lead times. Local responsiveness was achieved through the prior qualification of local suppliers, leading to lower costs, faster turnaround, and better customer service. The establishment of these redundancies was justified by the approval of local suppliers based on criteria such as reasonable qualification efforts and proportional monitoring costs. Interviewee CSC02 added, from the operational perspective, one further components of resilience to the interview that is SC network structure. The configuration of the SC network, as a component of resilience, was characterised by the collaborative efforts of suppliers and customers to identify solutions rather than strictly adhering to contractual obligations. For instance, in situations where components were held up by customs, relying on the contract would not have expedited their processing. Conversely, the network structure played a crucial role in CSC's discovery of alternative components, modification of delivery schedules, and alteration of customer shipments. CSC02 said: *“The suppliers have a big responsibility and contribution to support a ramp-up after the crisis. We ask that they have the people, the parts, and the material available as soon as we need it. Often the answer is no, due to waiting lines, long times, lead times, shortages and so*

on full stop to mitigate we need to be creative with our partners and commonly find solutions full stop.”

The concept of network structure pertains to the capacity of partners to converge on shared goals and mutually beneficial solutions, even in the absence of formal contractual agreements. Additionally, the emphasis on fostering long-term relationships underscored the necessity for solutions that cater not only to the needs of the customer but also to those of the supplier. The important notion of defining together is raised CSC02: *“We define together equivalences; we prioritise together and improve the lead times.”* This effort of the SC network structure, therefore, acted as an important, informal component of resilience in which the partners commonly find solutions to the problems at hand.

Interviewee CSC01 added from the strategic perspective three further components of resilience in the interview: risk management tools, financial resources and the political support as a novel component of resilience. Each one will be discussed in turn.

Risk management tools

The tools employed in risk management serve as a vital component of resilience, encompassing the processes of preparation, anticipation, and the proactive measures taken to diminish recognised risks through various mitigation strategies. The interviewee CSC01 provided insights into the methodical and strategic approach adopted to effectively minimise risk. CSC01 indicated: *“It’s our duty to prepare and anticipate. We use risk management tools such as PFMEA (Process Failure Mode Effect Analysis) to anticipate issues and problems and put preventative actions in place. For example, the Poka-Yoke is a tool by which we fool-proof possible issues. It helps eliminate issues. Of course, there are always new issues that could happen, and we work on discussing a plan B or alternative.”* An illustration of risk management instruments, the PFMEA methodology and its related elements were utilised across various facets of the organisation to foresee potential failures in areas such as delivery, production, inspection, and dispatch. The requisite measures subsequently served to avert future failures. This process was ongoing and enhanced precision progressively over time. CSC01 added: *“Of course, there are always new issues that*

could happen, and we work on discussing a plan B or alternative.” Risk management is crucial for enhancing SCR by identifying and analysing potential system failures. As failure probabilities rise, various strategies are implemented to mitigate their impact, particularly on production processes and equipment. The proactive nature of risk management tools underscores their importance in addressing potential challenges and ensuring SC robustness.

Financial Resources

The financial resources of CSC available to a privately-owned company, particularly one that is publicly listed, are constrained. Shareholders anticipate a return on their investments, necessitating that any new initiatives generate profit. The challenge of investing in resilience is significant, and it seems to be a more compelling subject for SOE. CSC01 said: *“The SOE has much more resources and capabilities to support”*. The government had the capacity to allocate resources towards inventory, personnel, or physical space. In contrast, a private entity such as CSC had to provide a rationale for the expected return on investment, the revenue generated by each employee, and the utilisation of land. In summary, financial resources serve as a crucial component, yet their acquisition poses significant challenges within the private sector.

Political support

CSC01 indicated that political support played a role in resilience, primarily in terms of its capacity to facilitate processes. This support allowed for the acquisition of resources, including the recruitment of potential employees and the establishment of connections with suppliers who are inclined to contribute to the initiative. CSC01 *“Thanks to the good political support, we are able to access vast resources such as very motivated suppliers and hire great employees. Regular trade fairs are a good platform for this.”* Highly motivated suppliers played a significant role in establishing local redundancies, particularly when they provided financial assistance for qualification expenses. The recruitment of exceptional employees fostered an environment conducive to innovation and effective knowledge management, both of which are essential elements of organisational resilience. Ultimately, political support served as an indirect factor in enhancing resilience, as it created an enabling

environment for direct components such as local supplier redundancy, employee-driven innovation, and knowledge management.

Redundancies

Interviewee CSC02 added, from the operational perspective, one further component of resilience to the interview that is redundancies. CSC02 identified redundancies as an essential element of resilience within the SC. The participant noted that these redundancies had been established prior to the crisis and were considered a viable option due to their advantageous regional proximity. CSC02 emphasised the advantages of redundancies: *“There can be qualifications of local sources, but there must be a benefit: either cheaper, more flexible, or faster delivery.”* Such redundancies needed to be set up ahead of when they are required, identifying critical elements that reduce dependencies. Furthermore, it was essential to maintain uniform coordination of redundancies to guarantee complete interchangeability. This means, for instance, that redundancies A must adhere to the same quality standards as redundancies B. Ultimately, redundancy played a crucial role as a component in enhancing SCR by facilitating straightforward and efficient transitions between suppliers, thereby mitigating the risks associated with capacity limitations or reliance on a supplier that may not be available.

In conclusion, the case study CSC discussed eight components of resilience. Both interviewees discussed the following three components of resilience: knowledge management, quality assurance system, and SC network structure. Interviewee CSC01 added from the strategic perspective three components of resilience in the interview: risk management tools, financial support and political support as a novel component of resilience. Interviewee CSC02 noted that, from an operational standpoint, redundancies constitute a significant component of resilience discussed during the interview.

When asked to illustrate in Q4 the difference to an SOE, CSC01 and CSC02 argued that the SOE is reacting rather than planning. This approach may be due to a relative abundance of resources such as staff, materials and space. CSC01 said: *“Our production depends very much on the deliveries of the SOE. The SOE has much more resources and capabilities to support. They will allocate people and resources as*

needed.” This planning process appears to be not fully optimised and mostly reactive. The ability to plan according to customer needs is overruled by top-level appointments and directives on SOE priorities. CSC01 commented: “This allocation happens at the highest level of the organisation. However, it’s mostly a reactive mode. I don’t see so much prevention and anticipation.”

Communication gaps and effective implementation were revealed as issues in the interaction between the SOE and its customers. That way, important data may be missed, outdated or irrelevant. CSC02 commented: *“With the SOE, a big issue is the communication. There are frequent issues. Nowadays, it’s about the ramp-up schedule that is communicated but not endorsed across the organisation.”* The communication issue also runs deep within the SOE. It was noted by CSC02 that communication within the SOE is not consistent, as top-level decisions are inadequately cascaded within the organisation. Shopfloor production may be inconsistent with the top-level direction or instruction. A specific example discussed was the inefficient implementation of production ramp-up. CSC02 commented: *“At local shopfloor level, they prepare for ramp-up, but the top of the organisation does not give the green light for resources and deliveries. So, we need to negotiate. The private sector is faster there. You give the order, and they propose a delivery schedule – not always perfect, but we have a basis for adjustment.”*

Within-case analysis CSD

The concept of resilience was also validated within the context of the CSD case setting. CSD02 stated: *“Resilience is for us being able to return to normal operations as quickly as needed.”* The participants in the interviews highlighted the importance of adopting a qualitative approach to resilience, emphasising that the organisation must be adequately prepared from this standpoint. While the ability to resume normal production levels—encompassing workforce, components, and facilities—is essential, any degradation in quality could have a profound impact on overall output and negatively influence customer satisfaction through issues such as scrap, rework, and defects. Consequently, it was crucial to assess production processes through a quality lens, ensuring that quality was maintained at every stage, including the materials received, the manufacturing process, the calibration of tools, employee training, and the inspection protocols.

CSD01 commented: *“For me, the resilience at CSD is the preparedness to ramp-up the production on quality, with the adequate skills ready.”* Alongside the competencies and abilities associated with tools, the importance of an appropriate mindset was also highlighted in CSD. The concept of a quality-oriented mindset among employees was crucial for maintaining a high standard in their work practices. This aspect, often overlooked in traditional educational resources, requires considerable time and experience to cultivate effectively. CSD02 said: *“The most important for me is the quality mindset of the workforce. That’s the biggest sign of resilience. Continuous training on quality standards and the highest level of precision. To achieve this goal, we need to keep turnover low, have a customer focus, and strong communication and a culture of trust. It takes time to develop this mindset in our context.”*

The subsequent analysis will focus on case CSD, emphasising the similarities observed between the perspectives of interviewees CSD01 and CSD02 of what key components of resilience are and how and why they affect SCs. Following this, a discussion will be presented regarding the varying viewpoints on the elements of resilience, leading to the conclusion of case CSD. Both interviewees, CSD01 and CSD02, identified two key components of resilience: the quality assurance system and the role of knowledge management.

Quality assurance system

CSD01 highlighted concerns regarding the SC's vulnerability due to challenges in retaining personnel and the prevalence of high employee turnover. This instability adversely affects the capacity for consistent task execution and adherence to quality standards. CSD01 said in that respect: *"This (staff retention issues) is a high risk on the quality and delivery."* Workforce stability was a crucial factor influencing the overall quality of work produced. This quality, in turn, contributed to stability, which became particularly vital during periods of uncertainty, upheaval, or other challenging circumstances. Beyond this strategic consideration, quality assurance has also been emphasised from an operational standpoint. The qualifications of the workforce played a significant role, as they ensured that consistent and repetitive tasks were executed effectively, such as adhering to each procedural step outlined in the work order. CSD02 said, *"Workforce qualification is key as it reflects on the product quality."* Failure to follow the steps, to bypass or to skip, would have led to irreversible production and operating issues that could have had devastating consequences. CSD02 added: *"We miss a process step; we mess up an operation, and the parts are scrapped. So, we need to reinforce and continuously keep the skill level sharp."* By ensuring continuous quality in everything, product conformity was ensured. Subsequently, quality losses were minimised. The consequence of resilience is that stability was achieved despite adverse events thanks to the quality assurance system. The quality assurance system, therefore, serves as a crucial component in enhancing the resilience of the SC.

Knowledge management

Knowledge management is a crucial component of resilience within SCs. This involved ensuring that there is a sufficient workforce that is not only present but also equipped with the requisite skills, particularly those operators tasked with the loading and unloading of components throughout the SC. Such personnel were integral to the capacity planning process of the SC. Observations indicate that the workforce was diminished during the COVID-19 pandemic, revealing critical gaps in knowledge that have become increasingly apparent. Interviewee CSD02 said: *"We have observed a loss of labour in the entire SC, and in particular in small suppliers."* Additionally, the decline in labour was intrinsically linked to the erosion of knowledge, skills, and

experience within the workforce. This phenomenon indicated that essential competencies had been lost. When prompted to provide specific examples, interviewees emphasised the significance of maintaining high-quality standards among employees. This perspective suggests that the workforce must be adequately prepared to perform tasks competently and efficiently.

Prolonged learning periods, reliance on trial and error, or extensive training processes are deemed unacceptable when assessing the preparedness of the workforce. CSD01 stated: *"We are just providing the labour here in the production. We get the material provided under frame contracts, and all the tools are provided by the customer. So, our job is to have qualified staff in the right quantity. There is no time or tolerance to start training when we get the order. People need to be effective right away."* CSD02 expressed a comparable perspective, emphasising that discussions surrounding long-term strategies for staff planning, career advancement, development, and prospects should have been integrated into a comprehensive human resources framework to effectively draw in the talents of tomorrow: *"We need long-term plans to keep people retained. And in addition, we need to attract new talents to prepare for the future."* The recruitment of new employees was essential, and their expertise and competencies were expected to evolve gradually.

Additionally, the process of acquiring operational proficiency, fostering an aerospace quality mindset, and re-establishing collaborative relationships with partners, customers, and suppliers would require a significant investment of time. Suppliers that demonstrate resilience have preserved the necessary skills to mitigate the challenges associated with staffing their SCs once more. Interviewee CSD01 commented on this regard: *"Layoffs lead to a loss of capabilities, know-how, relationship and puts risk in the SC and deliveries: workforce capabilities: the knowledge is no longer there."* The significance of knowledge management in bolstering SCR cannot be overstated, as it guarantees the presence of skilled and well-trained individuals at critical moments for the organisation, thus promoting the continuity of business operations.

Inventory level

Interviewee CSD02 added, from the operational perspective, the inventory level as a component of resilience. The inventory level is determined by the planning and implementation of an inventory strategy formulated by CSD. This strategy must consider various product characteristics, including importation limitations imposed by the European Union and transportation constraints related to temperature-sensitive materials, ensuring that it aligns with the operational requirements of the business. CSD02 *“We have long-term planning, for example, for our composite material to avoid shortages. The regular capacity simulation helps us identify bottlenecks, and we manage accordingly.”* The capacity to accurately predict demand is vital for effectively managing inventory levels. A comprehensive understanding of production processes is also necessary to ensure that the right materials are available to meet business requirements. Detailed insights regarding consumption patterns and material characteristics are typically integrated into ERP systems, which facilitate the management of inventory plans. There has been no engagement in discussions surrounding models such as risk-based assessments; the focus of CSD has been on the execution of planning strategies. Nonetheless, maintaining appropriate inventory levels is essential for enhancing SCR, as certain disruptions in delivery can be mitigated by using inventories or buffers. This topic warrants further exploration, as effective inventory management plays a significant role in bolstering SCR for both suppliers and customers.

Logistics network

Interviewee CSD02 also added logistics network as another component of resilience. The logistics network represents a critical aspect of resilience, as highlighted in the CSD case study. This network encompasses the capacity to manage the transportation and delivery of products in accordance with established specifications. In recent years, various significant events have negatively affected logistics operations, such as the Suez Canal blockage, the COVID-19 pandemic, the invasion of Ukraine, and ongoing conflicts in the Middle East. Consequently, the capability of a logistics network to effectively manoeuvre through such uncertainties has become an invaluable asset. From the operational perspective, CSD02 said: *“In our SC, we depend on import ... For me, this is resilience in logistics.”* Through its extensive

network, CSD had established close connections with logistics providers, including freight forwarders and express mail services, which offered valuable insights. An additional aspect of resilience highlighted was the logistics capacity to guarantee the timely arrival of imported materials, particularly under challenging circumstances. The materials in question not only had a limited shelf life but were also sensitive to temperature variations. Consequently, efficient customs processing was essential. Thus, the ability to depend on a logistics network serves as a crucial element of resilience for intricate SCs.

Political support

The previous aspect of resilience, the logistics network, contributes to the political backing that was provided for the project. Ultimately, the fundamental requirement is that political backing is vital to facilitate efficient processing. CSD02 commented: *“In our SC, we depend on the import of carbon fibre as a critical material. The importation of the temperature-controlled material must be smooth. So, we are cooperating 100% with customs to ensure adequate processing. For me, this is resilience in logistics.”* The network's ability to effectively manage logistics, including hazardous materials, containers, trucks, and SCs per Incoterms, is crucial. This logistics network strengthens SCR and is essential for both incoming and outgoing shipments. Additionally, political support plays a vital role in enhancing this resilience.

In conclusion, case study CSD discussed five components of resilience. Quality assurance systems and knowledge management were discussed by both interviewees (CSD01 and CSD02). CSD01 added no individual component from a strategic business perspective, and interviewee CSD02 added from the operational perspective three further components of resilience to the interview: inventory level, logistics network and political support.

When asked in Q4 about illustrating resilience compared to SOEs, the examples provided indicate that resilience in SOEs was not sustained over time and that it was rather specific to an event or milestone. Resources were more dynamically allocated, and quality was not necessarily sustained or inherent to the system.

One significant driver for the SOE was attaining technological know-how through technology transfer projects and increasing innovation as a component of resilience. That way, the SOE allocates key resources to grasp the know-how and innovation of its customers and partners. Once it had been attained, the resources were redeployed. Consequentially, the customers needed to retrain the new resources, and sustained deliveries, continuity and stability were not given. CSD01 commented *“SOE are interested in gaining a new technology, so the SOE will allocate the most skilled resources on the new projects. They will test, trial, and compare as long as it takes to achieve the technology transfer. However, once the knowledge of the technology is there, the entire team may vanish within a few weeks. Maintaining resources appointed or allocated on projects is a challenge as there is a high rotation within SOEs.”* The absence of a robust business continuity framework harmed quality standards and sustainable outcomes.

Employees' expertise at the SOE was not consistently documented or integrated into training materials and visual aids, hindering effective knowledge management. CSD01 noted: *“And then we get the next team, and everything starts from zero as the knowledge has gone too. This is a high risk for quality and delivery. So, I would say there is a difference in resilience between private enterprises and the SOE.”* Another aspect of resilience examined was the SOE's readiness to demonstrate its integrated technological capabilities. Motivated by critical state issues, the SOE aimed to showcase its proficiency in delivering advanced products and services. For instance, in line with China's strategic goals, like developing indigenous commercial aircraft, the SOE prioritised and allocated resources to meet targets resiliently. CSD02 elaborated: *“For the SOE, resilience is to show how strong they are for the State. So, whatever the topic, the SOE has to show its capability to do what the State wants. We need to look at the State priority to understand what resilience is for the SOE. For example, the goal to make a Chinese aircraft, the goal to fly a Chinese aircraft, the goal to certify the Chinese aircraft, the goal to ramp-up the production of a Chinese aircraft and finally the goal to export the Chinese aircraft.”*

Within-case analysis CSE

The definition of resilience was further validated in the context of case CSE. This case demonstrated that the performance of suppliers can be maintained through effective monitoring, in addition to the sufficiency of established procedures and processes. CSE01: *“For me, resilience is to follow our procedures and processes.”* Considering this, the case CSE presented a particular instance that illustrated how resilience is maintained. At the outset of the partnership strategy, the supplier was chosen according to various business-specific criteria for supplier selection. This evaluation aided in guaranteeing complete adherence to performance standards. CSE01 elaborated: *“For example, the supplier selection is based on a technical assessment. We select the partner, domestic or international, and then the person in charge manages the supplier. We achieve 100% on time and 100% on quality that way.”* Effective supplier supervision was essential for maintaining resilience. Local representatives managed key business parameters like delivery standards and quality metrics, enabling quick detection of discrepancies such as delays or low inventory. This proactive approach allowed for timely alerts and interventions. CSE02 noted: *“We have local representatives that manage the supplier to achieve a good level of resilience. We need to provide the right demand and forecast, and technically, the suppliers are very capable. Of course, sometimes we have delivery delays due to customs or transport, but we keep some buffer to overcome this issue.”*

The subsequent section will focus on the shared perspectives of interviewees CSE01 and CSE02 regarding the components of resilience: what they are and how and why they affect SCs. Following this, a discussion will be presented on the varying viewpoints concerning these components before concluding the analysis of case CSE. Both interviewees CSE01 and CSE02, reached a consensus on two key components of resilience: the structure of the SC network and the presence of redundancies, which will be examined in detail.

SC network structure

The structure of a SC network represents a systematic and collaborative approach aimed at achieving a shared objective. The careful and impartial selection of partners was essential in the case of CSE to foster a successful partnership. This selection

process required the establishment of clear measurement criteria, which included quality standards, pricing, and other relevant factors. Partners were subsequently chosen based on their adherence to these established criteria. CSE01 stated: *“We select the partner, domestic or international, and then the person in charge manages the supplier. We achieve 100% on time and 100% on quality that way.”* From a more operational perspective, CSE02 said: *“We can benefit from international suppliers. They have good levels, and we can adapt to this. So, for me, resilience is to work with the right partners.”* Careful partner selection greatly increases the likelihood of successful collaborations. In CSE's case, participants prioritised alliances with suppliers over government bodies, strengthening supplier-customer relationships. Once established, contracts emphasised long-term goals like 100% on-time delivery and high quality, with suppliers expected to exceed basic standards. This strategy enhances competitiveness during uncertainty, prioritising the network and improving SCR.

Redundancies

Both interviewees, CSE01 and CSE02, identified redundancies as the second component of resilience. Redundancies provide industrial alternatives, multiple sources, and increased capacity for customers, and they are designed to be as comparable as possible. However, creating redundancies involves balancing essential customer benefits with the costs of implementation. CSE01 noted that due to specialisation and limited economies of scale, establishing redundancies is not always feasible.: *“You see, there are some parts that are so specialised, and it really would take so much time and effort to set up an additional domestic source.”* An examination of operational projects revealed that the innovation and adaptability of local SCs played a crucial role in managing demand fluctuations. Additionally, the extra capacity achieved through redundancy is effectively utilised to meet customer demand. CSE02 said: *“We rely on a local supply base that is highly innovative and flexible. This helps when we face sudden changes in demand.”* This additional capacity was a valued asset in times of SC surge demand. CSE02 said: *“A component of SCR is to use the capacity of our SC for the right part at the right time. That way, we can reach a competitive advantage. Use local suppliers, when possible; use global when required.”* Consequently, redundancies were regarded as an asset within SCs and were viewed

as a crucial component of resilience. However, it was essential to exercise careful consideration regarding the establishment of redundancies and to minimise reliance on them, ensuring that the site or facility operates autonomously, including its sub-suppliers.

Innovation

Interviewee CSE01 highlighted that innovation is essential for resilience, defined as the intentional creation and application of new ideas, products, or methods that add value or drive change. This includes introducing unique concepts or creatively combining existing elements across technology, business, and culture. In an industrial context, it also involves adopting emerging technologies from advancements in products and services. CSE01 stated: *“The SOE, like us, has a big challenge to catch-up with the private sector. Therefore, we need to do more and more very quickly. We have very clear objectives to achieve the same level of quality and comfort like Western products... So, for me this is resilience, the way to catch up with others quickly.”* Technology has enhanced efficiency, safety, cost-effectiveness, and comfort. The supplier integrated advanced global products while considering SC factors, especially supplier technological maturity. This focus fostered product advancements, yielding multiple benefits and strengthening SCR through innovation.

Quality assurance system

Interviewee CSE01 indicated that the quality assurance system played a crucial role in enhancing the resilience of the SC. Adhering to established processes was essential for maintaining quality and ensuring timely delivery. CSE01 said: *“We have our procedures that ensure the best process, quality, and lead times.”* The commitment to these processes improved quality assurance and SC effectiveness. Following established protocols ensured results met CSE benchmarks, especially for timely deliveries. Standardised procedures were crucial for maintaining consistency and quality in supplier selection per CSE01: *“We have our procedures that ensure best process, quality and lead times.”* The implementation of these procedures requires a team that possesses the necessary knowledge and skills. Competence in performing the tasks was crucial for maintaining the team's resilience and ensuring the continuity of operations. As noted by CSE02, effective management presents a significant

challenge: *“We had the case of employees that left, and the job still needed to be done. So, it falls on the shoulders of those that remain.”* Additionally, it was crucial to define and measure quality criteria. Therefore, the implementation of a quality assurance system as a component, with its commitment to standardised operational procedures, played a vital role in enhancing resilience within the SC.

Inventory levels

On the other hand, the interviewee CSE02 disclosed that the strategy of maintaining certain buffer inventory levels to mitigate potential delivery shortages constituted an additional aspect of resilience. CSE02 stated: *“...but we keep some buffer to overcome the issue.”* The interviewee noted that the challenge of achieving complete delivery is significantly more complex than that of fulfilling partial deliveries. Contractual agreements may impose such customer requirements that could result in penalties for incomplete deliveries and necessitate compensation payments. CSE02 said: *“In our product, we have a wide range of components and part numbers. So, in order to deliver a full shipset for one aircraft, I need not need a large inventory but completeness. Any missing part number could block the full ships. So, the accuracy and attention to detail on the completeness, that's the resilience for me.”* The challenge in implementation arose from customers providing late definitions, necessitating a significant level of agility to deliver complete shipsets effectively. This precise management of inventory levels was directly associated with resilience, ensuring that the appropriate parts were accessible to satisfy customer requirements. Consequently, maintaining appropriate inventory levels was a crucial component of resilience within the SC.

IT systems

Interviewee CSE02 also mentioned IT systems as a component of resilience. To guarantee the precision of the data utilised for planning, forecasting, and production, it was essential that the IT systems operate flawlessly. CSE02 said: *“Planning data comes to us with the IT platform of our customers.”* This component of resilience has been identified as a crucial element in all planning and recovery frameworks. Consequently, the reliability and security of the IT system was essential. It was imperative to conduct regular updates and security assessments. Additionally, early

detection of threats posed by external intruders was necessary. A precise and secure IT system facilitated the simulation of resilience within the SC, allowing for more accurate planning of recovery scenarios. Thus, the IT system played a vital role in enhancing SCR through the accuracy and safety of data.

Knowledge management

The final component of resilience raised by CSE02 was knowledge management. *“We had the case of employees that left, and the job still needed to be done. So, it falls on the shoulders of those that remain.”* The characterisation of this component may seem subjective, but it underscores the importance of strategic capabilities planning and the cultivation of skills, experience, and knowledge among employees. How well can the organisation manage workload variations during instability, especially with high staff turnover, and retain knowledge? This is particularly critical during layoffs when experienced employees leave, taking their expertise with them. How does the organisation incorporate flexibility into its planning, and can external resources or subcontracting serve as viable alternatives? In conclusion, workforce capability was analysed through flexibility and resource allocation, showing that with proper planning, staff overload challenges can be effectively managed, enhancing SCR.

In summary, both interviewees indicated that adopting a SC network approach with suppliers and establishing redundancies when appropriate were essential elements of resilience. Interviewee CSE01 further emphasised that innovation and quality assurance systems contributed significantly to resilience. Meanwhile, Interviewee CSE02 highlighted that inventory levels, IT systems, and knowledge management from a resource planning standpoint were also critical components of resilience.

In addressing question four (Q4) about resilience in SOEs, respondents noted that these entities have improved their capabilities compared to international peers. This progress hinges on advancements in financial resources, knowledge management, and effective partnership and supplier strategies. Resilience is fundamentally the ability to adapt technology, which depends on the time needed for implementation. Graphically, this relationship shows technological maturity on the vertical axis and adoption timeline on the horizontal axis. Therefore, resilience is defined by an SOE's

ability to enhance its trajectory, aligning more closely with foreign enterprises and reducing disparities. CSE01 said: *“The SOE, like us, has a big challenge to catch-up with the private sector. Therefore, we need to do more and more very quickly. We have very clear objectives to achieve the same level of quality and comfort as Western products, but we don’t have so much time to achieve all the 30- or 40-year learning. So, for me, this is resilience, the way to catch up with others quickly.”*

An alternative perspective was presented, suggesting that the process of catching up should be facilitated by a suitable network infrastructure. This implies that SOEs should engage with a network of suppliers comparable to those utilised by foreign-owned companies to expedite technology transfer. A pertinent question that emerges is whether the sub-suppliers are willing to collaborate with SOEs. CSE02 added the viewpoint: *“We can benefit from international suppliers. They have good levels, and we can adapt to this. So, for me, resilience is to work with the right partners.”* And added that: *“... use global when required”*. This view was supported strategically by CSE01: *“You see, there are some parts that are so specialised, it really would take so much time and effort to set up an additional domestic source.”*

Within-case analysis CSF

The discourse surrounding CSF reaffirmed the definition of resilience as the capability to return to standard performance levels. CSF01 addressed the definition as: *“Resilience is the ability to withstand a shock.”* CSF02 confirmed the view: *“Resilience is the ability of the company to come back to nominal levels of performance.”* In addition, the interviewees emphasised the ability to withhold a shock by means of preparation. Procedures and processes are being assessed for their readiness and for their flexibility by understanding how quickly changes can be incorporated. These changes can occur from within the SC, such as new suppliers, adjusted production sequence or changes in materials. All of which will alleviate SC pressure by reducing variance. CSF01: *“So, what we do is, we prepare ourselves for it whenever possible. But mostly, it is the system readiness. So, we check our procedures and how they can be flexible. For example, if we have a delay on material, we try to keep agile in changing the sequence, or we adapt our resources from one station to the other to follow the critical parts.”* The procedural importance was further highlighted. A strong and reliable system reduces uncertainties and offers more reliable output and deliveries. Examples include standardisation in procedures, ways of working, and workflows. CSF01 commented: *“But it’s mostly very smooth production. We have a strong production system, and that gives us the priority and the flow.”* CSF02 added: *“The priority is the focus and the strong procedure. It should all be standardised as much as possible so that there is no deviation. That way, we can slow down and ramp-up more easily.”*

In addition to internal standardisation, the integration of collaboration throughout the SC has been identified as a crucial element of resilience. When all participants in the SC adhere to uniform standards and procedures, it leads to enhanced reliability and efficiency, fosters greater collaboration, and ultimately minimises efforts, costs, and inefficiencies. CSF02 commented: *“To have more resilience in the SC, we need to select suppliers that are resilient.”* Nevertheless, it starts at a local level by achieving reliability and by ensuring standards for processes and capabilities in the SC. CSF02: *“Of course, we need that our suppliers to do the same way. For example, on surface treatments of parts, we need the supplier to maintain capability, have available*

capacity, and prioritise according to our needs. It is easier with the local suppliers that are nearby. So, we prefer a local ecosystem than to go far to get suppliers.”

The subsequent discussion will focus on case CSF, emphasising the shared characteristics of components of resilience identified by interviewees CSF01 and CSF02. Following this, a variety of perspectives regarding the components of resilience will be examined before concluding the analysis of case CSF. Both interviewees, CSF01 and CSF02, concurred on one specific component of resilience, which is the quality assurance system.

Quality assurance system

Both interviewees identified the quality assurance system as a vital component of resilience demonstrated in the case of CSF. This indicates that the company adheres to established processes that are consistently applied, embodying the concept of "system readiness" as articulated by CSF01. This readiness implies that regardless of the circumstances, whether faced with disruptions or adverse events, operators can depend on a system governed by these processes. Furthermore, CSF01 emphasised that robustness served as a fundamental pillar of the organisation: *“Robustness in our processes is a key pillar of our organisation.”* This was underlining the importance of the processes. CSF02 also said that standardisation was a key element in the road to procedural and systematic ways of working. CSF02 said: *“The priority is the focus and the strong procedure. It should all be standardised as much as possible so that there is no deviation.”*

The process of standardisation streamlined operational procedures by minimising deviations and exceptions, thereby enhancing system conformity. Additionally, the strength of these processes had been identified as a crucial element of resilience, benefiting not only individual cases but the entire organisation. Given the potential for employee turnover and the necessity to adjust production levels, the robustness of these processes became especially significant. CSF01 stated: *Robustness in our processes is a key pillar of our organisation.”* The key pillar of organisational processes was reinforced by systemic training in accordance with processes as stated by CSF02: *“We use as reference for training the processes that have been established*

and that are part of our 9100 Quality Management System.” Consequently, attention should be directed towards the fundamental tasks, while exceptions remain unaddressed. In periods of instability, maintaining a focus on established standards is crucial for ensuring business continuity. Adhering to procedures is a vital component of resilience that guarantees the uninterrupted flow of processes within the SC.

SC flexibility

CSF01 identified SC flexibility as a crucial component of resilience, as it facilitated agility within the SC by minimising administrative and bureaucratic processes necessary for switching suppliers or qualifying new ones. CSF01 said: *“The private sector has a distinct advantage in the SC and that is the flexibility and the speed. It is less administrative ...”* The adaptability of CSF enabled swift decisions to collaborate with suppliers possessing available capacity. This adaptability within the SC was particularly effective for straightforward components, such as metallic detail parts or standardised items, where intricate approvals are unnecessary. Additionally, machine time was acquired for processes like four-axis or five-axis milling. Consequently, this flexibility within the SC served as a vital element of resilience, applicable to commodities and standard parts, though it may not extend to more complex components.

Redundancies

Additionally, interviewee CSF01 noted that a decrease in administrative responsibilities promoted the development of alternative suppliers and the creation of redundancies within the system. CSF01 stated, *“It is less administrative and bureaucratic to switch suppliers, activate new suppliers, or explore alternatives.”* These redundancies, on a smaller scale, consisted of machinery that was accessed during failures, as well as supplementary labour or subcontracting arrangements. Not all redundancies demanded specialised qualifications, especially when the same hardware is involved. The presence of these redundancies not only increased capacity but also provided alternatives in the event of significant disruptions, thereby a component that is enhancing the resilience of the SC.

Knowledge management

The interviewee CSF02 indicated that workforce knowledge management constituted a vital aspect of resilience observed within CSF. By proactively identifying and addressing staffing requirements, effective recruitment and training processes were implemented. For instance, it was essential that resources in the planning and ordering departments were fully operational with the adequate knowledge of tools, processes, and the context, prior to the production staff and quality inspectors commencing their duties, as a sequential approach was necessary. CSF02 remarked, *"It's a major challenge to get people back to work after such a big event..."* This underscored the necessity for meticulous staff planning and a thorough assessment of the labour market. Furthermore, the mapping of knowledge available within the company and on the labour market was an important contribution. When the workforce was adequately prepared, employees were effectively contributing to the ramp-up efforts and prioritised tasks. Consequently, knowledge management emerged as a critical component of resilience, ensuring that appropriate staffing levels are maintained across the various departments of the SC.

Political support

Interviewee CSF02 also identified political backing derived from relationships with authorities as a crucial component of resilience. This backing fostered collaborative efforts in addressing business priorities. CSF02 stated, *"A good relationship with the port authorities helps us work in a cooperative manner. Not more, not less."* This support was crucial in addressing business needs during periods of uncertainty, such as a pandemic. The example illustrated how political backing facilitated sufficient assistance from port authorities. It was important to uphold appropriate priorities while fostering a business-friendly environment. Such support proved essential in meeting business requirements during uncertain times, such as a pandemic. The example provided showed how political support ensured adequate port authority's support. Maintaining adequate priorities and maintaining a business-friendly mindset. Consequently, political support served as an indirect contributor to resilience by enabling the fulfilment of necessary needs.

Risk management tools

Additionally, interviewee CSF02 supported risk management as an essential component of resilience. The procedures associated with risk management facilitated the anticipation and handling of potential challenges. As noted by CSF02, *“Risk management is one of our key processes. They are performed to anticipate possible issues, for example, shortages in our SC.”* Consequently, conducting regular risk assessments helped prevent potential shortages. Thus, risk management served as a proactive element of resilience, aiding in the early identification and mitigation of risks and issues that would have significantly disrupted the SC.

IT systems

Interviewee CSF02 articulated that Information Technology (IT) systems constituted a vital element of resilience. These systems played a crucial role in the management of planning and forecasting processes of CSF. CSF02 noted, *“The Enterprise Resource Planning is companywide, and we integrate critical SC components in it. This avoids issues due to planning or forecasting.”* Consequently, the implementation of such systems facilitated the management of essential components.

Additionally, the utilisation of IT and the process of digitisation were identified as further avenues for enhancing resilience within the SC. Both aspects have the potential to further improve decision-making by leveraging real-time data and enabling predictive analytics or scenario planning. CSF02 reinforced this notion by stating, *“With the current level of digitisation in the SC, we have only seen the beginning. Much more advanced models for forecasting will be deployed enabling real-time decision making, anticipating risk, and working on scenario planning. All of it signs of resilience for me.”* As an illustration of initial digitisation efforts, CSF02 described how the SC acquires data via IT: *“Our demand planning is sent through IT system to our SC.”* This approach represented a comprehensive strategy for bolstering resilience in the SC by mitigating shortages through a digital resource planning system and was therefore an increasingly important component of resilience in the SC.

SC network structure

CSF02 emphasised the significance of the supplier network structure as a vital component of resilience. For a SC to exhibit resilience, it is imperative that the entire SC itself is robust. However, the criteria for selecting members of the SC network were often not clearly articulated. CSF02 remarked, *“To enhance resilience within the SC, it is essential to choose suppliers that demonstrate resilience.”* The criteria deemed critical for ensuring SCR had to be evaluated during the selection process. For example, it was important to consider whether the SC had an organised prioritisation system that was effectively communicated to customers, as well as the types of redundancies that were established. Additionally, CSF02 inquired whether *“the suppliers maintain capability, capacity, and prioritise according to customer needs.”* CSF02 noted, *“It is easier to work with suppliers that are geographically close.”* Consequently, an appropriate SC network structure guaranteed that certain resilience attributes were present among suppliers, thereby enhancing overall SCR.

Both interviewees, CSF01 and CSF02, agreed on a particular aspect of resilience, namely the quality assurance system. Interviewee CSF01 further elaborated from a strategic viewpoint by identifying two additional components of resilience: SC flexibility and redundancies. In contrast, interviewee CSF02 provided five more components from an operational perspective, which encompass knowledge management, political support, risk management tools, and the configuration of IT systems and SC networks.

When contrasting SOEs with the private sector (Q4), the integration of technology by the SOE is higher and they rely less on the SC. Interviewee CSF01 said: *“The SOE has a strong position, that the private cannot uphold. I mean as a small private enterprise, we don’t have the same vertical integration, so we need to find other ways. Of course, the good relationship with authorities is important. We must apply to all types of licenses. There the SOE is much more able to cooperate with authorities. For example, to receive import permits. It takes for us very long to apply. So, we lose time on administration.”* Furthermore, the stakeholder management with authorities is simpler for SOEs in their privileged position, as compared to the private sector. The private enterprises are perceived as more agile than SOEs. CSF02 said: *“I think the SOE is slower than the private sector. We can qualify our production much faster and*

deliver our first product in a few months. We give full commitment to our customer. This I think the SOE cannot do. They are more politicians.” However, CSF01 also notes a political willingness for the private sector to grow and to increase competition: *“There is a willingness for the private sector to grow and to increase competition.”*

Within-case analysis CSG

The case CSG highlighted resilience as the ability to withstand disruptions, particularly in work transfer. It addressed challenges like material shortages, design changes, and increased quality requirements, necessitating quick and effective responses to ensure timely, cost-effective, and high-quality product delivery. CSG01 provided a specific example of effective resilience in action: *“Resilience is to withstand to a shock. I am thinking of the case where we receive work package from our European sites. So that way our duty here is to prepare everything for the new work packages when they arrive. So, the expat teams that come bring knowledge and this we will integrate in the production. During a few months everything is done: qualify the people at first, then approve any type of special process and finally we qualify with the first article, the product and the production.”*

Alongside guaranteeing complete adherence to product specifications, the case study highlighted the necessity of resilience concerning authoritative mandates. Particularly within the context of China, which presents unique industrial challenges, it is imperative to comply with the standards and regulations set forth by the European Aviation Safety Agency (EASA). Citing a different geographical context would be inappropriate. Consequently, the supplier was required to demonstrate resilience in relation to EASA requirements through strict compliance. CSG02 said to this: *“We are under the surveillance of our European site. So, we have the duty to respond and to deploy what we are being instructed, for example if there is a new methodology for lean production, we will deploy it here. It’s a fully integrated site here.”*

Since case CSG found no shared characteristics between the interviewees CSG01 and CSG02, the distinctions will be emphasised through a discussion of both CSG01 and CSG02. Interviewee CSG01 discussed from the strategic perspective two components of resilience that are: redundancies and inventory levels. Each one will be discussed in turn.

Redundancies

According to CSG01, redundancies served as a crucial component of resilience within CSG. The presence of supplementary qualified sites and resources provided both tactical and strategic advantages. Such redundancies enabled the utilisation of extra capacity and facilitated the tactical mitigation of potential challenges. CSG01 said: *"The redundancy allows us to increase capacity and meet customer demand. We can tap into double sources,"* Long-term strategies prevented site closures by utilising alternative resources, enhancing resilience during crises and regulatory challenges. Redundancy introduced additional capacity, protecting the SC against disruptions. This ensured that when issues arose—like delays or demand spikes—there were alternative pathways to maintain operations. By implementing redundant systems, CSG improved reliability, customer satisfaction, and overall resilience.

Inventory level

Inventory levels represented another critical component of resilience that CSG01 addressed. An effective strategy was essential to mitigate any potential disruptions to production. CSG01 emphasised, *"The SC needs to get the strategy right: inventory, JIT, insourcing, and so on."* By establishing parameters such as the reorder point, batch size, and the choice between insourcing and outsourcing, the business's needs were effectively met. CSG also needed to evaluate local sourcing alternatives alongside international imports. Variations in lead times were considered, and the inventory strategy reflected this. Consequently, inventory management, with its capacity to reduce potential production impacts, played a vital role as component in enhancing the resilience of the SC.

Knowledge management

From an operational viewpoint, interviewee CSG02 indicated that knowledge management constitutes a vital component of resilience as noted in CSG. By proactively identifying and addressing staffing requirements, appropriate recruitment and training was implemented. For instance, it was essential that the resources within the planning and ordering departments were proficient in their roles prior to the production staff and quality inspectors performing their duties, as a sequential approach must be maintained. CSG02 said: *"It's a major challenge to get people back*

to work after such a big event..." A comprehensive approach to staff planning, along with a thorough assessment of the labour market, was essential. By ensuring that the workforce possessed the necessary skills for their roles, employees contributed effectively to the ramp-up initiatives and strategic priorities. Consequently, knowledge management was a vital component of resilience, as it guarantees appropriate staffing in the relevant sectors of the SC.

Political support

CSG02 identified the political backing derived from relationships with authorities as a key element of resilience. This support facilitated collaborative efforts in addressing business priorities. CSG02 said *"A good relationship with the port authorities helps us work in a cooperative manner. Not more, not less."* The endorsement of political entities was instrumental in meeting the demands of businesses during uncertain times, including pandemics. Political leaders advocated for policies that support economic stability, they created an environment where businesses could thrive despite external pressures. This endorsement led to the implementation of measures such as tax relief, grants, and loans that directly addressed the financial burdens faced by companies. Political support facilitated developing a local SC with benefits of proximity to the customer. According to CSG02: *"The local political leaders helped in facilitating privileged access to resources and to create a business friendly environment, despite central limitations. Limitations on transportation were lifted, production was continued and infrastructure was operative. Consequently, we could mobilise production and ensure deliveries to the customer."*

Furthermore, the facilitation of importing goods was voiced as a component of resilience, and more specifically, the support by port authorities to enable smooth cooperation. This component of resilience was perceived as adequate political support to ensure aligned priorities between business and authorities. CSG02 commented: *"We had cases where parts are delayed in the port and then we lose important lead-time for delivery. A good relationship with the port authorities helps us work in a cooperative manner. Not more, not less."* Thus, political support acted as an indirect mechanism that bolsters resilience by facilitating essential needs, allowing businesses to focus on recovery and growth rather than merely survival.

Risk management tools

Interviewee CSG02 argued that risk management tools are a crucial component of organisational resilience. The processes involved in risk management allow for the anticipation and management of potential obstacles. CSG02 emphasised that: "*Risk management is one of our key processes. They are performed to anticipate possible issues, for example, shortages in our SC.*" Conducting regular risk assessments using the available tools is essential for preventing potential shortages. Furthermore, risk management is recognised as a vital aspect of resilience and a core process. This function aided in identifying risks through assessments and initiating actions to mitigate or reduce those risks. These assessments yielded important insights into various factors that could jeopardise SC continuity, including supplier reliability, market volatility, and logistical issues. By comprehending these risks, organisations like CSG implemented specific strategies to effectively address them. Consequently, risk management served as a component within the resilience framework, facilitating the early detection and resolution of risks and challenges that could negatively impact the SC. This forward-thinking approach not only protected against disruptions but also cultivates a culture of readiness and adaptability within the organisation, thereby reinforcing its resilience.

IT Systems

Interviewee CSG02 articulated that IT Systems played a crucial role as a component in fostering resilience. These systems were integral to the management of planning and forecasting processes. CSG02 noted: "*The Enterprise Resource Planning is companywide, and we integrate critical SC components in it. This avoids issues due to planning or forecasting.*" The implementation of this information technology system markedly improved the oversight of vital elements within the SC. By optimising processes and enhancing communication, this initiative was essential to a holistic approach aimed at strengthening resilience throughout the entire SC network. The adoption of a digital resource planning system enabled CSG to effectively alleviate shortages, ensuring efficient resource allocation and proactive management of potential disruptions, thereby underscoring the significance of IT Systems as a key component of resilience.

In conclusion regarding case CSG, there were no shared components identified between the two interviewees. Interviewee CSG01 approached the topic from a strategic standpoint, highlighting two key components of resilience: redundancies, and inventories. Conversely, Interviewee CSG02 provided an operational perspective, identifying four further components of resilience during the discussion. These additional components encompass knowledge management, political support as a new dimension of resilience, risk management tools, and information technology systems.

In the context of question four (Q4), when examining aspects of resilience in relation to SOEs, interviewees CSG01 and CSG02 highlighted the methodological strategies employed by the private sector as a notable factor. CSG02 said: *“The SOE has of course in China a home benefit. Its operating in its system, with its people, with its policies. So, this gives a competitive advantage. Prioritisation will be in favour of the SOE, such as energy supply, erection of new facilities, access to skills and talents.”* In addition, the SOE has a benefit over foreign enterprises in employing staff. CSG02 said: *“Furthermore, SOEs possess an advantage over international companies in terms of workforce recruitment. CSG02 states, “It’s a major challenge to get people back to work after such a big event such as COVID-19. So, we pay premium, we bring in expats.”*

The private sector emphasises the implementation of systems that incorporate elements like quality assurance (total quality management) and risk management, both recognised as integral components of resilience. Conversely, the SOE primarily focuses on its internal processes, including compliance with the central five-year plan, personnel promotions, and the advancement of innovative technologies. CSG01 stated: *“I think it’s more about the mechanisms of the SOE than the tools and capabilities. So, we deploy a system such as TQM and continuous risk monitoring.”* Additionally, it was posited that CSG, being a foreign entity, occupies a less advantageous position due to its presence in a foreign jurisdiction, where it encounters more stringent regulations and requirements for survival or success. In contrast, the SOEs benefits from a home advantage, particularly in terms of access to skilled labour, personnel, and favourable policy frameworks.

Within-case analysis CSH

The definition of resilience for CSH was illustrated by maintaining determination in the face of obstacles. Interview participants defined resilience as the SC's persistent ability to meet customer demand, emphasising the need for regular assessments and appropriate resource allocation. In response to significant demand fluctuations, the SC must adjust its workforce accordingly. This effective resource allocation is recognised as a key aspect of resilience, which also applies to machine capacity. CSH01 remarked: *"Resilience means to respond to demand continuously. Therefore, it depends on the customer forecast and support we receive to fulfil the demand. Without that, it's difficult to plan the resources of our people. But more generally, resilience is the ability to continue, to deliver and to make it happen no matter the headwind."*

CSH02 introduced a perspective that emphasises the significance of capabilities and the capacity for independent and methodical problem-solving. A key aspect of this perspective was the local team's competencies, which refer to the skills and expertise that the local workforce has developed and can utilise autonomously, when necessary, rather than relying on expatriate assistance. For instance, the local team's proficiency in conducting a structured root-cause analysis, such as employing the "five why" technique, exemplifies this capability. When combined with effective communication and governance, these elements were essential for maintaining resilience in the face of adverse situations. CSH02 remarked: *"We try to get there. As a first step we put in place the local competences to manage day to day issues. For example, using a structured problem-solving methodology. These small mechanisms help work in a structured way. Then, it's about establishing the proper communication lines in the organisation. Using a methodology to increase competences and capabilities."* The discussion with CSH02 went on to discuss how this was achieved for example through a risk management culture: *"Then we quickly can take actions to find other ways to solve the problems."* Additionally, it was stated that the competencies of the local team have evolved progressively over months and years. This growth trajectory included structured skills development plans, on-the-job training, and experiential learning. Consequently, the acquired skills were effectively applied, leading to positive outcomes for the local team. CSH02 said: *"It's a long way from walking to running."*

Within year, we were able to bring these skills and capabilities, and it took only a few weeks to stabilise.”

The subsequent discussion will focus on case CSH, emphasising the similarities observed between interviewees CSH01 and CSH02. Following this, the varying perspectives regarding the elements of resilience will be examined before concluding the analysis of case CSH. Both interviewees CSH01 and CSH02 reached a consensus on one aspect of resilience, specifically concerning financial resources.

Financial resources

The significance of financial resources as a key component of resilience was highlighted by CSH01 and CSH02, particularly regarding financial support. This enabled the company to maintain its business operations for a limited duration, despite experiencing a financial shortfall, while aiming for long-term financial sustainability. CSH02 said: *“The SOE has more financial backing.”* And CSH01 contrasted the long-term view of the business model and said: *“There was some financial pain, however, we must think long term financial sustainability. There may be a cost to pay temporarily”*. Financial resources are essential for building resilience, achieving long-term goals, and managing short-term financial challenges, especially during unemployment or unexpected costs.

Organisations with strong financial resources, like CSH, recover more quickly and are better positioned to pursue long-term aspirations. Financial capability indicates stability and healthy cash flow, enabling sustained expenditures without depending on immediate profits, highlighting a strategy focused on long-term profitability over short-term gains. CSH01 said: *“When we have challenges, as we did on the recent work package, we needed to put top resources and huge effort to deliver. We did it. There was some financial pain, however we must think long term financial sustainability. There may be a cost to pay temporarily.”* In addition, the access and ability to sustain a shock with adequate resources was another component of resilience as team capabilities were deployed where needed. Consequently, organisations that emphasised financial stability were able to allocate resources towards employee development and infrastructure, thereby maintaining their competitive edge and

enhancing their ability to navigate short-term disruptions, which is regarded as an essential component of resilience.

Quality assurance system

From a strategic standpoint, interviewee CSH01 viewed quality assurance system as an integral element of resilience in the scenario under consideration. The deficiencies recognised during quality audits were actively rectified and managed to prevent any potential repercussions or complications. CSH01 said: *“Some of our current challenges are there, due to gaps in processes. So, I would say the stronger the processes, the more stable and resistant our SC is.”* The formalisation, evaluation, and validation of documented procedures were essential components in ensuring compliance with processes. The development of these processes represented an ongoing journey towards continuous enhancement and the maintenance of a progressively stable production environment, as noted by CSH01: *“Some of our current challenges are there, due to gaps in processes. So, I would say the stronger the processes, the more stable and resilient our SC is.”* The implementation of quality assurance systems and the formalisation of processes, coupled with their consistent application, constituted a vital component of resilience that bolsters standardisation and stability throughout the SC.

Political support

Interviewee CSH01 also noted the State's investments in critical infrastructure to facilitate future growth and attract future work and business opportunities. CSH01 remarked, *“I have seen that the SOE is appointed on a work package due to offset.”* The conditions necessary for offset include the establishment of minimum infrastructure standards to support additional work packages. This encompasses investments in facilities, energy provision, and technical training. Consequently, the role of political support is vital for sustaining or enhancing resilience within the SC.

Knowledge management

From an operational viewpoint, interviewee CSH02 indicated that knowledge management constitutes an essential component of resilience. CSH02 said: *“We mobilised our people during intense shifts. They were all on board, keeping the*

company interest as first goal.” The discourse regarding this element centred on the workforce's ability to tackle difficult tasks in intricate situations. Consequently, investing in knowledge management emerged as a crucial factor in bolstering competencies. Additionally, such investment served to increase motivation, resulting in substantial advantages when required. It was also essential for CSH to examine a managerial perspective concerning resource mobilisation. Thus, knowledge management stands out as a critical component, particularly when analysed through the framework of managerial motivation.

Risk management tools

An additional aspect of resilience highlighted by CSH02 pertains to the utilisation of risk management tools and their implementation as a vital component. In an industrial setting, the systematic identification and management of risks is crucial. CSH02 said: *“The gaps on assessments must be closed, issues resolved with action plans as these will be the weakness in times of crisis. For instance, before the event happened, we considered to ensure that chemicals could be delivered to us despite the licenses issue.”* The proactive identification of risks and challenges is essential for reducing potential shortages of specific resources. As a result, suitable mitigation strategies are put into place. Therefore, effective risk management is a vital component of resilience, enabling the timely recognition and handling of possible SC disruptions.

IT Systems

Another component of resilience raised by interviewee CSH02 pertains to the availability of IT systems. The accessibility of these systems ensures that critical data and information could be utilised for the tracking, monitoring, and management of various elements. CSH02 said: *“We have already a good ERP system that helps our monitoring and tracking. The next step is to integrate our suppliers in it.”* The system oversaw both deliveries and production processes, thereby minimising the impact of human-induced uncertainties. The role of information technology, as a vital component of resilience, was also highlighted in the context of CSH. These systems facilitated the monitoring and tracking of components, work orders, and customer demand, providing a foundation for potential expansion within the SC. CSH02 said: *“We have already a good ERP system that helps our monitoring and tracking. The next step is to integrate*

our suppliers in it." The implementation of an information technology system necessitated the utilisation of established processes and standardised procedures, which contributed to overall resilience. Such systems offer real-time data, enabling decision-makers to act promptly and effectively. Consequently, the capacity of IT systems for data collection and analysis served as a vital component of resilience.

In summary, both interviewees, CSH01 and CSH02, agreed on a particular dimension of resilience, notably in relation to financial resources. During the discussion, interviewee CSH01 highlighted the importance of the quality assurance system as a fundamental component of resilience from a strategic perspective. In contrast, interviewee CSH02 provided an operational lens by pinpointing four further components of resilience: political support, knowledge management, risk management tools, and the application of IT systems.

In response to the request for a comparison in Q4 to distinguish between CSH, an SOE, and the private sector, interviewee CSH01 highlighted that the SOE faces significantly higher achievement expectations. This is primarily because its supply of components is frequently dictated by offset requirements rather than market forces. However, CSH01 noted that the SOE might encounter difficulties in its technical capacity to provide the necessary products or services, stemming from decisions related to appointments and offsets. CSH01 commented: *"I have seen that the SOE is appointed on a work package due to offset; for the good or the bad. The work package might not be the core business, and the SC have to compensate for weaknesses or limitations. So, the challenge is higher. Whereas the private sector does its core business."* Additionally, interviewee CSH02 indicated that achieving resilience in SCs poses a significant challenge for all organisations, irrespective of their classification. Nevertheless, SOEs possess greater financial resources, enabling them to incentivise SC performance, potentially through the payment of a premium. CSH02: *"The management of SCs is a challenge for all suppliers. The SOE has more financial backing. The private company may on the contrary be more agile. But to get parts on time and on quality the same business challenge exists."*

Within-case analysis CSI

The subsequent discussion will focus on case CSI, emphasising the similarities observed between interviewees CSI01 and CSI02 of what the components of resilience are and how and why they affect SCs. Following this, various perspectives regarding the components of resilience will be examined prior to the conclusion of case CSI. Both interviewees CSI01 and CSI02 concurred on three key components of resilience: knowledge management, redundancies, and political support.

In relation to the concept of resilience, the interview participants affirmed a shared interpretation that it encompasses the readiness to respond to demands regardless of the circumstances. This readiness can be cultivated through several factors, including redundancies, capabilities, and strategic planning. Over time, the organisation acquires knowledge on the most effective ways to react to potential external shocks and implements appropriate measures. Interviewee CSI01 said: *“Resilience can be prepared, meaning by means of redundancies, capabilities, strategy.”* CSI02 added: *“Resilience, we prepare every day.”* In addition, recent advancements in digitisation and the implementation of information technology initiatives have contributed to the development of resilience.

Processes were increasingly being digitised and rendered more accessible, which resulted in improved operational efficiency. For example, there was a notable reduction in response times. Interviewee CSI02 remarked: *“In the way we work, the biggest initiative the last years is to digitise our way of working and to work together with customers to set-up full visibility of material supplies.”* Furthermore, CSI01 emphasised from a strategic standpoint the necessity for ongoing modifications and the recalibration of processes and operational methods within the context of China: *“It’s about a continuous adjustment and recalibration to the changing context and environment. Especially in China, a highly dynamic market.”* This recalibration and the adjustments included evaluating suppliers and performing supplier selection as CSI02 discussed: *“Our procurement and sourcing team continuously evaluates material availability.”* The continuous development of supplier capabilities constituted one of the components of resilience to avoid quality, delivery or cost issues. It was said by

CSI02: *“We don’t always have the best suppliers, and we need to continuously develop the supplier capabilities: better quality, leaner production, cost optimisation.”*

Knowledge management

Both participants provided insights into the role of knowledge management as a fundamental component of resilience. The formation of a cohesive team that encompasses diverse disciplines and a broad spectrum of knowledge was crucial for maintaining effective SCM, particularly in the identification of risks and opportunities. *“Our procurement and sourcing team continuously reevaluates material availability”* according to CSI02. In addition, regarding production related workforce, the availability on all process steps was essential. CSI01 said: *“We need the workforce to be available on all process steps. That way we avoid bottlenecks.”* Therefore, it was essential to adopt a comprehensive strategy for managing human resources and its knowledge and skills. Additionally, CSI02 noted the potential risk of a shortage of labour in the job market. *“After the current wave of reduction will come a wave of run for talent.”*

To remain competitive in the challenging landscape of talent acquisition in China, it was imperative to devise innovative strategies. Effective staffing was necessary for the operation of machinery, and robust recruitment practices were crucial to ensure a skilled workforce. CSI02 said: *“After the current wave of reduction will come a wave of run for talent.”* The opinion was also voiced by CSI01 *“We need the workforce to be available on all process steps. That way we avoid bottlenecks.”* In conclusion, knowledge management served as an essential element of resilience, facilitating operations within the SC, while the implementation of innovative solutions can significantly enhance talent acquisition.

Redundancies

An additional component of resilience was the presence of redundancies within the system. According to CSI01, these redundancies offered advantages, including diminished logistical efforts resulting from the local availability of materials. *“Redundancy can be set-up and, in some cases, it makes sense to reduce logistics.”* CSI02 said that the cost of redundancies needed to be observed against the benefits in a favourable business case: *“Once set up we have redundancy. We have doubled the cost and twice the capacity.”* Establishing redundancies for components or materials served as a competitive edge and provide unique advantages. The interviewees noted that while implementing redundancies requires considerable effort, they can ultimately prove to be a significant asset. Nonetheless, this implementation may also lead to heightened complexity, necessitating enhanced coordination and management efforts. CSI02 said: *“The redundancy can be set-up, and, in some cases, it makes sense to reduce logistics and to have a local SC available, however these redundancies are subject to lengthy qualification.”* CSI02 added: *“And once the production is qualified and we have redundancy in the system, we have doubled the cost of maintaining the qualification, the surveillance, the auditing, and so on for two sites. So that’s the cost of redundancy.”* Beyond the establishment of redundancies, a significant benefit of reduced logistics efforts was evident; however, it was crucial to analyse multiple cost-related elements to construct a persuasive business case. Furthermore, the intangible advantages offered additional rationale for the creation of a local secondary source. In summary, the presence of redundancies as a component yielded a variety of both tangible and intangible benefits that strengthened SCR; nonetheless, the related costs were meticulously evaluated in relation to the overall business case.

Political support

The recognised element of resilience was introduced by CSI01 and CSI02. Both highlighted the significance of maintaining positive relationships with a range of stakeholders, including businesses and governmental entities, as noted by CSI02: *“We have to keep a good relationship with everyone here to ensure stability”*. Therefore, the political support ensured continuity in business practices. CSI01 added that these relations are excellent and very important in the cultural and political context

of China. CSI01 said: *“We maintain excellent relations with authorities as it is very important in China to cooperate. The relationship is a long-term investment that can facilitate doing business in China.”* Keeping a good relationship, during times of crisis, was a further remark by CSI02 *“We have to keep a good relationship with everyone here to ensure stability.”* It can be interpreted that the term “everyone” encompasses customers, suppliers, and various stakeholders, including governmental authorities and policymakers. The latter group played a crucial role in providing political support and ensuring stability at the political level, which is essential for the maintenance of valid licenses and permits. CSI01 commented: *“We maintain excellent relations with authorities as it is very important in China to cooperate. The relationship is a long-term investment that can facilitate doing business in China.”* Maintaining a strong and ongoing relationship fosters an expectation of support, which has been particularly beneficial during the recent pandemic. Consequently, this investment in political support plays an indirect role in enhancing resilience, as it is not linked to any specific or individual element.

IT system

Interviewee CSI02 (from an operational perspective) indicated that the IT system played a crucial role in resilience by enabling access to essential data, thereby supporting informed decision-making and being indispensable for effective execution. CSI02 said: *“In the way we work, the biggest initiative the last years is to digitise our way of working and to work together with customers to set-up visibility of material suppliers.”* The consolidation of all data into a single platform facilitated the swift access to critical information. This functionality was vital during critical situations, where timely and efficient decision-making is essential. As a result, information technology systems as a component, were instrumental in improving decision-making processes and strengthening SCR by integrating real-time data.

SC visibility

Interviewee CSI02 has also revealed integrated SC visibility as a vital aspect of resilience in the SC. Customers clearly anticipate being kept informed about progress, especially during recovery situations. Effective communication characterised by clarity and precision serves to bolster customer confidence. CSI02 said: *“The key is the communication with customers. We need to be able to tell them 100% accurately where parts are and when the expected delivery is. The same we expect from our suppliers.”* Through the establishment of appropriate governance frameworks, comprehensive reporting systems, and a disciplined approach, CSI successfully achieved its objectives. The governance frameworks provided a structured approach to decision-making, ensuring that all actions align with the organisation's strategic goals. Comprehensive reporting systems enhanced visibility into operations, allowing for real-time monitoring and assessment of performance metrics. A further remark on resilience was the ability of effective and efficient prioritise and create visibility by means of creating transparency for suppliers and customers alike. The level of accuracy had to be precise as well as the commitment to delivering on agreed schedules solid. CSI02 said: *“The key is the communication with our customer. We need to be able to tell them 100% accurate where parts are and when the expected delivery is. The same we expect from our suppliers.”* This increased visibility was vital for identifying potential risks and opportunities within the SC. In turn, it built trust among stakeholders, as they were able to rely on the organisation's commitment to transparency and accountability. This trust facilitated the execution of resilience plans within the SC as intended, enabling CSI to proactively address challenges and adapt to changing market conditions.

In summary of the case discussion, both interviewees, CSI01 and CSI02, agreed on three fundamental components of resilience: knowledge management, redundancies, and political support. CSI01 did not introduce any additional components, whereas CSI02 identified IT systems and SC visibility as further component of resilience.

In relation to Q4, the analysis conducted by CSI indicates that SOEs exhibit a greater degree of vulnerability in terms of demand and planning when compared to private sector entities. The nature of demand in SOEs tends to be characterised by urgency,

spontaneity, or ad-hoc requirements, which significantly constrains the ability to engage in thorough planning and optimise delivery processes. Conversely, the strategic plans formulated by these enterprises are noted to be robust and ambitious. CSI01 stated that: *“We have several customers on the SOE side. They are behaving a little different. A lot of times the demand is ad-hoc and urgent. So, the planning mechanism to support resilience is a challenge that we have to overcome. Of course we do what is needed to support the customer.”*

Operationally, not many ‘advanced’ approaches were observed such as lean, digitisation and IT system deployment. CSI02 added: *“The SOE show resilience when it comes to the deployment. Plans are bold and do not frequently change; plans are executed. Operationally, when it comes to resilience in IT systems deployment, lean principles and digitisation, I have not witnessed a lot of cases.”* With respect to the question Q2 applied on the private sector, it was noted that CSI, as a private company, needed to be more resourceful to find solutions. Also, behavioural flexibility and collaboration was key components. CSI01 said *“the non-SOE need to be more resourceful within a VUCA world. It’s about a continuous adjustment and recalibration to the changing context and environment; especially in China, a highly dynamic market.”* As example of the change, the situation on the labour market had been referenced, where skilled workers were required to fill critical positions. CSI02 said: *“We had to reduce our workforce during the pandemic and now we turn back to the market and it’s empty. People are no longer available with the skills that we need and at the quantity needed. It really slows us down to ramp-up our capacity.”*

Surprisingly, some concerns were raised regarding the ability to deploy resilience in the context of China as some limitations and challenges have been observed due to regulatory constraints such as customs processing, energy availability and arbitration. The company internal capabilities need to be aligned with macroenvironmental constraints that may be imposed by the State. CSI01 elaborated: *“You see, we can prepare our level of resilience all we want but at the end we depend on external forces here in China, such as customs clearance, such as controls across provinces, such as regulation on production due to energy shortages. It’s difficult to manage the various stakeholders bottom-up.”*

In conclusion of this section, within case analysis, a total of 14 components has been discussed with 18 interview participants. The components are listed Table 5.2 from the one with the highest number of discussions (knowledge management) to the one only mentioned once (innovation, SC visibility and local sourcing):

Table 5.2: Components of resilience

Component of resilience	CSA	CSB	CSC	CSD	CSE	CSF	CSG	CSH	CSI
Knowledge management		x	x	x	x	x	x	x	x
Political support	x		x	x		x	x	x	x
Quality assurance system	x	x	x	x	x	x		x	
Redundancies			x		x	x	x		x
Inventory levels	x	x		x	x		x		
IT systems					x	x	x	x	x
Financial resources	x	x	x					x	
SC network structure		x	x		x	x			
Risk management tools			x			x	x	x	
Logistic network	x			x					
SC flexibility		x				x			
Innovation					x				
SC visibility									x
Local sourcing		x							

Source: prepared for this research

The next sub-section will build on the discussion of the individual cases and will reflect on common key components from a cross-case perspective.

Cross-case analysis of SQ1

This sub-section will examine the cases through a thematic lens within the framework of a cross-case analysis. The SQ1 to be addressed is “*What are the key components of resilience in SC in the aviation manufacturing industry in China? How and why do these components influence SCs?*”

The examination of the cases revealed three common key components that promote a more structured discourse regarding the cases. These three common key components are:

- 1) political support, meaning what authorities do to support a firm with respect to resilience,
- 2) resources, meaning the internal resources a firm can use at its disposal to avert events and create resilience,
- 3) quality assurance system and processes, methods and tools, meaning the components that a firm can develop to ensure resilience.

The themes that will be discussed are based on the previously revealed categories:

1. Type of ownership (SOE versus the private sector either as foreign-owned enterprise, or as domestic privately-owned enterprise)
SOE: CSA, CSB, CSE, CSH
Private: CSF
Foreign-owned: CSC, CSD, CSG, CSI
2. Size of enterprise (Large enterprise versus small and medium-sized enterprise)
Large: CSA, CSB, CSF, CSG, CSH, CSI
SME: CSC, CSD, CSE
3. Product complexity (Low complexity versus high complexity)
Low complexity: CSE, CSF, CSG, CSH, and CSI
High complexity: CSA, CSB, CSC, and CSD
4. Business perspective (Strategic perspective versus operational perspective)
Strategic view CSA01, CSB01, CSC01, CSD01, CSE01, CSF01, CSG01, CSH01, CSI01
Operational view: CSA02, CSB02, CSC02, CSD02, CSE02, CSF02, CSG02, CSH02, CSI02

The first common key component of resilience observed across all case studies was **political support at large**. This refers to the policies implemented by governmental authorities that support businesses and reduce administrative burdens. An example of this is the creation of a conducive environment for the expansion of SCs and the development of SC network structures, access to an innovative talent pool, reduced barriers through SC flexibility, IT knowledge and by means of infrastructure access. As a result, local SCs expand and thrive, thereby enhancing SCR through the provision of capacity, expertise, and components. The subsequent discussion will focus on these elements categorised by ownership type, enterprise size, product complexity, and business perspective.

The common key component of political support will first be discussed from the perspective of the **types of ownership**. During the discussion with companies that are **SOEs**, a high degree of political support was mentioned by interviewees (CSA, CSB, CSH) as a key contributor to resilience to increase general support, second to build a local SC. Both of which will be discussed in turn, supported by quotes.

First, political backing may enhance the ability of SOEs to draw in both labour and investment. As a result, the significance of these enterprises within the aerospace sector increases, leading to the anticipation of additional support during critical periods. Political endorsement is likely to ease access to financial resources, workforce, and expertise. It has been noted that local political actions align with the broader national political strategy. Therefore, the necessary level of resilience will be established. Targeted investments will occur in essential areas such as infrastructure, land, facilities, and human resources, as part of governmental initiatives to provide support. CSH01 stated: *“I have seen that the SOE is appointed on a work package due to offset.”* In addition, it is noted that the SC is supporting and even prioritising the political decisions with resources. Therefore, it may be concluded that the Government plays an important role in the execution of tasks and allocation of resources to projects. CSB02 said: *“Once top-level decisions are taken, we will perform the task given to us. For example, to deliver the program that has government priority. We are able to allocate the resources.”* A further statement was made that the State acts as an umbrella in a protective manner to ensure that companies can act

their internal mechanisms. CSA01 added: *“In addition the support from local authorities is important to make things happen. In addition to everything we do internally. It’s like an umbrella for us.”*

Second, political backing plays a crucial role in establishing a local network of suppliers and SC opportunities. By offering political incentives such as tax benefits, enhanced security, and improved infrastructure, policymakers can attract suppliers to establish their operations in preferred locations. The formation of these local networks diminishes reliance on singular sources and alternative suppliers, thereby enhancing flexibility through the proximity of suppliers. As a result, the SOE can engage local suppliers, thereby bolstering the resilience of the SC. CSB02 indicated: *“The local material production....”* This local presence of the SC also increases the degree of reactivity, communication and overall corporation. Response time to queries is increased, and deliveries potentially accelerated. CSA02 commented: *“That way we have a good control on local suppliers.”*

When looking at cases from the perspective of companies that are **foreign-owned enterprises**, two key components are pointed out by the interviewees (CSG, CSI) as political support which are involvement in transportation processes and development of infrastructure.

Crucial for a robust and resilient SC are transportation processes. Authorities have a direct influence on the ability of customs (import and export) to process goods that enter and depart China by allocating capacity to process (such as customs inspectors). It has been observed that good relations with authorities are required to ensure smooth operations and to avoid delays. This ability of customs processing is a component of resilience in the logistics SC. Interviewee CSG02 commented: *“We had cases where parts are delayed in the port and then we lose important lead-time for delivery. A good relationship with the port authorities helps us work in a cooperative manner. Not more, not less.”*

During the discussion of case CSG, a view was expressed that the SOE is favoured over foreign enterprises when it comes to infrastructure development. SOEs gain the

“home benefit” when it comes to the influence of policies and prioritisation over non-indigenous firms. For instance, policies for developing land and erecting new facilities, policies to attract and develop skills and talent, prioritisation on the allocation of infrastructure such as energy, water, transportation. It is therefore of particular interest and importance for the foreign-owned enterprises to ensure an adequate relationship with government and authorities. CSG02 said: *“The SOE has of course in China a home benefit. Its operating in its system, with its people, with its policies. Prioritisation will be in favour of the SOE, such as energy supply, erection of new facilities, access to skills and talents.”* By maintaining an impeccable local image, the playing field may level, and the firm may be perceived as a local player. CSI02 added: *“We have to keep a good relationship with everyone here to ensure stability.”*

When looking at components of resilience from the perspective of the **domestic privately-owned** enterprise (CSF), one key component is pointed out. It is observed that authorities support, through their policies, the growth of the domestic privately-owned sector and increase capacity and rate flexibility. Governmental policies lead to incentives to attract suppliers, to growing further capacities, to develop skills and to increase visibility towards the OEM and the ecosystem. These measures lead to further resilience, in particular the capacity and capability front. Support is expressed as required by the ecosystem. CSF01 said: *“There is a willingness for the private sector to grow and to increase competition. So, the authorities help promote our vision. There is no specific funding, but we have high rank visits and support as required. This helps to grow our local SC.”*

In conclusion, when observing the cases from an ownership perspective the support from authorities and policymakers is important to have positive effects on components that lead to SCR. The cases had different views as to the type of policies and how these are being applied, defined or delivered. SOEs see political support as a source to attract business and to offer guidance and support in times of need. Foreign-owned enterprises perceive political support as an enabler for infrastructure that is directed to companies supported by the State. The domestic privately-owned enterprise perceives to receive political support needed to grow the local SC and increase capacity and flexibility. These components have in common that the political support

helps to reduce barriers, supports investment in projects and facilitates resilience through capacity in the SC.

Next, the discussion will observe components of resilience from the **enterprise size perspective** by first discussing large enterprises, followed by small and medium-sized enterprises. **Large enterprise** such as CSA and CSI comment that political support materialised through financial support and through long-term business friendly policies that attract businesses. The political support is an important element that stretches across all business areas. The political support was, however, not directly correlated to a specific component of resilience. It is rather the sum of long-term incentives and investments that are meaningful to large enterprises. The political support translates for instance into financial support from Ministries. This enables investments, paying employees and supplies, and to sustain the SC during difficult times. Inventory levels are increased, and facilities grow to accommodate more work packages, to maintain employment and to keep the system going. Interviewee CSA01 stated: *“We benefit from a high level of financial ability to withstand. This means, that during the pandemic we were able to invest further in inventory, in continuing the production and in paying salaries to employees and bills of our suppliers. That way we meet customer orders and keep the system going, despite the pandemic.”*

Besides the political support to maintain the system going and maintaining job levels stable, the good relationship with authorities helps to ensure in the long-term a business-friendly environment. Consequently, further investments can be attracted, and cooperation fostered. Capacities are increased and SCR is achieved. CSI01 commented: *“We maintain excellent relations with authorities as it is very important in China to cooperate. The relationship is a long-term investment that can facilitate doing business in China.”*

From a **small and medium-sized enterprise** perspective, political support is seen as a business facilitation component that offers connectivity across the ecosystem (cases CSC, CSD). Small enterprises suggest that authorities can facilitate the day-to-day business, for example, by enabling customs clearance or by connecting suppliers and potential employees. Custom clearance can be a complex process to small and

medium-sized enterprises. Close coordination with customs officials facilitates adequate processing specifically in times of disturbance such as the recent COVID-19 pandemic. CSD02 commented: *“In our SC we depend on import of carbon fibre as a critical material. The importation of the temperature-controlled material must be smooth. So, we are cooperating 100% with customs to ensure adequate processing. For me this is resilience in logistics.”*

In addition, the adequate political support opens doors to the small and medium-sized enterprises in the sense of connecting them with suppliers and attracting innovative talent. Consequently, the supplier base is diversified, and innovative talent is made accessible that would otherwise have been hidden. Recurring trade fairs connect people and suppliers. This continued growth of network and talent is a sign of resilience as opposed to static environment. CSC01 said: *“Thanks to the good political support we can access vast resources such as very motivated suppliers and hire great employees. Regular trade fairs are a good platform for this.”*

In conclusion, key similarities include that both small and medium-sized enterprises and large organisations comment that political support is helpful and sometimes essential for business success during times in which resilience is required, such as the recent COVID-19 pandemic. Small and medium-sized enterprises, illustrating the case of customs facilitation and connecting people, see this support on an ad-hoc basis. Large corporations see that support rather on long-term investment and incentives that share the industry. This is possibly due to the impact large enterprises have on employment and therefore on political capital.

Next, the discussion will be based on the **product complexity** by beginning with the low complexity product perspective before moving on to complex ones. When discussing cases with a **low product complexity** (CSE, CSG) SCR and the association to political support has not been voiced as an element of consideration. CSE suggested that resilience was based on the procedural way of working. The political willingness to support was not mentioned as a component of resilience. CSE01: *“For me resilience is to follow our procedures and processes.”*

In the discussion on case CSG it became evident that the supplier can benefit from locally set-up SCs. These local SCs originate from a political willingness to attribute licenses or other benefits. CSG01 commented: *“The redundancy allows us to increase capacity and to meet customer demand. We can tap into double sources, meaning we have twin sites and multiple qualified suppliers. This redundancy is flexibility”*.

When discussing the cases in which **high product complexity** plays a role (CSC, CSD), political support helped in facilitating networks of experts, such as suppliers and prospected employees. CSC01 said: *“Thanks to the good political support we are able to access vast resources such as very motivated suppliers and hire great employees. Regular trade fairs are a good platform for this.”* Similarly, the case CSD sees political support as helpful in the context of complex technological projects and technology transfer. As authorities are interested in the technology, the political support will facilitate business and possibly reduce requirements. CSD02 said: *“In our case the set-up and the government support were helpful. It was their interest in our project that led to full support. It is required as we have challenges ahead.”*

In conclusion to the perspective of product complexity, key differences include that on low complexity products, the political support is perceived as a facilitating mechanism to attract suppliers and employees. There may be no political objective in attracting this work to China. In the case of complex products, it is observed that authorities are interested in making the technology transfer a success and enable policies of resilience. Therefore, policies will be in favour of complex products. Barriers may be reduced, and support is widely available and prioritised.

Lastly, the discussion will be based on **management versus operational** perspective. From a **management perspective**, political support has been voiced in numerous cases as an important contributor to resilience in the SC (CSC01, CSI01). Several comments from the management perspective suggest a political support in order to achieve business goals. Interviewee CSC01 suggested that political support facilitates access to resources: *“Thanks to the good political support we are able to access vast resources such as very motivated suppliers and hire great employees. Regular trade fairs are a good platform for this.”* In addition, the cooperation in China was pointed

out as an important component of resilience and that the relationship with authorities facilitates it. CSI01 commented: *“We maintain excellent relations with authorities as it is very important in China to cooperate.”*

From an **operational perspective** the interviewees did not make political support as a contributor to SCR. The components of resilience were mostly technical and will be discussed the section of other components of resilience. The exception was interviewee CSD02 that saw government support as helpful in order to achieve project goals. CSD02 said: *“In our case the set-up and government support were helpful. It was their interest in our project that led to full support. It is required as we have challenges ahead.”* From the view of CSD02, the political interest to show the strength of its enterprises, facilitates political support. If it can be demonstrated how strong the enterprise is, then political support may be expected. CSD02 added: *“For the SOE resilience is to show how strong they are, as they are part of the State.”* A further view was regarding incentives and long-term perspectives in employee retention. This may indirectly be supported by political support such as benefits (housing, schooling, etc.) according to CSD02: *“We need long-term plans to keep people retained.”*

Interviewees with a strategic business view concur on the importance of political support as a component of resilience by facilitating long-term business success and being a partner in the economic development. On the other hand, interviewees with an operational business perspective do not systematically concur, however some agreement exists with respect to some political support for long-term initiatives such as employee development and retention.

In conclusion of the first common key component observed, political support, it is found that all cases consider it as an important element and that multiple components of resilience are impacted. Not only the structural situation of China but also the nature of the aviation industry, require close cooperation with political actors, even at local levels such as within the city or district. This political support translates into a variety of components of resilience depending on the case, such as support to obtain permits by using collaboration platforms, enabling local SCs to flourish through a SC network structure, attracting potential employees and fostering innovation, or through

privileged access to customs clearance through logistics network. All of which are directly or indirectly influenced by governmental authorities or institutions; therefore, they are an important stakeholder when discussing SCR in China's aviation industry.

The second common key component observed was resources. There are two components of resilience within this component: financial resources and knowledge management. By financial resources are understood the financial means accessible to enterprises to conduct their business such as paying invoices, salaries, business operations and investments. knowledge management is the human capital, i.e. people, that work at an enterprise as well as their skills, competences and talent to do their job at an enterprise.

The components will first be discussed from the perspective of the **types of company ownership**. During the discussion with **SOE's** (CSC, CSD, CSH) the observations were made that there were two principal components of resilience as far as the resource view is concerned: firstly, financial resources, secondly, knowledge management. The view across the SOE's was that financial resources is a key component of resilience: specifically, the availability of capital to invest in new projects. For instance, a capital may be required to enable a possible transfer of technology to the SOE. It may be reasonable to assume that this capital is used to invest in SCs, in capacities and in capabilities in favour of this project. CSC01 commented on the case: *"The SOE has much more resources and capabilities to support."*

In the search of finding why these resources are made available it became evident that the State, through the SOE, wants to demonstrate their size, strength, and power. For those reasons, financial resources are made available to the SOE's. CSD02 added: *"For the SOE, resilience is to show how strong they are for the State."* The repercussions and the consequences on the SC are evident; financial capabilities are made available for the purpose of capacity increase across the SC. CSH02 said: *"The management of SCs is a challenge for all suppliers, regardless the SOE or the private sector. ... The SOE has more financial backing."* Furthermore, a willingness to spend in the short term with the perspective of long-term profitability is given. The horizon for payback or return-on-investment is longer than in the private sector and for listed

companies that report profitability on a quarterly basis. CSH01 stated: *“There was some financial pain, however we must think long term financial sustainability. There may be a cost to pay, temporarily.”*

The second observation was on knowledge management and the availability of human capital. In the SOEs it has been observed across several cases (CSA, CSD, CSH) that knowledge management is a key component of resilience. Sufficient skilled workers are available to the SOEs across various disciplines including blue collar workers for the production. In addition, it is observed that the workforce contributes with a relative level of flexibility when it comes to overtime and shift-patterns. CSA01 commented: *“We have of course the workers available, and they can give overtime when needed”*.

In addition to this relative flexibility, it is noticed that SOE's also mobilise its workforce based on the company's goal that employees understand and share. This is possibly a cultural nuance that prevails in SOEs. CSH02 commented: *“We mobilised our people during intense shifts. They were all on board, keeping the company interest as first goal.”* SOEs prioritise enhancing their workforce's knowledge and skills through long-term training aligned with their strategic goals. For instance, they are considering developing expertise in carbon fibre production and stress analysis of composite materials. CSD01 commented: *“SOE are interested in gaining a new technology, so the SOE will allocate the most skilled resources on the new projects.”* To this view, a further comment was given that skills development and capability growth is a long-term talking to my see how much plan to keep people retained. This may be to compensate for financial incentives from the private sector. CSD01 said: *“We need long-term plans to keep people retained.”*

When looking at cases from the perspective of companies that are **foreign-owned enterprises**, (CSG and CSI) these confirmed that knowledge management and the availability of skilled workforce was a key component of resilience. The availability of the right skill is fundamental for them in the foreign land in which they operate. Gaps in the availability of skills is observed and the availability of qualified resources would have been a sign of resilience. CSG02: *“It’s a major challenge to get people back to*

work after such a big event such as COVID-19. And still many restrictions limit us. Some of the skills we had, are no longer available. So, we pay premium, we bring in expats, or we train people which takes time and a risk of their leaving.” Companies are hit by the low availability of people and resilience in capacity is slowed by staff shortages across many disciplines. CSI02 added: *“We had to reduce our workforce during the pandemic and now we turn back to the market and it’s empty. People are no longer available with the skills that we need and at the quantity needed. It’s really slowing us down to ramp-up our capacity.”* As alternative, foreign-owned enterprises may call on expatriates for short-term needs, at a financial premium, to overcome local shortage of knowledgeable people. CSG02: *“So we pay premium, we bring in expats, or we train, which takes time and a risk of their leaving.”*

When looking at components of resilience from the perspective of the **domestic privately-owned enterprise** (CSF), the availability of skilled and knowledgeable labour is seen as a key component of resilience. Financial capability was not mentioned as a prime concern, possibly as the supplier manages capacity in a flexible way. The case of CSF discussed that operators for the shopfloor are generally available and supplied by the industry. The case discussed the ability to attract the operators and to develop their skills and competences in line with business requirement. Once the resources are needed, they can be allocated to the production. CSF02 said: *“The availability of our operators is a strong point we have and that helps to ramp-up quickly again. We have strong qualification systems to have the skilled workforce. It is a big competition for skills in our region.”* In addition, the flexibility and speed to deploy is distinct to the private sector. People are quickly added to the production and quickly allocated to where it is needed. CSF01 suggested: *“The private sector has a distinct advantage in the SC and that is the flexibility and the speed.”*

In conclusion, the three perspectives concur that human capital is a crucial component of resilience. Availability not just of people but also of the adequate skills is fundamental, in times of production ramp-up (the right skills at the right location). When it comes to financial capabilities, the SOE and foreign-owned enterprises sees this as an important component due to facilitation of production, payments, inventory. The domestic private firms do not see this as a fundamental component of resilience,

possibly as they are more flexible in their approach. For instance, they can reduce labour quicker and be leaner on work in progress, inventory and reducing orders to suppliers.

Next, the discussion will observe components of resilience from the **enterprise size** perspective by first discussing large enterprises, followed by small and medium-sized enterprises. For **large enterprises** (CSA, CSI) it is observed that specialisation is important, and the availability of sufficient experts is required. Workforce is critical to respond to business needs in terms of both knowledge and volume of employees. CSA02 commented: *“The technical skills are that our operators have, are really impressive. The training plans and qualifications take a long time. We cannot afford to lose this so that during the pandemic we did not fire anybody.”* In terms of number of employees. It is mentioned that the cases discussed are seeking a relatively large number of knowledgeable employees and that this wave will happen simultaneously in the industry. The question arising is how the aviation industry will in coordinated matter manage this situation. CSI02 said: *“After the current wave of reduction will come a wave of run for talent. That’s when we quickly need the right employees available on the shopfloor. That is a challenge that we are preparing now because everyone will do the same at the same time.”*

From a **small and medium-sized enterprise** perspective, it is observed (CSC, CSE) that resource knowledge level as a generalisation is important and a sign of resilience. For instance, during the COVID-19 pandemic, CSC used time to train its employees and to develop their capability in other domains through programs of staff rotation. That is a sign of investing in resources and growing the knowledge and skills, widening the capability and demonstrating the long-term commitment to employees. CSC02 said: *“During the pandemic we used the time to train our staff. We offered rotation between jobs, for example from the flowline operations to quality management. It is an enriching experience and for the company it gives the benefit of widen perspectives. That way we grow, and we don’t need to let anybody go.”* It was added that due to departures, gap in the staffing were observed. To fill these gaps, employees had to be ‘stretched’ vertically by absorbing further responsibilities. This is

a distinct component of SMEs. CSE02 said: *“We had the case of employees that left, and the job still needed to be done. So, it falls on the shoulders of those that remain.”* In summary, the analysed cases indicate that having knowledgeable and skilled personnel is essential for successfully achieving the ramp-up. Notably, the issue of financial resources was not addressed in either case perspective. This omission may be related to the contractual agreements between suppliers and their clients. The payment conditions tend to favour suppliers, as the ramp-up is financially facilitated through mechanisms such as pre-delivery payments and the provision of materials.

Next, the discussion will be based on the **product complexity** by beginning with the low complexity product perspective before moving on to complex ones. From a **low product complexity** perspective of cases, it is observed that the volume of resources is a determining factor to resilience. The speed of availability of operators determines the level of resilience, for example to operate CNC machines (programming, loading, unloading, cleaning, maintaining). CSI01 illustrated this: *“We need the workforce to be available on all process steps. That way we avoid bottlenecks.”*

When discussing cases in which **high product complexity** plays a role (CSA, CSB, CSC and CSD) it is found that SCR depends highly on the workforce skill level. That means the workers are technically well trained and knowledgeable and know exactly how to effectively perform their job. Interviewee CSA02 commented: *“The technical skills are that our operators have are really impressive. The training plans and qualifications take a long time. We cannot afford to lose this and during the pandemic we did not fire anybody.”* CSB02 added that development and qualification of employees takes a long time and needs to be ensured to be ready when the skills are required: *“The assembly work requires many years of training and experience. It is very clear, and we are proud to keep our workers with us.”* The case CSC complemented that a ramp down of resources bares a risk that needs to be assessed and evaluated. The question of readiness of the skills needs to be asked as CSC01 pointed out: *“During this crisis it was clear that we had to ramp down all our activity. However, we used the time to train our staff on another task. Also, we decided not to stop but to slow down. That way we don’t lose any key skill such as NDT.”* CSD02 said: *“Workforce qualification is key as it reflects on the product quality. We miss a*

process step; we mess up an operation and the part are scrapped. So, we need to reenforce and continuously keep the skill level sharp.”

The examination of cases involving both simple and complex components highlights the significance of knowledge management for both categories. Nevertheless, in terms of workforce capability, firms producing simple components prioritise the consistent availability of labour, while those engaged in the production of complex components focus more on the skills and competencies of their workforce. Specifically, companies in the latter theme may opt to retain their employees and invest in their development, whereas firms that manufacture simple components might adopt a more flexible approach, employing a hire-and-fire strategy as a suitable policy.

Lastly, the discussion will be based on **management versus operational perspective**. From a **management perspective**, interviewees see the financial resources as a fundamental component (CSC, CSI). Interviewees argue that during turbulent times it is companies that are financially viable that will be able to remain in the market CSC01 said: *“It’s a fact, if you manage your business well you stay, if you don’t, competition will eat you.”* The financial viability is not just paying salaries, suppliers and maintaining a reasonable margin, it’s also the investment in the future. Transforming the business to new levels of efficiency, for instance by means of digitisation. CSI01: *“The crisis offers an opportunity to invest in the next models, the next systems, technologies of digitisation, digital twin and AI.”*

From an **operational perspective** the availability of knowledge management is more dominant in the discussion (CSG). The primary operational priorities necessitate the engagement of employees who possess specific knowledge in managing current facilities. Notably, it has been observed that inefficiencies, including shortages of materials, absent components, or depleted inventories, resulted in an increased demand for skilled personnel, thus knowledge management is an important component. These knowledgeable resources can mitigate the impact of inefficiencies and enhance the speed of deliveries. CSG02: *“Then for the ramp-up we need material and people. Material shortages are evident. And we miss people as this would allow us to accelerate. So, more people are required.”*

In conclusion, from a strategic viewpoint, financial resources are recognised as a fundamental element of SCR, as they facilitate the continuity of business operations and ensure future viability. From an operational standpoint, the presence of skilled human capital is identified as a crucial factor in maintaining resilience, enabling the timely delivery of parts, products, and services to customers. It is evident that both financial resources and expertise are vital components of resilience across numerous cases examined. Typically, SOEs, which have greater access to financial resources, regard financial capability as a significant aspect of resilience. This critical resource is then allocated at the discretion of management for purposes such as investments, inventory management, or other operational expenditures. Additionally, it is observed that companies adopt varying approaches to human resource and knowledge management, ranging from transient hiring practices to long-term career development strategies. The competition for talent in the aftermath of disruptive events poses significant challenges for organisations lacking long-term employee engagement. Insufficient human resources may ultimately hinder the recovery process, affecting the restoration of delivery and performance levels.

The third common key component of resilience identified pertains to the capacity to implement a **quality assurance system** (7th component of resilience in Figure 4.5) that comprehensively addresses the processes, methodologies, and tools utilised within the SC. This encompasses the formalised procedures and operational practices, including methodological frameworks such as guidelines, production techniques, and protocols, as well as the tools—both software and hardware—employed, alongside their ongoing monitoring and regulation.

The component of quality assurance system will first be discussed from the perspective of the **type of company ownership**. The **SOE** does rarely refer to the quality assurance system during the discussion. This suggests a naïve view on the potential of lean and high performance of processes. The basic requirements are covered by processes; topics of resilience however are not observed as a key factor. This may be due to organisational culture. CSE01 stated: *“We have our procedures that ensure best process, quality and lead-times.”*

When looking at cases from the perspective of companies that are **foreign-owned enterprises** (CSC, CSG, CSI), a first component of resilience observed is the effective and efficient use of tools as well as its systematic application of the quality assurance system. Consequently, the level of resilience is increased as adequate responses to issues are found for example by using root-cause analysis. Process-thinking enables anticipation of risk by means of systemic issue eradication. CSC01 said: *“It’s our duty to prepare and to anticipate. We use tools such as PFMEA to anticipate issues and problems and put preventative actions in place. For example, the Poka-Yoke is a tool by which we fool-proof possible issues. It helps eliminate issues. Of course, there are always new issues that could happen, and we work on discussing a plan B or alternative.”* CSG01 added that the deployment of tools needs to be systematic rather than ad hoc or subjective. Additionally, the adequate tool needs to be selected out of a range of possible tools. CSG01 said: *“So, we deploy a system such as TQM (total quality management).”* In addition to tools and processes, it is observed that combining them with digitisation offers an opportunity to simplify and to accelerate the degree of resilience. CSI02 said: *“Digitisation offers a potential to accelerate the resilience building and returning to a new normal.”*

A component of resilience observed across **privately held enterprises** is the ability to innovation. CSG02 noted: *“The private company may on the contrary be more agile.”* It is observed that the speed at which SCs deliver is a component of resilience. Innovative ideas had been used to continuously adjust and to be more resourceful. CSI01 added: *“The non-SOE need to be more resourceful within a VUCA³ world. It’s about a continuous adjustment and recalibration to the changing context and environment. Especially in China, a highly dynamic market.”* The ability to debounce back and to recover may be shorter as the ability to deliver products is faster. CSC02 commented: *“The private sector is faster there. You give the order, and they propose a delivery schedule – not always perfect, but we have a basis of adjustment.”*

When looking at components of resilience from the perspective of the **domestic privately-owned enterprise** (CSF) the quality assurance system and its processes,

³ VUCA stands for Volatility, Uncertainty, Complexity, and Ambiguity. It is a concept that originated in the field of military strategy but is now widely used in business and leadership contexts to describe environments or situations that are characterised by these four elements.

methods and tools are part of the training of its employees. The capability of employees to execute the processes is key to achieve stability in the SC. It's the ability to reproduce and reducing quality defects. In addition, the development of capabilities was a key investment with experts over many years. CSF01 said: *"Robustness in our processes is a key pillar of our organisation. The analytical approach to problems by means of tools, processes, methods is fundamental to ensure long-term stability and customer satisfaction. We deployed experts to do exactly that over many years."*

A strong remark on the potential to further digitise SCs was given with the ability to take better decisions. This right decision-making is fundamental when evaluating critical recovery situations. CSF02, said: *"With the current level of digitisation in the SC, we have only seen the beginning. Much more advanced models for forecasting will be deployed enabling real time decision making, anticipating risk, and working on scenario planning. All of it signs of resilience for me."*

Finally, the ability to remain agile on processes, methods and tools is seen as a distinct element of resilience. CSF01 said: "The private sector has a distinct advantage in the SC and that is the flexibility and the speed. It is less administrative and bureaucratic to switch suppliers, to activate new suppliers, or to work on alternatives".

In conclusion, key similarities include between foreign-owned enterprises and the domestic privately-owned enterprise the importance of the quality assurance system and its processes, methods and tools to achieve resilience in the SC. As for the foreign-owned enterprises, they are largely driven by process tools and methods. Some flexibility and innovation of the processes was mentioned. For SOE no specific mention on processes tools and methods was made as a component of resilience.

Next, the discussion will observe components of resilience from the **enterprise size perspective** by first discussing large enterprises, followed by small and medium-sized enterprises. For **large enterprises** (CSA, CSF, CSI) the organisation of the structure that manages and deploys the quality assurance system was an element of discussion. The department was comprised of a substantial workforce committed to overseeing supplier performance, which included quality assurance measures, timely deliveries, and the enforcement of contractual obligations. As a result, the company

CSF was proficiently organising delivery schedules for production components and subsequent shipments to clients. This organisation played a crucial role in ensuring accountability, monitoring actions, and executing tasks effectively. This was discussed by CSF02: *“Our procurement team has the job to manage all the deliveries and enforce the contractual terms. So, with this we have planned dates and deliveries. On our products we have a complex global supplier base that needs to be coordinated.”* The systemic and orchestrated way of working under the quality assurance system was emphasised as the key component of resilience. CSA02 said: *“Procurement manages the purchase orders, dates and deliveries. As we manage many suppliers, we need a large team for the job.”* The continuous monitoring is a further important task of the risk management, that contributes to the resilience and agility of SCs. CSI02 discussed: *“Our procurement and sourcing team continuously evaluates material availability. It’s a continuous task and following standard procedures, assessments and analysis is important to ensure the best supplier selection and customer satisfaction.”*

A further component of resilience in large enterprises (CSF, CSG, CSH, CSI) is use and deployment of risk management tools and its continuous process of risk screening of the SC. Multifunctional teams consistently assess the capabilities of suppliers, focusing on aspects such as increasing production capacity, fulfilling orders, and maintaining quality standards within the suppliers' production systems. The objective of these evaluations is to identify potential risks at an early stage and implement measures to mitigate them. Subsequently, action and recovery plans are developed to address the identified risks until they are fully resolved. This process of risk assessment necessitates both resources and, crucially, experience. The accumulation of such experience is a gradual process and represents a significant investment in risk management. Interviewee CSG02: *“Risk management is one of our key processes. They are performed in order to anticipate possible issues for example shortages in our SC. By checking the capacity of suppliers to produce, we know early on the bottleneck and can put in place actions to mitigate them and avoid shortages, stoppage or need to arbitrate between customer orders.”*

The evaluation of risk should take place in multi-functional team to ensure different perspectives are considered and avoiding silo mentalities. CSH02 said: *“The procurement team and the program team are the interfaces with the suppliers for early risk anticipation. They will first know if we have issues from the SC. Then we quickly can take actions to find other ways to solve the problems.”* Furthermore, the risk assessment capability is appropriate to be deployed when finding new suppliers. At an early stage the supplier capability to deliver the product from a technical, quality, SC and cost perspective should be assessed. In function of the result, an adequate action plan or contingencies should be taken. CSI02 commented: *“We don’t always have the best suppliers, and we need to continuously develop the supplier capabilities: better quality, leaner production, cost optimisation. The earlier we know the weaknesses, the more adequate we can manage and avoid issues. At supplier selection is a good moment to assess.”* It was voiced that resilience could also be a criterion for supplier assessment, evaluation and selection. Effectively this does not take place at present. CSF02 commented: *“To have more resilience in the SC, we need to select suppliers that are resilient. We do this by assessing the capability to deliver the products on time, on cost and on quality.”*

From a **small and medium-sized enterprise** perspective the main component of resilience discussed (CSC, CSD, CSE), is the agility and flexibility to maintain business operations in times of crisis. Primary as a reactive mode, the cases discussed allowed fast decision-making and quick response in difficult moments on key SC topics. It was observed that production adjustments, changes in the sequence, modifications in logistics medium and thinking outside of standard processes were some of the components most favoured. CSC02 commented: *“Compared to our large facility, here we are more flexible, for example on the production sequence and assembly. We can adjust more easily and accommodate some changes, for example in the commercial furnishing.”* A view that flexibility could be combined with creativity in a context-specific setting to achieve new outcomes was voiced by CSD02: *“We need to stay flexible and even a bit creative when we are faced with shortages or limitations. I would call it agility in interpreting processes. It’s not always desirable but it keeps the business going. For example, when our traditional suppliers are not responding due to shut-down, we will activate a highly agile local SC.”* Interviewee

CSE02 added about its SC flexibility that it is context specific and that local solutions can help the local context: *"We rely on a local supply base that is highly innovative and flexible. This helps when we face sudden changes in demand, modifications that were not planned or even shortage from overseas suppliers. It can really be seen as a resilience in local SC."*

In conclusion, large enterprises emphasise the importance of methodological ways of working. The robustness and the capability of the SC organisation is an important asset and sign of SCR. Continuous risk management is a further key component. These elements may be linked to the large size, where processes and functions need to run the business and not necessarily the individuals. On the contrary, SMEs perceive that their flexibility and agility is the key component of resilience that is required in times of crisis.

Next, the discussion will be based on the **product complexity** by beginning with the low complexity product perspective before moving on to complex ones. When looking at **less complex products** (CSE, CSF, CSG, CSH, CSI) the common component of interconnectivity of IT systems as component of resilience is observed. The interviewees discussed that the transmission of data and subsequently working with the same data for planning and prioritisation purposes is a key element for SCR. CSF02 commented: *"Our demand planning is sent through IT system to our SC. That way they know what we need, and no time is lost for changes."* Internally working in the same system is a first important component, for all departments to be synchronised. CSG02 commented: *"The Enterprise Resource Planning is companywide, and we integrate critical SC components in it. This avoids issues due to planning or forecasting."* The next element to synchronise are external suppliers and their inputs, deliverables and parts. This extension would be an enhancement of resilience of the IT system. CSH02 said: *"We have already a good ERP system that helps our monitoring and tracking. The next step is to integrate our suppliers in it."* Last, the connection across the value9-chain would include customers as well as suppliers. CSE02 said that: *"Planning data comes to us with the IT platform of our customers."*

When discussing the cases in which **high product complexity** plays a role (CSC, CSD) the importance of processes and the challenge to stay agile during unplanned events was voiced as a bit of a contradiction. CSC02 said: *"We have some agility in our processes, but we need to plan for it."* The evidence for the successful flexibility in processes could not be given. CSD02 said: *"We expect processes and flexibility. But hard to achieve."*

In conclusion, low complexity products see that IT systems are a key component of resilience. On complex companies' flexibility and agility were mentioned as a capability of resilience but hard to achieve.

Lastly, the discussion will be based on **management versus operational** perspectives. From a **management perspective** (CSC, CSH), resilience in the SC is seen to rely heavily on robustness of processes. Consequently, rates can be reduced and increased as required by customer demand. Adequate resources can be allocated, and production be finetuned or optimised. Quality and deliveries are taken care of by the processes. Interviewee CSC01 said: *"For our industry we rely on the processes to ensure resilience in the SC: quality, deliveries, rates. So, I would say it is fundamental to continuously audit our process adherence and efficiency."* A case discussed showed the failure in processes and the issues that can be caused by absence of robust processes. Therefore, it is important to ensure robust processes across the entire SC covered under the quality assurance system. CSH01 *"Some of our current challenges are there, due to gaps in processes. So, I would say the stronger the processes, the more stable and resilient our SC is."*

From an **operational perspective** the interviewees comment (CSB, CSC, CSF) that robustness in processes is to ensure staff training, quality adherence and robustness in the execution that is formalised in a quality assurance system. The process robustness ensures solid deliveries based on quality. It means that quality losses on the overall output are minimised. Net of loss outputs are reduced and ramp-up and deliveries could meet target levels. CSC02 said: *"The strong processes help to ensure quality."* In addition to the quality of processes, the skill of workers is important. For the purpose of adequate training, the processes that are defined and formalised are

used as training material. CSF02 said: *“We use as reference for training the processes that have been established and that are part of our 9100 Quality Management System.”* Last, the robustness of processes it is said that processes robustness is considered as a component of resilience by interviewee CSB02: *“For resilience the process is important as it is the point of reference for the product and references.”*

In summary, from a managerial standpoint, the focus lies in sustaining the efficiency and effectiveness of processes via a quality assurance system, while incorporating a level of agility whenever feasible. From an operational viewpoint, the emphasis shifts to ensuring that personnel adhere to established protocols, that quality is monitored, and that the overall system's robustness is maintained.

In conclusion of the third common key component, which focuses on quality assurance systems along with their associated processes, methods, and tools, the significance of these elements has been predominantly noted within both domestic and international private sectors, applicable to enterprises of varying sizes. This observation may be attributed to workforce variability and the adaptability required in response to fluctuating customer demands. Organisations aim to preserve institutional knowledge and mitigate training-related risks; consequently, established processes dictate operational methodologies. Furthermore, it has been highlighted that digitisation serves to streamline processes, thereby enhancing overall efficiency. Future developments will provide evidence of the potential that has been realised. While SOEs comply with established processes, they often do not recognise these as integral to resilience. As the adoption of IT and integrated systems becomes more widespread, this trend may foster elevated standards throughout the industry and promote process alignment. Such advancements are likely to diminish training requirements, reduce process inefficiencies, and facilitate more straightforward collaborative efforts.

5.4 Findings of sub-question SQ2

This section presents the findings and data patterns related to sub-question SQ2, which examines the features of resilience that impact SCs and the mechanisms through which these characteristics exert their influence. Initially, a within-case analysis will be conducted to explore the findings for each individual case. Subsequently, a cross-case analysis will be performed to compare and contrast the cases based on pre-established attributes. These attributes encompass the type of ownership (SOEs, foreign-owned enterprises, or domestic privately-owned companies), organisational size (distinguished by those with fewer than or more than 1,000 employees), and product complexity (categorised as low versus high complexity), ensuring equal representation across these categories.

The discussion will be structured around the interview questions: “What are the key features of resilience in the supply chains of the aviation manufacturing sector in China?” and “How and why do these features influence supply chains?” Following this, the cross-case analysis will elaborate on the findings in relation to ownership type, company size, product complexity, and business perspective.

Overall summary of findings on SQ2:

Regarding SQ2 it was found that out of the 16 features identified from the literature and the Stage 1, eleven have been discussed in Stage 2, case study: capacity management and rate flexibility, management of buffers and inventories, team capability, management of SCs, behavioural flexibility, quality levels, alternative availability, prioritisation, financial capacity, international logistic network, and risk awareness. Furthermore, one new feature has emerged during the case study discussion: digitisation. Additionally, the discussion addressed the impact of these features of SCR, particularly through their capacity to enhance the delivery of products to customers. The discussion also explored the reasons behind the influence of these features on resilience, revealing that there is frequently a direct correlation with capacity, facilitated by targeted actions such as the enhancement of capabilities, proactive risk anticipation, and effective prioritisation.

Features of resilience

A feature refers to a distinctive attribute or trait inherent to an object or entity. It encompasses the specific characteristics that set it apart from others, providing a unique identity or functionality (Patrucco et al., 2022, Kegenbekov & Jackson, 2021). Features can be physical, such as the colour, shape, or size of an object, or they can be abstract, such as a particular skill, capability, or quality that defines a person or system (Christopher & Holweg, 2011).

In the context of products, features are often highlighted to showcase the advantages and benefits they offer to consumers. For example, a smartphone may have features like a high-resolution camera, long battery life, or advanced security options, all of which contribute to its appeal and usability (MacPherson & Pritchard, 2007). In technology, features can also refer to software functionalities, such as user interface elements, integration capabilities, or performance metrics that enhance the user experience (Kazancoglu et al., 2022, Akerman et al., 2020, Brennan et al., 2019).

Overall, features play a crucial role in differentiating entities within a theme, influencing choices and preferences, and ultimately shaping perceptions and experiences. They are essential for understanding the value and purpose of an object or entity in various contexts, whether in marketing, design, or analysis.

Figure 4.5 identified the features of resilience as:

- Risk awareness
- Management of SC
- Financial capability
- Management of buffers and inventories
- Management of capacity and rate flexibility
- Availability of alternatives
- Behavioural flexibility
- Quality levels
- International logistics network
- Integrated technology
- Empowerment of workforce

- Prioritisation
- Team capability
- Manufacturing methods
- Sustainability challenges
- Partnership approach

Within-case analysis CSA

The following section will focus on case CSA, emphasising the features observed. Both interviewee CSA01 and CSA02 concur that quality levels are an important feature of resilience that influences SCs. Interviewee CSA01 discussed the feature of financial capability and how it influences SCs. Interviewee CSA02 contributed four key features of resilience: international logistics network, management of buffers and inventory, prioritisation, and team capability.

Quality levels

The two interviewees, CSA01 and CSA02, emphasised that superior quality levels were a crucial feature of resilience that impacted the SC performance. CSA02 remarked: *"One key feature is the consistency in quality of our deliveries. We need 100% quality, and this is vital for our production. Inspectors ensure this either by measurement, paperwork or testing. That way, we ensure continuous quality outputs and smooth internal production."* Furthermore, interviewee CSA01 provided a strategic viewpoint, indicating that the feature was essential for the comprehensive planning of the customer delivery schedule. The commitment to established processes, along with consistent quality in both production and components, was deemed a critical requirement. CSA01 said: *"The most crucial aspect we must safeguard is the quality of our production, our components, and our processes. This enables us to effectively plan our output deliveries and ensure customer satisfaction."* In summary, both CSA01 and CSA02 concurred that the levels of quality represent a significant feature of resilience that has a direct impact on SC performance and customer delivery outcomes.

Financial capability

From a strategic perspective, Interviewee CSA01 highlighted financial capability as a critical feature that enhances resilience within the SC. The case examined CSA's capacity to procure additional inventory, thereby guaranteeing the availability of necessary parts and materials. Furthermore, the organisation effectively utilised its financial capability to pay its employees, suppliers, and its network of partners. This strategic approach facilitated uninterrupted production processes. The interviewee, CSA01, remarked: *"Our company has the financial capability to buy inventory and to keep operations ongoing."* This feature facilitated uninterrupted production by enabling

financial transactions with suppliers. Employees were able to maintain their work as they received their salaries. Sufficient financial resources guaranteed that disruptions were minimised, thereby serving as a crucial feature that directly impacts the resilience of the SC.

International logistics network

Interviewee CSA02 (operational viewpoint) offered an example demonstrating the availability of logistical capabilities of CSA and their impact on SCs. The robust connections with regulatory bodies and logistics firms facilitated prompt processing, ensuring that parts were delivered to the customer without delay. CSA02 remarked: *"With logistics, we send shipments and organise our SC flows. It's really a critical component during the pandemic. We see many parts stuck in customs or in transit and never reach. So, with our network of customs and logistic partners, we are able to prioritise the incoming logistics. And final products go straight to the customer. So, the stronger the logistics is, the more we can rely on the SC to deliver on time."* The availability of an international logistics network facilitated the receipt of parts from suppliers and the distribution of products to customers. This availability significantly enhanced the resilience of SCs, as it enabled efficient logistics operations on a global scale. Without such a network, suppliers and customers would face isolation, hindering the delivery of essential parts and products. Establishing this network necessitated a contractual framework that outlines terms and conditions, including delivery lead times and specific details regarding pick-up and drop-off locations. In summary, the existence of an international logistics network is crucial for maintaining connectivity between suppliers and customers, thereby ensuring that SCs can effectively deliver parts to manufacturing facilities when required.

Management of buffers and inventory

Interviewee CSA02 also highlighted that the management of buffers and inventories constitutes a critical feature of resilience impacting the SC. Effective planning, a structured approach, problem-solving capabilities, and a committed organisational framework are essential for fostering adequate SCR. CSA02 said: *"The logistics and inventory management are impacting the SC every day. We expedite and receive products daily. Any logistics problem will lead to delivery issues. So, we rely on a*

strong logistics and transport department. The same is true for inventory. We plan very detailed. The inventory will determine reordering points; it will provide the stock level and so on." Inventory management plays a crucial role in SCR, primarily due to its capacity to absorb shocks. It reflects the organisation's capability, particularly in the context of case CSA, to endure disruptions over a specified duration. This system of engagement was linked to inventory management and possessed the ability to maintain adequate stock levels, thereby preventing shortages. CSA02 said: *"We maintain our warehouses with several months of stock on critical components. On some specific material, we are limited by shelf life, and there we have to evaluate the cost of scraping and the cost of running out."* Furthermore, CSA02 highlighted that the characteristic of resilience is facilitated by CSA's possession of essential infrastructure, including warehouses, as well as its financial capacity to invest in inventory. In summary, effective management of inventory and buffers was a vital aspect of SCR.

Prioritisation

Prioritising customer needs is an essential feature of resilience as suggested by interviewee CSA02. Some customers may show urgency based on preference rather than true necessity. A robust SC effectively prioritises genuine business requirements. However, within CSA, non-commercial initiatives often take precedence over actual business needs, limiting the ability to prioritise effectively. Nonetheless, CSA's policy clearly outlines its customer hierarchy. CSA02 said this: *"The SOE clearly prioritises non-civil projects, and it's something that needs to be managed. Even if it means that we need to adjust to the SOEs plan."* Non-commercial projects were prioritised to meet the CSA customer needs, primarily because it operates as a SOE. Consequently, commercial projects were regarded as secondary in terms of development, production, and delivery. This prioritisation was further influenced by the financing model, which relied heavily on State funding. Therefore, prioritisation is the most important factor for resilience in the SC.

Team capability

An additional feature of resilience pertains to the capability of the team was nominated by interviewee CSA02; specifically, a higher level of capability enables more effective navigation through challenging circumstances, such as those experienced during the recent pandemic. The expertise and abilities of the procurement team can be leveraged to collaborate with the SC in developing solutions. In the instance of CSA, it has been noted that the procurement team has engaged with the SC to improve and optimise delivery processes and purchase order timelines, ultimately resulting in enhanced delivery schedules. CSA02 said: *"Procurement manages the purchase orders, dates and deliveries. As we manage many suppliers, we need a large team for the job."* This feature significantly improved schedules and created a mutually beneficial scenario for the SC. By enabling negotiation, identifying alternative suppliers, and adjusting priorities, suppliers can optimise their delivery processes, particularly during the difficult periods of a pandemic. Consequently, the competencies of the team play a crucial role in enhancing resilience within the SC.

In summary of the case study CSA, six essential features of resilience have been analysed. Both interview participants agreed that quality levels represent a crucial feature. Interviewee CSA01 addressed financial capabilities, while interviewee CSA02 provided insights into the international logistics network, the management of buffers and inventories, the prioritisation of demands, and the competencies of the team as features of resilience that impact SCs. Additionally, the discussion highlighted the ways how and why these features impact SCR.

Within-case analysis CSB

The section will concentrate on case CSB, highlighting the common features identified among the interviewees CSB01 and CSB02. Following this, the discourse will explore CSB01's perspective on alternatives available, then proceed to analyse CSB02's viewpoint that discussed management of buffers and inventories, culminating in a comprehensive assessment of case CSB. Both interview participants emphasised the importance of team capability within the SC as feature as well as capacity management and rate flexibility.

Team capability

CSB01 and CSB02 illustrated that team capability serves as an essential feature of resilience and to ensure knowledge management, safeguarding proprietary knowledge within the organisation and preventing its transfer to subcontractors. The potential risks associated with subcontractors, such as their disappearance, mergers, or failures, could result in the loss of valuable knowledge. CSB01 emphasised this point: *"We have vertically integrated the core processes to keep our knowledge under control."* Essential operations and core processes were conducted internally, thereby minimising reliance on an external SC. The significance of these processes, highlighted by CSB02 as a feature of resilience, was crucial for maintaining product integrity: *"For resilience the process is important as it is the point of reference for the product and serves as reference."* The presence of local resources enhanced capacity through collaborative strategies. Unique network configurations provided specific raw materials that played a significant role in bolstering local capabilities and increasing knowledge about the product. CSB02 remarked: *"We negotiate with local material production capacities."*

In the context of intricate products or SCs, international OEMs typically restricted the utilisation of locally sourced materials. This restriction resulted in a heightened reliance on the OEM during periods of recovery or disruption, given the limitations in available capacities. CSB02 remarked: *"However, that's not usually the case for the international OEM. On this case, they don't usually give the local approvals away and they want to keep control."* The current SC circumstances compelled CSB to implement targeted inventory management strategies for international imports to

mitigate the impacts of fluctuations, including delayed logistics, lost shipments, and other unforeseen events. *“CSB depends on overseas suppliers. So CSB inventory is like an extension of suppliers. We try to keep it high to absorb fluctuations in supplies.”* In summary, the feature of team capability encompasses a range of sub elements that collectively form a localised ecosystem. These sub elements consist of knowledge management, inventory management strategies, local sourcing practices, and logistics, all of which are integral to vertical integration and significantly enhance the resilience of the SC.

Capacity management and rate flexibility

Both CSB01 and CSB02 identified capacity planning and rate flexibility as crucial features of resilience. This feature enhanced SCR by minimising dependencies, thereby enabling the generation of local capacity to meet local demand. Consequently, intricate SCs that involve the global transportation of parts and materials are streamlined, leading to a reduction in shipping routes, complicated planning processes, and prioritisation challenges. CSB01 remarked: *CSB01 said: “Local sourcing allows us to plan our capacity accordingly. Dependency on SCs is reduced, particularly on global SCs.”* The establishment of local sourcing initiatives did garner significant backing from local authorities and political stakeholders, facilitating effective implementation within the Chinese context. The concept of political support was thus integral to this process. CSB02 further elaborated: *“Once top-level decisions are taken, we will perform the task given to us.”* In summary, the analysis of the feature capacity management and rate flexibility indicated that local sourcing enhanced capacity, minimised planning requirements, and facilitated prioritisation. Additionally, political backing played a crucial role in the implementation process. Consequently, capacity management and rate flexibility emerged as vital feature of resilience.

Alongside the characteristics that both interviewees agree upon, there are two additional features that were not mutually acknowledged. Interviewee CSB01 will elaborate on the alternatives available as an additional aspect of resilience, while interviewee CSB02 will address the management of buffers and inventories as a resilience feature that has been observed.

Alternatives available

Interviewee CSB01 emphasised that the presence of industrial alternatives is a crucial feature of resilience that has a direct impact on SCs. The existence of secondary sources and redundancies allowed CSB to select a different supplier rather than relying solely on the traditional one. This capability not only increased operational capacities but also improved collaboration with the new supplier. As a result, deliveries were maintained, and SCs were secured. CSB01 remarked, *“Double sources are supporting SC alternatives and quick actioning alternatives. So, we have alternatives and more capacity.”* The availability of alternatives played a significant role in enhancing the overall performance of the SC.

Management of buffers and inventories

The capability for managing buffers and inventories was introduced by CSB02. The interviewee previously identified inventory levels as a critical component of resilience and provided further insights into the management of these levels. This management process not only dictates the appropriate size of buffers and inventories but also involves the analysis of various data, including configurations. CSB02 remarked, *“We not only maintain a high inventory but also adaptively manage it based on current circumstances. For example, configurations, shelf life, and references must be carefully overseen. It is a sophisticated skill that requires ongoing attention.”* Consequently, the management of components will influence the size of order batches, the strategies implemented, and even the placement of buffers and inventories. Moreover, effective management can significantly mitigate SC disruptions, as evidenced by CSB. Thus, the management of buffers and inventories has emerged as a vital aspect of resilience that affects SC dynamics.

The case CSB has highlighted two fundamental features of resilience that impact SCs, which were unanimously recognised by both interview participants: the first dimension is the capability of the team, while the second relates to the management of capacity and flexibility in rates. Furthermore, CSB01 noted that the availability of alternatives was a significant feature of resilience, and interviewee CSB02 emphasised the importance of the management of buffers and inventories.

Within-case analysis CSC

The subsequent section will concentrate on case CSC, highlighting the common features identified among the interviewees CSC01 and CSC02, followed by the individual perspectives. Both interview participants emphasised the importance of capacity management and rate flexibility as feature of resilience. CSC01 incorporated management of SC as a feature of resilience, while CSC02 introduced team capability as a feature of resilience that impacts SCs.

Capacity management and rate flexibility

Rate flexibility within the production system refers to the extent to which minor modifications can be implemented in the production process without significantly affecting resource planning and ensuring timely deliveries. Both interviewees noted that flexibility was a feature they had observed to positively impact resilience within the SC. Interviewee CSC02 said: *“We can adjust more easily and accommodate some changes, for example in the commercial furnishing.”* Even though CSC01 said: *“Our production depends very much on the deliveries ...”* It was essential to establish a harmonious balance between the degree of flexibility and the strictness in execution. It can be argued that a certain degree of flexibility was evident in the case of CSC. When modifications to delivery schedules were communicated, CSC had the capacity to plan accordingly, enabling adjustments to shifts and the rescheduling of content, whether by advancing or postponing it, all while maintaining uninterrupted customer deliveries. However, it was essential to acknowledge that any change incurred associated costs that had to be considered. This inherent flexibility fostered a level of resilience concerning production continuity. For example, if a specific part was unavailable, production would still proceed, albeit at a less-than-optimal efficiency, without any disruption. Consequently, rate flexibility embedded within the production system emerged as a critical attribute, enhancing agility in supplier deliveries and contributing to the overall resilience of the SC.

Management of SCs

Interviewee CSC01 emphasised that the management of SCs i.e. coordinating suppliers, represent a crucial feature of resilience, influencing the overall performance of the SC. Thus, posited that effective management of SCs constituted an additional

feature of resilience within the SC framework. The extensive array of parts assembled by CSC necessitated careful coordination to ensure their timely arrival and synchronisation. An imbalance, such as an excess of parts from supplier A coupled with shortages from supplier B, undermined operational efficiency. CSC01 said: *“Due to the complex SC that we operate, we need all parts to be synchronised with our system. It needs to operate like clockwork. This is the job of our SC department.”* Therefore, the responsible department was tasked with the coordination of all parts and their respective deliveries. The intricacy of a SC configuration directly correlated with the difficulty of this coordination. A comprehensive understanding of product specifications and the production timeline was essential to grasp the ramifications of any disruptions within the SC. For example, in the event of material shortages, the procurement team had to identify and to suggest viable alternatives. The expertise and capability of the procurement team to maintain parts availability amidst complexity, as well as to facilitate synchronisation within the SC, significantly influenced the overall resilience of the SC. Early identification of impacts, assessment of consequences, and the proposal of alternatives contributed to the establishment of an agile and adaptable SC, capable of withstanding various challenges to its conventional operations. The efficient management of SCs was thus a crucial feature of resilience.

Interviewee **CSC02** emphasised that team capability was a crucial feature of resilience, influencing the overall performance of the SC, which will be elaborated upon in the following section.

Team capability

From an operational viewpoint, interviewee CSC02 emphasised that team capability was a crucial feature of resilience, influencing the overall performance of the SC and was demonstrated through recent initiatives in employee training. Interviewee CSC02 indicated that these efforts improved the skill set of the workforce. Additionally, it is possible that this training bolstered both self-esteem and team cohesion. As a result, the dynamics and energy levels within the team experienced a notable enhancement in comparison to the period prior to the crisis. CSC02 said: *“The training and job rotation programs we implemented for our employees greatly improved the team's*

overall skill set. Also important was the development of a strong team spirit. Despite the challenges imposed by lockdowns and restrictions, the energy and dynamics within the team reached new levels after the pandemic concluded, enabling us to confront significant challenges as one unified team.” The observed level of energy and dynamism may stem from an enhanced ability to manage complex issues, a deeper comprehension of processes, and an increase in training and related skills. Additionally, this may be attributed to a greater sense of self-confidence that has been fostered through training and job rotations.

In summary, both participants in the interview underscored the importance of capacity management and rate flexibility as vital features of resilience that influence SCs. Interviewee CSC01 highlighted that effective SCM is a key feature of resilience. Additionally, Interviewee CSC02 contributed to this perspective by identifying team capability as a critical feature that enhances team dynamics and fosters a collective approach to problem-solving.

Within-case analysis CSD

The subsequent section will concentrate on case CSD, highlighting the common features identified among the interviewees CSD01 and CSD02. Following this, the discourse will explore CSD01's perspective, then proceed to analyse CSD02's viewpoint, culminating in a comprehensive assessment of case CSD. Both interview participants emphasised the importance of capacity management and rate flexibility as well as behavioural flexibility as key features of resilience influencing SCs. Interviewee CSD01 emphasised prioritisation as a significant feature, while interviewee CSD02 highlighted the availability of alternatives as a crucial feature of resilience.

Capacity management and rate flexibility

Both interviewees assessed the ability for capacity management and rate flexibility as an essential feature of resilience. CSD01 emphasised its critical importance for industrial operations: *“For me resilience at CSD is the preparedness to ramp-up the production on quality, with the adequate skills ready.”* The SC faced financial burdens to meet quality standards and ensure skilled availability. However, costs from unpreparedness and inadequate capacity, especially contractual penalties, could surpass these expenses. To manage capacity effectively, the SC regularly assesses investment strategies, supplier competencies, and internal performance metrics.

CSD01 added: *“We regularly review all the actions that we have in place to ensure the ramp-up, it includes sub suppliers and their investment plans, as well as our data of operator efficiency.”* This follow-up on ramp-up strategies enabled the supplier to regain capacity after the adverse event, boosting production. The team's readiness and flexibility were crucial for enhancing SCR through effective ramp-up measures. Additionally, CSD02 noted that the team's skills significantly impacted the quality of processes and communications: *“Workforce qualification is key as it reflects on the product quality. We miss a process step; we mess up an operation and the part are scrapped. So, we need to reenforce and continuously keep the skill level sharp.”* Alongside workforce capacity, the effective management of production capacity had been identified as crucial. This was particularly relevant in terms of its effects on bottlenecks and overall capacity within the SC. CSD02 stated: *“We have long-term*

planning for example on our composite material to avoid shortages. The regular capacity simulation helps us identify bottlenecks and we manage accordingly." In summary, the ability to orchestrate a series of actions to facilitate ramp-up capability is a crucial feature of resilience that impacts SCs.

Behavioural flexibility

The interviewees identified behavioural flexibility as an additional characteristic of resilience while discussing case CSD. They both agreed that it was essential for individuals to maintain a flexible approach to business during challenging periods to enable the exploration of solutions and alternatives for addressing intricate issues. Even with established plans and delivery timelines, unforeseen events, such as delays in shipments or absent parts, did arise. Consequently, incorporating a degree of flexibility within the system was deemed a vital aspect of resilience, as noted by CSD02: *"We need to stay flexible and even a bit creative when we are faced with shortages or limitations. We expect processes and flexibility. But hard to achieve."* From a strategic standpoint, CSD01 highlighted the challenges to flexibility and underscored the necessity for precision and proper implementation: *"We need to get the priorities right. All of them."* In summary, behavioural flexibility constitutes a significant feature of resilience that impacts SCs.

Prioritisation

The concept of prioritisation is an additional feature of resilience highlighted by CSD01 (strategic perspective). It was emphasised that the implementation of actions must align with the appropriate priorities. During periods of constrained resources and time, particularly for executives, managers, and team leaders, it was essential to concentrate on these priorities. CSD01 stated: *"We need to get the priorities right. All of them."* An example of a critical decision-making scenario involved determining whether to focus on enhancing customer visibility regarding order status or to assign a production slot to a new customer, particularly when resources are constrained. It was essential for such inquiries to be explicitly resolved, with clear guidance provided through the management hierarchy across the SC. This approach helped prevent misalignment of priorities and minimises time spent in debates over priorities instead of acting. By establishing appropriate priorities, the pathway to reinstating standard

levels within the SC became more transparent, effective, and efficient, thereby bolstering SCR. Prioritisation is therefore a key feature of resilience that influences SC directly.

Alternatives availability

From an operational viewpoint, interviewee CSD02 highlighted the significance of the availability of alternatives, noting its impact on SCs. This inherent characteristic allows customers to change suppliers, engage in competitive practices, and respond more swiftly to their needs. Interviewee CSD02 said: *“The availability of local sources that we have is a feature that strongly influences the SC. If overseas suppliers don’t respond we can switch to local production. That way we are more agile, keep competition and can respond to the demand faster.”* The establishment of alternative options necessitates extensive supplier qualifications, which demand significant investment. Nevertheless, this approach provides substantial negotiation leverage, facilitating enhanced cost transparency and an increase in available capacity. It is important to note that alternatives may not be applicable in every situation. Specifically, they may not be suitable for highly complex or capital-intensive products. The existence of alternatives is more defensible for commodities and analogous products that are subject to trade, as opposed to those that are specifically developed. Consequently, SCs are influenced by an increase in agility, a reduction in response time, and enhanced transparency regarding inventory and costs.

In summary, the examination of case CSD revealed four essential characteristics of resilience that were assessed concerning their impact on SCs. Initially, both participants underscored the significance of capacity management and rate flexibility, and behavioural adaptability. Subsequently, CSD01 accentuated the importance of prioritisation as a critical feature. In addition, interviewee CSC02 supported this perspective by noting that the availability of alternatives, especially alternative suppliers, constitutes a feature of resilience that has a direct effect on SCs.

Within-case analysis CSE

The case CSE reveals three features of resilience that will be discussed. The first, feature, capacity management and rate flexibility was discussed by both interviewees. Following this, CSE01 addresses quality levels as a fundamental feature of resilience. In conclusion, CSE02 wraps up the discussion by providing insights into the management of SCs.

Capacity management and rate flexibility

Interviewees CSE01 and CSE02 identified capacity management and rate flexibility as a significant feature they had noted. They provided an example of rate flexibility by highlighting the strategic selection of suppliers based on business requirements. This selection may involve domestic sub-suppliers, international suppliers, or leveraging internal capabilities to ensure capacity constraints. CSE01 remarked: *“You see there are some parts that are so specialised, it really would take so much time and effort to set-up an additional domestic source. It’s much better to buy internationally and have ..., if the part is not available, we need to work with the OEM to find alternatives.”*

The fulfilment of deliveries was crucial; therefore, the inventory strategy had to be modified to prioritise completeness over the management of large volumes, as indicated by CSE02: *“In our product we have a wide range of components and part numbers. ..., I need not so much large inventory but completeness. Any missing part number could block the full shipset. So, the accuracy and attention to detail on the completeness, that’s the resilience for me.”* The interplay between pricing mechanisms and consumer demand was bolstered by an additional element of resilience, namely the implementation of an IT system. CSE02 indicated that: *“Planning data comes to us with the IT platform of our customers.”* The appropriate selection of suppliers had to be based on their capabilities, with a preference for local suppliers rather than engaging in more complicated import processes. This perspective was highlighted by CSE02: *“A component of SCR is to use the capability of our SC for the right part at the right time. That way we can reach a competitive advantage. Use local suppliers, when possible, use global when required.”* However, it was essential for the SC to exhibit a similar level of flexibility, as contracts were deferred, delayed, terminated, or expedited. Consequently, the adaptability of capacity was a crucial element of

resilience, as indicated by CSE02. *“We rely on a local supply base that is highly innovative and flexible. This helps when we face sudden changes in demand.”*

In summary, rate flexibility served as a crucial feature of resilience, encompassing various elements that contribute to its effectiveness. These elements included sourcing strategies, management of bottlenecks, IT interconnectivity, and commercial factors. Consequently, rate flexibility emerged as a vital feature of resilience that significantly impacts SC dynamics.

Quality levels

Interviewee CSE01 elaborated on the aspect of quality levels of resilience and its influence on SCs from a strategic viewpoint. Notably, the team’s capacity to address quality-related challenges was emphasised. The training and experience accumulated by the team significantly enhanced their proficiency. As an illustration, the interviewee cited a scenario where the team employed a systematic approach to identify issues and solutions. Subsequently, these solutions underwent testing and validation. CSE01 said: *“The Problem-solving skills are essential... The teams deployed systematic methodologies, supported by prior quality training to enhance these capabilities. They successfully identified the root causes of the issues, for example on the missing temperature control of facilities, ... Subsequently, these remedies were validated. This, of course, has a direct impact on our capacity to manage SC performance effectively.”* Problem-solving is a skill that requires development. As a team gains the right skills and experience, they can effectively tackle complex challenges, reducing reliance on the SC and speeding up solution identification. Validating these solutions as sustainable is crucial, ultimately enhancing outcome quality and impacting SC dynamics. The subsequent feature of resilience, particularly the capacity to oversee SCs, was emphasised by CSE02.

Management of SCs

On the other hand, interviewee CSE02 said that SCM constituted a significant feature of resilience that had been noted from an operational viewpoint. In spite of a complex SC configuration, which included the outsourcing of intricate parts and specialised processes, as well as fluctuations in planning and customer demands, it was essential

for deliveries to be executed punctually. CSE02 said: *“We have local representatives that manage the supplier to achieve a good level of resilience. We need to provide the right demand and forecast, and technically the suppliers are very capable. Of course, sometimes we have delivery delay due to customs or transport...”*

The case study highlighted the importance of SCM and local representation. Proximity to international suppliers facilitated regular communication and oversight, mitigating challenges like distance, language barriers, and time zone differences, which improved delivery efficiency and overall SCR. Effective navigation of complex global SCs emerged as crucial for operational resilience.

Both interviewees agreed that capacity management and rate flexibility are essential for SCR. Interviewee CSE01 discussed the impact of quality levels on SC dynamics, while Interviewee CSE02 emphasised the importance of management capabilities during crises.

Within-case analysis CSF

The next section will focus on case CSF, emphasising the shared characteristics noted among the interviewees CSF01 and CSF02. Subsequently, the discussion will delve into the perspective of CSF01, followed by an analysis of CSF02's viewpoint, ultimately leading to a thorough evaluation of case CSF. Both interview participants underscored the significance of capacity management and rate flexibility and management ability over SCs as critical features of resilience that impact SCs.

Capacity management and rate flexibility

Both interviewees highlighted this feature, which had also emerged in other instances, emphasising the SC's capacity to guarantee the availability of resources, including human and financial investments. CSF02 said: *"The availability of our operators is a strong point we have and that helps to ramp-up quickly again."* CSF achieved this by standardising its operations, maintaining its workforce, and developing a significant reservoir of potential candidates who can quickly perform tasks like machine operation. This case exemplified the balance struck between essential roles that require extensive qualifications and simpler positions that relied on standardisation and clear instructions.

Internal redundancies (a component of resilience) encompass both the quantity of personnel and the competencies of the team. In particular, the ability to effectively manage the increase in workforce capacity and skill set was identified as a critical element of organisational resilience. CSF02 said: *"Then for the ramp-up we need material and people. Material shortages are evident. And we miss people as this would allow us to accelerate. So, more people are required."* An alternative approach involved incorporating redundancies within the SC by utilising a subcontractor that possesses external qualifications, as stated by CSF01: *"The redundancy allows us to increase capacity and to meet customer demand. We can tap into double sources, meaning we have twin sites and multiple qualified suppliers. This redundancy is flexibility."* CSF01 commented: *"The redundancy allows us to increase capacity and meet customer demand. We can tap into double sources, meaning we have twin sites and multiple qualified suppliers. This redundancy is flexibility"*. Redundancies may exist within an organisation, indicating that various locations possess identical

capabilities. In summary, the capacity for ramp-up encompasses a broad range of factors that characterise resilience. The availability of various parts such as operators, the accessibility of parts, as well as the existence of redundancies and a diverse pool of qualified suppliers, all play a significant role in enhancing the feature of ramp-up capability.

Management of SCs

Both interviewees confirmed the management over SCs as a key feature of resilience. A clear responsibility was seen with the relevant teams to manage contracts and deliveries of the SC. The adequate team was required in order to utilise tools, methods and negotiation in order to achieve the delivery times that are required. CSF02 said: *“Our procurement team has the job to manage all the deliveries and enforce the contractual terms.”* From a strategic perspective the expectation on the procurement team was to be flexible and to keep transaction cost at a minimum. The effort on administration needed to be at a minimum. Full responsibility was also to be able to navigate switching suppliers, adding suppliers or developing new suppliers. CSF01 said: *“It is less administrative and bureaucratic to switch suppliers, to activate new suppliers, or to work on alternatives”*. In summary, both the operational and strategic viewpoints underscore that the capacity of management to oversee SCs is a crucial feature of resilience that impacted SC effectiveness.

Behavioural flexibility

Interviewee CSF01 added behavioural flexibility as a feature of resilience. Specifically, a significant level of adaptability and rapidity was evident, particularly in the context of changing suppliers. Additionally, there was an increase in the capacity to approve alternatives, alongside a reduction in administrative costs. CSF01 said: *“It is less administrative and bureaucratic to switch suppliers, to activate new suppliers, or to work on alternatives.”* The adaptability observed in behavioural flexibility stems from the competitive nature of the private market. Within this market, ongoing evaluations of suppliers yield alternative options that can be utilised as necessary. In conclusion, behavioural flexibility is a crucial characteristic when discussing the resilience of SCs in the private sector.

Digitisation

Finally, CSF02 added digitisation as a newly emerged and as an essential feature of resilience. In the preliminary phase, demand planning was conducted via IT systems throughout the SC. This facilitated the cascading of information and ensured that all suppliers were in sync. CSF02 remarked: *“Our demand planning is sent through IT system to our suppliers.”* This approach guaranteed the minimisation of errors and facilitated a certain level of synchronisation throughout the SC. Furthermore, CSF02 indicated that digitisation possesses significantly enhanced capabilities for utilising data in forecasting, as well as for supporting real-time decision-making, risk anticipation, and scenario planning. CSF02 said: *“...more advanced models for forecasting will be deployed...”* As a result, it was expected that this feature of resilience would become increasingly important in the future and may possibly include further features, such as inventory management or prioritisation.

In summary of the case study concerning CSF, both participants agree that effective capacity management and rate flexibility, and SCM are essential features of resilience that influence SCs. Furthermore, interviewee CSF01 emphasised the importance of behavioural flexibility as a critical feature of resilience. Interviewee CSF02 highlighted the role of digitisation as a novel feature in shaping SCs.

Within-case analysis CSG

The next section will focus on case CSG, emphasising the shared characteristics noted among the interviewees CSG01 and CSFG02. Both interviewees concur that capacity management and rate flexibility are a key feature of resilience. Following this, interviewee CSG01 addresses the management of buffers and inventories, while interviewee CSG02 emphasises the importance of risk awareness as a critical aspect.

Capacity management and rate flexibility

Both interviewees stated that capacity management was essential to meet customer demand. The case of CSG had already established capacity plans to increase production sites through double sources. This allowed to deliver more products to the customer and was a key feature to resilience. CSG01 said: *“We can tap into double sources, meaning we have twin sites and multiple qualified suppliers.”* Interviewee CSG02 provided additional insights regarding the challenge of adequately staffing the capacity management plan with enough personnel capable of enhancing production capacity. CSG02 said: *“Within the management of capacity the most challenging on adding workers, it’s difficult to find the heads we need to fill production positions. Also, quality resources have proven to be challenging.”* Capacity management involved contingency planning and systematic documentation of customer demand, leading to actions like workforce expansion to meet capacity needs. This strategy effectively addressed demand, as confirmed by the resulting output. Overall, it enhanced resilience in fulfilling customer demand.

Management of buffers and inventories

The interviewee CSG01 emphasised that the management of inventories constitutes a fundamental feature of resilience. This management strategy varies according to the type of product, necessitating distinct approaches to inventory control. In general terms, the risk of inventory depletion tends to be greater for complex products. Conversely, it was observed that the JIT methodology and philosophy are particularly applicable to commodities, as noted by CSG01: *“To me, JIT represents a feature of resilience. It goes beyond just managing stock levels; it’s a whole philosophy that defines the SC. It’s about being lean, getting only what you need, cutting down on waste, and relying on suppliers. That said, we should evaluate whether JIT is the best*

fit for our industry. We have seen some cases where it worked just fine, such as chemicals and paints, others, such as detailed parts, where we ran into production stops due to missing inventories.” The analysis revealed that some JIT strategies were effective, particularly for commodities. However, production was disrupted for complex components due to low inventory levels. JIT inventory management is closely tied to the supplier-customer relationship, which can range from minimal to substantial dependency. A strong relationship should be built on trust, communication, and reduced risk, while high dependency can lead to delivery disruptions that affect production. Therefore, effective inventory management is crucial for enhancing SC efficiency.

Risk awareness

CSG02 highlighted risk awareness as a crucial feature in SCs, noting a significant increase in risk consideration across the organisation. Employees consistently factored in risks during decision-making, particularly regarding outsourcing. They carefully evaluated potential delays, qualifications, expertise, and other relevant criteria, raising expectations beyond mere price comparisons to include technical assessments. CSG02 stated: *“A feature that has developed over the last few months is the general risk awareness. ... It’s not about the solving it but raising awareness to peers and colleagues ..., we evaluate if they are qualified, available, knowledgeable, etc. Subsequently the relevant procedures will manage the risk.”* The awareness of risk serves as a critical element by prompting users to evaluate their choices prior to making decisions. Proposals originating from the SC undergo thorough examination to assess potential risks and to present the most advantageous overall proposal. As a result, risk awareness plays a significant role in enhancing the resilience of the SC.

In summary of case CSG, it is observed that both interviewees emphasised the importance of capacity management and rate flexibility. Interviewee CSG01 further highlighted the management of buffers and inventories as additional features. Meanwhile, Interviewee CSFG02 pointed out that risk awareness serves as a resilience feature that impacts SCs.

Within-case analysis CSH

During the interviews conducted with participants of CSH, the respondents emphasised various attributes associated with resilience. One particular feature of resilience that was acknowledged by both interviewees is financial capability. This feature of resilience that influences SCs will be discussed further, followed by the features specific to interviewees CSH01 (quality levels) and CSH02 (behavioural flexibility) respectively.

Financial capability

Interview participants emphasised the significance of financial capability in influencing SCs, noting that financial resources are crucial for resilience. They highlighted that CSH's financial capability reflects resilience and affects SCs, focusing more on its strategic implications than on the actual monetary amount. CSH01 expressed this perspective strategically: *"A feature that we have is the financial capability to build confidence. We can sign contracts, negotiate, and give perspective to our SC."* CSH02 with the operational perspective added the view that the financial capability removed the constraints from short term planning and that CSH was able to tackle long term and strategic topics. CSH02 said: *"Our financial resources enable us to adopt a strategic approach to our core issues. We are not constrained by the need to manage short-term cash flow, allowing us to focus on long-term planning and negotiations."* Therefore, financial capabilities are a feature of resilience that influences SCs strategically.

Quality levels

Interviewee CSH01 identified quality levels as a significant aspect of resilience. The discussion extended beyond merely the quality of the product or process; it also encompassed the mindset associated with these quality levels. This mindset was characterised by a commitment to continuous improvement, ultimately striving for zero defects and optimal quality. As a result, the SC evolves into a completely dependable resource. CSH01 said: *"Quality levels keep rising. We need to elevate them further, both internally and across the SC: raw material, parts, and services. At the end it's ... total quality management. That way we shape our SC for the future."* The interviewee indicated that the quality levels within the SC were improving. This enhancement

yielded advantages such as a decrease in concessions and defects. Additionally, the overall costs throughout the SC were diminished due to a reduction in waste. The SC experiences positive outcomes from the heightened quality levels, as their processes attained greater stability. Consequently, quality levels serve as a feature of resilience that impacts SCs.

Behavioural flexibility

CSH02 indicated that the organisation successfully integrated the appropriate personnel at critical moments to execute the necessary tasks. Flexibility was attained through the implementation of shift work and the provision of overtime. This suggests that there was backing from unions and the works council for these shifts during challenging periods. CSH02 stated: *“We mobilised our people They were all on board, keeping the company interest as first goal.”* A pertinent illustration regarding the SC department highlighted the necessity of not only evaluating suppliers but also addressing and resolving identified issues. This approach facilitated effective supplier management. CSH02 stated: *“The gaps on assessments have to be closed, issues resolved with action plans as these will be the weakness in times of crisis.”* The ability to engage with stakeholders and attain adaptability reflected a robust commitment to collaboration among all involved parties. This approach significantly influenced the resilience of the SC through a focus on outcome-driven actions. Therefore, behavioural flexibility contributed as a feature of resilience to SC performance.

In conclusion of case CSH, both participants recognised the significant impact that financial capabilities exert on the SC. Interviewee CSH01 contributed to the dialogue by highlighting the aspect of quality levels, while Interviewee CSH02 emphasised behavioural flexibility as a crucial feature of resilience.

Within-case analysis CSI

The forthcoming section will concentrate on case CSI, highlighting the common traits identified among the interviewees CSI01 and CSI02. Following this, the discourse will explore the insights of CSI01 (team capability), and then proceed to an examination of CSI02's perspective (capacity management and rate flexibility, and management of buffers and inventories), culminating in a comprehensive assessment of case CSI. Both interviewees emphasised the importance of vertical integration in SCs as essential feature of resilience that influence SC dynamics.

Availability of alternatives

Both participants in the interview emphasised the significance of alternative options as a characteristic of resilience that influences SCs. Specifically, CSI01 highlighted successful instances that resulted in increased capacity and the availability of alternative locations. This development yielded various commercial advantages and enhancements within the SC such as capacity, reliability and lead-times. CSI01 said: *“For me it’s our continuous discussion about qualifying alternative sources for material. We have come a long way and can already propose alternative sites, but there is still a lot to be done.”*

Alongside the strategic viewpoint, CSI02 incorporated an operational dimension. The ability to provide various material types, grades, and similarities presents a distinctive opportunity for customers to acquire materials more swiftly, potentially at a reduced cost and with increased capacities. CSI02 said: *“We possess the expertise and experience necessary to offer our clients alternative material options..... This approach significantly benefits our customers and enhances the efficiency of their SCs.”* Consequently, the presence of alternatives is considered a characteristic of resilience that has a direct effect on SCs.

Team capability

Interviewee CSI01 indicated that the company has successfully maintained high competence levels throughout every stage of the value chain in the case of CSI. Consequently, each stage enhances the overall capability of the team and meets established requirements. Whether it pertains to inspection, lead time, or processing, CSI's value chain meticulously implements the necessary actions to guarantee

customer satisfaction. CSI01 said: *“The competence of our workforce is a clear feature of resilience ... This competence and team capability ensures that requirements are managed adequately.”* Consequently, team capability is an essential feature that influences SCs.

Capacity management and rate flexibility

CSI02 had incorporated capacity management and rate flexibility into its resilience feature. This addition indicated that rates were adjusted based on the requirements to either an increase or a decrease in response to business demands. CSI02 stated. CSI02 said: *“We had to reduce our workforce during the pandemic and now we turn back to the market and it’s empty. People are no longer available It really slows us down to ramp-up capacity.”* The case study revealed challenges in re-engaging the workforce, which hindered production levels. A long-term personnel management strategy is needed to enhance workforce adaptability, including skill development, resource allocation, and a diverse talent network. Capacity management has been aligned with suppliers to ensure the SCs is equipped with essential resources and maintains flexibility for customers. CSI02 said: *“With our customers we run regular capacity simulation to be sure to get everyone’s capacity registered and book the relevant volume with the production sites. It’s a detailed process to ensure that all volume is met.”* As a result, rate flexibility and capacity management were an integral feature to enhancing the resilience of the SC.

Management of buffer and inventories

A further feature of resilience raised by CSI02 was the management of buffers and inventories. The previous approaches such as just in time delivery or relying on a global SC was not adequate in the set-up and was reassessed based on the business need. CSI02 said: *“The JIT⁴ is not adequate in our industry. We see so many disruptions. So, our role is to keep the inventories for our customers. We are where the customer is with warehouses around the globe and within proximity of the production site.”* Autonomously managing buffers and inventories, independent of JIT global SCs, was crucial for production. This capability improved SC agility and

⁴ JIT stands for Just-In-Time. It is a strategy used in manufacturing and inventory management where materials are only ordered and produced as they are needed in the production process, minimising inventory holding costs and waste.

minimised production interruptions from unforeseen disruptions, leading to enhanced planning, efficiencies, and cost reductions. In summary, effective buffer and inventory management significantly impacted SC performance.

In summary of the case study on CSI, four features of resilience were examined through discussions with the interviewees. Both interviewees addressed availability of alternatives, while CSI01 discussed team capability and CSI02 provided insights on rate flexibility and capacity management, and the management of buffers and inventories, all of which were essential features of resilience that impact SCs.

In conclusion of the comprehensive examination of features of resilience within the nine case studies, 12 distinct features have been discussed and analysed. These are summarised in 0 per respective case.

Table 5.3 Features of resilience per case study

Feature of resilience	CSA	CSB	CSC	CSD	CSE	CSF	CSG	CSH	CSI
Capacity management and rate flexibility		x	x	x	x	x	x		x
Management of buffers and inventories	x	x					x		x
Team capability	x	x	x						x
Management ability of SC			x		x	x			
Behavioural flexibility				x		x		x	
Quality levels	x				x			x	
Alternatives available		x		x					x
Prioritisation	x			x					
Financial capability	x							x	
Availability of international logistics network	x								
Digitisation - as a newly identified feature						x			
Risk awareness							x		

Source: field data

Cross-case analysis of SQ2,

This sub-section will discuss the cases from a thematic perspective in a cross-case analysis. The SQ2, to be addressed is guided by the interview questions:

“What are key features of resilience that affect SCs?”

“How and why do these features influence SCs?”

“When investigating resilience in the SC, we are investigating the factors of success, such as best-in-class cases. Could you elaborate on your experience with how features of resilience influence the SC?”

The examination of the cases revealed four main common key themes that promote a more structured discourse regarding the cases that are:

- a. Technical features: capacity management and rate flexibility, quality levels, risk awareness,
- b. Behavioural features: team capability, management ability of SC, behavioural flexibility,
- c. Strategic features: alternatives available, financial capability, digitisation;
- d. Tactical features: management of buffers and inventories, prioritisation, availability of international logistics network.

The common key features that will be discussed are based on the categories applied when conducting the cross-case analysis of SQ1:

1. Type of ownership (SOEs versus the private sector either as foreign-owned enterprise, or as domestic privately-owned enterprise)
SOE: CSA, CSB, CSE, CSH
Private: CSF
Foreign-owned: CSC, CSD, CSG, CSI
2. Size of enterprise (Large enterprise versus small and medium-sized enterprise)
Large: CSA, CSB, CSF, CSG, CSH, CSI
SME: CSC, CSD, CSE
3. Product complexity (Low complexity versus high complexity)
Low complexity: CSE, CSF, CSG, CSH, and CSI

High complexity: CSA, CSB, CSC, and CSD

4. Business perspective (Strategic perspective versus operational perspective)

Strategic view CSA01, CSB01, CSC01, CSD01, CSE01, CSF01, CSG01, CSH01, CSI01

Operational view: CSA02, CSB0, CSC0, CSD02, CSE02, CSF02, CSG02, CSH02, CSI02

The **first common key theme is related to technical features** of resilience that influence SCs. This common key theme encompasses, firstly, the levels of quality; secondly, the management of capacity and the flexibility of rates ; and thirdly, an awareness of risk. The discussion will elaborate on **what** the features are, **how** the features influence SCs and **why** these features affect SCs?

This first common key theme will now be discussed according to the four categories: company ownership, size of enterprise, product complexity and business perspective. Related to **technical features**, the subsequent features of resilience have been examined concerning SOEs (CSA, CSB, CSE, CSH) from the standpoint of company ownership. Quality levels and capacity management and rate flexibility were discussed by the interviewees.

Quality levels was discussed in three cases (CSA, CSE, CSH) and the cases confirmed the importance of product quality and process quality. CSA01 and CSA02 stress that quality levels are crucial for resilience, focusing on product and system attributes that directly influence product quality and maintain consistent SC standards. CSA02 expressed this from an operational perspective. *“One key feature is the consistency in quality of our deliveries. We need 100% on quality.”* CSA01 also added the importance: *“The most crucial aspect we must safeguard is the quality of our production.”* The perception of quality levels in case CSE was predominantly shaped by the perspective of employees. Interviewee CSE01 emphasised that the skills possessed by employees concerning quality are essential. *“The Problem-solving skills are essential, and we encountered many challenges that required resolution”*. To complement the perspective, a view of growing quality levels was voiced for case CSH as a customer expectation, and it was said by CSH01 that: *“Quality levels keep rising. We need to elevate them further, both internally and across the SC”*. In conclusion, the quality standards of SOEs are vital across various contexts, including product, production, and workforce quality. These standards directly impact the SC, backed by norms, inspections, and effective problem-solving. Furthermore, quality is increasingly recognised as essential, with customer expectations driving improvements and the adoption of quality benchmarks.

The second aspect of the technical feature pertained to **capacity management and rate flexibility**, which were identified by CSB and CSE as essential feature of resilience. Case CSB contended that the management of capacity and the flexibility of rates were aspects that were governed internally, integral to the vertical integration of essential process stages. Consequently, CSB was positioned to oversee these processes effectively, thereby preventing the loss of knowledge and critical competencies. CSB01 said: *"We have vertically integrated these processes to keep our core knowledge under control."* CSE noted that vertical integration benefits complex products. CSE01 argued that it was necessary for highly specialised components, as external sources lack economies of scale. This specialisation posed challenges, and maintaining internal capabilities reduced complexity and ensured sufficient capacity. CSE01 stated: *"You see there are some parts that are so specialised, it really would take so much time and effort to set-up an additional domestic source."* Furthermore, the geographic separation of international suppliers was emphasised, with the advantage of proximity significantly reducing complexity during periods of uncertainty. CSE02 said: *"... use global when required"*. In conclusion, the feature of capacity management and rate flexibility are evident in two instances (CSB, CSE) as a technical feature of resilience, aimed at maintaining knowledge and oversight of rates. It has been posited that implementing this approach is justifiable in intricate and specialised sectors.

None of the interview participants addressed **risk awareness** as a feature of resilience. This omission could be attributed to the operational nature of SOEs, which typically adhere to established processes and lack a culture that prioritises risk sensitivity. Additionally, this may stem from a deficiency in capability or an inadequate organisational structure.

In summary, the technical features of SOEs significantly influence SCs. Three instances highlighted improvements in quality through product quality, process efficiency, and employee skill development. Additionally, two cases (CSB, CSE) emphasised the importance of capacity management and rate flexibility. However, none addressed risk awareness as a resilience factor in SCs.

When it comes to **privately-owned enterprises** (CSF) the following observations are made. CSF discussed the importance of **capacity management and rate flexibility** as an important feature. Both CSF01 and CSF02 recognised this feature. The interview participants emphasised this aspect, which has been observed in various contexts, highlighting the SC's capacity to guarantee the availability of resources, including both human and financial investments. CSF02 said: *"The availability of our operators is a strong point we have and that helps to ramp-up quickly again."* CSF achieved this by standardising operations, maintaining its workforce, and building a pool of candidates ready for tasks like machine operation. This illustrates the balance between highly qualified roles and simpler, standardised positions where CSF02 said: *"Then for the ramp-up we need material and people. Material shortages are evident. And we miss people as this would allow us to accelerate. So, more people are required."* An alternative approach involved incorporating redundancies within the SC by collaborating with a subcontractor possessing external qualifications, as highlighted by CSF01 *"The redundancy allows us to increase capacity and to meet customer demand. We can tap into double sources, meaning we have twin sites and multiple qualified suppliers. This redundancy is flexibility."*

In conclusion, CSF emphasises the importance of capacity management and rate flexibility by utilising both workforce and financial resources. Additionally, in contrast to SOEs, the private sector often depends on external partners and subcontracting arrangements.

The case study CSF did not address quality levels or risk awareness. This omission may stem from the fundamental significance attributed to quality levels and that they are institutionalised. Additionally, the concept of risk awareness might be too nascent within the organisation to warrant discussion at this stage. The company appears to be in the process of implementing its operational procedures, suggesting that its risk management practices are still in their early development.

A third theme of company ownership includes the **foreign-owned enterprises** that are functioning within China (CSC, CSD, CSG, and CSI). In four case studies **capacity management and rate flexibility** emerged as pivotal feature of resilience. This issue is significant due to its impact on SCs, emphasising the importance of preparedness in managing capacity and pricing flexibility. It highlights the need to anticipate production demand surges through routine evaluations and workforce adjustments. This proactive approach contrasts with typical practices in SOEs, where private companies face harsher consequences for unmet delivery expectations, motivating them to maintain adequate capacity. The CSC case study illustrates effective capacity management and pricing adaptability, showcasing the organisation's ability to adjust production levels and its reliance on SCs. CSC02 said: *"We can adjust more easily and accommodate some changes, for example in the commercial furnishing."* The dependence on SC deliveries was recognised as a crucial element in achieving efficient capacity management and rate adaptability. This assertion was highlighted by CSC01: *"Our production depends very much on the deliveries ..."*

The discussion in case CSD viewed effective capacity management and adaptable rates as essential for resilience, with CSD01 highlighting their critical importance in industrial operations. CSD01 said: *"For me resilience at CSD is the preparedness to ramp-up the production on quality, with the adequate skills ready."* The SC had to meet quality standards and ensure essential competencies, leading to significant financial implications. However, costs from unpreparedness and insufficient capacity could exceed these expenses, particularly regarding contractual penalties. To improve capacity management, the SC regularly evaluates critical activities, including investment strategies, supplier competencies, and internal performance metrics. CSD01 said: *"We regularly review all the actions that we have in place to ensure the ramp-up, it includes sub suppliers and their investment plans, as well as our data of operator efficiency."* The CSI case study examined capacity management and rate flexibility, highlighting how CSI02's resilience feature allowed for rate adjustments based on business demand fluctuations, which was deemed essential: *"We had to reduce our workforce during the pandemic and now we turn back to the market and it's empty. People are no longer available with the skills that we need and the quantity we need. It really slows us down to ramp-up capacity."*

The CSI case study highlighted the challenges of re-engaging the workforce. CSG had previously implemented dual sourcing strategies to enhance production capacity, which improved product delivery and was recognised as vital for resilience, according to CSG01: *“We can tap into double sources, meaning we have twin sites and multiple qualified suppliers.”* Interviewee CSG02 offered further perspectives on the difficulty of sufficiently staffing the capacity management plan with personnel who possess the necessary skills to improve production capacity. CSG02 stated: *“Within the management of capacity the most challenging on adding workers, it’s difficult to find the heads we need to fill production positions. Also, quality resources have proven to be challenging.”*

A technical feature related to **risk awareness** was identified in a singular case study of CSG. CSG02 emphasised risk awareness as crucial for SCs, noting significant improvements within the organisation. Employees proactively integrated risk factors into decision-making, especially regarding outsourcing. They carefully assessed elements like potential delays and required qualifications, enhancing SC standards beyond just price considerations to include technical analyses. CSG02 stated: *“A feature that has developed over the last few months is the general risk awareness.... It’s not about the solving it but raising awareness to peers and colleagues. Subsequently the relevant procedures will manage the risk.”*

None of the interviewees identified quality levels as a defining feature of resilience. This omission may stem from the widespread belief that quality is an inherent, universally applicable rather than a distinct feature; rather, it is expected to be intrinsically integrated into every facet consistently within the private sector.

In summary, the analysis shows consistent technical characteristics across ownership types. SOEs prioritise quality, capacity management, and rate flexibility, with no mention of risk awareness. The indigenous private sector focuses on capacity management and rate flexibility but lacks additional traits due to its recent emergence. Foreign-owned enterprises also emphasise capacity management and rate flexibility linked to contractual obligations, with little reference to risk awareness and no case studies on quality levels, indicating its widespread presence.

The second perspective that will discuss technical features is from the size of enterprise perspective (large enterprise versus small and medium-sized enterprise). First, large enterprises (CSA, CSB, CSF, CSG, CSH, CSI) will be discussed. The overwhelming majority of cases with four out of six cases (CSB, CSF, CSG and CSI) discussed **capacity management and rate flexibility** as a technical feature of resilience. Capacity management appears to be an important feature of large companies, particularly as they have capabilities of setting-up local SCs.

Both CSB01 and CSB02 noted that the large enterprise is reducing dependencies to enhance local capabilities for local demand. This streamlining of complex SCs minimises international transportation, leading to fewer shipping routes, simplified planning, and reduced prioritisation challenges. CSB01 stated: *"Local sourcing allows us to plan our capacity accordingly. Dependency on SCs is reduced, particularly on global SCs."* The initiation of local sourcing initiatives received considerable support from local government entities and political figures, which played a crucial role in their successful execution within the Chinese framework.

Consequently, the notion of political endorsement was essential to this endeavour. CSB02 further elaborated: *"Once top-level decisions are taken, we will perform the task given to us."* Furthermore, both interviewees CSF01 and CSF02 underscored this feature, stressing the SC's ability to ensure the availability of resources, encompassing both human and financial investments. CSF02 remarked: *"The availability of our operators is a strong point we have, and that helps to ramp-up quickly again."* CSF achieved this by standardising operational protocols, maintaining its workforce, and building a pool of candidates for tasks like machine operation. This illustrates the balance between highly qualified roles and simpler positions that depend on standardisation and clear directives.

CSF02 said: *"Then, for the ramp-up, we need material and people. Material shortages are evident. And we miss people as this would allow us to accelerate. So, more people are required."* The case CSG underscores the importance of integrating supplementary resources. Interview participants emphasised capacity management's role in meeting customer needs. CSG's capacity plans, which included dual sourcing strategies, enhanced production capabilities and increased product delivery,

contributed to their resilience, as noted by CSG01: *"We can tap into double sources, meaning we have twin sites and multiple qualified suppliers."* Interviewee CSG02 offered further perspectives on the difficulty of sufficiently staffing the capacity management plan with personnel who possess the necessary skills to improve production capacity. CSG02 stated: *"Within the management of capacity, the most challenging part of adding workers is finding the heads we need to fill production positions. Also, quality resources have proven to be challenging."* Finally, the case study on CSI highlighted the integration of capacity management and rate flexibility through the intermediary of CSI02, which incorporated these elements into its resilience framework.

This enhancement demonstrated that rates were modified in accordance with the needs arising from fluctuations in business demands, whether necessitating an increase or a decrease. According to CSI02, this approach was pivotal. CSI02 said: *"We had to reduce our workforce during the pandemic, and now we turn back to the market and it's empty. People are no longer available with the skills that we need and the quantity we need. It really slows us down to ramp-up capacity."* The case study highlighted significant challenges in re-engaging the workforce, hindering production improvements. To enhance adaptability, a comprehensive long-term personnel management strategy is needed, focusing on essential skills, resource allocation, and a diverse skill acquisition network.

Additionally, CSA and CSH addressed the **quality level** solely. Both participants emphasised the significance of this feature in guaranteeing 100% product quality, as well as the importance of fostering a quality-oriented mindset among employees. It is noteworthy that certain large organisations, such as CSB, CSF, CSG, and CSI, did not identify quality levels as a feature of resilience. As previously mentioned, particularly in the context of large enterprises, quality levels may be perceived as an inherent and ubiquitous feature that does not warrant specific mention. The two interview participants, CSA01 and CSA02, highlighted that high-quality standards were an essential feature of resilience that influenced the performance of the SC. CSA02 noted: *"One key feature is the consistency in quality of our deliveries. We need 100% on quality...."* The interviewee CSA01 emphasised the feature's importance for

structuring the customer delivery schedule, noting that adherence to protocols and consistent quality in production and components are essential. CSA01 stated: *"The most crucial aspect we must safeguard is the quality of our production, our components, and our processes...."* Interviewee CSH01 emphasised that quality levels are crucial for resilience, extending beyond product and process quality to include mindsets focused on continuous improvement and zero defects. This approach transforms the SC into a reliable resource. CSH01 stated: *"Quality levels keep rising. We need to elevate them further, both internally and across the SC.... At the end it's about the mindset of this journey to zero concession, total quality management...."*

CSG uniquely identified a third technical dimension of **risk awareness**, complicating cross-case comparisons. Recently, CSG has seen significant improvements in risk awareness, likely reflecting a new cognitive understanding of COVID-19 that may not be present in other cases. As time goes on, further awareness is expected to develop. Employees are increasingly sharing information about potential risks, focusing on peer awareness rather than just problem-solving. For example, when assessing a supplier for an aircraft project, we evaluate their qualifications and establish procedures to manage identified risks. CSG02 remarked: *"A feature that has developed over the last few months is the general risk awareness. Our people ... are now much more aware of the probability of a risk It's not about the solving it but raising awareness to peers and colleagues."*

From the perspective of small and medium-sized enterprises or **SMEs** (CSC, CSD, CSE) the following key features have been discussed. **Capacity management and rate flexibility** was raised in all three cases CSC, CSD, CSE. The cases had in common that the rate flexibility in a production system referred to the ability to make minor adjustments in the process without causing major disruptions in resource management and timely deliveries. In the case of CSC, both interviewees acknowledged that this flexibility enhances SCR. Interviewee CSC02 noted: *"We can adjust more easily and accommodate some changes, for example in the commercial furnishing."* Even though CSC01 said: *"Our production depends very much on the deliveries ..."* Achieving a balance of flexibility and rigor during implementation was

crucial. Both CSD interviewees noted that managing and adjusting rates was key to resilience, with CSD01 highlighting its fundamental importance in industrial operations: *“For me resilience at CSD is the preparedness to ramp-up the production on quality, with the adequate skills ready.”* The SC had to meet quality standards and maintain key competencies, putting financial strain on the organisation. However, costs from inadequate preparedness and limited capacity could surpass these expenses, especially regarding contractual penalties. To improve capacity management, the SC regularly assesses investment strategies, supplier qualifications, and internal performance metrics. CSD01 added: *“We regularly review all the actions that we have in place to ensure the ramp-up, it includes sub suppliers and their investment plans, as well as our data of operator efficiency.”*

Within the framework of CSE, the participants CSE01 and CSE02 elucidated the notion of rate flexibility by highlighting the strategic selection of suppliers in accordance with business requirements. This decision-making process may involve domestic sub-suppliers, international suppliers, or the deployment of internal resources to mitigate capacity constraints. CSE01 noted: *“You see there are some parts that are so specialised, it really would take so much time and effort to set-up an additional domestic source. For us, it’s much better to buy internationally if the part is not available, we need to work with the OEM to find alternatives.”* The successful execution of deliveries was essential; consequently, the inventory strategy required adjustment to emphasise the importance of completeness rather than the handling of substantial quantities, as discussed by CSE02: *“In order to deliver a full shipset, I need not so much large inventory but completeness. Any missing part number could block the full shipset. So, the accuracy and attention to detail on the completeness, that’s the resilience for me.”*

CSE1 exclusively examined the second technical aspect of resilience related to **quality levels**, complicating cross-case comparisons. There is a common perception that the quality department alone manages quality, neglecting the contributions of all employees. Interviewee CSE01 highlighted the importance of diverse resilience quality levels on SCs and discussed the team's enhanced ability to address quality challenges through training and experience. They implemented a systematic approach

to identify problems and develop solutions, which were rigorously tested and validated. CSE01 remarked: *“The Problem-solving skills are essential, and we encountered many challenges that required resolution. The teams deployed systematic methodologies, supported by prior quality training to enhance these capabilities. They successfully identified the root causes of the issues, ..., and suggested innovative solutions.”*

The case studies reviewed in this theme did not address risk awareness as a feature of resilience. It is possible that smaller organisations may lack a robust system or sufficient awareness in this regard.

In summary, large corporations focus on capacity management and rate flexibility, prioritising resource availability and local sourcing incentives. Two case studies highlighted their commitment to achieving 100% product quality and fostering a quality-driven culture. Risk awareness was mentioned by only one interviewee, suggesting it may be a new strategic consideration. In contrast, SMEs also addressed capacity management and rate flexibility, emphasising adaptability and local sourcing. Quality was noted by one interviewee, while risk awareness was not discussed, possibly reflecting the smaller scale of these organisations.

The third perspective is from a **product complexity angle**. First the cases that deal with **low complexity products** will be discussed (CSE, CSF, CSG, CSH, and CSI). All technical features had been identified in the case studies and will be reviewed in sequence. Four cases (CSE, CSF, CSG, CSI) discussed **capacity management and rate flexibility**. Meeting customer demand was a key driver for this feature's creation. A common challenge is securing enough personnel to meet capacity needs. Interview participants within case CSF emphasised the SC's role in ensuring the availability of both human and financial resources. CSF02 said: *"The availability of our operators is a strong point we have and that helps to ramp-up quickly again."* CSF achieved this by standardising operational processes, retaining its workforce, and building a pool of candidates for tasks like machine operation. This illustrates the balance between highly qualified roles and simpler, standardised positions.

Additionally, CSF incorporated redundancies in the SC by partnering with a qualified subcontractor. CSF01 said: *"The redundancy allows us to increase capacity and to meet customer demand. We can tap into double sources, meaning we have twin sites and multiple qualified suppliers. This redundancy is flexibility."* CSF01 commented: *"The redundancy allows us to increase capacity and meet customer demand. We can tap into double sources, meaning we have twin sites and multiple qualified suppliers. This redundancy is flexibility"*. Redundancies within an organisation may suggest that multiple locations have similar capabilities. CSI02 integrated capacity management and rate adaptability into its resilience framework.

This enhancement signified that rates were modified according to the necessity for either an escalation or a reduction in alignment with business needs, as articulated by CSI02: *"We had to reduce our workforce during the pandemic and now we turn back to the market and it's empty. People are no longer available with the skills that we need and the quantity we need. It really slows us down to ramp-up capacity."* This case study revealed significant challenges in re-engaging the workforce, hindering production improvements. To enhance adaptability, a comprehensive long-term personnel management approach is essential, focusing on skill development, resource allocation, and a diverse talent network. Capacity management is crucial, with interviewees emphasising rate flexibility through strategic supplier selection—

whether domestic, international, or internal—to address capacity constraints. CSE01 noted: *“You see there are some parts that are so specialised, it really would take so much time and effort to set-up an additional domestic source. For us, it’s much better to buy internationally and have it delivered to our facility. Of course, if the part is not available, we need to work with the OEM to find alternatives.”* The successful execution of deliveries was essential; consequently, the inventory strategy required adjustment to emphasise the importance of completeness rather than the handling of substantial quantities, as noted by CSE02: *“In our product we have a wide range of components and part numbers. So, to deliver a full shipset, I need not so much large inventory but completeness. Any missing part number could block the full shipset. So, the accuracy and attention to detail on the completeness, that’s the resilience for me.”*

CSG emphasised the importance of capacity management in meeting customer demand. CSG developed capacity plans to enhance production through dual sourcing strategies, which increased product delivery and contributed to organisational resilience, as noted by CSG01.: *“We can tap into double sources, meaning we have twin sites and multiple qualified suppliers.”* Interviewee CSG02, like CSI, offered further perspectives on the difficulty of sufficiently staffing the capacity management plan with personnel who possess the necessary skills to improve production capacity. CSG02 stated: *“Within the management of capacity the most challenging on adding workers, it’s difficult to find the heads we need to fill production positions.”* Capacity management was implemented through contingency planning and organised documentation of customer demand. Measures, including workforce expansion, were taken to ensure sufficient capacity to meet this demand. The strategy's effectiveness was validated by the resulting output, highlighting capacity management's vital role in enhancing resilience and fulfilling customer needs.

The second technical feature of **quality levels** was addressed by two cases (CSE, CSH). This subject has been examined in only two instances, as most products are machine-produced, limiting human labour involvement. Thus, reliance on labour factors is restricted, but this conclusion requires further verification. Interviewee CSH01 highlighted quality levels as crucial for resilience, emphasising a commitment to continuous improvement, zero defects, and achieving top quality standards. As a

result, the SC becomes a fully reliable asset. CSH01 said: *“Quality levels keep rising. We need to elevate them further, both internally and across the SC: raw material, parts, and services. At the end it’s about the mindset of this journey to zero concession, total quality management. That way we shape our SC for the future.”* Interviewee CSE01 conducted a thorough analysis of resilience quality levels and their impact on SCs, highlighting the team's expertise in tackling quality challenges. The training and experience of team members were vital to their skill development. CSE01 illustrated how the team systematically identified issues and developed solutions, which underwent extensive testing and validation: *“The teams deployed systematic methodologies, supported by prior quality training to enhance these capabilities. They successfully identified the root causes of the issues, for example on the missing temperature control of facilities, and suggested innovative solutions.”*

A third feature addressed, albeit in a single case (CSG), was **risk awareness**. The industrial risk linked to this theme seems low due to the product's simplicity, with no modifications, complex assemblies, or reliance on a sophisticated SC. CSG02 noted significant improvements in risk awareness within the organisation, as employees now consistently factor in risks during decision-making, especially regarding outsourcing. They assess potential delays and qualifications before finalising decisions, enhancing SC standards by prioritising technical evaluations over cost alone. CSG02 commented: *“A feature that has developed over the last few months is the general risk awareness. ... It’s not about the solving it but raising awareness to peers and colleagues ... Subsequently the relevant procedures will manage the risk.”*

In conclusion, discussions on low-product scenarios highlighted capacity and rate management as key to resilience, impacting customer satisfaction and employee retention. Product quality and the need for ongoing training were emphasised, while risk awareness was noted due to the simplicity of the products, resulting in lower associated risks.

On the other hand, are products with a relatively high complexity (CSA, CSB, CSC, and CSD). **Capacity management and rate flexibility** was discussed in three case studies (CSB, CSC, CSD). This feature strengthened SCR by reducing dependencies and fostering local capabilities to meet domestic demand. As a result, complex SCs requiring international transport are streamlined, leading to shorter shipping routes, simplified planning, and fewer prioritisation issues. CSB01 observed: *“Local sourcing allows us to plan our capacity accordingly. Dependency on SCs is reduced, particularly on global SCs.”* The initiation of local sourcing initiatives received considerable support from local government entities and political figures, which aided in their successful execution within the Chinese framework. Consequently, the notion of political endorsement played a crucial role in this endeavour. CSB02 provided additional insights on this matter: *“Once top-level decisions are taken, we will perform the task given to us.”*

The CSC emphasised rate flexibility in production, allowing minor modifications without disrupting resource planning or on-time deliveries. Both interviewees acknowledged that this flexibility enhances SCR. CSC02 remarked: *“We can adjust more easily and accommodate some changes, for example in the commercial furnishing.”* Even though CSC01 said: *“Our production depends very much on the deliveries ...”* As a result, the incorporation of rate flexibility within the production system has become an essential feature, improved the responsiveness of supplier deliveries and bolstered the overall resilience of the SC. CSD01 highlighted their paramount significance for industrial operations. *“For me resilience at CSD is the preparedness to ramp-up the production on quality, with the adequate skills ready.”* The SC faced financial pressure to meet quality standards and essential skills. However, costs from inadequate readiness and limited capacity could exceed these expenses, particularly due to contractual penalties. To strengthen capacity management, the SC regularly evaluates investment strategies, supplier qualifications, and internal performance metrics. CSD01 said: *“We regularly review all the actions that we have in place to ensure the ramp-up, it includes sub suppliers and their investment plans, as well as our data of operator efficiency.”*

The only case that did not address capacity management and rate flexibility was CSA; rather, the focus was on **quality levels**. The interviewees CSA01 and CSA02 highlighted that high-quality standards were essential for resilience, significantly influencing SC performance. CSA02 noted that... *“One key feature is the consistency in quality of our deliveries. We need 100% on quality and this is vital for our production ... That way we ensure continuous quality outputs and smooth production internally.”* CSA01 emphasised the feature's strategic importance for structuring the customer delivery schedule, noting that adherence to protocols and consistent quality in production and components are essential: *“The most crucial aspect we must safeguard is the quality of our production, our components, and our processes. This enables us to effectively plan our output, deliveries, and ensure customer satisfaction.”* In conclusion, both CSA01 and CSA02 agreed that the quality levels are a crucial feature of resilience, which directly influences SC performance and the outcomes of customer deliveries.

None of the interview participants addressed the concept of risk awareness. As illustrated by a particular case study (CSG), this aspect represents a novel paradigm that may become more widespread in the future.

In summary, in contexts with complex products, capacity management and rate flexibility were key features in three of the four analysed cases. A common element was the focus on local sourcing, production modifications, and responsiveness. Additionally, quality standards were crucial in two cases, emphasising the importance of process and product quality. Notably, risk awareness was not addressed in any case.

The fourth and final perspective in discussing technical features of resilience was from a **business perspective** (Strategic perspective versus operational perspective). The initial focus will be on the strategic perspective. Six interviewees, namely CSB01, CSC01, CSD01, CSE01, CSF01, and CSG01, addressed the topics of **capacity management and rate flexibility**. In the interview of CSA01 and CSH01, the respective studies did not identify this feature. CSI01 highlighted the importance of local sourcing in capacity management, emphasising production flexibility and the need for strategic long-term planning. CSB01 noted strong support from local authorities and political figures for local sourcing initiatives in China: *“Local sourcing allows us to plan our capacity accordingly. Dependency on SCs is reduced, particularly on global SCs.”* The same argument was given by CSE01. This choice may encompass domestic sub-suppliers, international suppliers, or the utilisation of internal resources to address capacity limitations. CSE01 remarked: *“You see there are some parts that are so specialised, it really would take so much time and effort to set-up an additional domestic source. For us, it’s much better to buy internationally and have it delivered to our facility.”*

Achieving a harmonious equilibrium between flexibility and rigor in execution was crucial. One could contend that a notable level of flexibility was apparent in the instance of CSC. CSC01 said: *“Our production depends very much on the deliveries.”* CSD01 highlighted its essential significance for industrial activities: *“For me resilience at CSD is the preparedness to ramp-up the production on quality, with the adequate skills ready.”* The SC had to meet quality standards and ensure skill availability, which placed financial pressure on the organisation. However, costs from inadequate preparedness could surpass these expenses, especially regarding contractual penalties. Redundancies may suggest that different locations have similar competencies. CSF01 commented: *“The redundancy allows us to increase capacity and meet customer demand. We can tap into double sources, meaning we have twin sites and multiple qualified suppliers. This redundancy is flexibility”*. CSG’s circumstances previously shaped capacity strategies aimed at enhancing production through dual sourcing, which boosted product distribution and was crucial for resilience, as noted by CSG01: *“We can tap into double sources, meaning we have twin sites and multiple qualified suppliers.”*

The concept of **quality management** was highlighted by the interviewees CSAS01, CSE01, and CSH01. All three participants emphasised the feature's strategic importance, cost advantages, and problem-solving aspects. Interviewee CSA01 highlighted its essential role in planning customer delivery schedules, noting the need for adherence to protocols and consistent quality in production and components and said: *"The most crucial aspect we must safeguard is the quality of our production, our components, and our processes. This enables us to effectively plan our output, deliveries, and ensure customer satisfaction."* Interviewee CSE01 highlighted the importance of resilience quality in SCs, focusing on the team's capability to address quality issues. Their training and experience enhanced their skills, exemplified by a situation where they systematically identified problems and developed solutions, which underwent thorough testing and validation. CSE01 remarked: *"The problem-solving skills are essential, and we encountered many challenges that required resolution. The teams deployed systematic methodologies, supported by prior quality training to enhance these capabilities. They successfully identified the root causes of the issues, ... and suggested innovative solutions."* Problem-solving is a competency that requires ongoing refinement. A skilled and experienced team can effectively address complex issues, reducing reliance on the SC and enabling faster solution identification.

Validating these solutions as sustainable alternatives is crucial, as it significantly affects SC dynamics. Interviewee CSH01 emphasised the importance of quality levels for resilience, discussing not just product or process quality but also the attitudes towards them. This commitment to continuous improvement and zero defects transforms the SC into a reliable resource: *"Quality levels keep rising. We need to elevate them further ... At the end it's about the mindset of this journey to zero concession, total quality management. That way we shape our SC for the future."* The interviewee noted significant improvements in SC quality standards, leading to reduced concessions, defects, and overall expenses due to less waste. These enhancements have stabilised processes, making quality levels a feature of resilience in SCs.

There was no discourse regarding **risk awareness** at the strategic level, which may be attributed to the gradual emergence of this feature. In summary, from a strategic perspective, the relationship between capacity and rate is associated with long-term development strategies that necessitate production flexibility, redundancies, and local sourcing. The quality level attributes were addressed by only two interviewees, focusing on cost-benefit analysis and problem-solving capabilities. There was no discussion regarding risk awareness.

From an **operational perspective**, the interviewees addressed three technical features that will be discussed in turn (capacity management and rate flexibility, risk awareness and quality levels). **Capacity management and rate flexibility** has been discussed by seven interviewees (CSB02, CSC02, CSD02, CSE02, CSF02, CSG02 and CSI02). The perspectives mainly focus on operational constraints related to capacity and rate flexibility, highlighting the need for readily available parts and accessible labour resources. CSC02 specifically analysed the flexibility that allows for capacity changes, noting that certain isolated segments of the production process exhibit some flexibility. CSC02 said: *"We can adjust more easily and accommodate some changes, for example in the commercial furnishing."* Interviewee CSE02 emphasised the importance of the completeness of the shipset, as opposed to merely possessing multiple partial shipsets. This approach facilitates a more efficient production throughput and helps to prevent the accumulation of unfinished work and the storage of incomplete shipsets. CSE02: *"In order to deliver a full shipset, I need not so much large inventory but completeness. Any missing part number could block the full shipset."*

The interviewees categorised under operations highlighted the essential importance of workforce availability in fulfilling capacity demands. CSF02 noted that the case saw a good level of availability of operators. CSF02 said: *"The availability of our operators is a strong point we have and that helps to ramp-up quickly again."* Opposed to it is case CSG02 that faces a critical challenge regarding workforce availability, which poses a substantial risk to the ramp-up of production. CSG02 said: *"Within the management of capacity the most challenging on adding workers, it's difficult to find the heads we need to fill production positions. Also, quality resources have proven to*

be challenging.” CSI02 integrated capacity management and rate adaptability into its resilience framework, emphasising essential personnel planning to meet rate commitments. This allowed for flexible rate adjustments based on business needs, which CSI02 effectively communicated: *“We had to reduce our workforce during the pandemic and now we turn back to the market and it’s empty. People are no longer available.”* The case study demonstrated the significant challenges involved in re-engaging the workforce when required. This shortcoming subsequently hindered the ability to enhance production levels.

Risk awareness as a technical feature of resilience has been raised by CSG02 from an operational perspective. The lack of dialogue suggests a shift towards cognitive risk awareness. CSG02 noted that this awareness impacts SCs, as employees now factor in risks when making decisions, especially about outsourcing. They evaluate criteria such as potential delays and qualifications, raising SC standards to include cost and technical assessments. CSG02 stated: *“A feature that has developed over the last few months is the general risk awareness. Our people in all areas of the business are now much more aware It’s not about the solving it but raising awareness to peers and colleagues. ... Subsequently the relevant procedures will manage the risk.”* The recognition of risk functions as an essential component, encouraging individuals to assess their options before arriving at decisions.

The **quality levels** as feature of resilience were addressed by CSA02 from an operational perspective. It is possible that this aspect was not mentioned by other case studies involved in operations, as their viewpoint might suggest that quality is an inherent feature of business operations. CSA02 emphasised that maintaining high-quality standards is a critical feature of resilience, significantly impacting the effectiveness of the SC. CSA02 noted: *“One key feature is the consistency in quality of our deliveries. We need 100% on quality and this is vital for our production. Inspectors ensure this either by measurement, paperwork or testing. That way we ensure continuous quality outputs and smooth production internally.”* In conclusion quality levels are a crucial feature of resilience, which directly influences SC performance and the outcomes of customer deliveries.

In conclusion, seven interview participants discussed capacity management and rate flexibility, highlighting the importance of part readiness and workforce availability. One interviewee also noted that risk awareness contributes to resilience and quality standards.

The **second common key theme pertain to behavioural features** of resilience that impact on SCs. This feature encompasses, first, team capability, second, the management of SC, and third, behavioural flexibility. These key features will now be examined in relation to four categories: company ownership, enterprise size, product complexity, and business perspective. The discussion will take the perspective of company ownership (SOEs, the domestic privately-owned enterprise and foreign-owned enterprise) and begins with **SOEs** (CSA, CSB, CSE, CSH).

Cases of CSA and CSB highlight that **team capability**, a key behavioural aspect of resilience, significantly impacts SC dynamics. This resilience involves the team's skills and strategies to enhance operational effectiveness. Higher capability allows for better navigation of challenges, such as those during the recent pandemic. The procurement team's expertise has been crucial in collaborating with the SC to develop effective solutions. Specifically, in CSA, the procurement team has actively engaged with the SC chain to improve delivery processes and purchase order timelines, leading to enhanced delivery schedules. CSA02 said: *"Procurement manages the purchase orders, dates and deliveries. As we manage many suppliers, we need a large team for the job."* This feature improved scheduling and benefited the SC by facilitating negotiations, identifying alternative suppliers, and adjusting priorities. It enables suppliers to enhance delivery processes, especially during challenges like a pandemic. The team's skills are vital for building SCR. Both CSB01 and CSB02 emphasised that team capability is essential for resilience and knowledge management, safeguarding proprietary knowledge and preventing its transfer to subcontractors.

Risks from subcontractors, such as dissolution or operational failures, could result in the loss of significant knowledge assets. CSB01 said: *"We have vertically integrated the core processes to keep our knowledge under control."* Fundamental operations

and primary processes were performed in-house, thus reducing dependence on an external SC. The importance of these processes, emphasised by CSB02 as a feature of resilience, was vital for preserving product integrity: *“For resilience the process is important as it is the point of reference for the product and serves as reference.”* The availability of local resources improved capacity by means of collaborative approaches. Distinct network structures supplied raw materials that were crucial in strengthening local competencies and augmenting understanding of the product. CSB02 noted: *“It’s locally produced material.”* In the realm of complex products or SCs, international OEMs often limited the use of locally sourced materials. This limitation led to an increased dependence on the OEM during times of recovery or disruption, due to the constraints in available capacities, as noted by CSB02: *“However, that’s not usually the case for the international OEM. On this case, they don’t usually give the local approvals away and they want to keep control.”* Therefore, half of the cases discusses the importance of team capability as a behavioural feature resilience.

The case study CSE focuses as only one on **management of SC**. Interviewee CSE02 highlighted that effective SCM is crucial for resilience. Despite the complexity of outsourcing and varying customer demands, timely delivery execution remains paramount. CSE02 said: *“We have local representatives that manage the supplier to achieve a good level of resilience. We need to provide the right demand and forecast, and technically the suppliers are very capable.”* The intricacy of the components, as noted by CSE01, highlights the strategic difficulties associated with outsourcing and overseeing a complex SC. The complicated nature of these parts suggests that establishing a local SC may not be economically viable and could present significant technical challenges, according to CSE01: *“You see there are some parts that are so specialised,”* It is understandable that other SOEs regard SCM as a fundamental aspect, given their significant vertical integration. Most operations are conducted internally and are viewed as essential expertise. Consequently, SCM is frequently seen merely as an administrative function focused on ordering.

The case study CSH highlights that the organisation effectively incorporated the right personnel at pivotal times to carry out essential tasks, demonstrating **behavioural**

flexibility. This adaptability was achieved by introducing shift work and offering overtime opportunities. Such measures imply that there was support from both unions and the works council for these shifts during demanding periods. CSH02 stated: *“We mobilised our people during intense shifts. They were all on board, keeping the company interest as first goal.”* An illustrative example concerning the SC department underscored the importance of not merely assessing suppliers but also tackling and rectifying any identified problems. This strategy enabled efficient management of suppliers. CSH02 stated: *“The gaps on assessments have to be closed, issues resolved with action plans as these will be the weakness in times of crisis.”* Effective stakeholder engagement and adaptability demonstrate a strong commitment to collaboration, significantly enhancing SCR through outcome-driven actions. Behavioural flexibility has become a key trait of resilience that boosts SC performance. However, some viewpoints overlook this aspect, particularly in SOEs, where a strict adherence to directives limits discussions on flexibility and behaviour.

In conclusion, the common feature identified in two cases is team capability. Case CSE addresses the management of SCs, while CSH focuses solely on behavioural flexibility. Although all features are present, they do not exhibit a distinctly recognisable pattern.

The subsequent perspective pertains to **domestic privately-owned enterprises** (CSF). The case CSF examines both the management of SCs and behavioural flexibility. Both interviewees acknowledged that effective **management of SCs** is a crucial feature of resilience. There was a distinct sense of accountability among the relevant teams for overseeing contracts and SC deliveries. It was essential to have the appropriate team in place to employ tools, methodologies, and negotiation strategies to meet the necessary delivery timelines. CSF02 remarked: *“Our procurement team has the job to manage all the deliveries and enforce the contractual terms”*. The procurement team was expected to adapt and reduce transaction costs while minimising administrative burdens. They were fully responsible for managing supplier transitions, integrating new suppliers, and developing new supplier relationships. CSF01 stated: *“It is less administrative and bureaucratic to switch suppliers, to activate new suppliers, or to work on alternatives”*.

In conclusion, both the operational and strategic perspectives highlight that the ability of management of SCs is an essential feature of resilience that influences the effectiveness of SCs. In contrast to SOEs and foreign-owned enterprises, the case of CSF may demonstrate the agility associated with switching and the flexibility inherent in SCs.

The interviewee CSF01 identified **behavioural flexibility** as an essential feature of resilience, making a cross-case comparison difficult. A notable degree of flexibility and speed was observed, especially regarding the transition between suppliers. Furthermore, there was an enhancement in the ability to endorse alternative options, coupled with a decrease in administrative expenses. CSF01 stated: *“It is less administrative and bureaucratic to switch suppliers, to activate new suppliers, or to work on alternatives.”* Behavioural flexibility, driven by competitive market forces, allows for ongoing evaluations of suppliers, providing various options as needed. This adaptability is crucial for assessing the resilience of private sector SCs. However, the aspect of team capability in domestic privately-owned enterprises remains unexplored.

The third perspective with respect to company ownership observes the foreign-owned enterprises (CSC, CSD, CSG, CSI). The following features are discussed as influencing SCs. Both CSC and CSI emphasise the significance of **team capability**. The two case studies highlight the critical role of training and competence management. Recent employee development efforts showcased the team's capabilities, with interviewee CSC02 noting their importance in enhancing workforce skills. This training likely boosted self-esteem and reinforced team cohesion, leading to improved dynamics and energy levels compared to the pre-crisis period. According to CSC02: *“The training and job rotation programs we implemented for our employees greatly improved the team's overall skill set. Also important was the development of a strong team spirit.”* The observed energy and dynamism may stem from enhanced problem-solving skills, a better understanding of operations, and extensive training, which boost self-confidence through diverse experiences. Interviewee CSI01 highlighted that the organisation maintains high competence across the CSI value chain, essential for improving team effectiveness and meeting standards, ultimately

ensuring customer satisfaction in inspection, lead time, and processing. CSI01 said: *“Competence is a clear feature of resilience... We see competence across the value chain and that is an important consistency required.... This competence and team capability ensures that requirements are managed adequately.”* As a result, team capability is considered a feature that impacts SCs.

CSC was the sole case examined that addressed the **management of SCs**. CSC01 argued that proficient SCM represented a crucial feature of resilience within the SC framework. The diverse collection of components utilised by CSC required meticulous coordination to guarantee their prompt delivery and alignment. Any discrepancies, such as an overabundance of parts from supplier A alongside deficits from supplier B, compromised operational efficiency, as noted by CSC01. *“Due to the complex SC that we operate, we need all parts to be synchronised with our system. It needs to operate like clockwork. This is the job of our SC department.”* The assigned department handled the delivery process but encountered challenges from a complex SC. Understanding product specifications and timelines was essential to avoid disruptions. For example, during material shortages, the procurement team sourced substitutes to enhance resilience. Quick impact assessments and alternative solutions were crucial for agility, highlighting the need for skilled management. While areas like cabin furnishing demonstrate adaptability, this should be viewed as a safeguard against errors rather than a clear advantage. CSC02 said: *“We can adjust more easily and accommodate some changes, for example in the commercial furnishing.”* This aspect hasn't been explored in other case studies, but it's important to note that many SC responsibilities are centralised in the primary countries supplying components to China, rather than managed by Chinese teams.

The feature of **behavioural flexibility** is discussed in case CSD only. Participants in the study highlighted behavioural flexibility as a key feature of resilience in case CSD. They noted that maintaining a flexible mindset in business during challenges is crucial for finding solutions to complex problems. Unforeseen events, like shipment delays or missing components, are inevitable, making flexibility in the operational framework essential for resilience, as emphasised by CSD02: *“We need to stay flexible and even a bit creative when we are faced with shortages or limitations. We expect processes*

and flexibility. But hard to achieve.” From a strategic perspective, CSD01 emphasised the difficulties associated with flexibility and stressed the importance of accuracy and effective execution: *“We need to get the priorities right. All of them.”* In conclusion, behavioural flexibility represents a crucial feature of resilience that influences SCs. CSG did not contribute any behavioural aspects to the discourse. This absence may be attributed to the organisation's well-established focus on technical matters.

In conclusion, within the framework of company ownership, a notable behavioural feature observed in SOEs was the capability of teams. Two organisations underscored the strategic potential of their teams to engage in proactive initiatives. The management of SCs was mentioned exclusively by CSE, as SOEs generally demonstrate vertical integration and do not rely on complex SC structures. Behavioural flexibility was identified in only one instance, indicating that SOEs may not emphasise this quality within their organisational culture, which is often marked by hierarchical arrangements.

In contrast, private enterprises in China prominently discussed both SCM and behavioural flexibility. This observation aligns with the notion that private firms must adeptly manage SCs to improve efficiency, alongside the need for adaptability and responsiveness.

Finally, foreign-owned enterprises revealed that team capability was a significant behavioural feature in about half of the cases analysed, shaped by initiatives focused on employee development and growth. One case specifically concentrated on SCM, likely reflecting a dependence on established corporate SC frameworks. Behavioural flexibility was exclusively examined in CSD, where agility and adaptability are highly esteemed.

This further perspective focuses on the **size of the enterprise**, contrasting large enterprises with small and medium-sized enterprises when discussing behavioural features of resilience. In the context of **large enterprises** (CSA, CSB, CSF, CSG, CSH, and CSI), several key features are examined. Notably, **team capability** is addressed by CSA, CSB, and CSI, while no additional behavioural features are explored within these cases. Resilience includes the team's capabilities to manage challenges, such as those faced during the recent pandemic. At CSA, the procurement team has worked with the SC to optimise delivery processes and purchase order timelines, resulting in improved delivery schedules. CSA02 stated: *"Procurement manages the purchase orders, dates and deliveries. As we manage many suppliers, we need a large team for the job."* This capability has greatly improved scheduling and streamlined negotiations, benefiting the SC by identifying alternative suppliers and realigning priorities, especially during crises like a pandemic. The team's expertise is crucial for SCR, as highlighted by CSB, which emphasises the need for effective knowledge management to safeguard proprietary information from subcontractors. Risks from subcontractors, such as dissolution or operational failures, jeopardise the retention of valuable knowledge.

CSB01 articulated: *"We have vertically integrated the core processes to keep our knowledge under control."* Fundamental operations and primary processes were performed in-house, thus reducing dependence on an external SC. The importance of these processes, emphasised by CSB02 as a feature of resilience, was vital for preserving product integrity: *"For resilience the process is important as it is the point of reference for the product and serves as reference."* The availability of local resources improved capacity by means of collaborative approaches. Distinct network structures supplied raw materials that were crucial in strengthening local competencies and enhancing understanding of the product, as noted by CSB02: *"Thanks to local sourcing, we could use raw material locally produced."* CSI01 highlighted that the organisation has upheld high competence throughout the CSI value chain, boosting team capability and meeting criteria, while ensuring customer satisfaction through effective inspection, lead time, and processing actions. CSI01 stated: *"The competence of our workforce is a clear feature of resilience. The team is not only dedicated but we see competence across the value chain and that is an*

important consistency required.” Therefore, the capability of a team is a critical factor that impacts SCs.

The second behavioural feature is **behavioural flexibility** noted by CSF and CSH. CSF01 recognised behavioural flexibility as a feature of resilience observed during the study. Notably, a high degree of adaptability and speed was apparent, especially regarding the transition between suppliers. Furthermore, there was an enhancement in the ability to endorse alternative options, coupled with a decrease in administrative expenses, as stated by CSF01: *“The private sector has a distinct advantage in the SC and that is the flexibility and the speed.”* Behavioural flexibility in the private market arises from competitive forces and supplier evaluations, essential for assessing SCR. CSH02 highlighted the successful integration of key personnel during critical times, with flexibility achieved through shift work and overtime, supported by unions and the works council during peak demand saying: *“We mobilised our people during intense shifts. They were all on board, keeping the company interest as first goal.”* An illustrative example concerning the SC department underscored the importance of not merely assessing suppliers but also tackling and rectifying any issues that arise. This strategy proved beneficial for efficient supplier management. CSH02 remarked: *“The gaps on assessments have to be closed, issues resolved with action plans as these will be the weakness in times of crisis.”* Engaging constructively with stakeholders and demonstrating adaptability shows a strong commitment to collaboration, enhancing SCR through outcome-driven actions. This behavioural flexibility has improved overall SC performance.

CSF adds **management of SCs** as a behavioural feature of resilience. Both participants in case study CSF the interview acknowledged that effective management of SCs is a fundamental feature of resilience. They emphasised the importance of designated teams being accountable for overseeing contracts and the logistics of SC deliveries. It was noted that the appropriate team must be in place to leverage tools, methodologies, and negotiation strategies to meet the necessary delivery timelines. CSF02 remarked: *“Our procurement team has the job to manage all the deliveries and enforce the contractual terms.”* The procurement team was expected to adapt while minimising transaction costs and administrative workload. They were also responsible

for managing supplier transitions, integrating new suppliers, and fostering new supplier partnerships. CSF01 stated: *“It is less administrative and bureaucratic to switch suppliers, to activate new suppliers, or to work on alternatives”*. In conclusion, both operational and strategic perspectives emphasise that effective SCM is essential for resilience and efficiency, a fact often overlooked due to reliance on international SCs. Furthermore, CSG did not address any behavioural aspects.

The forthcoming discussion will examine the cases based on the **SME** classification of enterprises (CSC, CSD, CSE) and will address the following points. Both the cases of CSC and CSE focused on the **management of SCs**. The perspectives underscored the complexity of SCs and the need for effective management. Interviewee CSE02 stressed that skilled SCM, and fluctuating demands, timely delivery is crucial. CSE02 said: *"We have local representatives that manage the supplier to achieve a good level of resilience. We need to provide the right demand and forecast, and technically the suppliers are very capable."* The case study underscored the critical role of SCM and local representation. Proximity to international suppliers facilitated regular communication, site visits, and oversight, mitigating challenges like distance, language, cultural differences, and time zones. This geographical closeness improved delivery efficiency and significantly enhanced SCR. Consequently, adept management of complex global SCs emerged as vital for operational resilience. CSC01 said: *"Due to the complex SC that we operate, we need all parts to be synchronised with our system. It needs to operate like clockwork. This is the job of our SC department."*

The case of CSC was examined as only one in terms of **team capabilities** of the SME, highlighting resilience as a behavioural feature. Recent initiatives in employee training showcased the team's competencies. The interviewee, CSC02, noted that these training efforts enhanced the workforce's skill set. Furthermore, it is likely that this training contributed to an increase in both self-esteem and team cohesion. Consequently, the dynamics and energy levels within the team showed significant improvement compared to the time before the crisis. CSC02 remarked: *"The training and job rotation programs we implemented for our employees greatly improved the team's overall skill set. Also important was the development of a strong team spirit."* The observable energy and dynamism may arise from improved problem-solving skills, better understanding of operations, and enhanced training. This could also be linked to increased self-confidence from training programs and job rotations. Given the limited resources of SMEs, their investment in capabilities and skills is likely constrained.

Case CSD discussed as further behavioural feature **behavioural flexibility**. Participants highlighted behavioural flexibility as crucial for resilience in case CSD. They emphasised the importance of a flexible mindset in business during challenges, as it helps find solutions to complex problems. Despite having set plans and schedules, unforeseen issues like shipment delays were inevitable, making flexibility a key element of resilience in operations. CSD02 said: *"We need to stay flexible and even a bit creative when we are faced with shortages or limitations. We expect processes and flexibility. But hard to achieve."* From a strategic perspective, CSD01 emphasised the difficulties associated with flexibility and stressed the importance of accuracy and effective execution: *"We need to get the priorities right. All of them."* In conclusion, behavioural flexibility represents a crucial feature of resilience that influences SCs. It is noteworthy that neither of the cases examined addressed this feature.

In conclusion, large enterprises identified team capability as a crucial attribute in three instances, emphasising its role in enhancing workforce skills and competencies. Additionally, two cases highlighted the significance of behavioural flexibility, particularly during periods requiring adaptation. The management of SCs was mentioned in only one case study. In contrast, small and medium-sized enterprises regarded SCM as a vital behavioural feature, which was subsequently followed by team capability and behavioural flexibility.

The subsequent viewpoint will involve examining the cases from the standpoint of **product complexity**, leading to the ensuing discussion (low complexity versus high complexity). Initially, we will consider the **low complexity** theme, which includes CSE, CSF, CSG, CSH, and CSI. The **management of SCs** was examined through two case studies (CSE and CSF). Both organisations acknowledged the importance of SCs and committed to efficient management. Interviewee CSE02 highlighted that effective SCM is essential for resilience. Despite the complexities of outsourcing advanced components and varying customer demands, timely delivery remained crucial. CSE02 stated: *“We have local representatives that manage the supplier to achieve a good level of resilience Of course, sometimes we have delivery delay due to customs or transport.”* Both interviewees in case CSF acknowledged that effective SCM is essential for resilience. Designated teams had clear responsibilities for managing contracts and logistics, and a skilled team was deemed crucial for using the necessary tools, methodologies, and negotiation tactics to meet delivery schedules. CSF02 said: *“Our procurement team has the job to manage all the deliveries and enforce the contractual terms.”* From a strategic standpoint, the procurement team was anticipated to exhibit flexibility while maintaining minimal transaction costs. Additionally, the administrative burden was required to be kept to a minimum. The team was also expected to take full responsibility for managing the transition between suppliers, incorporating new suppliers, or fostering the development of new supplier relationships. CSF01 said: *“It is less administrative and bureaucratic to switch suppliers, to activate new suppliers, or to work on alternatives”.*

Behavioural flexibility was raised by two interviewees (CSF, CSH). Resilience demonstrates the adaptability of the workforce and organisational systems, essential for effective action in critical moments. The study emphasised behavioural flexibility, especially in supplier transitions, and noted enhanced capacity for approving alternatives and lower administrative costs. CSF01 said: *“The private sector has a distinct advantage in the SC and that is the flexibility and the speed. It is less administrative and bureaucratic to switch suppliers, to activate new suppliers, or to work on alternatives.”* Behavioural flexibility in privately-owned enterprises arises from competitive dynamics, enabling continuous supplier evaluations and alternative options, which are crucial for assessing SCR. CSH02 also noted the effective

integration of key personnel during critical periods, supported by shift work and overtime, with union and works council backing during peak demand. CSH02 remarked: *“We mobilised our people during intense shifts. They were all on board, keeping the company interest as first goal.”* An illustrative example concerning the SC department underscored the importance of not merely assessing suppliers but also tackling and rectifying any issues that arise. This strategy proved beneficial for efficient supplier management. CSH02 remarked: *“The gaps on assessments have to be closed, issues resolved with action plans as these will be the weakness in times of crisis.”* Engaging constructively with stakeholders and demonstrating adaptability shows a strong commitment to collaboration, enhancing SCR through outcome-driven actions. This behavioural flexibility has improved overall SC performance.

CSI was the only case to have raised **team capability** as a behavioural feature of resilience. The interviewee CSI01 reported that the organisation has effectively sustained elevated levels of competence across all phases of the value chain concerning CSI. As a result, each phase contributes to the overall proficiency of the team and fulfils the predetermined standards. In terms of inspection, lead time, or processing, CSI's value chain carefully executes the requisite measures to ensure customer satisfaction, as stated by CSI01: *“The competence of our workforce is a clear feature of resilience. The team is not only dedicated but we see competence across the value chain and that is an important consistency required. The weakest link may be a disruption, and we need to avoid it. This competence and team capability ensures that requirements are managed adequately.”* Team effectiveness is crucial for SCs. While no other case study highlights this, large organisations often assign specialised roles that prioritise specialisation over a broad skill set.

Case CSG raised no behavioural feature of resilience. The discussion centred on the features of capacity management and rate flexibility, as well as the management of buffers and inventories, alongside an emphasis on risk awareness. The lack of behavioural features may be attributed to the company's ongoing recovery phase resulting from SC challenges, leading the conversation to delve into recent case experiences that highlighted technical elements.

In summary, from a low complexity standpoint, it has been noted that the management of SCs was analysed through two case studies, while behavioural flexibility was also examined. However, team capability was addressed in only one of the cases.

From the standpoint of high product complexity, specifically regarding CSA, CSB, CSC, and CSD, the subsequent behavioural feature has been examined in the relevant cases. The enhancement of **team capability** was achieved through the efforts of CSA, CSB, and CSC. A common theme in these instances is the recognition that training and ongoing development of personnel are vital for enhancing team capabilities. Large organisations typically invest significant time and resources in this, as seen in most analysed cases. Improved capabilities allow for better management of challenges, such as those during the recent pandemic. For example, CSA's procurement team worked closely with the SC to optimise delivery processes and purchase order timelines, leading to improved delivery schedules. CSA02 said: *"Procurement manages the purchase orders, dates and deliveries. As we manage many suppliers, we need a large team for the job."* This feature has markedly enhanced scheduling, fostering a scenario that benefits the SC. By facilitating negotiations, recognising alternative suppliers, and realigning priorities, suppliers can refine their delivery processes, especially during challenging times such as a pandemic. As a result, the skills and competencies of the team are vital in bolstering resilience within the SC. Case studies CSB01 and CSB02 demonstrated that team capability is a fundamental feature of resilience, highlighting the importance of knowledge management to protect proprietary information within the organisation and to prevent its transfer to subcontractors.

The potential risks linked to subcontractors, including their sudden disappearance, mergers, or operational failures, could lead to the loss of critical knowledge. CSB01 underscored this concern. *"We have vertically integrated the core processes to keep our knowledge under control."* Fundamental operations and primary processes were executed within the organisation, thus reducing dependence on an external SC. The importance of these processes, emphasised by CSB02 as a feature of resilience, was vital for preserving product integrity. *"For resilience the process is important as it is the point of reference for the product and serves as reference."* CSC highlighted the significance of showcasing the team's capabilities through recent employee training programs. Interviewee CSC02 noted that these initiatives enhanced workforce skills, boosted self-esteem, and improved team unity. Consequently, the team's dynamics and energy levels showed notable improvement compared to the pre-crisis period.

CSC02 said: *“The training and job rotation programs we implemented for our employees greatly improved the team's overall skill set. Also important was the development of a strong team spirit. Despite the challenges imposed by lockdowns and restrictions, the energy and dynamics within the team reached new levels after the pandemic concluded, enabling us to confront significant challenges as one unified team.”* The apparent degree of energy and dynamism could be a result of an improved capacity to navigate intricate challenges, a more profound understanding of operational processes, and an augmentation of training and associated competencies. Furthermore, this phenomenon may also be linked to an elevated sense of self-assurance cultivated through training initiatives and job rotation experiences.

CSC added **management of SCs** as a behavioural feature of resilience. No other case discussed it probably due to the limited influence of management of SCs in the cases of complex products. CSC01 proposed that proficient SCM represents a crucial feature of resilience within the SC paradigm. The diverse collection of components brought together by CSC required meticulous coordination to guarantee their prompt delivery and alignment. A disparity, such as an overabundance of components from supplier A alongside deficits from supplier B, compromised operational effectiveness. CSC01 said: *“Due to the complex SC that we operate, we need all parts to be synchronised with our system. It needs to operate like clockwork. This is the job of our SC department.”* The assigned department managed all elements and deliveries of the complex SC, requiring a thorough understanding of product specifications and production timelines to address potential disruptions. In cases of material shortages, the procurement team identified viable alternatives, playing a crucial role in ensuring component availability and enhancing overall SCR.

The case CSD was examined in the context of **behavioural flexibility**. The participants in the interview recognised behavioural flexibility as a significant feature of resilience while reflecting on the CSD case. They concurred that it is crucial for individuals to adopt a flexible mindset in business during difficult times, as this facilitates the identification of solutions and alternatives for complex challenges. Despite having set plans and timelines for delivery, unexpected occurrences, such as shipment delays or missing components, did occur. Therefore, the integration of a

certain level of flexibility within the system was considered an essential feature of resilience, as highlighted by CSD02: *"We need to stay flexible and even a bit creative when we are faced with shortages or limitations. We expect processes and flexibility. But hard to achieve."* From a strategic perspective, CSD01 emphasised the difficulties associated with flexibility and stressed the importance of accuracy and effective execution and said: *"We must prioritise correctly. All of them."* In summary, behavioural flexibility represents a vital feature of resilience that significantly impacts SCs. It is understandable that instances of behavioural flexibility are limited, as such flexibility often proves challenging in the context of complex products.

In summary, the discussion highlighted the analysis of SCM through two case studies, alongside an examination of behavioural flexibility, from a low complexity perspective. Notably, team capability was only considered in one of these cases. Conversely, from a high product complexity viewpoint, team capability emerged as a significant feature of resilience, as discussed in three cases. This was complemented by the management of SCs and behavioural flexibility, each addressed in a single instance.

Ultimately, the fourth viewpoint on behavioural flexibility as a common key theme emerges from the **business perspective**, distinguishing, first, **strategic** and, second, operational dimensions. The feature of **team capability** is examined from a strategic viewpoint by two interviewees, specifically CSB01 and CSI01. Participants emphasised that a team's capability is vital for resilience and affects knowledge management practices, such as safeguarding proprietary knowledge and managing subcontractor risks. They noted that issues like subcontractor dissolution, mergers, or operational failures could result in the loss of critical knowledge assets, with CSB01 particularly highlighting this concern: *"We have vertically integrated the core processes to keep our knowledge under control."* Fundamental operations and primary processes were executed within the organisation, thus reducing dependence on an external SC. The availability of local resources improved capacity by means of collaborative approaches.

The interviewee CSI01 reported that the organisation has effectively sustained elevated levels of competence across all phases of the value chain concerning CSI. As a result, each phase contributes to the overall proficiency of the team and fulfils the predetermined standards. In terms of inspection, lead time, or processing, CSI's value chain carefully executes the requisite measures to ensure customer satisfaction, as stated by CSI01: *"The team is not only dedicated but we see competence across the value chain and that is an important consistency required This competence and team capability ensures that requirements are managed adequately."* As a result, the capability of a team is a critical factor that impacts SCs.

The behavioural feature of **management of SCs** was raised by CSC01, CSF01 about understanding the strategic importance of the role of SCs. CSC01 argued that proficient SCM represents a crucial feature of resilience within the SC paradigm. The diverse collection of components brought together by CSC required meticulous coordination to guarantee their prompt delivery and alignment. A disparity, such as an overabundance of components from supplier A alongside deficits from supplier B, compromised operational effectiveness, according to CSC01: *"Due to the complex SC that we operate, we need all parts to be synchronised with our system. It needs to operate like clockwork. This is the job of our SC department."* CSF01 identified the

oversight of SCs as a fundamental feature of resilience. It was evident that specific teams held clear responsibilities for managing contracts and ensuring timely deliveries within the SC. Strategically, the procurement team was expected to demonstrate flexibility while minimising transaction costs. Additionally, the administrative burden was required to be kept to a minimum. The teams were also tasked with the full responsibility of navigating the process of switching suppliers, incorporating new suppliers, or developing additional supplier relationships, as stated by CSF01: *“It is less administrative and bureaucratic to switch suppliers, to activate new suppliers, or to work on alternatives”*. In conclusion, both strategic perspectives highlight that the ability of management to supervise SCs is an essential feature of resilience that influences the effectiveness of SCs. It might have been anticipated that a greater number of interviewees would identify this aspect as a strategic feature.

Two interviewees, CSD01 and CSF01, highlighted **behavioural flexibility** as a significant feature. They recognised this trait as an important feature of resilience while analysing cases CSD and CSF from a strategic business viewpoint. Both interviewees concurred that maintaining a flexible business approach during difficult times is crucial for exploring various solutions and alternatives to complex problems. Despite having established plans and timelines for delivery, unexpected occurrences, such as shipment delays or missing components, can still occur. CSD01 emphasised the obstacles to maintaining flexibility and stressed the importance of accuracy and effective execution: *“We need to get the priorities right. All of them.”* In conclusion, behavioural flexibility is a crucial feature of resilience that influences SCs. CSF01 recognised behavioural flexibility as a feature of resilience observed during the study. Notably, a high degree of adaptability and speed was apparent, especially regarding the transition between suppliers. Furthermore, there was an enhancement in the ability to endorse alternatives, coupled with a decrease in administrative expenses, as noted by CSF01: *“The private sector has a distinct advantage in the SC and that is the flexibility and the speed.”* The behavioural flexibility exhibited can be attributed to the competitive dynamics inherent in the private market. In this environment, continuous assessments of suppliers provide various alternatives that can be employed as needed. Therefore, it can be concluded that behavioural flexibility is an essential attribute when examining the resilience of SCs within the private sector.

In conclusion, the strategic perspective revealed that two interviewees emphasised the significance of team capabilities, particularly in relation to knowledge management and employee competencies. Similarly, the strategic importance of SCM was noted by two interviewees. Additionally, two interviewees highlighted the necessity of behavioural flexibility, especially in the context of addressing complex challenges.

In addition to the strategic business perspective, the subsequent sub-section will examine the **operational perspective** in discussing the behavioural features of resilience, beginning with an analysis of team. The concept of **team capability** is addressed by three interview participants (CSA02, CSB02, CSC02). Specifically, CSA has observed that the procurement team has collaborated with the SC to enhance and streamline delivery processes and purchase order timelines, which has led to improved delivery schedules. CSA02 remarked: *“Procurement manages the purchase orders, dates and deliveries. As we manage many suppliers, we need a large team for the job.”* This feature improved scheduling and fostered a beneficial SC environment by enabling negotiations, identifying alternative suppliers, and adjusting priorities. This allowed suppliers to enhance delivery systems, especially during challenges like a pandemic. The team's expertise is vital for strengthening SCR, as illustrated by CSB02, which emphasised the importance of knowledge management to protect proprietary information and minimise reliance on external SCs. CSB02 highlighted that maintaining essential operations internally is crucial for product integrity, stating: *“For resilience the process is important as it is the point of reference for the product and serves as reference.”* The availability of local resources improved capacity by means of collaborative approaches. Distinct network structures supplied raw materials that were crucial in strengthening local competencies and enhancing understanding of the product, as noted by CSB02: *“Thanks to local sourcing, we could use raw material locally produced.”*

The recent initiatives in employee training showcased the team's competencies. The interviewee, CSC02, noted that these initiatives contributed to an enhancement of the workforce's skill set. Furthermore, it is likely that this training also strengthened both individual self-esteem and team unity. Consequently, the dynamics and energy levels

within the team saw a significant improvement when compared to the time before the crisis. CSC02 stated: *“The training and job rotation programs we implemented for our employees greatly improved the team's overall skill set. Also important was the development of a strong team spirit. Despite the challenges imposed by lockdowns and restrictions, the energy and dynamics within the team reached new levels after the pandemic concluded, enabling us to confront significant challenges as one unified team.”* The apparent degree of energy and dynamism could be a result of an improved capacity to navigate intricate challenges, a more profound understanding of processes, and an augmentation of training and associated competencies. Furthermore, this phenomenon may be linked to an elevated sense of self-assurance cultivated through training initiatives and job rotations. Consequently, this feature is prominently reflected in the operational viewpoint.

Additionally, the **management of SCs** represents another behavioural aspect highlighted by CSE02 and CSF02. Interviewee CSE02 emphasised that effective SCM is a crucial feature of resilience that has been observed. Despite the complexities inherent in the SC structure, which encompasses the outsourcing of sophisticated components and specialised processes, along with variations in planning and customer requirements, timely delivery execution remained imperative. CSE02 remarked: *“We need to provide the right demand and forecast, and technically the suppliers are very capable. Of course, sometimes we have delivery delay due to customs or transport...”*

A competent team was essential for the effective use of tools, methodologies, and negotiation strategies to meet the necessary delivery timelines. CSF02 stated: *“Our procurement team has the job to manage all the deliveries and enforce the contractual terms.”* Additionally, the administrative burden was required to be kept to a minimum. The team was also expected to take full responsibility for managing the transition between suppliers, incorporating new suppliers, or fostering the development of new supplier relationships.

Two interviewees, CSD02 and CSH02, highlighted the feature of **behavioural flexibility** as a significant feature of resilience. They concurred that it is crucial for

individuals to adopt a flexible mindset in business operations during difficult times, as this adaptability facilitates the identification of solutions and alternatives to complex problems. Despite having set plans and timelines for delivery, unexpected occurrences, such as shipment delays or missing components, can still occur. Therefore, the integration of a certain level of flexibility within the operational framework was recognised as an essential feature of resilience, as articulated by CSD02. *"We need to stay flexible and even a bit creative when we are faced with shortages or limitations. We expect processes and flexibility. But hard to achieve."*

CSH02 reported that the organisation effectively incorporated the necessary personnel at pivotal times to carry out essential tasks. The achievement of flexibility was facilitated by the adoption of shift work and the availability of overtime. This implies that there was support from both unions and the works council for these shifts during demanding periods, as noted by CSH02: *"We mobilised our people during intense shifts. They were all on board, keeping the company interest as first goal."* An illustrative example concerning the SC department underscored the importance of not merely assessing suppliers but also tackling and rectifying any issues that arise. This strategy proved beneficial for efficient supplier management. CSH02 remarked: *"The gaps on assessments have to be closed, issues resolved with action plans as these will be the weakness in times of crisis."* The capacity to interact effectively with stakeholders and demonstrate adaptability signifies a strong dedication to collaboration among all participants. This methodology had a considerable impact on the resilience of the SC by emphasising actions oriented towards achieving results. Consequently, behavioural flexibility emerged as a feature of resilience that enhanced SC performance.

In summary from an operational standpoint, three interviewees emphasised that team capability is a behavioural feature. The management of SCs was addressed by two interviewees, who also discussed the concept of behavioural flexibility.

The **third common key theme pertains to the strategic features of resilience** that impact on SCs. This feature encompasses, firstly, the availability of alternatives, secondly, financial capacity, and thirdly, the process of digitisation. This key feature will now be examined through the lens of four categories: ownership type, enterprise size, product complexity, and business perspective. Regarding **ownership type**, the following three will be compared: SOEs, the domestic privately-owned enterprises and foreign-owned enterprises. Four **SOEs** (CSA, CSB, CSE, CSH) have been identified and will first discuss financial capability, followed by alternatives available. **Financial** capability is vital for resilience in CSA and CSH, ensuring operational continuity through timely payments and material flow. CSA01 emphasised its importance in enhancing SCR by enabling the procurement of critical inventory. The organisation effectively used its financial resources to compensate employees, suppliers, and partners, ensuring uninterrupted production operations, as noted by CSA01: *“Our company has the financial capability to buy inventory and to keep operations ongoing.”* This capability ensured continuous production by allowing financial transactions to be conducted with suppliers. Employees could sustain their work as they received their salaries. Adequate financial resources ensured that interruptions were kept to a minimum, thus representing a vital aspect that directly influences the resilience of the SC.

Furthermore, it was observed that the financial strength of CSH acts as a resilience factor that impacts SCs. The significance lay not merely in the monetary balance available but in what it represented: the capacity for strategic leadership and influence. CSH01 articulated this from a strategic viewpoint: *“A feature that we have is the financial capability to build confidence. We can sign contracts, negotiate, and give perspective to our SC.”* CSH02, incorporating an operational perspective, posited that enhanced financial capability alleviated the limitations associated with short-term planning, thereby enabling CSH to address long-term and strategic issues effectively. CSH02 stated: *“Our financial resources enable us to adopt a strategic approach to our core issues. We are not constrained by the need to manage short-term cash flow, allowing us to focus on long-term planning and negotiations.”* Consequently, the financial capabilities of an organisation represent a strategic feature of resilience that purposefully impacts SCs.

The second strategic feature identified only in case CSB pertains to the **availability of alternatives**. This feature necessitates strategic oversight and long-term planning. It is not unexpected that SOEs exhibit only one instance of this feature, given that their SCs are predominantly vertically integrated. Collaborations are typically formed through interactions with other SOEs, which diminishes the frequency of alternative options. Interviewee CSB01 highlighted that the availability of industrial alternatives is a vital feature of resilience that significantly influences SCs. The presence of secondary sources and redundancies enabled CSB to opt for a different supplier instead of depending solely on the conventional one. This ability not only enhanced operational capabilities but also fostered improved collaboration with the new supplier. Consequently, deliveries were sustained, and SCs were fortified. CSB01 said: *“The locally produced raw material is an important feature in our SC set-up. By having these alternatives, we can quickly adjust our SC based on business need. Consequently, we improve relations and derisk SC blockages.”* The presence of alternative options significantly contributed to the improvement of the SC's overall performance.

In case CSE, no strategic feature of resilience impacting SCs was recognised, suggesting that the company may be functioning in a tactical capacity considering the pressures exerted by the COVID-19 pandemic. Furthermore, none of the case studies addressed the topic of digitisation, potentially reflecting the restricted technological integration prevalent in SOEs.

In conclusion, the analysis of SOEs reveals that two of the cases examined identified financial capability as a critical strategic element. One of the case studies explored the various alternatives that are accessible. However, none of the cases addressed digitisation as a factor impacting SCs.

In addition to SOEs, **domestic privately-owned enterprises** (CSF) have primarily regarded digitisation as a strategic feature of resilience. This observation is not particularly unexpected, given that the private sector tends to be more receptive to innovative initiatives and, due to inherent resource limitations, must seek avenues to enhance operational efficiencies.

CSF identifies **digitisation** as merely one feature of this strategy. Furthermore, CSF02 highlighted digitisation as a newly recognised and vital feature of resilience. During the initial phase, demand planning was executed through IT systems across the SC, which enabled the seamless flow of information and ensured alignment among all suppliers, as noted by CSF02: *“Our demand planning is sent through IT system to our suppliers.”* This methodology ensured the reduction of errors and promoted a degree of synchronisation across the SC. Additionally, CSF02 highlighted that digitisation offers markedly improved functionalities for data utilisation in forecasting, alongside bolstering real-time decision-making, risk management, and scenario analysis. CSF02 said: *“...more advanced models for forecasting will be deployed...”* Consequently, it was anticipated that the feature of resilience would gain greater significance in the future, potentially encompassing additional elements such as inventory management or prioritisation.

Financial capability and alternative available has not been discussed by the domestic privately-owned enterprise. CSF has entered the aerospace industry only in recent years. It can be inferred that financial capacity has not been a crucial feature in terms of resilience, given the relatively modest volumes involved and the predominance of goodwill over financial resources. Additionally, as a new entrant in the aerospace industry, CSF may prioritise the stabilisation of its initial suppliers over exploring alternatives, secondary sources, and redundancy options.

The third category of ownership identified pertains to **foreign-owned enterprises** (CSC, CSD, CSG, CSI) and their strategic features. The strategic options were analysed through the lenses of CSD and CSI, highlighting the benefits of alternatives and increased capacity, which alleviate SC strain and enhance the local landscape. Interviewee CSD02 stressed the importance of alternative availability, noting its positive impact on SCs by enabling customers to switch suppliers, foster competition, and respond quickly to their needs. Interviewee CSD02 remarked: *“The availability of local sources that we have is a feature that strongly influences the SC. If overseas suppliers don’t respond we can switch to local production. That way we are more agile, keep competition and can respond to the demand faster.”* Developing alternative options involves thorough supplier evaluations and significant financial investment, enhancing negotiation leverage, cost visibility, and capacity. While less suitable for complex products, alternatives are viable for commodities, improving SC agility, response times, and transparency. Interview participants emphasised the role of alternatives in boosting SCR, with CSI01 noting successful cases that improved capacity and location access, leading to better reliability and shorter lead times. CSI01 said: *“For me it’s our continuous discussion about qualifying alternative sources for material ... We have come a long way and can already propose alternative sites, but there is still a lot to be done.”*

In addition to its strategic perspective, CSI02 integrated an operational aspect. The capacity to offer a diverse range of material types, grades, and similarities creates a unique opportunity for clients to obtain materials more rapidly, possibly at a lower expense and with enhanced capabilities, as stated by CSI02: *“We possess the expertise and experience necessary to offer our clients alternative material options.”* As a result, the availability of alternatives is regarded as a key feature of resilience that directly influences SC dynamics.

Cases CSC and CSG did not mention any strategic feature of resilience. Given that strategic business decisions are primarily made in foreign territories, this may serve as a rationale for the lack of this feature in the analysis of these cases.

In conclusion, the SOEs examined financial capacity as a critical feature of resilience in two specific cases. One of these cases focused on the various alternatives that can be considered a strategic feature. In contrast, the case involving a domestic privately-owned enterprise addressed the topic of digitisation. Additionally, foreign-owned enterprises referenced the availability of alternatives in two separate instances.

The subsequent perspective examines the features associated with the size of enterprises, specifically contrasting large enterprises with small and medium-sized enterprises. Initially, an analysis of large enterprises (CSA, CSB, CSF, CSG, CSH, CSI) reveals several features of resilience. The strategic dimension of **financial capability** is explored through two case studies (CSA, CSH). Both studies indicate that financial capabilities enhance inventory management in the SC, providing a competitive advantage. They also highlight that financial capability influences strategic direction and increases customer confidence. Interviewee CSA01 noted its importance in strengthening SCR. The case study examined CSA's ability to procure essential inventory while effectively utilising financial resources to support employees, suppliers, and partners, ensuring smooth production. Interviewee CSA01 noted: *"Our company has the financial capability to buy inventory and to keep operations ongoing."*

This feature enabled continuous production by optimising financial dealings with suppliers, allowing employees to keep their jobs and salaries. Adequate financial resources minimised disruptions, highlighting their crucial role in SCR. Interviewees emphasised financial capability as essential for resilience, noting that CSH's financial strength reflects both capital availability and its strategic implications. CSH01 articulated this from a strategic perspective: *"A feature that we have is the financial capability to build confidence. We can sign contracts, negotiate, and give perspective to our SC."* CSH02, incorporating an operational perspective, posited that enhanced financial capability alleviated the limitations associated with short-term planning, thereby enabling CSH to address long-term and strategic issues effectively. CSH02 stated: *"Our financial resources enable us to adopt a strategic approach to our core issues. We are not constrained by the need to manage short-term cash flow, allowing us to focus on long-term planning and negotiations."* Consequently, the financial capabilities of an organisation represent a critical feature of resilience that strategically impacts SCs.

A second strategic feature was identified in two cases (CSB CSI), specifically the **availability of alternatives**. Both cases highlighted the advantages associated with alternatives, noting that their availability offers a range of benefits, including commercial advantages, enhanced capacity, and improved reactivity. Interviewee

CSB01 underscored that the existence of **industrial alternatives** is a vital feature of resilience that directly influences SCs. The availability of secondary sources and redundancies enabled CSB to opt for a different supplier instead of depending exclusively on the traditional one. This flexibility not only augmented operational capacities but also fostered better collaboration with the new supplier. Consequently, deliveries were sustained, and SCs were fortified, as noted by CSB01: *“The locally produced raw material is an important feature in our SC set-up.”* The availability of alternative options significantly improved SC performance. CSI01 noted successful cases that increased capacity and alternative locations, leading to commercial benefits like enhanced capacity, reliability, and shorter lead times. CSI01 said: *“For me it’s our continuous discussion about qualifying alternative sources for material ... We have come a long way and can already propose alternative sites, but there is still a lot to be done.”* In addition to its strategic perspective, CSI02 integrated an operational aspect. The capacity to offer a range of material types, grades, and similarities creates a unique opportunity for clients to obtain materials more rapidly, possibly at a lower expense and with enhanced capabilities, as stated by CSI02: *“We possess the expertise and experience necessary to offer our clients alternative material options. Our understanding of the product requirements allows us to suggest different grades of materials, which we align with our insights into market capacity.”* As a result, the availability of alternatives is regarded as a defining feature of resilience, which directly influences SCs.

Case CSF has analysed the strategic aspect of **digitisation**, addressing the aviation industry's hesitance to adopt transformative changes. They may set a model for other firms by highlighting digitisation as key to resilience. Initially, demand planning used IT systems across the SC for smooth information exchange among suppliers. CSF02 said: *“Our demand planning is sent through IT system to our suppliers.”* This methodology ensured a reduction in errors and promoted a degree of synchronisation across the SC. Additionally, CSF02 highlighted that digitisation offers markedly improved functionalities for data utilisation in forecasting, alongside bolstering real-time decision-making, risk management, and scenario analysis. CSF02 stated: *“More advanced models for forecasting will be deployed...”* Consequently, it was anticipated

that the feature of resilience would gain greater significance in the future, potentially encompassing additional elements such as inventory management or prioritisation.

Participants in the interviews regarding CSG did not comment on any strategic aspects. This lack of observation may be attributed to the company's current operational crisis mode, wherein strategic initiatives might be suspended in favour of prioritising short-term industrial recovery.

In conclusion, representatives from large enterprises identified financial capability as a significant factor affecting the SC in two specific instances. Both cases were viewed similarly regarding the availability of alternatives. However, digitisation was mentioned in only one of the cases.

An analysis of the cases from the perspective of **small and medium-sized enterprises** (SMEs) reveals that among the three strategic features of resilience, only the availability of alternatives has been identified in a single instance. There is a noticeable absence of discussion regarding financial capabilities and digitisation. This observation leads to the conclusion that SMEs appear to exhibit limited concern for strategic features. In the case of CSD, the **availability of alternatives** was specifically addressed as a strategic feature of resilience. Interviewee CSD02 emphasised the importance of having alternatives, pointing out its influence on SCs. This intrinsic quality enables customers to switch suppliers, engage in competitive behaviours, and respond more rapidly to their requirements. Interviewee CSD02 remarked: *“The availability of local sources that we have is a feature that strongly influences the SC. If overseas suppliers don’t respond we can switch to local production.”* Developing alternatives involves extensive supplier evaluations and financial investment, but it improves negotiation leverage, cost transparency, and capacity. Alternatives are less feasible for complex or high-capital products. They are more beneficial for commodities than uniquely engineered products, resulting in greater SC flexibility, faster response times, and improved inventory and expense management.

In summary, representatives from major corporations highlighted financial capacity as a key factor in the SC across two contexts, both of which were similarly assessed for alternatives, though digitisation was noted in only one. In contrast, SMEs only addressed alternatives in one context, with no mention of financial capacity or digitisation.

The third viewpoint on strategic features of resilience affecting SCs addresses **product complexity**, divided into low and high complexity. It starts with low-complexity products (CSE, CSF, CSG, CSH, and CSI), which have recorded only three distinct responses.

The case CSF addressed the topic of digitisation, which is particularly noteworthy from the standpoint of low product complexity. This innovative strategy may initially be trailed on simpler products before being expanded to encompass more complex items at a later stage. CSF02 said: *“Besides demand planning that we send, we are also expecting to receive real-time production status from our suppliers by IT.”*

The case CSH focused solely on financial capability, which is reasonable given that low-complexity products face intense competition and lower profit margins. Investments in these products are often amortised in advance. CSH01 noted strategically: *“A feature that we have is the financial capability to build confidence.”* Consequently, effective inventory and stock management becomes critical, with financial resources playing a vital role during periods of crisis. CSH02 added that its financial capability allowed to tackle issues and identify strategic solutions: *“Our financial resources enable us to adopt a strategic approach to our core issues.”*

The case CSI examined the available alternatives as their only case. CSI01 said: “For me it’s our continuous discussion about qualifying alternative sources for material.” Which was also confirmed by CSI02: “We possess the expertise and experience necessary to offer our clients alternative material options.” A broader response could have been anticipated, as the costs associated with switching and the availability of alternatives are generally lower for less complex products compared to their more intricate counterparts.

The cases CSE and CSG did not reveal any strategic feature throughout the study. In the examination of cases characterised by **high product complexity**, specifically CSA, CSB, CSC, and CSD, several strategic features have been identified. The strategic aspect of **available alternatives** has been examined in two cases (CSB, CSD). The cases highlighted the importance of local SCs and material accessibility.

Some companies prioritise complex components while neglecting upstream procurement. Interviewee CSB01 noted that industrial alternatives are vital for resilience and operations. By partnering with an alternative supplier, CSB reduced reliance on traditional sources, improving operational flexibility, collaboration, and delivery reliability. CSB01 remarked: *“By having these (locally produced) alternatives, we can quickly adjust our SC based on business need. Consequently, we ... derisk SC blockages.”* The availability of alternative options significantly enhanced SC efficiency. Interviewee CSD02 emphasised their importance, noting that they enable customers to switch suppliers, adopt competitive strategies, and respond quickly to needs. Interviewee CSD02 stated: *“The availability of local sources that we have is a feature that strongly influences the SC. If overseas suppliers don’t respond we can switch to local production. That way we are more agile, keep competition and can respond to the demand faster.”* Developing alternative options requires thorough supplier assessments and significant financial investments. However, this approach offers benefits in negotiations, such as improved cost transparency and increased capacity. While alternatives may not be practical for complex products, they are more suitable for commodities and tradable goods, enhancing SC flexibility, response times, and clarity on inventory and costs.

The feature of **financial capability** as a strategic asset has been explored in a singular case study (CSA). This investigation focused on CSA's ability to acquire supplementary inventory, ensuring the consistent availability of essential components and materials. Additionally, the organisation adeptly leveraged its financial resources to compensate its workforce, suppliers, and partner network. This strategic manoeuvre contributed to the seamless continuity of production operations, as noted by the interviewee, CSA01: *“Our company has the financial capability to buy inventory and to keep operations ongoing.”* This capability ensured continuous production by allowing seamless financial transactions with suppliers. Adequate financial resources assured that interruptions were kept to a minimum, thus acting as an essential element that directly influences the robustness of the SC.

The case study CSC revealed a lack of strategic elements pertaining to strategic features of resilience. This may arise because CSC functions primarily as a satellite

location in China, associated with its main facility in Europe. Strategic decisions are made at the headquarters and are simply implemented in China.

In summary of the discourse regarding product complexity, it is noted that cases characterised by low product complexity exhibit a lack of shared features. Conversely, in instances of high product complexity, the presence of alternatives available is addressed in two separate cases.

The fourth and final viewpoint considered regarding the strategic features of resilience that affect SCs is the **business perspective**, contrasting the **strategic perspective** with the operational perspective. Two strategic attributes were articulated by two interviewees, each contributing insights into the significance of **financial capability** as a strategic element for the business. The interviewee designated as CSA01 emphasised the importance of financial capability as a vital feature that bolsters resilience within the SC. The analysis focused on CSA's ability to acquire supplementary inventory, ensuring the consistent availability of essential components and materials. Additionally, the organisation adeptly leveraged its financial resources to compensate its workforce, suppliers, and partners within its network. This strategic manoeuvre enabled seamless production operations. Interviewee CSA0 said: *"Our company has the financial capability to buy inventory and to keep operations ongoing."* Two interviewees stressed the importance of financial capability for the business. CSA01 noted that it enhances SCR by allowing the procurement of additional inventory for critical components and effectively supports workforce, supplier, and partner payments, ensuring uninterrupted production. CSH01 articulated this view from a strategic perspective: *"A feature that we have is the financial capability to build confidence. We can sign contracts, negotiate, and give perspective to our SC."* Consequently, the financial capabilities of an organisation represent a critical feature of resilience that strategically impacts SC.

The discussion regarding **available alternatives** was illustrated by CSB01 and CSI01, both of whom highlighted the strategic significance of these options in contexts such as negotiation and alleviating SC pressures. Interviewee CSB01 emphasised that industrial alternatives are crucial for SCR. Access to secondary sources allowed CSB

to partner with an alternative supplier, reducing reliance on the primary source and improving operational efficiency and collaboration, which ensured consistent deliveries and maintained SC integrity. CSB01 said: *“By having these alternatives, we can quickly adjust our SC based on business need.”* The availability of alternative options significantly improved SC efficiency. Both interview participants stressed their importance for resilience and SC dynamics. CSI01 noted successful cases that increased capacity and created alternative locations, leading to commercial benefits like enhanced capacity, reliability, and shorter lead times. CSI01 said: *“For me it’s our continuous discussion about qualifying alternative sources for material. The cases we have established were all successes. We have come a long way and can already propose alternative sites, but there is still a lot to be done”* As a result, the availability of alternatives is regarded as a defining feature of resilience, which directly influences SC.

Upon examining the cases from an **operational business perspective**, it is evident that all three strategic features of resilience have been addressed. The feature of **available alternatives** has been identified as a strategic element by both CSD02 and CSI02, primarily because it enhances the capacity of the SC and ensures a robust response to business demands. Interviewee CSD02 emphasised the importance of having alternatives, pointing out their influence on SC dynamics. This feature enables customers to switch suppliers, participate in competitive activities, and adapt more rapidly to their requirements, as noted by Interviewee CSD02: *“The availability of local sources that we have is a feature that strongly influences the SC. If overseas suppliers don’t respond we can switch to local production. That way we are more agile, keep competition and can respond to the demand faster.”* CSI02 introduced an operational aspect to its offerings. The capability to supply a diverse range of material types, grades, and similarities creates a unique opportunity for clients to obtain materials more efficiently, possibly at a lower cost and with enhanced capacities, as stated by CSI02: *“Our understanding of the product requirements allows us to suggest different grades of materials, which we align with our insights into market capacity.”* As a result, the availability of alternatives is regarded as a defining feature of resilience, which directly influences SCs.

Only one interviewee, CSH02, addressed the strategy of **financial capability**. CSH02 emphasised that the financial capability of CSH acts as a resilience factor influencing SCs. From an operational standpoint, CSH02 further articulated that financial capability alleviates constraints associated with short-term planning, enabling CSH to engage with long-term and strategic issues. CSH02 remarked: *“Our financial resources enable us to adopt a strategic approach to our core issues. We are not constrained by the need to manage short-term cash flow, allowing us to focus on long-term planning and negotiations.”*

The strategic aspect of **digitisation** was noted solely from an operational viewpoint, which is unexpected given that this strategic feature is emphasised by an interviewee (CSF02). CSF02 identified digitisation as a newly emerged and crucial feature of resilience. During the initial phase, demand planning was executed through IT systems across the SC, enabling the flow of information and ensuring alignment

among all suppliers. CSF02 commented: “*Our demand planning is sent through IT system to our suppliers.*” This approach ensured a reduction in errors and promoted a degree of synchronisation across the SC. Additionally, CSF02 highlighted that digitisation offers markedly improved functionalities for data utilisation in forecasting, alongside bolstering real-time decision-making, risk management, and scenario analysis. CSF02 stated: “*...more advanced models for forecasting will be deployed...*” Consequently, it was anticipated that the feature of resilience would gain greater significance in the future, potentially encompassing additional elements such as inventory management or prioritisation.

In conclusion, the operational business viewpoint highlighted the importance of accessible alternatives and financial capacity as key features. Additionally, CSF02 emphasised that digitisation is a fundamental feature of strategic resilience.

The **fourth common key theme pertains to the tactical feature of resilience** and their impact on SCs. This theme encompasses three specific features of resilience: first, the management of buffers and inventories; second, the prioritisation; and third, the accessibility of an international logistics network. This key feature will be examined through the lens of four categories: company ownership, enterprise size, product complexity, and business perspective. The initial analysis will focus on **ownership types**, including SOEs, domestic privately-owned entities, and foreign-owned companies, with a particular emphasis on the perspectives of **SOEs** (CSA, CSB, CSE, CSH).

The **management of buffers and inventories** has been examined in two distinct cases (CSA and CSB). CSA02 emphasised that the management of these elements is a vital feature of resilience that influences the SC. To cultivate sufficient SCR, it is imperative to implement effective planning, adopt a systematic methodology, possess strong problem-solving skills, and maintain a dedicated organisational structure. CSA02 stated: *“Disruptions in logistics can cause delivery issues, so we depend on a strong logistics team. We also strategically plan inventory to set reorder points and maintain stock levels, ensuring effective SC operations.”* Effective inventory management is vital for enhancing SCR by mitigating disruptions. It demonstrates an organisation's ability to withstand interruptions, as seen in case CSA. This approach ensures adequate stock levels, preventing shortages, as noted in CSA02: *“We maintain several months' worth of essential components in our warehouses, but some materials have shelf-life limitations, requiring us to weigh the costs of scrapping against the risks of running out.”*

CSA02 highlighted the importance of resilience through CSA's oversight of critical infrastructure and financial capacity for inventory investment. Effective inventory and buffer management are vital for enhancing SCR. CSB02 contributed by discussing capabilities in this area, emphasising the role of inventory levels and management strategies. This process is key for optimising buffer and inventory sizes while evaluating different data configurations. CSB02 said: *“We keep a substantial inventory but also manage it flexibly according to the prevailing conditions. For example, we must meticulously monitor configurations, shelf life, and references. This is a complex*

skill that demands continuous focus.” Effective component management is vital for optimising order batch sizes, strategies, and buffer configurations, and can mitigate SC disruptions, as demonstrated in the CSB case. Therefore, managing buffers and inventories is key to improving SCR.

Prioritisation as a tactical feature of resilience has been evidenced in a specific case (CSA), which appears credible given the observation that SOEs often systematically favour non-civil business activities. Prioritising customer requirements is crucial for resilience. Some customers express urgency based on preference rather than actual need, and a strong SC must accurately identify genuine demands. In the case CSA, non-commercial initiatives often take precedence over real business needs, hindering effective prioritisation. However, CSA policies clearly define customer hierarchy. CSA02 said: *“I have observed repeatedly that the SOE, which also engages in non-civil projects, tends to swiftly divert resources away from civil projects.”* Due to CSA customer requirements and the organisation's status as a SOE, non-commercial initiatives were prioritised over commercial projects in development, production, and delivery. This was further influenced by a financing structure reliant on State funding, making prioritisation essential for maintaining SCR.

The discussion regarding the **availability of international logistics network** was limited to a single case. This is not unexpected, given that SOEs frequently depend on other SOEs for logistics service provision, resulting in a vertically integrated business structure. However, CSA02 provided an illustrative example that highlighted the logistical capabilities of CSA and their influence on SCs. The strong relationships with regulatory agencies and logistics companies enabled efficient processing, guaranteeing timely delivery of parts to the customer, as noted by CSA02: *“We handle shipments and manage our SC processes....”* A global logistics network has significantly enhanced component procurement and goods distribution, strengthening SCR through effective international logistics. Without this network, suppliers and customers would face isolation, hindering timely delivery of essential parts and products.

Both case study CSE and CSH have not discussed any tactical feature of resilience. The lack of challenges necessitating tactical reflections in both CSE and CSH, as SOEs dealing with low-complexity products, may explain their focus on strategic considerations instead. For example, the need for buffers, prioritisation, and international logistics may be diminished due to the availability of sufficient inventory, the capacity to meet all customer demands, and the existence of an established international logistics network.

In summary, the examination of SOEs included a discussion on the management of buffers and inventories across two distinct cases. The issue of prioritisation was highlighted in one instance, revealing a general perception that SOEs do not prioritise commercial clients. Additionally, one case addressed the accessibility of an international logistics network. Notably, two cases lacked any tactical elements related to resilience.

China's private sector lacks identifiable tactical resilience features, likely due to its early development stage. The supplier operates as a dual source, allowing the OEM to address urgent needs by engaging a secondary supplier. The SC is evolving, and complexities typical of mature SCs have not yet emerged, suggesting that historical legacy challenges are also absent. This situation may indicate that the private sector is well-positioned to focus on strategic planning for long-term SCR.

The third perspective presented in the overview concerning enterprise ownership pertains to foreign-owned enterprises (CSC, CSD, CSG, CSI). The tactical feature of **managing buffers and inventories** was highlighted in two instances (CSG and CSI). The importance of policy implementation and continuous evaluation was emphasised, though less frequently discussed, especially given many companies' inventory shortages. Interviewee CSG01 highlighted that effective inventory management is crucial for organisational resilience and must be tailored to the product type. Complex products face a higher risk of depletion, while the JIT approach is particularly suited for commodities. CSG01 said: *"JIT represents a feature of resilience. It goes beyond just managing stock levels; it's a whole philosophy that defines the SC. It's about being lean, getting only what you need, cutting down on waste, and relying on suppliers. That said, we should evaluate whether JIT is the best fit for our industry."* The earlier strategies, including JIT delivery and dependence on a global SC, proved insufficient for the current framework and were reevaluated in light of the business requirements, as stated by CSI02: *"The JIT is not adequate in our industry. We see so many disruptions. So, our role is to keep the inventories for our customers."* The ability to manage buffers and inventories independently of JIT global SCs was crucial for production, enhancing SC agility and reducing the risk of disruptions from unexpected events.

The tactical aspect of **prioritisation** was mentioned in only one instance (CSD). It can be argued that other cases do not cater to as extensive a customer base or as many OEMs. As the customer base grows, prioritising individual customers becomes more challenging. CSD acknowledges this issue, though its validity is unproven. Interviewee CSD01 emphasised that prioritisation is vital for resilience, urging alignment of actions with priorities, especially during resource scarcity and time constraints for executives

and managers. CSD01 remarked: *“We need to get the priorities right. All of them.”* A key decision-making scenario involved choosing between improving customer visibility on order status and allocating production to a new customer amid limited resources. Clear directives were essential to prevent misalignment of priorities and minimise time spent on discussions rather than actions. CSD01 added: *“We established an order of priorities based on customer, program, logistics and volume. It wasn’t perfect but nobody was forgotten.”* By establishing clear priorities, the process of restoring standard levels in the SC became more transparent and efficient, enhancing resilience. Thus, prioritisation is a crucial feature of resilience that directly affects the SC.

The CSC case overlooked tactical resilience, likely because the foreign-owned small manufacturing enterprise already integrates elements like buffers, customer prioritisation, and optimised logistics. There is also a lack of case studies on international logistics as a strategic resilience factor, possibly due to access challenges in China, where many logistics providers are foreign-owned, limiting local influence. While domestic logistics in China is competitive, State involvement in imports and exports imposes stricter regulations, hindering the full benefits of the international logistics network.

The examination of SOEs through two case studies on buffer and inventory management revealed key findings. The first case highlighted prioritisation challenges, showing that SOEs often neglect commercial client needs. The second case focused on the accessibility of an international logistics network, but neither case addressed strategic resilience. Domestic privately-owned enterprises showed no tactical resilience aspects, while foreign-owned enterprises emphasised buffer and inventory management, with prioritisation mentioned once.

The next perspective will be from the **size of the enterprise** (large enterprise versus small and medium-sized enterprise) by first discussing the large enterprises: (CSA, CSB, CSF, CSG, CSH, CSI). The **management of buffers and inventories** was examined across four distinct cases (CSA, CSB, CSG, CSI). This analysis reveals that large organisations rely on buffers and inventories for a steady flow of components. However, COVID-19 disruptions require a re-evaluation of these practices. CSA02 highlights that effective management of components is crucial for SCR. To improve resilience, organisations should prioritise effective planning, systematic approaches, enhanced problem-solving, and a committed structure. CSA02 said: *“Logistics and inventory management are vital to the daily SC. Disruptions in logistics can lead to delivery issues, so we rely on a strong logistics team. Similarly, we carefully plan our inventory to set reorder points and maintain stock levels”* Efficient inventory management is vital for enhancing SCR by mitigating disruptions. It demonstrates an organisation's ability to withstand interruptions, as seen in case CSA, and helps maintain adequate stock levels to prevent shortages. CSA02 stated: *“We keep several months' supply of critical components in our warehouses; however, certain materials have limited shelf lives.”* CSB02 remarked, *“We not only maintain a high inventory but also adaptively manage it based on current circumstances It is a sophisticated skill that requires ongoing attention.”* As a result, the management of components will affect the dimensions of order batches, the strategies employed, and the arrangement of buffers and inventories.

In contrast, it has been noted by CSG01 that the JIT methodology and philosophy are especially relevant to commodities: *“JIT is a feature of resilience that goes beyond inventory management, promoting efficiency by acquiring only what is necessary and minimising waste. However, we must evaluate its suitability for our industry.”* The examination showed that JIT strategies worked well for commodities, but the client's production faced disruptions for complex components due to low inventory. Previous methods, including JIT delivery and a global SC, were deemed inadequate and reassessed based on business needs. CSI02 said: *“We are where the customer is with warehouses around the globe and within proximity of the production site.”* The ability to manage buffers and inventories independently, separate from JIT global SCs, was vital for production methods. This capability increased SC agility and reduced the

risk of disruptions from unexpected events, leading to better planning, efficiencies, and cost savings. In summary, effective buffer and inventory management significantly enhanced overall SC performance.

The feature of the **international logistics network** was exclusively addressed by CSA. The response pattern indicates that major corporations typically form framework agreements with logistics specialists. Interviewee CSA02 highlighted CSA's logistical advantages and their positive impact on SCs, noting that strong relationships with regulatory agencies and logistics firms enabled quick processing and timely delivery of components to clients. CSA02 noted: *“Logistics plays a vital role in managing shipments and coordinating our SC operations. This has become especially crucial during the pandemic. However, thanks to our established network of customs and logistics partners, we can prioritise incoming shipments effectively. This ensures that final products are delivered directly to customers.”* The presence of a global logistics network enabled the procurement of components from suppliers and the delivery of products to consumers. This network greatly improved the robustness of SCs by allowing for effective logistics operations across international boundaries.

The concept of **prioritisation** was introduced solely by CSA as a tactical feature of resilience. This raises the question of why prioritisation is not regarded with greater significance as a tactical feature. As a result, the capacity to prioritise based on necessity was not sufficiently implemented. Nonetheless, CSA's policy clearly delineates its customer hierarchy, as noted by CSA02. *“Prioritising non-civil projects, by the SOE means other customers orders are not their priority.”* Within the context of CSA customer needs, non-commercial projects were given precedence, largely due to its status as a SOE. As a result, commercial projects were considered subordinate in the areas of development, production, and delivery. This prioritisation was additionally shaped by the financing model, which was predominantly dependent on State funding. Thus, prioritisation emerges as a critical element for enhancing resilience within the SC.

During the analysis of case CSF and CSH no tactical feature of resilience has been observed. CSF and CSH are substantial enterprises in size that offer products

characterised by low complexity, which indicates that their output is primarily commoditised. This suggests that both CSF and CSH possess enhanced capabilities to meet customer demand, including machine capacity, workforce availability, and product stability. Consequently, it can be inferred that CSF and CSH prioritise strategic features of resilience, such as digitisation (as elaborated in CSF) and financial robustness (as examined in CSH) over tactical features.

In conclusion, large corporations recognise the management of buffers and inventories as a strategic element in four instances. The aspect of international logistics was mentioned in only one case, along with prioritisation. Additionally, two cases did not exhibit any tactical feature.

From the viewpoint of **small and medium-sized enterprises** (SMEs), specifically CSC, CSD, and CSE, only the aspect of prioritisation has been mentioned by a single instance. Consequently, it can be inferred that SMEs do not perceive these features as having a direct impact on SCs. The case of CSD was noted as the sole instance among SMEs regarding **prioritisation**. The notion of prioritisation is an additional feature of resilience underscored by CSD01. It was highlighted that the execution of actions must be in accordance with the relevant priorities. During times of limited resources and time constraints, particularly for executives, managers, and team leaders, it is crucial to focus on these priorities. CSD01 stated: *"We need to get the priorities right. All of them."* A key decision involved balancing customer visibility on order status with production efforts for a new customer with limited resources. Establishing clear directives was essential for aligning priorities and reducing deliberation time. This clarity improved the SC's transparency and efficiency, enhancing its resilience. Thus, prioritisation is crucial for strengthening SCR.

The cases CSC and CSE discussed no tactical features of resilience. Both instances share the characteristic of being SMEs with considerable expertise in the production of aircraft components. Additionally, both establishments have been developed as greenfield sites, resulting in processes that are newly conceived and optimised for efficiency. The facilities are well-lit and promote a productive work environment. The approach to business is strategic and oriented towards long-term goals, rather than being reactive and driven by immediate needs. For example, both CSC and CSE benefit from long-term customer contracts that facilitate strategic planning of capacity and workforce.

In summary, major corporations identify the management of buffers and inventories as a strategic component in four specific instances. The dimension of international logistics was referenced in only one instance, alongside the concept of prioritisation. Furthermore, two instances did not demonstrate any tactical features. In the context of SMEs, prioritisation was noted in a single case, which did not offer any definitive involvement. Additionally, two cases lacked any tactical features.

The third perspective is taken from a **product complexity perspective** (low complexity versus high complexity) view on the features of tactical resilience that influence SCs. First, the cases are examined from the standpoint of low product complexity, specifically focusing on CSE, CSF, CSG, CSH, and CSI. The strategic aspect of **managing buffers and inventories** is highlighted in two instances (CSG, CSI). Both instances stressed the importance of material availability and an effective inventory strategy for timely deliveries to manufacturing and clients. The JIT approach is especially relevant for low-complexity products, as noted by CSG01: *“Just-In-Time is a feature of resilience that goes beyond inventory management, promoting efficiency by acquiring only what is necessary and minimising waste. However, we must evaluate its suitability for our industry.”* The earlier strategies, including JIT delivery and dependence on a global SC, proved insufficient for the current framework and were re-evaluated considering the business requirements, as stated by CSI02: *“The JIT is not adequate in our industry.”* Managing buffers and inventories independently of JIT SCs was crucial for production, enhancing agility and reducing disruptions. This led to improved planning, efficiencies, and cost savings, significantly impacting overall SC performance.

The cases of CSE, CSF, and CSH do not exhibit any tactical features of resilience. The companies in question can be categorised as either SOEs or foreign-owned, and they vary in size from large to small. Nonetheless, a shared characteristic among them is their production of low-complexity products. These commodity-like products may necessitate fewer tactical attributes; instead, they demand technical and strategic considerations, including capacity management and rate flexibility (CSE, CSF), as well as quality standards (CSE, CSH). In addition, the examination of low complexity products reveals a lack of tactical elements altogether, including prioritisation and access to an international logistics network. This absence may stem from the commoditisation of the product, leading to a focus on resilience that is more aligned with technical and behavioural attributes. These attributes encompass capacity management, rate flexibility, quality standards, and the overall management capabilities within the SC.

Furthermore, from the standpoint of **high product complexity** (CSA, CSB, CSC, and CSD), all three tactical features have been identified. In terms of high complexity, the **management of buffers and inventories** was noted in two instances (CSA, CSB). To cultivate sufficient SCR, it is crucial to implement effective planning, adopt a structured methodology, enhance problem-solving skills, and establish a dedicated organisational framework. CSA02 remarked: *“The logistics and inventory management are impacting SC every day. We expedite and receive products daily. Any problem in logistics will lead to delivery issues. So, we rely on a strong logistics and transport department. The same is for inventory. We plan very detailed. The inventory will determine reordering points, it will provide stock level and so on.”* Effective inventory management is essential for enhancing SCR, largely because of its ability to mitigate disruptions. It demonstrates the organisation's competence, especially in the context of case CSA, to withstand interruptions for a defined period. This engagement framework is associated with inventory management and has the capacity to sustain sufficient stock levels, thus averting shortages, as noted by CSA02: *“We keep a supply of critical components in our warehouses for several months; however, some materials have a limited shelf life, requiring us to weigh the costs of disposal against the risks of running low on inventory.”* CSB02 said, *“We maintain a flexible inventory, carefully tracking configurations, shelf life, and references, which requires a complex skill set and ongoing attention.”* Effective management of components is crucial for determining order batch sizes, strategies, and buffer configurations. It can also reduce SC disruptions, as seen in the CSB case. Thus, overseeing buffers and inventories is essential for resilience and operational efficiency in the SC.

The tactical feature of **prioritisation** was recognised in two instances (CSA, CSD). Prioritising customer needs is crucial for resilience. Some customers express urgency based on preference rather than essential needs, highlighting the SC's strength in addressing genuine demands. However, in the context of CSA, non-commercial initiatives often overshadow actual business necessities, indicating that true prioritisation hasn't been fully achieved. Nonetheless, CSA's policy clearly defines its customer hierarchy, as noted by CSA02: *“I've noticed that the SOE often reallocates resources from civil projects to non-civil ones, leading to critical shortages.”* CSA

prioritised non-commercial projects due to its identity as a SOE, making commercial ventures less crucial. This focus stemmed from a funding model reliant on State resources, highlighting the need for prioritisation to ensure SCR. CSD01 emphasised that initiatives should align with set priorities, especially when resources and time are limited. CSD01 stated: *“We need to get the priorities right. All of them.”* A key decision was whether to enhance customer visibility on order status or focus production on a new client, given resource constraints. Clear directives were vital to align priorities and reduce time spent on discussions. By establishing clear priorities, the SC's restoration became more efficient and transparent, enhancing resilience. Thus, prioritisation is essential for resilience and directly impacts the SC.

The tactical aspect of the **international logistics network** was identified in only one instance (CSA). Interviewee CSA02 illustrated CSA's logistical capabilities and their impact on SCs, noting that strong relationships with regulatory agencies and logistics companies ensured timely delivery of components to customers. CSA02 remarked: *“With logistics we send shipments and organise our SC flows. It's really a critical component in times of the pandemic. We see many parts stuck in customs or in transit and never reach.”* The establishment of an international logistics network has improved component procurement and goods distribution, enhancing SCR. Without it, suppliers and customers would face isolation, delaying deliveries. This network requires a clear contractual framework for terms, timelines, and collection points. In summary, it is essential for maintaining connectivity and ensuring reliable SC operations.

The case CSC observed no tactical feature of resilience. The lack of tactical features in the context of CSC seems to stem from the company's emphasis on maintaining long-term stability within the SC. For example, CSC prioritises aspects such as capacity management and rate flexibility, SCM, and team capabilities. This indicates that the management's and business's focus is not directed towards the development of tactical features, primarily due to resource constraints.

In conclusion, from the standpoint of low product complexity, the management of buffers and inventories emerged as a tactical element noted in two instances. In contrast, when examining cases involving high complexity products, all features were

identified. Specifically, the management of buffers and inventories was highlighted in two cases, while prioritisation was also mentioned in two instances. However, the feature of the available international logistics network was referenced only once.

The final analysis of the tactical feature of resilience that impact SCs is examined **from different business viewpoints**, specifically contrasting the strategic perspective with the operational perspective. This discussion begins with the **strategic viewpoint**, encompassing CSA01, CSB01, CSC01, CSD01, CSE01, CSF01, CSG01, CSH01, and CSI01.

The feature of **prioritisation** was exclusively mentioned by CSD01, suggesting that it is not a strategically significant feature. CSD01 underscored that prioritisation serves as an additional feature of resilience, asserting that the execution of actions should correspond with established priorities. In times of limited resources and time constraints, especially for executives, managers, and team leaders, it becomes crucial to focus on these priorities, as noted by CSD01 said: *“We established an order of priorities based on customer, program, logistics and volume. It wasn’t perfect but nobody was forgotten.”*

CSG01 identified the **management of buffers and inventories** as a critical feature of resilience. Since no other interviewee mentioned this feature, it can be inferred that it is not a strategic element but rather, as indicated by the theme, a tactical one. The interviewee highlighted that effective inventory management is essential for resilience, with strategies differing based on product type, which requires tailored inventory control methods. Generally, the risk of running low on inventory is more pronounced for complex products. In contrast, CSG01 noted that the JIT approach is especially relevant for commodities: *“To me, JIT represents a feature of resilience. It goes beyond just managing stock levels; it’s a whole philosophy that defines the SC. It’s about being lean, getting only what you need, cutting down on waste, and relying on suppliers. That said, we should evaluate whether JIT is the best fit for our industry.”* The analysis revealed that some JIT strategies succeeded, especially for commodities, but production of complex components was disrupted due to low inventory. JIT inventory management relies on the supplier-customer relationship, which can vary in dependency. Strong relationships foster trust and communication, while high dependency can lead to delivery disruptions. Thus, effective inventory management is essential for improving SC efficiency.

From a **business operational perspective**, interviewees identified several tactical features. The most frequently mentioned feature was the **management of buffers and inventories**. This emphasis is understandable, as the operational view typically encompasses these elements rather than a strictly strategic business perspective. Three participants (CSA02, CSB02, CSI02) emphasised the importance of regularly assessing buffer and inventory strategies for organisational adaptability during challenging times. CSA02 noted that effective management of these elements is crucial for enhancing SCR, which requires strategic planning, a systematic approach, problem-solving skills, and a committed organisational structure. CSA02 said: *“Logistics and inventory management are vital to the daily SC. Disruptions in logistics can lead to delivery issues, so we rely on a strong logistics team. Similarly, we carefully plan our inventory to set reorder points and maintain stock levels. Effective inventory management is essential for a functioning SC.”*

This engagement system is associated with inventory management and has the capability to sustain appropriate stock levels, thus averting shortages, as stated by CSA02: *“We maintain our warehouses with several months of stock on critical components. On some specific material we are limited by shelf life and there we have to evaluate the cost of scraping and the cost of running out.”* This management process not only determines the optimal dimensions of buffers and inventories but also encompasses the examination of diverse data, including configurations, as noted by CSB02: *“We not only maintain a high inventory but also adaptively manage it based on current circumstances. For example, configurations, shelf life, and references must be carefully overseen. It is a sophisticated skill that requires ongoing attention.”* Effective component management is vital for determining order batch sizes, strategies, and inventory arrangements. It significantly minimises SC disruptions, as shown by CSB. Thus, managing buffers and inventories is crucial for resilience in SC dynamics. CSI02 noted that previous strategies like JIT delivery and reliance on global SCs are now inadequate and have been reassessed based on current business needs. CSI02 stated: *“We see so many disruptions. So, our role is to keep the inventories for our customers. We are where the customer is with warehouses around the globe and within proximity of the production site.”* Independent management of buffers and inventories, separate from JIT SCs, significantly enhanced production processes. This

autonomy improved SC agility, reduced disruptions, and increased planning efficiency, leading to cost savings. In summary, effective management of buffers and inventories greatly impacted overall SC performance.

An additional tactical aspect was highlighted by one participant (CSA02), specifically regarding the **international logistics network**. The interviewee CSA02 provided an example that illustrated the logistical capabilities of CSA and their influence on SCs. The strong relationships with regulatory agencies and logistics companies enabled swift processing, guaranteeing timely delivery of parts to the customer. CSA02 noted: *“Logistics is essential for overseeing shipments and coordinating our SC activities, a need that has become even more critical during the pandemic...Fortunately, our well-established network of customs and logistics partners allows us to effectively prioritise incoming shipments. This guarantees that final products reach customers directly. The stronger our logistics, the more we can rely on prompt SC deliveries.”* The presence of a global logistics network enabled the procurement of components from suppliers and the delivery of products to consumers. This network greatly improved the robustness of SCs by allowing for effective logistics operations across international boundaries.

One interviewee (CSA02) highlighted a third tactical feature of resilience **prioritisation** as a crucial tactical feature. The ability to prioritise based on customer demands is vital for resilience. Some customers express urgency that may reflect preference rather than essential needs. A strong SC must accurately identify genuine business requirements. Moreover, in Corporate Social Accountability (CSA), non-commercial initiatives often take precedence over actual business needs, indicating that true prioritisation has not been fully realised. Nonetheless, CSA's policy clearly delineates its customer hierarchy, as articulated by CSA02: *“Prioritising non-civil projects, by the SOE means other customers orders are not their priority.”*

In summary, from a strategic business viewpoint, the prioritisation and management of buffers and inventories are referenced by only one interviewee, leading to the conclusion that these elements do not align with a strategic focus. Conversely, from an operational business perspective, all three features are emphasised, with three

distinct observations regarding the management of buffers and inventories. The other features are noted only once.

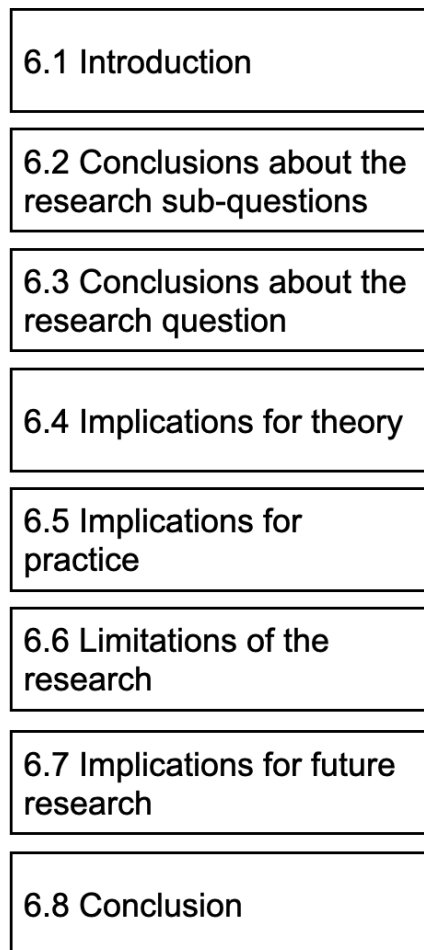
5.5 Conclusion

In conclusion, this chapter discussed and analysed the data collected from the interviews in the stage two of the research. The chapter began by describing the case study organisation and the interviewees participating in it. Each case has then been described in section 5.2. The research sub-questions and findings have been discussed in Section 5.3 according to SQ1 and 5.4 to SQ2, respectively. The findings were reported to each sub-question in sequential order. Each section consisted of a within-case analysis and was followed by a cross-case analysis by common key theme to conclude this chapter.

CHAPTER 6: CONCLUSION AND IMPLICATIONS

The concluding chapter of this research will synthesise the findings and propose avenues for future inquiry. Section 6.1 will introduce the final chapter, while Section 6.2 will encapsulate the conclusion drawn from the research question and highlight the contributions made towards addressing the research gap and advancing theoretical frameworks. In Section 6.3, the conclusion regarding the research question will be articulated. Section 6.4 will delve into the theoretical implications of the findings. Section 6.5 will focus on the practical implications and address the limitations encountered during the research process will be discussed in Section 6.6. Finally, Section 6.7 will explore the implications for future research, culminating in a conclusion in Section 6.8.

Figure 6.1 Outline of Chapter Six



Source: Developed for this research

6.1 Introduction

The first chapter of this thesis established the foundational framework. It presented the context of the research topic in Section 1.1, addressing the expansion of the aviation sector and the strategic significance and intricacies associated with China. In Section 1.2, the primary research question and its corresponding sub-question were articulated, reflecting the limited existing literature on the subject. Section 1.3 provided a rationale for the research, grounded in three key areas: resilience, SCM within the aviation industry, and China's specific contributions. The research methodology was delineated in Section 1.4, which proposed a two-phase qualitative approach. Section 1.5 detailed the organisational structure of the research. Section 1.6 clarified the boundaries of the study's scope.

Chapter Two provided a comprehensive literature review over six sub-sections, focusing on the foundational disciplines of SCM in Section 2.2 and resilience in Section 2.3. This was succeeded by an exploration of the essential elements of resilience, the impact of resilience on SCs, and the strategies organisations employ to cultivate resilience. Additionally, the identified gaps within the existing literature were outlined in Section 2.4 leading to the research question. Consequently, the sub-questions that arouse are summarised below:

Research question: “How and why does resilience affect SCs in the aviation manufacturing industry in China?” Two sub-questions have been elaborated to assist in addressing the primary research inquiry:

SQ1: “What are the key components of resilience in the SC in the aviation manufacturing industry in China? How and why do these components influence SCs?”

SQ2: “What are the key features of resilience in the SC in the aviation manufacturing industry in China. How and why do these features influence SCs?”

A preliminary theoretical framework was proposed in Section 2.5.

Chapter Three, comprising six distinct sections, has examined the critical realism paradigm employed in this research and articulated the underlying rationale. Section

3.3 elaborated on the research procedure and design, categorising it as exploratory in nature. The objectives and methodologies of the in-depth interviews were outlined in sub-section 3.3.2, which subsequently informed the development of the interview protocol and the data collection strategy. A comprehensive discussion of the stage two case study approach was presented in sub-section 3.3.3, emphasising its aim to acquire profound insights. The methodology was further detailed, addressing aspects such as piloting, criteria for case selection, and the number of cases involved. Section 3.4 addressed the data analysis process, which would ensure anonymity for data privacy purposes. The limitations of the methodology were explored in Section 3.5, culminating in the conclusion drawn in Section 3.6.

Chapter Four commenced with an explanation of the rationale behind employing in-depth interviews as the initial phase of the research. Section 4.2 presented the outcomes of these interviews, detailing the profiles of the participants and the findings aligned with the research objectives. Subsequently, Section 4.3 introduced a modified theoretical framework, culminating in the conclusion drawn in Section 4.4.

Chapter Five has examined and evaluated the data obtained from the interviews conducted during the second phase of the research. It commenced with an overview of the case study organisation and the participants involved in the interviews. Sub-section 5.2.1 provided a detailed account of each case. The research sub-questions and their corresponding findings were addressed in Section 5.3, aligned with SQ1 and SQ2, respectively. The results were presented in a sequential manner for each sub-question. Each section included an analysis within each case, followed by a cross-case analysis based on shared key characteristics, thereby concluding Chapter Five.

Chapter Six structure is outlined in Figure 6.1. The chapter has synthesised the key findings related to the research sub-questions, as detailed in Section 6.2. The conclusion relevant to the primary research question were presented in Section 6.3. The theoretical implications were analysed in Section 6.4. Additionally, Section 6.5 explored the practical implications. The study's limitations were discussed in Section 6.6. Finally, Section 6.7 examined the implications for future research endeavours, concluding with Section 6.8.

6.2 Conclusion about the research sub-questions

This section will provide a summary of the principal findings related to the research objectives, specifically addressing sub-questions SQ1 and SQ2. The analysis demonstrated that the notion of resilience was uniformly validated throughout all case studies (Sub-section 5.3.1), characterised as an organisation's ability to withstand difficulties and return to normal operational levels within a specified period. Key elements include the maintenance of critical operations to sustain the business and the retention of competencies within the organisation.

6.2.1 Sub-question 1

“What are the key components of resilience in SC in the aviation manufacturing industry in China? How and why do these components influence SCs?”

Key components of resilience had been introduced in Chapter Two and discussed in sub-section 2.3.3. The key component of resilience significantly affects SC, with impacts potentially improving or worsening overall performance. For instance, reduced logistics availability impacts material delivery speed, as supported by interviews and literature across industries. Key questions arise from the literature about which components directly influence SCR and how and why this occurs. Three main categories of components have been identified in sub-section 2.3.4: internal firm, SC-specific, and system-related. Internal firm components include controllable elements such as resources, assets, and competencies, such as mobilising a temporary workforce, managing warehouse space, and in-sourcing previously outsourced activities. SC components are influenced by suppliers and include customer collaboration, quality assurance processes, and order fulfilment agility. System-related components involve the system's adaptability and resilience, encompassing effective ERP systems, reliable local infrastructure, access to ports, and a strong risk management culture.

The analysed cases explored multiple examples of resilience in the SC, with a particular emphasis on the enhancement of capabilities and capacities in the within-case analysis. The organisations involved in the cases recognised several shared critical components, that have been discussed in sub-section 5.3.1 which can be

outlined as follows: logistics network, financial resources, political backing, inventory levels, quality assurance mechanisms, SC adaptability, redundancies, knowledge management practices, SC network configuration, risk management instruments, innovation, and information technology systems. A significant proportion of the components recognised in the existing literature have been validated through the case study analysis. These cases offered contextual insights and practical relevance regarding the components. Components associated with the three identified categories were noted in the literature, alongside the emergence of several new components related to the extensive utilisation of information technology (IT Knowledge, IT System, IT interconnectivity), infrastructure, SC flexibility, social capabilities, and portfolio diversification. The additional components are examined in Section 4.3, which emphasises the confirmation and incorporation of these elements.

The analysis revealed that the elements contributing to the resilience of SOEs encompass a solid financial foundation, a prioritisation framework favouring non-civil initiatives, an understanding of essential processes, and a dedicated, knowledgeable workforce. SOEs often exhibit a reactive nature due to variable planning. In contrast, foreign-owned enterprises typically demonstrate a higher degree of flexibility and robustness in their processes, particularly in problem-solving. Additionally, these enterprises benefit from clearer communication and expedited decision-making. Notably, some of these components are also present in the case study of domestic privately-owned enterprises.

The cross-case examination of components of resilience discussed from various perspectives and found that political support, meaning what authorities do to support a firm with respect to resilience, is a crucial factor influencing resilience across all examined cases (sub-section 5.3.1). China's unique structural context and aviation sector require strong collaboration with political entities, including local governments. This support impacts various components of resilience, such as facilitating permit acquisition, developing local SCs, attracting talent, and providing preferential customs access. Each component is shaped by governmental bodies, highlighting their importance in the SCR discourse within China's aviation industry.

The discussion emphasised the role of internal resources in building resilience and reducing negative impacts. Financial assets are essential for SCR and business continuity, while a skilled workforce is crucial for timely delivery. This synergy is particularly important for SOEs. Organisations use various human resource strategies, such as temporary staffing and long-term development programs. However, post-disruption talent competition poses challenges, as insufficient human resources can impede recovery and performance. The discussion on components has mainly centred on quality assurance systems, which include the processes and tools organisations use to enhance resilience. These systems are crucial for entities of all sizes in both domestic and international private sectors, highlighting the need for adaptability to changing customer expectations. Organisations aim to retain knowledge and reduce training risks through clear processes. Digitisation plays a key role in improving these processes and operational efficiency. While SOEs follow established protocols, they often overlook their importance in building resilience. The growing use of information technology is expected to raise industry standards, streamline processes, reduce training needs, and promote collaboration.

In examining product complexity, it was found that for less complex products, integrating information technology systems is crucial for resilience. Participants emphasised effective data transmission as vital for planning and prioritisation, which enhance SCR. Internal alignment within a unified system is also essential for departmental coordination. The analysis highlights the need for synchronisation with external suppliers and customer involvement, expanding the focus beyond supplier management to understanding customer demand. In highly complex contexts, the emphasis shifts to process significance and the challenges of maintaining agility in unforeseen circumstances, though examples of successful adaptability are limited. Examining business angles reveals that SCR depends on strong processes, which enable adjustments to customer demand and ensure effective resource allocation, optimised production, and quality standards. A case study demonstrated the negative effects of process failures, highlighting the importance of robust quality assurance. Interviewees noted that strong processes are crucial for staff training, compliance, and reliable task execution, all vital to a quality assurance system. This robustness leads to consistent delivery quality, reduced production losses, and efficient ramp-up to meet

targets. Well-defined processes also enhance employee skills, serving as essential training tools. Ultimately, interviewees agree that strong processes are key to resilience.

In conclusion to SQ1, the components of resilience within the SC of the aviation manufacturing industry in China have been examined through multiple lenses and viewpoints. The impact of these elements on SCs has been explored from various dimensions, including company ownership, organisational size, product complexity, and business angle.

6.2.2. Sub-question 2

“What are the key features of resilience in the SC in the aviation manufacturing industry in China; how and why the features influence SCs?”

The literature reviewed in Section 2.4 reveals a notable deficiency in the understanding of resilience, highlighting the need for a more comprehensive examination of its components. Furthermore, the notion of resilience in SCs, as discussed in Section 2.3, warrants additional investigation. Firstly, there is a need for additional empirical research to elucidate the processes involved in resilience-building, as outlined in sub-section 2.3.1, which remains underexplored. Secondly, it is crucial to conduct additional research on maintaining performance over extended periods, emphasising the importance of consistent performance and the implementation of effective anticipatory strategies, including the creation of buffer stocks in advance of expected increases in demand. Thirdly, it is advisable to conduct practical research on managerial tools and policies, alongside the development of guidelines for managers aimed at fostering resilient organisations. The COVID-19 pandemic has highlighted deficiencies in SC capabilities, as discussed in sub-sections 2.3.2 and 2.3.4, prompting a need for fundamental rethinking and redesign of SCs, a topic that will be further examined through recent industry interviews, including the creation of redundancies. Additionally, it is crucial to not only identify the components of resilience but also to explore its defining features. An attempt is made to incorporate the categories in Figure 2.8, preliminary model. The features have therefore not been sufficiently addressed from a SC perspective and warrant further inquiry.

Consequently, this leads to the formulation of the research sub-question: what are the key features of resilience in the SC in the aviation manufacturing industry in China; how and why the features influence SCs?

The stage one interviews have examined essential features of resilience (sub-section 4.2.2) and has delineated a total of 16 distinct features (summarised in Figure 4.2). This categorisation has revealed four primary categories: critical functions, which consist of two features; thresholds, which also encompass two features; time (and scale), which includes eight features; and memory/adaptive management, which comprises four features.

The 16 features were examined in stage two specifically within the case study context (sub-section 5.3.2). The identified features include capacity management, rate flexibility, inventory management, team capabilities, SCM, behavioural flexibility, quality levels, alternative availability, prioritisation, financial capacity, international logistics, digitisation, and risk awareness. Notably, digitisation emerged during discussions as crucial for enhancing SCR and improving product delivery. The analysis revealed a direct correlation between these features and resilience, with capacity being strengthened through strategic initiatives like capability development, proactive risk management, and effective prioritisation. In total, sixteen distinct features have been identified and analysed across the nine case studies, including one new addition.

During the cross-case discussion four key themes had been identified and discussed (sub-section 5.3.2). These are distinct to the four categories identified and proposed in Figure 2.8 preliminary model.

The technical features, i.e. capacity management and rate flexibility, quality levels, risk awareness were discussed, and capacity management and rate flexibility were addressed by seven interviewees from an operational standpoint focusing on part readiness and employee availability. Risk awareness as feature of resilience was raised by one interviewee and the same applies to quality levels. The analysis shows consistent technical features across enterprise types. SOEs prioritise quality, capacity

management, and rate flexibility, with limited focus on risk awareness. The domestic privately-owned enterprises emphasise capacity management and rate flexibility but lacks further features, likely due to its early stage. Foreign-owned enterprises mainly focus on capacity management and rate flexibility, linked to contractual obligations, with minimal mention of risk awareness and no case studies on quality levels. Large corporations prioritise capacity management, rate flexibility, resource availability, and local sourcing, with a strong focus on quality and emerging risk awareness. In contrast, small and medium-sized enterprises (SMEs) also value capacity management and adaptability but mentioned quality only once and lacked discussions on risk awareness, reflecting their limited scope.

For low-complexity products, capacity and rate management are crucial for resilience, impacting customer satisfaction and employee retention. Quality and continuous training were mentioned twice, while risk awareness was noted once. In contrast, complex products highlighted capacity management and rate flexibility more frequently, with local sourcing and production modifications being common. Quality was emphasised in two cases, but there was no mention of risk awareness.

The second key theme was behavioural features: team capability, management ability of SC, behavioural flexibility. SOEs emphasise team capability, particularly in SCM due to vertical integration, with little focus on behavioural flexibility. In contrast, privately-owned enterprises in China prioritise both SCM and behavioural flexibility for efficiency and adaptability. Foreign-owned enterprises acknowledge team capability, driven by employee development, with some focus on SCM and behavioural flexibility discussed mainly in domestic privately-owned enterprises, where agility is valued. From a company size perspective, large corporations highlighted team capability for skill enhancement in three instances and behavioural flexibility during change in two, with one mentioning SCM. In contrast, small and medium-sized enterprises prioritised SCM alongside team capability and behavioural flexibility. From a product complexity perspective, it was found for low complex products that SCM and evaluating team capability as the key features which is not surprising. In contrast, high product complexity underscored the importance of team capability for resilience, illustrated by three cases how workforce matters. From the business perspective view the analysis

showed strategically that two participants stressed the importance of team capabilities in knowledge management and employee skills, while two others recognised the significance of SCM and two interviewees pointed out the need for behavioural flexibility. Operationally, three participants viewed team capability as a behavioural attribute, and two discussed SCM in relation to behavioural flexibility.

The third key theme on strategic features examined several aspects: availability of alternatives, financial capability, and digitisation. SOEs viewed financial capacity as essential for resilience, followed by alternatives. In contrast, a domestic privately-owned enterprise focused solely on digitisation, while foreign-owned enterprises mentioned alternatives twice. Larger enterprises emphasised financial capacity and alternatives in their SCs, with digitisation noted only once. SMEs prioritised alternatives, neglecting financial capacity and digitisation. Low-complexity products lacked common traits, whereas high-complexity products highlighted the importance of alternatives. Operationally, accessible alternatives and financial capacity were crucial, while strategically, digitisation was deemed vital for resilience.

Last, the fourth key theme was tactical features: management of buffers and inventories, prioritisation, availability of international logistics network.

From a company type perspective, the SOEs revealed the management of buffer and inventory as a key feature. One case highlighted prioritisation challenge, indicating that SOEs often overlook commercial client needs. In domestic privately-owned enterprises, no resilience tactics were found, while foreign-owned enterprises discussed buffer and inventory management, with prioritisation mentioned in one instance. From a company size perspective, major corporations identify the management of buffers and inventories as a strategic component in four instances. The dimension of international logistics was referenced once, alongside the concept of prioritisation. In SMEs, prioritisation was mentioned once. Buffer and inventory management were crucial for low-complexity products in two cases, while high-complexity products needed detailed documentation, with buffer and inventory management noted twice and prioritisation twice. The international logistics network was acknowledged once. Strategically, only one participant emphasised buffer and inventory management, suggesting it may not be viewed as essential. However,

operationally, all three features were highlighted, with three insights on buffer and inventory management, while other features were mentioned only once.

In conclusion the investigation into SQ2 revealed twelve features that enhance the resilience of SCs within China's aviation manufacturing sector. The findings indicated a clear relationship between these features and resilience, which can be bolstered through strategic initiatives such as improving capabilities and implementing proactive risk management. The cross-case analysis identified four key themes: technical features, behavioural features, strategic features, and tactical features. This section has comprehensively explored the features and qualities that define resilience, as well as the reasons and mechanisms by which they affect SCs, considering factors such as company ownership, size, product complexity, and business perspective.

6.3 Conclusion about the research question

This section will summarise the evolution of the theoretical framework from its inception to its final form. The research revealed that resilience encompasses various components and features of resilience that affect SCs. These components and features exert differing impacts on various types of enterprises in China, including SOEs, foreign-owned, and domestica privately-owned companies. Furthermore, the size of an enterprise plays a crucial role in shaping its SC dynamics. The complexity of products also influences the observed effects within these SCs. Ultimately, the importance of these components and features may vary depending on whether a strategic or operational perspective is adopted concerning the business. To address the research question, a summary of the derived preliminary framework will be provided, along with the conclusion leading to the finalised theoretical framework and its main confirmations and differences. The purpose being to address the research question “How and why does resilience affect SCs in the aviation manufacturing industry in China?”

Preliminary model

The preliminary model (Figure 2.8) illustrates the twelve components and the four categories of features influencing SCR has undergone refinement through the integration of relevant theories. The categories of robustness and adaptability were closely aligned with the Resource-Based View of the firm, which emphasises the importance of leveraging financial, tangible, and intangible assets to achieve competitive advantage (discussed in Section 2.5). Robustness refers to the ability of a SC to withstand shocks and maintain functionality during adverse conditions, while adaptability highlights the capacity to adjust and respond effectively to changing circumstances. Both dimensions underscore the significance of resource allocation and management in enhancing SC performance and resilience.

On the other hand, the category of transformability is linked to DCT, which focuses on the ability of organisations to reconfigure their resources and capabilities in response to evolving market demands and environmental challenges (Section 2.5). Transformability encompasses the capacity to innovate and fundamentally change operational processes, structures, and strategies to better align with new realities.

However, it is important to note that certain aspects of DCT, specifically the components of sensing and seizing opportunities, have been deliberately excluded from this model. This exclusion is based on their perceived irrelevance to the specific research inquiries being addressed, allowing for a more focused exploration of how transformability can enhance SCR.

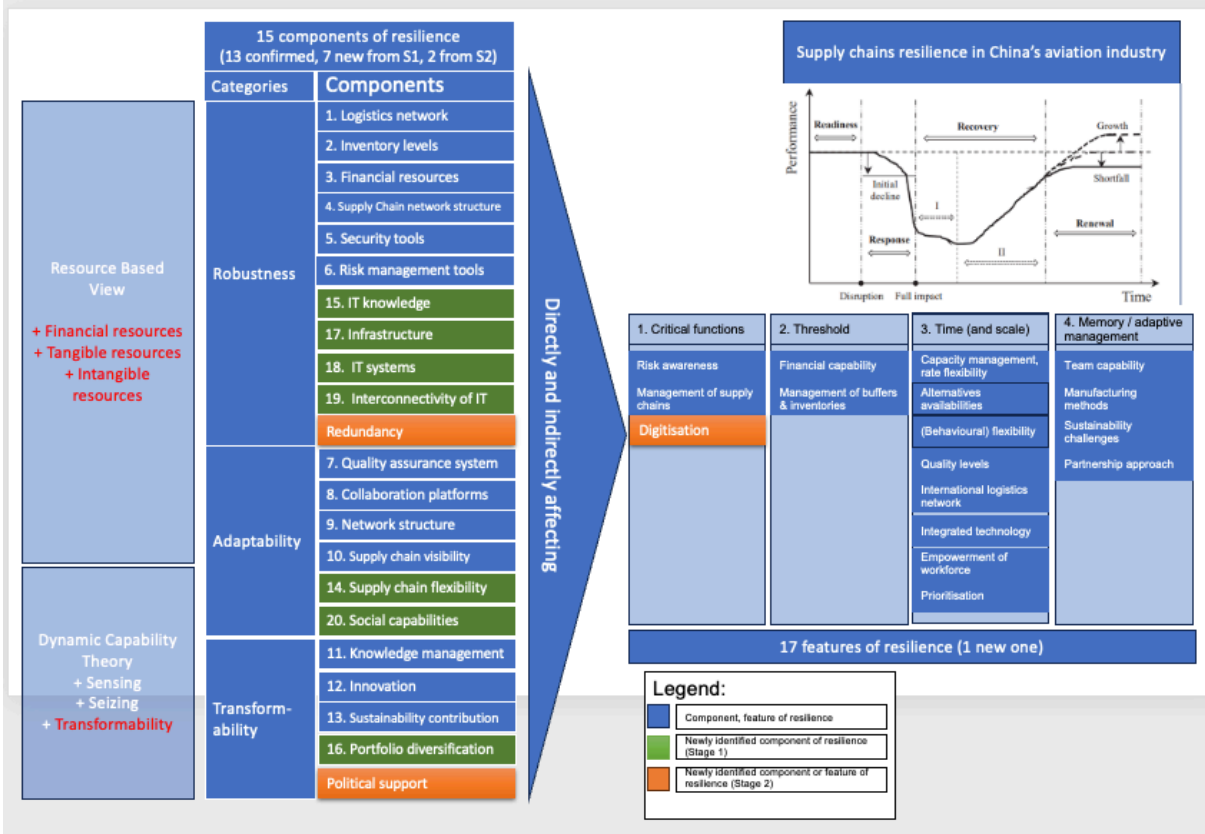
In summary, the initial model provides a comprehensive framework for understanding SCR. By classifying the components of resilience into robustness, adaptability, and transformability, and anchoring these classifications in well-established theoretical frameworks, the model yields significant insights for the strategic management of SCs as informed by existing literature. This methodology underscores the critical role of resource management while also stressing the necessity for organisations to develop dynamic capabilities that allow them to succeed in a progressively intricate and uncertain business environment.

The finalised theoretical framework

The finalised framework has been meticulously developed, drawing upon valuable insights gained from in-depth interviews and case-study research. This framework serves not only to validate the preliminary model but also to reinforce and affirm its various components and features of resilience that are at the core of the research question. In the first stage of the research, in-depth interviews had been conducted that provided a wealth of information, leading to the incorporation of seven (7) new components of resilience into the revised theoretical framework. These additions are highlighted in green in Figure 4.5, showcasing the evolution of the preliminary framework based on expert opinions and discussed in Section 4.3. Moving to stage-two of the research, two significant new components that contribute to the concept of resilience within SCs have been added: redundancy and political support. These components are highlighted in Figure 6.2 and were recognised as critical to enhance the robustness and adaptability of SCs in the face of disruptions. Moreover, the case-study research conducted during the stage-two not only validated the existing components and features of resilience but also underscored the pivotal role that digitisation plays in strengthening SCR. The integration of digital technologies has

emerged as a key feature, allowing organisations to respond more effectively to challenges and uncertainties and enhance resilience.

Figure 6.2 Revised and finalised theoretical model



Source: Prepared for this research

In conclusion, the findings from the interviews conducted in the stage one has significantly reinforced the model by integrating additional components that enhance its comprehensiveness. Meanwhile, the insights gained in the stage-two have introduced further components and features confirmed the framework's relevance in practical contexts, ensuring that it is well-equipped to address the complexities of modern SCs. This iterative process of refinement and validation underscores the framework's robustness and its potential to guide organisations in building resilient SCs.

6.4 Implications for theory

This section will examine the implications and contributions of the principal theories presented in Chapter Two. Furthermore, it will address the implications related to the theory of case study methodology theory.

Implications and contributions to principal theories

The research inquiry centred on the feasibility of operational strategies and the strategic significance of resilience, necessitating a theoretical framework that encompasses both mid-term and long-term effects of resilience on the organisation. The RBV and DCT were found to be mutually reinforcing in this context, as discussed in Section 2.5. This study contributes to theoretical understanding through case studies that illustrate how resources have been utilised to foster resilience, thereby achieving a competitive edge.

Initially, the focus was placed on the process of capability creation, which involves proactive measures taken to establish resilience before adverse events occur. This includes identifying essential skills such as risk management proficiency, the capacity to navigate complex SCs, and the establishment of redundancies within those SCs.

Furthermore, given the expansive nature of the RBV, the research highlighted the importance of knowledge and managerial competencies, offering managerial insights that enhance the RBV framework. This includes strategic decision-making aimed at reallocating resources in response to fluctuations in production rates, such as capacity management capabilities and financial resource allocation for inventory management. The DCT was introduced in Section 2.5 and served as a framework for recognising and reallocating capabilities to align with organisational requirements, including the reconfiguration of SCs in reaction to disruptions. This study investigated the impact of opportunity recognition, strategic implementation, and organisational transformation on strategic management by exploring in SQ2 how resilience characteristics affect SCs. The discussion will centre on the three fundamental elements of dynamic capabilities: sensing, seizing, and transforming, which have been incorporated into the framework model and validated.

Lastly, the inquiry into capabilities concentrated on the effective deployment and redeployment of existing resources to bolster resilience within the SC. This was exemplified by strategies such as resource retention, training initiatives, and the advancement of knowledge management practices within the organisation.

In summary, the study confirms the relevance and applicability of both RBV and DCT within the framework of this research. The research employed multiple examples to illustrate their applicability effectively.

Implications on in-depth interviews and case study methodology theory

The research employed an exploratory research design, which is particularly useful in fields where existing knowledge is limited or where new perspectives are needed. This design was implemented through a two-stage research methodology, allowing for a comprehensive exploration of the research topic.

In stage one, the research conducted in-depth interviews with a diverse group of nine participants. These interviews were designed to elicit rich, qualitative data that would provide insights into the various dimensions of resilience. The interviews allowed participants to share their experiences and perspectives in their own words, thereby capturing the nuances and complexities of resilience that might not be evident through more structured research methods. The findings were crucial as they served as a foundation for understanding the multifaceted nature of resilience and inform the subsequent stage of the research.

Sub-section 3.3.3 of the study elaborates on stage two, which focused on case study research. This stage was essential for contextualising the insights gained from the 18 interviews within real-world scenarios. By examining nine specific cases, the research aimed to validate and further explore the components and features of resilience identified in stage one. The combination of in-depth interviews and case studies created a robust methodological framework that enhances the validity and depth of the findings.

An exploratory research design was chosen for this investigation to analyse the diverse characteristics of resilience, deepening understanding and laying the groundwork for future research. The findings contributed to an initial model for guiding discussions and interventions to enhance resilience.

Insights from extensive interviews were expected to improve the identified components of resilience. By integrating participant perspectives with case study outcomes, the research aims to validate these components in both theoretical and practical contexts. This iterative refinement process was crucial for developing a holistic understanding of resilience to inform future research and applications.

The decision to utilise in-depth interviews was substantiated by several key factors. First, the collection of inductive data was crucial for generating new theories and insights rather than merely testing existing hypotheses. Second, the involvement of subject matter experts ensured that the research was informed by individuals with deep knowledge and experience in the field, enhancing the credibility of the findings. Third, the need for a comprehensive understanding of the research topic and objectives necessitated a qualitative approach that could capture the complexity of participants' experiences.

In conclusion, the case study methodology has demonstrated its suitability for the research objectives, reinforcing its relevance in the complex and real-world contexts central to this study.

6.5 Implications for practice

The practical implications encompass three primary propositions that will be elaborated upon. The first proposition pertains to the development of a guide aimed at enhancing resilience capabilities. The second involves providing support for strategic decision-making related to resilience. Lastly, the third proposition addresses the policies of government and industry, along with the potential roles they can undertake. Each of these propositions will be examined sequentially in this section.

Guide for developing resilience capability

The findings of this research hold significant promise for enhancing resilience capacities within the industry, suggesting that organisations can better prepare for and respond to challenges and disruptions. The cases examined in this study serve as exemplary models of best practices that can guide organisations in cultivating the resilience capabilities illustrated in Figure 1.5 of sub-section 1.1.2. These best practices encompass a range of strategies and approaches that have been successfully implemented by various organisations, demonstrating their effectiveness in fostering resilience. Moreover, this notion is further reinforced by the insights gained from the comprehensive interviews discussed in sub-section 3.3.2.1.

These interviews not only provide qualitative data but also highlight the experiences and perspectives of industry leaders who have navigated challenges and emerged stronger. Objective 5, as outlined in these interviews, emphasises the importance of learning from past experiences and integrating those lessons into organisational practices. By doing so, organisations can develop a more robust framework for resilience that is informed by real-world applications and success stories. A further potential contribution could have been the creation of a comprehensive guide for enhancing resilience capabilities. However, the fragmented nature of the SC in China—characterised by varying ownership types, product complexities, and enterprise sizes—renders a singular guide impractical. Instead, the research framework allows for a nuanced analysis that can be tailored to different perspectives, facilitating a deeper understanding of the results. For example, the attributes that foster resilience in SOEs may not be applicable to domestic privately-owned enterprises due to specific limitations they face.

In summary, the research findings, coupled with the best practices identified and the insights from industry interviews, create a compelling case for organisations to invest in resilience-building initiatives. This multifaceted approach not only enhances their ability to withstand disruptions but also positions them for long-term success in an increasingly unpredictable environment.

Assist in making strategic decisions regarding resilience

This study holds significant promise in offering valuable insights that can enhance strategic decision-making processes concerning resilience within the SC. Objective 4, as elaborated in sub-section 4.2.2, provides a comprehensive analysis of the research findings, which are further validated through expert interviews. The expert perspectives may serve as a robust framework to guide organisations in their decision-making processes, enabling them to navigate the complexities of SCR more effectively. The research indicates that fostering resilience within the SC can yield substantial advantages, both in the immediate and extended time frames. The positive impacts of resilience manifest in various critical areas, including product quality, timely delivery, and overall business continuity. These benefits are shown to outweigh the financial investments required for implementing resilience strategies, suggesting that organisations can achieve a favourable return on investment by prioritising resilience. However, the journey toward achieving varying levels of resilience is not without its challenges. Organisations must recognise that developing resilience necessitates a specific set of skills and competencies among their workforce. Additionally, cultivating a culture that emphasises risk management is essential for embedding resilience into the organisational fabric. This cultural shift requires a commitment to ongoing training and development, as well as the establishment of clear protocols that must be adhered to rigorously. Compliance with these protocols is crucial, as it ensures that the organisation is prepared to respond effectively to disruptions and uncertainties in the SC.

The conclusion regarding three primary challenges that organisations encounter in their pursuit of resilience from a strategic viewpoint and long-term sustainability are summarised in relation to objective 4 of sub-section 4.2.2. This summary emphasises the importance of addressing these challenges, which include the development of

necessary skills, the implementation of effective processes, and the cultivation of a robust risk management culture.

In summary, this study not only highlights the importance of resilience in SCM but also outlines the necessary steps and considerations for organisations aiming to enhance their resilience capabilities. By leveraging the insights gained from this research, decision-makers can make informed choices that ultimately strengthen their SCs and position their organisations for long-term success in an increasingly volatile business environment.

Government and industry policies, as well as the roles they can assume

This study has the potential to provide significant insights that could inform and enhance governmental and industrial policy frameworks. By examining the interplay between policy measures and industry responses, the research aims to elucidate the various roles that both government and industry can play in fostering resilience and adaptability, particularly in times of crisis. The evidence gathered from the case-study interviews, detailed in sub-sections 5.3.1 and 5.3.2, underscores several instances where well-crafted policies led to successful outcomes for the industry during the challenging conditions imposed by the pandemic. These examples illustrate how timely and targeted interventions can not only mitigate adverse effects but also create opportunities for growth and innovation. For instance, policies that provided financial support, regulatory flexibility, and access to resources were pivotal in enabling businesses to navigate the uncertainties of the pandemic. The interviews revealed that industries that engaged proactively with policymakers were better positioned to adapt to rapidly changing circumstances, demonstrating the importance of collaboration between the public and private sectors.

Furthermore, the study highlights the need for ongoing dialogue and feedback mechanisms between government entities and industry stakeholders. Such interactions can ensure that policies remain relevant and responsive to the evolving needs of the industry, particularly in the face of future crises. In conclusion, the findings of this study not only contribute to the academic discourse on policy effectiveness but also serve as a practical guide for policymakers and industry leaders. By learning from

the successes and challenges documented in the case studies, stakeholders can develop more robust frameworks that enhance resilience and promote sustainable growth in the face of unforeseen challenges.

6.6 Limitations of the research

This section will explore the constraints of the research from three distinct perspectives: methodological limitations, contextual factors, and participant-related challenges.

From a methodological perspective, the research may encounter limitations associated with the study's design and execution. These limitations encompass factors such as sample size, methods of data collection, and the potential for analytical bias. For example, a limited sample size could restrict the generalisation of the results, while dependence on self-reported data might lead to response bias, although this was not an issue in the current study. Furthermore, the selection of qualitative methods, as employed in this research, as opposed to quantitative approaches, can significantly affect the richness and scope of the insights obtained, thereby potentially limiting the overall conclusion derived from the study. It is crucial to recognise that this research was exploratory in nature, indicating that the findings may not be broadly applicable to all scenarios related to SCs, resilience, and China. Nevertheless, the outcomes of this study can provide a basis for theoretical advancement. To strengthen the findings and offer a more comprehensive viewpoint, further qualitative and empirical research is essential. Such additional data could enable a certain level of generalisation.

Secondly, contextual factors significantly influence the research environment. These factors encompass socio-economic conditions, cultural dynamics, and temporal elements that can affect the relevance and applicability of research findings. For instance, conducting research in a particular geographical location may restrict the generalisability of results to other regions or demographic groups. The interviews conducted during the COVID-19 pandemic illustrate this point, as conducting them at a different time might have resulted in different outcomes and revealed distinct experiences among participants. Additionally, external events, such as shifts in political landscapes or public health emergencies, can affect both the research process and the interpretation of results, thereby limiting the overall validity of the study. The research utilised a two-stage research methodology, consisting of nine in-depth interviews (stage one) and nine case studies (stage two) by analysing 18

interviews within the Chinese aviation manufacturing SC. The focus was on the relationship between resilience and SC dynamics in the aviation industry, supported by practical examples. However, the findings from these case studies cannot be generalised to the entire population (Yin, 2017). Therefore, it is inappropriate to assume that all cases and companies studied would yield similar results. Consequently, resilience may not exert a uniform influence on SCs across all cases and firms, indicating that further research will be required to generalise these findings (further elaborated in Section 6.7).

Finally, challenges related to participants can significantly restrict the scope of research. These challenges include difficulties in recruitment, issues with participant engagement, and various ethical considerations. Ethical dilemmas surrounding informed consent and confidentiality may limit the range of data that can be gathered, thereby further restricting the research findings. The richness of the data obtained through interviews and the ability to employ triangulation through a cross-case validation method were somewhat limited. Despite thorough efforts to uphold confidentiality and comply with all applicable guidelines, it is possible that interviewees did not reveal all relevant details of their situations. This issue was alleviated by anonymising both personal and case-specific information of the participants. Such strategies likely bolstered the interviewees' trust in the confidentiality of their responses, which may have contributed to a more comprehensive dataset.

This section outlined the constraints that could influence the research findings and their implications by exploring three distinct perspectives: methodological limitations, contextual factors, and challenges related to participants. In summary, the research has pinpointed three primary limitations. Comprehensive measures were implemented to mitigate these limitations and to ensure the validity and reliability of the research results.

6.7 Implications for future research

This section outlines three potential implications for future research endeavours. Firstly, it emphasises the importance of examining additional cases. Given that the research was exploratory, it relied significantly on inductive analysis, and no statistical evaluations were performed. Future studies could enhance the findings by expanding the dataset and employing quantitative methodologies, such as surveys and questionnaires, to investigate a related research topic that could validate the initial results.

A second avenue for potential future research pertains to the replication of findings in different business contexts. This replication may occur on two levels: geographically, by examining economies that exhibit characteristics akin to those of China, such as a large population, emerging market status, or active political engagement in aviation-related matters. Notably, several of these traits are also present in the BRICS nations, including Brazil, Russia, India, and South Africa. Additionally, further research could focus on industries that possess similar attributes, including high regulatory demands, capital intensity, and complex, lengthy product development cycles. Relevant sectors might encompass aerospace (particularly satellites), pharmaceuticals, and Electric Vertical Take-off and Landing (EVTOL) aircraft. This expanded perspective could yield valuable insights.

A third consideration for future research pertains to the companies and cases examined, as the interview participants represented merely a subset of the broader population. Expanding this sample through additional case study investigations could yield more comprehensive insights. Moreover, it is essential to recognise that this study was conducted during a significant historical period, specifically during and after the COVID-19 pandemic. Investigating different temporal contexts may uncover varying results. Additionally, recent macroenvironmental and geopolitical developments, such as sanctions, military actions, and political instability, are likely to affect the perspectives of interviewees regarding the research topic.

A fourth avenue for future research could focus on the characteristics of the companies under examination. Given the ongoing trends in mergers and acquisitions,

privatisations, and the rise of new enterprises, tracking these changes will yield significant insights into the evolving nature of businesses. This study has gathered data on SOEs, privately-owned Chinese firms, and foreign-owned companies. It is anticipated that an increasing number of domestic enterprises will emerge. Additionally, there have been indications of ongoing mergers, and the potential privatisation of certain components of SOEs may represent a significant aspect of the economic landscape moving forward.

In future research, it is advisable to implement extensive surveys to evaluate the framework's relevance and predictive capabilities. The framework may be enhanced to align more closely with the specific industry by distinguishing between external and internal factors. For example, external factors such as regulatory constraints and supplier relationships could be examined independently from internal capabilities like adaptability and financial stability. Another approach could involve creating a hierarchical model that encompasses attributes, such as adaptability and collaboration, along with their respective sub-attributes, including agility as a component of adaptability and information sharing as a facet of collaboration.

A further avenue for future research could focus on clarifying both the direct and indirect connections among different components of resilience and their related features. By delineating these relationships, researchers can develop a nuanced understanding of how specific components interact with one another to enhance overall resilience. Attaining this knowledge may provide practical benefits by pinpointing which component specifically influence certain features of resilience. Understanding these dynamics allows organisations to prioritise investments in certain areas, ensuring that resources are allocated efficiently to maximise resilience-building efforts, in a proactive manner.

Furthermore, these insights could enable the development of targeted proactive strategies designed to improve resilience within SCs. By utilising the information gleaned from research on the interconnectedness of components and features of resilience, organisations can craft tailored interventions that address their unique vulnerabilities and strengths. This could involve implementing specific technologies to

enhance visibility, establishing stronger communication protocols, or diversifying suppliers to mitigate risks. Ultimately, such strategic initiatives could lead to more robust and resilient SCs, better equipped to withstand and recover from various types of disruptions, thereby enhancing overall organisational performance and sustainability in an increasingly complex global environment.

Finally, the integration of Multi-Criteria Decision Analysis (MCDA) techniques, including the Analytical Hierarchy Process (AHP) or other quantitative methodologies, has the potential to substantially improve the robustness and relevance of the research. This approach offers a systematic and empirical means to further substantiate the proposed framework for enhancing SCR.

6.8 Conclusion

In conclusion, this chapter has integrated the principal findings associated with the research sub-questions, as elaborated in Section 6.2. The conclusion pertinent to the main research question were outlined in Section 6.3. The theoretical implications were examined in Section 6.4. Furthermore, Section 6.5 considered the practical implications. The limitations of the study were addressed in Section 6.6. Lastly, Section 6.7 discussed the implications for future research initiatives, culminating in Section 6.8.

Finally, this study has offered comprehensive insights into the SCM practices within the aviation manufacturing industry in China, focusing on three primary themes: SCM in China, resilience in the aircraft manufacturing industry, and resilience within the SC. The theme of resilience, which is gaining recognition for its importance, was analysed from various angles, resulting in the formulation of organised perspectives pertinent to the research question. This analysis included in-depth interviews of the components and features of resilience. Additionally, the essential function of aviation in promoting global connectivity was thoroughly examined, particularly how resilience within the SC guarantees sufficient production to satisfy the aviation industry's demand for new aircraft. The field of SCM has become increasingly crucial, enhancing comprehension and offering innovative insights derived from practical applications regarding components and features that are significant not only in the present but may also play a critical role in future preparedness, particularly through the digitisation of SCs.

The proposed model is intended to serve as a basis for future research endeavours. This could include investigations in different geographical contexts, the exploration of other aircraft categories such as EVTOL vehicles, and the incorporation of additional case studies into the framework.

APPENDIX

Appendix I: Interview protocol in-depth interviews

Interview Protocol for in-depth interviews

This document summarizes in detail the interview protocol for the in-depth interview. The purpose of interview protocol is to standardize the approach and to ensure reproducibility of the interviews.

1. The researcher will contact potential interviewees by email and invite them to join the research using a customized invitation email.
2. The invitation email received contains a link to the research website, background, and the Participant Information Sheet (P.I.S.)
3. The participant will schedule the interview using an online platform of the Calendly app.
4. The participant will receive an immediate confirmation email that includes the ZOOM link to the interview.
5. The interviewee will be asked to fill the consent form that will be sent by email. It is also available online. The participant will also be asked to fill and return it during the scheduling process.
6. The researcher is to ensure that the consent form is filled, prior to undertaking the interview.
7. The researcher is to archive the consent form properly.
8. Twenty-four hours ahead of the interview, a reminder will be sent to the interviewee by Calendly.
9. The researcher will open the meeting five minutes ahead of the interview and will ensure sound and video capabilities.
10. The researcher will welcome the interviewee and will launch the voice recording and transcription software (except where requested not to do so). The researcher will confirm this information from the consent form.
11. The researcher will briefly introduce the procedure and introduce the research topic and ask if there are any questions.
12. The researcher will then execute the interview based on the questions prepared.
13. At the end of the interview, the researcher will ask the interviewee for any comment about the subject matter and the interview conduction.
14. The interviewee will be invited to contribute to snowballing by sharing relevant contacts.
15. The researcher will outline the next steps of the research of case studies and invite the interviewee to contribute with relevant case studies. The interviewee will be invited to contribute to the case study interview.
16. The researcher will thank the interviewee and to inform that the transcription will be made available for verification and confirmation.
17. The researcher will close the meeting and complete recording.
18. The researcher will transcribe the interview.
19. The researcher will verify accuracy of the transcription.
20. The researcher will save the transcription in two separate data storage media.
21. The researcher will send the transcription to the interviewees registered email and request a confirmation of the accuracy.
22. The researcher will receive a confirmation from the interviewee or send a reminder to the interviewee.
23. The researcher will be able to validate the transcription or amend the transcription.
24. The researcher will store the validated transcription in two separate data storage media.

Source: Prepared for this research

Appendix II: Participant Information Sheet

Participation

Your participation will involve partaking in an interview that will take approximately 60 minutes of your time.

Some sample questions include:

- I. What are the key features of a resilient QSC?
- II. What are the key components of resilience that affect QSC?
- III. How and why are key components of resilience affected?

Your participation in this project is entirely voluntary. If you do not wish to take part, you are not obliged to. If you decide to take part and later change your mind, you are free to withdraw from the project at any stage. You may also request that any data collected about you be withdrawn and confidentially destroyed.

If you wish to withdraw from this project or withdraw data collected about yourself, please contact the Research Team (contact details at the top of this form).

Your decision to take part, not to take part, or to take part and then withdraw, will in no way impact your current or future relationship with the University of Southern Queensland.

Page 1 of 2

Expected benefits

It is expected that as a participant, you will benefit by being part of a study relevant to your professional practice in the Aviation industry, and therefore gain insights into a rarely studied phenomenon. As a participant in the in-depth interview, you will be de-identified and will not be mentioned anywhere in the study.

Risks

In participating in the interview, there is a time-imposed risk of conducting the interview within a limited period of 60 minutes.

Sometimes thinking about the sorts of issues raised in the interview can create some uncomfortable or distressing feelings. If you need to talk to someone about this immediately, please contact the EU support helpline on 116123.

Privacy and confidentiality

All comments and responses will be treated confidentially unless required by law. Any data collected as a part of this project will be stored securely as per University of Southern Queensland's Research Data Management policy. Data is encrypted and/or password protected.

The interview will be audio recorded for the purpose of transcription.

A transcript of the interview will be provided to you further to the interview by email. You will then be asked to confirm the accuracy of the content within seven (7) calendar days.

The recording will not be used for purposes other than transcription and verification of accuracy of transcription.

The principle researcher will have access to the recording and he will ensure the transcription of records.

Participation without recording is possible and can be requested.

Your data will not be made available for further research purpose.

You may contact the researcher about the summary findings and results of the research.

Consent to participate

We would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate in this project. Please return your signed consent form to the Principal Investigator at maximilian.fahr@usq.edu.au prior to participating in your interview.

Appendix III: Case study interview protocol

Interview Protocol for case-study interviews

This document summarizes in detail the interview protocol for the in-depth interview. The purpose of interview protocol is to standardize the approach and to ensure reproducibility of the interviews.

1. The researcher will contact potential interviewees by email and invite them to join the research using a customized invitation email.
2. The invitation email received contains a link to the research website, background, and the Participant Information Sheet (P.I.S.)
3. The participant will schedule the interview using an online platform of the Calendly app.
4. The participant will receive an immediate confirmation email that includes the ZOOM link to the interview.
5. The interviewee will be asked to fill the consent form that will be sent by email. It is also available online. The participant will also be asked to fill and return it during the scheduling process.
6. The researcher is to ensure that the consent form is filled, prior to undertaking the interview.
7. The researcher is to archive the consent form properly.
8. Twenty-four hours prior to the interview, a reminder will be sent to the interviewee by Calendly.
9. The researcher will open the meeting five minutes ahead of the interview and will ensure sound and video capabilities.
10. The researcher will welcome the interviewee and will launch the voice recording and transcription software (except where requested not to do so). The researcher will confirm this information from the consent form.
11. The researcher will briefly introduce the procedure and introduce the research topic and ask if there are any questions.
12. The researcher will then execute the interview based on the questions prepared.
13. At the end of the interview, the researcher will ask the interviewee for any comment about the subject matter and the interview conduction.
14. The interviewee will be invited to contribute to snowballing by sharing relevant contacts.
15. The researcher will outline the next steps of the research.
16. The researcher will thank the interviewee and to inform that the transcription will be made available for verification and confirmation.
17. The researcher will close the meeting and complete recording.
18. The researcher will transcribe the interview.
19. The researcher will verify accuracy of the transcription.
20. The researcher will save the transcription in two separate data storage media.
21. The researcher will send the transcription to the interviewees registered email and request a confirmation of the accuracy.
22. The researcher will receive a confirmation from the interviewee or send a reminder to the interviewee.
23. The researcher will be able to validate the transcription or amend the transcription.
24. The researcher will store the validated transcription in two separate data storage media.

Source: Prepared for this research

Appendix IV: Interview protocol case study

Interview Protocol for case-study interviews

This document summarizes in detail the interview protocol for the in-depth interview. The purpose of interview protocol is to standardize the approach and to ensure reproducibility of the interviews

1. The researcher will contact potential interviewees by email and invite them to join the research using a customized invitation email
2. The invitation email received contains a link to the research website, background and the Participant Information Sheet (P.I.S.)
3. The participant will schedule the interview using an online platform of the Calendly app
4. The participant will receive an immediate confirmation email that includes the ZOOM link to the interview
5. The interviewee will be asked to fill the consent form that will be sent by email. It is also available online. The participant will also be asked to fill and return it during the scheduling process
6. The researcher is to ensure that the consent form is filled, prior to undertaking the interview
7. The researcher is to archive the consent form properly
8. Twenty-four hours prior to the interview, a reminder will be sent to the interviewee by Calendly
9. The researcher will open the meeting five minutes ahead of the interview and will ensure sound and video capabilities
10. The researcher will welcome the interviewee and will launch the voice recording and transcription software (except where requested not to do so). The researcher will confirm this information from the consent form
11. The researcher will briefly introduce the procedure and introduce the research topic and ask if there are any questions
12. The researcher will then execute the interview based on the questions prepared
13. At the end of the interview, the researcher will ask the interviewee for any comment about the subject matter and the interview conduction
14. The interviewee will be invited to contribute to snowballing by sharing relevant contacts
15. The researcher will outline the next steps of the research
16. The researcher will thank the interviewee and to inform that the transcription will be made available for verification and confirmation
17. The researcher will close the meeting and complete recording
18. The researcher will transcribe the interview
19. The researcher will verify accuracy of the transcription
20. The researcher will save the transcription in two separate data storage media
21. The researcher will send the transcription to the interviewees registered email and request a confirmation of the accuracy
22. The researcher will receive a confirmation from the interviewee or send a reminder to the interviewee
23. The researcher will be able to validate the transcription or amend the transcription
24. The researcher will store the validated transcription in two separate data storage media

Source: Prepared for this research

Appendix V: Ethical consent form

 UNIVERSITY OF SOUTHERN QUEENSLAND	University of Southern Queensland Consent form Interview USQ HREC Approval number: H21REA232

Project Title

Supply Chain and Quality Resilience Building in China's aviation industry.

Research team contact details

Principal Investigator Details:

Mr. Maximilian D. Fahr

Email: Maximilian.Fahr@usq.edu.au

Phone: +49 179 416 0408

Principal Supervisor:

Associate Professor Eric Ng

Email: Eric.Ng@usq.edu.au

Phone: +61 7 4631 1298

Statement of consent

By signing below, you are indicating that you:

- Have read and understood the information document regarding this research. ☐ Yes / ☐ No
- Have had any questions answered to your satisfaction. ☐ Yes / ☐ No
- Understand that if you have any additional questions, you can contact the research team. ☐ Yes / ☐ No
- Are over 18 years of age. ☐ Yes / ☐ No
- Understand that the interview will be audio / video recorded ☐ Yes / ☐ No
 - Understand that you can participate in the interview without being audio/ video recorded ☐ Yes / ☐ No
- If you **do not** want to be audio/ video recorded during the interview, please initial here: ☐ Yes / ☐ No
- Agree to participate in the research. ☐ Yes / ☐ No

Name (first & last)			
Signature *		Date	

* simply use the draw function to add a digital signature or insert a signature from your photo library

Please return this document to a research team member before undertaking the interview:
Maximilian.Fahr@usq.edu.au

REFERENCES

- Abdallah, AB et al. 2021, 'Supply chain integration and export performance: the mediating role of supply chain performance', *International Journal of Productivity and Performance Management*, no. April.
- Abdel-Basset, M et al. 2019, 'A framework for risk assessment, management and evaluation: Economic tool for quantifying risks in supply chain', *Future Generation Computer Systems*, vol. 90, pp. 489–50.
- Abu-Rayash, A & Dincer, I 2020, 'Analysis of mobility trends during the COVID-19 coronavirus pandemic: Exploring the impacts on global aviation and travel in selected cities', *Energy Research and Social Science*, vol. 68, no. July, p. 101693,
- Acikgoz, Y 2019, 'Employee recruitment and job search: Towards a multi-level integration', *Human Resource Management Review*, vol. 29, no. 1, pp. 1–13,
- Adedoyin, FF et al. 2020, 'The effects of air transportation, energy, ICT and FDI on economic growth in the industry 4.0 era: Evidence from the United States', *Technological Forecasting and Social Change*, vol. 160, no. August, p. 120297,
- Adenso-Díaz, B, Mar-Ortiz, J, & Lozano, S 2018, 'Assessing supply chain robustness to links failure', *International Journal of Production Research*, vol. 56, no. 15, pp. 5104–5117.
- Adeoye-Olatunde, OA & Olenik, NL 2021, 'Research and scholarly methods: Semi-structured interviews', *JACCP Journal of the American College of Clinical Pharmacy*, vol. 4, no. 10, pp. 1358–1367.
- Adhabi, E & Christina, BA 2017, *Literature Review for the Type of Interview in Qualitative Research*.
- Adobor, H 2020, 'Supply chain resilience: an adaptive cycle approach', *International Journal of Logistics Management*, vol. 31, no. 3, pp. 443–463.
- Afzal, S et al. 2020, 'State-of-the-art review on power system resilience and assessment techniques', *IET Generation, Transmission and Distribution*, vol. 14, no. 25, pp. 6107–6121.
- Agarwal, S, Kirrane, S, & Scharf, J 2017, 'Modelling the general data protection regulation', *Jusletter IT*, vol. 2014, no. February.
- Agasti, T 2022, *Air Transport Deregulation in India: A Comparative and critical analysis within the US*, McGill.

Agrawal, N et al. 2023, 'Supply Chain Flexibility and Post-pandemic Resilience', *Global Journal of Flexible Systems Management*, vol. 24, no. Suppl 1, pp. 119–138,

Aguila, JO 2018, 'Design of a Global Supply Chain for the Unexpected',

Agustini, E, Kareng, Y, & Victoria, OA 2021, 'The Role of ICAO (International Civil Aviation Organization) in Implementing International Flight Safety Standards', *KnE Social Sciences*, vol. 2020, no. Iwpospa, pp. 100–114.

Akerman, E, Mikhalechuk, A, & Chistyakova, N 2020, *Local Innovations and Global Technology Leadership: Rethinking Approaches to the Effective Intra-Industry Technology Transfer*.

Akkermans, HA, Bogerd, P, & Wassenhove, LN Van 2011, 'Structured Analysis, Design, and Implementation of Information System', *SpringerReference*, vol. 146, pp. 284–301.

Al-Hakimi, MA et al. 2022, 'The moderating role of supplier relationship on the effect of postponement on supply chain resilience under different levels of environmental uncertainty', *Production and Manufacturing Research*, vol. 10, no. 1, pp. 383–409,

Al-Talib, M et al. 2020, 'Achieving resilience in the supply chain by applying IoT technology', *Procedia CIRP*, vol. 91, no. March, pp. 752–757,

Alam, MK 2021, 'A systematic qualitative case study: questions, data collection, NVivo analysis and saturation', *Qualitative Research in Organizations and Management: An International Journal*, vol. 16, no. 1, pp. 1–31.

Albers, M & Chen, ZZ 2017, 'Socialism Capitalism and Sino-European Relations in the Deng Xiaoping Era, 1978–1992*', *Cold War History*, vol. 17, no. 2, pp. 115–119.

Ali, I, Golgeci, I, & Arslan, A 2023, 'Achieving resilience through knowledge management practices and risk management culture in agri-food supply chains', *Supply Chain Management*, vol. 28, no. 2, pp. 284–299.

Alicke, K, Gupta, R, & Trautwein, V 2020, 'Resetting supply chains for the next normal', *McKinsey & Company Insights*, , no. July, pp. 1–6,

Alikhani, R et al. 2023, 'Towards increasing synergistic effects of resilience strategies in supply chain network design', *Omega (United Kingdom)*, vol. 116, p. 102819.

Alikhani, R, Torabi, SA, & Altay, N 2021, 'Retail supply chain network design with concurrent resilience capabilities', *International Journal of Production Economics*, vol. 234, no. January, p. 108042.

- Alshurideh, MT et al. 2022, 'The influence of supply chain partners' integrations on organizational performance: The moderating role of trust', *Uncertain Supply Chain Management*, vol. 10, no. 4, pp. 1191–1202.
- Althaf, S & Babbitt, CW 2021, 'Disruption risks to material supply chains in the electronics sector', *Resources, Conservation and Recycling*, vol. 167, no. September 2020, p. 105248,.
- Ambulkar, S, Blackhurst, J, & Grawe, S 2015a, 'Firm's resilience to supply chain disruptions: Scale development and empirical examination', *Journal of Operations Management*, vol. 33–34, pp. 111–122.
- Ambulkar, S, Blackhurst, J, & Grawe, S 2015b, 'Firm's resilience to supply chain disruptions: Scale development and empirical examination', *Journal of Operations Management*, vol. 33–34, pp. 111–122, viewed 3 May 2020,
- Angeler, DG & Allen, CR 2016, 'EDITORIAL: Quantifying resilience', *Journal of Applied Ecology*, vol. 53, no. 3, pp. 617–624.
- Annarelli, A, Battistella, C, & Nonino, F 2020, 'A framework to evaluate the effects of organizational resilience on service quality', *Sustainability (Switzerland)*, vol. 12, no. 3, pp. 1–15.
- Annarelli, A & Nonino, F 2016, 'Strategic and operational management of organizational resilience: Current state of research and future directions', *Omega (United Kingdom)*, vol. 62, pp. 1–18,
- Ansari, F 2019, 'Knowledge Management 4.0: Theoretical and practical considerations in cyber physical production systems', *IFAC-PapersOnLine*, vol. 52, no. 13, pp. 1597–1602.
- Antwi, SK & Kasim, H 2015, 'Qualitative and Quantitative Research Paradigms in Business Research: A Philosophical Reflection Performance Management Practices in the Ghanaian local government system View project', *European Journal of Business and Management*, vol. 7, no. 3, pp. 217–226,
- Anyan, F 2013, 'ERIC - EJ1005513 - The Influence of Power Shifts in Data Collection and Analysis Stages: A Focus on Qualitative Research Interview, Qualitative Report, 2013', *Journal Articles; Reports - Evaluative*, vol. 18, no. 1983, pp. 1–9,.
- Arden, NS et al. 2021, 'Industry 4.0 for pharmaceutical manufacturing: Preparing for the smart factories of the future', *International Journal of Pharmaceutics*, vol. 602, p.

120554,.

Arora, P, Kumar, H, & Panigrahi, BK 2020, 'Prediction and analysis of COVID-19 positive cases using deep learning models: A descriptive case study of India', *Chaos, Solitons and Fractals*, vol. 139, p. 110017

Arzu Akyuz, G & Erman Erkan, T 2010, 'Supply chain performance measurement: A literature review', *International Journal of Production Research*, vol. 48, no. 17, pp. 5137–5155.

Asamoah, D et al. 2021, 'Inter-organizational systems use and supply chain performance: Mediating role of supply chain management capabilities', *International Journal of Information Management*, vol. 58, no. August 2020, p. 102195,

Asiamah, N, Mensah, HK, & Oteng-Abayie, EF 2017, 'General, target, and accessible population: Demystifying the concepts for effective sampling', *Qualitative Report*, vol. 22, no. 6, pp. 1607–1621.

Asquith, J 2020, 'If Aviation Was A Country It Would Be The World's 20th Largest By GDP', *Forbes*.

Attaran, M & Attaran, S 2007, 'Collaborative supply chain management: The most promising practice for building efficient and sustainable supply chains', *Business Process Management Journal*, vol. 13, no. 3, pp. 390–404.

Australian Government: National Health and Medical Research Council 2018, *Section 1: Values and Principles of Ethical Conduct*.

Azimli, A 2020, 'The impact of COVID-19 on the degree of dependence and structure of risk-return relationship: A quantile regression approach', *Finance Research Letters*, vol. 36, no. April, p. 101648.

Badorf, F et al. 2019, 'How Supplier Economies of Scale Drive Supplier Selection Decisions', *Journal of Supply Chain Management*, vol. 55, no. 3, pp. 45–67, viewed 16 April 2020,

Bak, O, Jordan, C, & Midgley, J 2019, 'The adoption of soft skills in supply chain and understanding their current role in supply chain management skills agenda: A UK perspective', *Benchmarking*, vol. 26, no. 3, pp. 1063–1079.

Bakshi, N & Kleindorf, P 2009, 'Reproduced with permission of the copyright owner . Further reproduction prohibited without', *Production and Operations Management*, vol. 180, no. 6, pp. 583–603.

Balakrishnan, AS. & Ramanathan, U 2021, 'The role of digital technologies in supply

chain resilience for emerging markets' automotive sector', *Supply Chain Management*, vol. 26, no. 6, pp. 654–671.

Banerjee, A, Duflo, E, & Qian, N 2020, 'On the road: Access to transportation infrastructure and economic growth in China', *Journal of Development Economics*, vol. 145, no. February, p. 102442.

Barney, J 1991, 'Firm Resources and Sustained Competitive Advantage', *Journal of Management*, vol. 17, no. 1, pp. 99–120.

Barney, JB 2012a, 'Purchasing, Supply Chain Management and Sustained Competitive Advantage: The Relevance of Resource-based Theory', *Journal of Supply Chain Management*, vol. 48, no. 2, pp. 3–6.

Barney, JB 2012b, 'Purchasing, Supply Chain Management and Sustained Competitive Advantage: The Relevance of Resource-based Theory', *Journal of Supply Chain Management*, vol. 48, no. 2, pp. 3–6, viewed 12 April 2020.

Basias, N & Pollalis, Y 2018, 'Quantitative and Qualitative Research in Business & Technology: Justifying a Suitable Research Methodology', *Review of Integrative Business and Economics Research*, vol. 7, no. 1, pp. 91–105.

Başkarada, S 2014, 'Qualitative Case Study Guidelines', *The Qualitative Report*.

Bastas, A & Liyanage, K 2018, 'Sustainable supply chain quality management: A systematic review', *Journal of Cleaner Production*, vol. 181, pp. 726–744.

El Baz, J & Ruel, S 2021, 'Can supply chain risk management practices mitigate the disruption impacts on supply chains' resilience and robustness? Evidence from an empirical survey in a COVID-19 outbreak era', *International Journal of Production Economics*, vol. 233, no. October 2020.

Becken, S & Carmignani, F 2020, 'Are the current expectations for growing air travel demand realistic?', *Annals of Tourism Research*, vol. 80, no. November 2019, p. 102840.

Bednarski, L et al. 2023, 'Geopolitical disruptions in global supply chains: a state-of-the-art literature review', *Production Planning and Control*, vol. 0, no. 0, pp. 1–27.

Behzadi, G, O'Sullivan, MJ, & Olsen, TL 2020, 'On metrics for supply chain resilience', *European Journal of Operational Research*, vol. 287, no. 1, pp. 145–158.

Belhadi, A et al. 2021, 'Manufacturing and service supply chain resilience to the COVID-19 outbreak: Lessons learned from the automobile and airline industries', *Technological Forecasting and Social Change*, vol. 163, no. October 2020, p.

120447,.

Belz, AP 2011a, 'Models for technology transfer in the aerospace industry', *IEEE Aerospace Conference Proceedings*, pp. 1–11.

Belz, AP 2011b, 'Models for technology transfer in the aerospace industry', in, *IEEE Aerospace Conference Proceedings*, IEE,.

Berkeley Iii, AR, Wallace, M, & NIAC 2010, 'A Framework for Establishing Critical Infrastructure Resilience Goals: Final Report and Recommendations', *Final Report and Recommendations by the Council*, pp. 1–73.

Beshara, S 2023, 'Designing Supply Chain to Hedge Against Disruptions: A Review of Literature in General and Agro Food Supply Chains', , pp. 135–146.

Beuren, IM, dos Santos, V, & Theiss, V 2022, 'Organizational resilience, job satisfaction and business performance', *International Journal of Productivity and Performance Management*, vol. 71, no. 6, pp. 2262–2279.

Bhamare, D et al. 2020, 'Cybersecurity for industrial control systems: A survey', *Computers and Security*, vol. 89.

Bhamra, R, Dani, S, & Burnard, K 2011, 'Resilience: The concept, a literature review and future directions', *International Journal of Production Research*, vol. 49, no. 18, pp. 5375–5393.

Bhaskar, R 1978, 'On the Possibility of Social Scientific Knowledge and the Limits of Naturalism', *Journal for the Theory of Social Behaviour*, vol. 8, no. 1, pp. 1–28.

Bhaskaran, S & Sukumaran, N 2007, 'National culture, business culture and management practices: Consequential relationships?', *Cross Cultural Management: An International Journal*, vol. 14, no. 1, pp. 54–67.

Biermann, F, Bolten, M, & Bräuninger, M 2011, 'Die Zukunft der Luftfahrt in Indien', , p. 16.

Bleady, A, Ali, AH, & Ibrahim, SB 2018, 'Dynamic capabilities theory: Pinning down a shifting concept', *Academy of Accounting and Financial Studies Journal*, vol. 22, no. 2, pp. 1–16.

Blos, MF et al. 2009, 'Supply chain risk management (SCRM): A case study on the automotive and electronic industries in Brazil', *Supply Chain Management: An International Journal*, vol. 14, no. 4, pp. 247–252.

Boeing Commercial Airplanes 2016, 'Current Market Outlook 2016-2035', *Boeing.Com*, p. 54,

Bombelli, A, Santos, BF, & Tavasszy, L 2020, 'Analysis of the air cargo transport network using a complex network theory perspective', *Transportation Research Part E: Logistics and Transportation Review*, vol. 138, no. April, p. 101959,

Bonner, RL et al. 2023, 'Triaging your human capital: an integrative perspective on strategic human capital asset allocation', *Management Research Review*, vol. 46, no. 3, pp. 467–482.

Booth, TF, Gould, EA, & Nuttall, PA 1991, 'Structure and morphogenesis of Dugbe virus (Bunyaviridae, Nairovirus) studied by immunogold electron microscopy of ultrathin cryosections', *Virus Research*, vol. 21, no. 3, pp. 199–212.

Boston, W 2022, 'Ukraine War Plunges Auto Makers Into New Supply-Chain Crisis', *Wall Street Journal*, pp. 1–6.

Bouarfa, S et al. 2013, 'Agent-based modeling and simulation of emergent behavior in air transportation', *Complex Adaptive Systems Modeling*, vol. 1, no. 1, pp. 1–26.

Boulaksil, Y et al. 2021, 'Comparing policies for the stochastic multi-period dual sourcing problem from a supply chain perspective', *International Journal of Production Economics*, vol. 232, no. December 2019, p. 107923.

Bowman Jr., J 2015, 'Strategies for Mitigating Supply Chain Disruptions', *ProQuest Dissertations and Theses*, p. 143.

Brahmana, S et al. 2019, 'Supply Chain governance, corporate governance and supply chain capabilities: An unexplored nexus', *International Journal of Supply Chain Management*, vol. 8, no. 2, pp. 134–141.

Brandao, MS & Godinho-Filho, M 2022, 'Is a multiple supply chain management perspective a new way to manage global supply chains toward sustainability?', *Journal of Cleaner Production*, vol. 375, no. September, p. 134046.

Brennan, NM, Subramaniam, N, & van Staden, CJ 2019, 'Corporate governance implications of disruptive technology: An overview', *British Accounting Review*, vol. 51, no. 6.

Brönnimann, A 2022, 'How to phrase critical realist interview questions in applied social science research', *Journal of Critical Realism*, vol. 21, no. 1, pp. 1–24.

Brown, AJ 2017, *Development of a supplier segmentation method for increased resilience and robustness: A study using agent based modeling and simulation*.

Brown, M & Singh, P 2018, *China's Technology Transfer Strategy: How Chinese Investments in Emerging Technology*, viewed 11 January 2020.

- Brown, R & Abuatiq, A 2020, 'Resilience as a strategy to survive organizational change', *Nursing management*, vol. 51, no. 2, pp. 16–21.
- Browning, T et al. 2023, 'From supply chain risk to system-wide disruptions: research opportunities in forecasting, risk management and product design', *International Journal of Operations and Production Management*.
- Brun, A, Karaosman, H, & Barresi, T 2020, 'Supply chain collaboration for transparency', *Sustainability (Switzerland)*, vol. 12, no. 11.
- Brusset, X & Teller, C 2017, 'Supply chain capabilities, risks, and resilience', *International Journal of Production Economics*, vol. 184, no. October 2015, pp. 59–68.
- Burgos, D & Ivanov, D 2021, 'Food retail supply chain resilience and the COVID-19 pandemic: A digital twin-based impact analysis and improvement directions', *Transportation Research Part E: Logistics and Transportation Review*, vol. 152, no. June, p. 102412.
- Cabello, M, Junqueira, DM, & Bello, G 2015, 'Dissemination of nonpandemic Caribbean HIV-1 subtype B clades in Latin America', *Aids*, vol. 29, no. 4, pp. 483–492.
- Cabral, I, Grilo, A, & Cruz-Machado, V 2012, 'A decision-making model for Lean, Agile, Resilient and Green supply chain management', *International Journal of Production Research*, vol. 50, no. 17, pp. 4830–4845.
- Caiado, RGG et al. 2022, 'Challenges and Benefits of Sustainable Industry 4.0 for Operations and Supply Chain Management—A Framework Headed toward the 2030 Agenda', *Sustainability (Switzerland)*, vol. 14, no. 2.
- Cambridge Dictionary 2020, *aviation*, viewed 7 July 2020.
- Cameron, D 2020, 'Boeing, Airbus Slash Production As Pandemic Scuttles Plane Orders', *Dow Jones Institutional News*.
- Capros, P et al. 1999, 'Literature Review', pp. 5–26.
- Carnahan, S, Agarwal, R, & Campbell, B 2010, 'The Effect of Firm Compensation Structures on the Mobility and Entrepreneurship of Extreme Performers', *Business*, vol. 920, no. October, pp. 1–43.
- Carr, A, Muthsamy, S, & Owens, C 2012, 'Strategie repositioning of the service supply chain', *Organization Development Journal*, vol. 30, no. 1, pp. 63–78.
- Castillo-Montoya, M 2016, 'Preparing for interview research: The interview protocol

- refinement framework', *Qualitative Report*, vol. 21, no. 5, pp. 811–831.
- Çebi, F & Bayraktar, D 2003, 'An integrated approach for supplier selection', *Logistics Information Management*, vol. 16, no. 6, pp. 395–400.
- Centobelli, P, Cerchione, R, & Esposito, E 2019, 'Efficiency and effectiveness of knowledge management systems in SMEs', *Production Planning and Control*, vol. 30, no. 9, pp. 779–791.
- Chae, BK, Olson, D, & Sheu, C 2014, 'The impact of supply chain analytics on operational performance: A resource-based view', *International Journal of Production Research*, vol. 52, no. 16, pp. 4695–4710.
- Chapple, E, Walsh, K, & Shen, Y 2020, 'Corporate Culture and Fraud', *Corporate Fraud Exposed*, pp. 85–106.
- Chari, A et al. 2022, 'Dynamic capabilities for circular manufacturing supply chains—Exploring the role of Industry 4.0 and resilience', *Business Strategy and the Environment*, vol. 31, no. 5, pp. 2500–2517.
- Chen, C, Zhang, J, & Delaurentis, T 2014a, 'Quality control in food supply chain management: An analytical model and case study of the adulterated milk incident in China', *International Journal of Production Economics*, vol. 152, pp. 188–199, viewed 20 April 2020.
- Chen, C, Zhang, J, & Delaurentis, T 2014b, 'Quality control in food supply chain management: An analytical model and case study of the adulterated milk incident in China', *International Journal of Production Economics*, vol. 152, pp. 188–199.
- Chen, Z et al. 2021, 'Sustainability drivers in road transportation system: Evidence from China', *Science of the Total Environment*, vol. 798, p. 149259.
- Cheng, Y, Elsayed, EA, & Huang, Z 2022, 'Systems resilience assessments: a review, framework and metrics', *International Journal of Production Research*, vol. 60, no. 2, pp. 595–622.
- Chinoperekweyi, J 2019, 'A Global Analysis of the Role of Offsets in Aerospace Industry Credibility Challenge in Organizational Research-a call to order for those in academe View project', *Saudi Journal of Business and Management Studies*, vol. 4(1), no. January, pp. 147–163.
- Choi, FKH 2018, 'How to establish a good government? Lessons from Lee Kuan Yew in Singapore and Deng Xiaoping in China', *Public Administration and Policy*, vol. 21, no. 2, pp. 107–119.

- Choi, TM 2021, 'Risk analysis in logistics systems: A research agenda during and after the COVID-19 pandemic', *Transportation Research Part E: Logistics and Transportation Review*, vol. 145, no. November 2020.
- Choi, TY. et al. 2023, 'Just-in-time for supply chains in turbulent times', *Production and Operations Management*, vol. 32, no. 7, pp. 2331–2340.
- Chopra, S, Sodhi, MM, & Lücker, F 2021, 'Achieving supply chain efficiency and resilience by using multi-level commons', *Decision Sciences*, vol. 52, no. 4, pp. 817–832.
- Chou, YC, Lu, CH, & Tang, YY 2012, *Identifying inventory problems in the aerospace industry using the theory of constraints*, *International Journal of Production Research*, vol. 50, no. 16, pp. 4686–4698, viewed 16 April 2020.
- Chow, DCK 2023, 'Why the United States Was Wrong in the Forced Technology Transfer Debate with China', *SSRN Electronic Journal*.
- Chowdhury, MMH & Quaddus, M 2016, 'Supply chain readiness, response and recovery for resilience', *Supply Chain Management*, vol. 21, no. 6, pp. 709–731.
- Chowdhury, MMH & Quaddus, M 2017, 'Supply chain resilience: Conceptualization and scale development using dynamic capability theory', *International Journal of Production Economics*, vol. 188, no. July, pp. 185–204.
- Chowdhury, P et al. 2021, 'COVID-19 pandemic related supply chain studies: A systematic review', *Transportation Research Part E: Logistics and Transportation Review*, vol. 148, no. February, p. 102271.
- Christopher, M & Holweg, M 2011, "Supply Chain 2.0": Managing supply chains in the era of turbulence', *International Journal of Physical Distribution and Logistics Management*, vol. 41, no. 1, pp. 63–82.
- Christopher, M & Peck, H 2004, 'International Journal of Logistics Management', Vol. 15, No. 2, pp1-13, 2004', *International Journal of Logistics Management*, vol. 15, no. 2, pp. 1–13.
- Chun Tie, Y, Birks, M, & Francis, K 2019, 'Grounded theory research: A design framework for novice researchers', *SAGE Open Medicine*, vol. 7, p. 205031211882292.
- Chunsheng, L et al. 2020, 'Value of supply chain resilience: roles of culture, flexibility, and integration', *International Journal of Physical Distribution and Logistics Management*, vol. 50, no. 1, pp. 80–100.

Cliff, R, Ohlandt, CJR, & Yang, D n.d., 'RAND Corporation Chapter Title: The Role of Foreign Firms in the Development of China's Commercial Aviation Manufacturing Industry Book Title: Ready for Takeoff Book Subtitle: China's Advancing Aerospace Industry'.

Cohen, MA & Kouvelis, P 2021, 'Revisit of AAA Excellence of Global Value Chains: Robustness, Resilience, and Realignment', *Production and Operations Management*, vol. 30, no. 3, pp. 633–643.

Collins, CS & Stockton, CM 2018, 'The Central Role of Theory in Qualitative Research', *International Journal of Qualitative Methods*, vol. 17, no. 1, pp. 1–10, viewed 14 February 2021.

Connelly, EB et al. 2017a, 'Features of resilience', *Environment Systems and Decisions*, vol. 37, no. 1, pp. 46–50.

Connelly, EB et al. 2017b, 'Features of resilience', *Environment Systems and Decisions*, vol. 37, no. 1, pp. 46–50.

Cooke, P & Ehret, O 2009, 'Proximity and procurement: A study of agglomeration in the welsh aerospace industry', *European Planning Studies*, vol. 17, no. 4, pp. 549–567.

Cooper, C 2016, 'China to Surpass U.S. as World's Largest Aviation Market by 2024', *Bloomberg*.

Craighead, CW, Ketchen, DJ, & Darby, JL 2020, 'Pandemics and Supply Chain Management Research: Toward a Theoretical Toolbox*', *Decision Sciences*, vol. 51, no. 4, pp. 838–866.

Creazza, A, Dallari, F, & Melacini, M 2010, 'Evaluating logistics network configurations for a global supply chain', *Supply Chain Management*, vol. 15, no. 2, pp. 154–164.

Creswell, J 2013, 'Steps in Conducting a Scholarly Mixed Methods Study Abstract for DBER Group Discussion on 2013 - 11 - 14', in JW Creswell (ed.), *Steps in Conducting a Scholarly Mixed Methods Study*, University of Nebraska, Lincoln, pp.1–54.

Creswell, JW & Tashakkori, A 2007, 'Editorial: Differing Perspectives on Mixed Methods Research', *Journal of Mixed Methods Research*, vol. 1, no. 4, pp. 303–308.

Crotty, M 1998, 'Introduction : The research process', *The foundations of social research*, pp. 1–17.

- Cruz-Cázares, C, Bayona-Sáez, C, & García-Marco, T 2013, 'Make, buy or both? R&D strategy selection', *Journal of Engineering and Technology Management - JET-M*, vol. 30, no. 3, pp. 227–245.
- Cui, L et al. 2023, 'Effects of control mechanisms on supply chain resilience and sustainability performance', *Australian Journal of Management*, vol. 48, no. 2, pp. 323–340.
- Czerny, AI & Lang, H 2021, 'Privatization and Deregulation of the Airline Industry', *International Encyclopedia of Transportation: Volume 1-7*, vol. 1, no. May, pp. 397–403.
- Danermark, B 2002, 'Interdisciplinary Research and Critical Realism The Example of Disability Research', *Alethia*, vol. 5, no. 1, pp. 56–64.
- Daniela, M 2015, 'Management strategies in the aerospace industry. Particular case: The Boeing Company', *Incas Bulletin*, vol. 7, no. 1, pp. 111–119.
- Davies, G 2019, 'Related Primary Literature', *AccessScience, McGraw-Hill Education*, vol. 65, no. 1, pp. 45–46.
- Delic, M & Eysers, DR 2020, 'The effect of additive manufacturing adoption on supply chain flexibility and performance: An empirical analysis from the automotive industry', *International Journal of Production Economics*, vol. 228, no. April 2019, p. 107689.
- Denning, S 2013, 'What went wrong at Boeing', *Strategy and Leadership*, vol. 41, no. 3, pp. 36–41.
- Deveci, M et al. 2022, 'Impact of COVID-19 pandemic on the Turkish civil aviation industry', *Sustainable Operations and Computers*, vol. 3, no. October 2021, pp. 93–102.
- Diaye, MA, Greenan, N, & Pekovic, S 2014, 'Sharing the fame of ISO standard adoption: Quality supply chain effects evidence', *International Journal of Production Research*, vol. 52, no. 18, pp. 5396–5414.
- Dickson, BJ 2017, *Critical Reading on the CCP*, Brill, Leiden, The Netherlands.
- Do, H et al. 2022, 'Building organizational resilience, innovation through resource-based management initiatives, organizational learning and environmental dynamism', *Journal of Business Research*, vol. 141, no. November 2021, pp. 808–821.
- Doerfler, I, Baumann, O, & Becker, M 2012, 'Choosing Paths to Becoming a

Systems Integrator : Lessons from Airbus ' " New Systems Policy "', *Druid* 2012, , no. 1.

Doerr, L et al. 2020, 'How new airport infrastructure promotes tourism: evidence from a synthetic control approach in German regions', *Regional Studies*, vol. 54, no. 10, pp. 1402–1412.

Dogu, O et al. 2021, 'The chemistry of chemical recycling of solid plastic waste via pyrolysis and gasification: State-of-the-art, challenges, and future directions', *Progress in Energy and Combustion Science*, vol. 84, p. 100901.

Dolci, PC, Maçada, ACG, & Paiva, EL 2017, 'Models for understanding the influence of Supply Chain Governance on Supply Chain Performance', *Supply Chain Management*, vol. 22, no. 5, pp. 424–441.

Dolgui, A, Ivanov, D, & Sokolov, B 2018a, 'Ripple effect in the supply chain: an analysis and recent literature', *International Journal of Production Research*, vol. 56, no. 1–2, pp. 414–430.

Dolgui, A, Ivanov, D, & Sokolov, B 2018b, 'Ripple effect in the supply chain: an analysis and recent literature', *International Journal of Production Research*, vol. 56, no. 1–2, pp. 414–430.

Domnina, O et al. 2022, 'Risk management in supply chains under COVID-19 conditions', *International Journal of Business Performance and Supply Chain Modelling*, vol. 13, no. 1, pp. 53–68.

Dong, C & Transchel, S 2020, 'A dual sourcing inventory model for modal split transport: Structural properties and optimal solution', *European Journal of Operational Research*, vol. 283, no. 3, pp. 883–900.

Dong, S et al. 2019, 'Robust component: A robustness measure that incorporates access to critical facilities under disruptions', *Journal of the Royal Society Interface*, vol. 16, no. 157.

Dong, X & Ryerson, MS 2019, 'Increasing civil aviation capacity in China requires harmonizing the physical and human components of capacity: A review and investigation', *Transportation Research Interdisciplinary Perspectives*, vol. 1, pp. 1–7.

Dossou, PE 2018, 'Impact of Sustainability on the supply chain 4.0 performance', *Procedia Manufacturing*, vol. 17, pp. 452–459.

Drost, E 2011, 'Validity and Reliability in Social Science Research', *Education*

Research and Perspectives, vol. 38, no. 1, pp. 105–123.

Dube, K, Nhamo, G, & Chikodzi, D 2021, 'COVID-19 pandemic and prospects for recovery of the global aviation industry', *Journal of Air Transport Management*, vol. 92, no. January, p. 102022.

Dubey, R et al. 2021, 'Empirical investigation of data analytics capability and organizational flexibility as complements to supply chain resilience', *International Journal of Production Research*, vol. 59, no. 1, pp. 110–128.

Duong, LNK & Chong, J 2020, 'Supply chain collaboration in the presence of disruptions: a literature review', *International Journal of Production Research*, vol. 58, no. 11, pp. 3488–3507.

Dupré, M 2006, *How to get a PhD*, Fifth, Open University Press, Maidenhead, England.

Dyre, J, Wujin, C, & Cho, DS 1998, 'Strategic supplier segmentation: The next "best practice" in supply chain management', *Journal of Allergy and Clinical Immunology*, vol. 130, no. 2, p. 556.

Ebrahimi, M & Sadeghi, M 2013, 'Quality management and performance: An annotated review', *International Journal of Production Research*, vol. 51, no. 18, pp. 5625–5643.

Echefaj, K, Charkaoui, A, & Cherrafi, A 2022, 'Analyzing Capabilities for Resilient Supply Chain in Unexpected Event', *IFAC-PapersOnLine*, vol. 55, no. 10, pp. 3190–3195.

Edwards, PK, O'Mahoney, J, & Vincent, S 2014, *Critical Realism and Interviewing Subjects*.

Eisenhardt, KM 1989, 'Building Theories from Case Study Research Published by : Academy of Management Stable', *The Academy of Management Review*, vol. 14, no. 4, pp. 532–550.

Eisenhardt, KM 2021, 'What is the Eisenhardt Method, really?', *Strategic Organization*, vol. 19, no. 1, pp. 147–160.

Eisenhardt, KM & Martin, JA 2000, 'Dynamic capabilities: What are they?', *Strategic Management Journal*, vol. 21, no. 10–11, pp. 1105–1121.

Ellinger, AE & Ellinger, AD 2014, 'Leveraging human resource development expertise to improve supply chain managers' skills and competencies', *European Journal of Training and Development*, vol. 38, no. 1–2, pp. 118–135.

- Elluru, S et al. 2019, 'Proactive and reactive models for disaster resilient supply chain', *Annals of Operations Research*, vol. 283, no. 1–2, pp. 199–224.
- Elmore, PB et al. 2024, 'Procedures and Their Rationales'.
- Elmqvist, T et al. 2019, 'Sustainability and resilience for transformation in the urban century', *Nature Sustainability*, vol. 2, no. 4, pp. 267–273.
- Engert, S & Baumgartner, RJ 2016, 'Corporate sustainability strategy - Bridging the gap between formulation and implementation', *Journal of Cleaner Production*, vol. 113, pp. 822–834.
- Eriksson, D & Engström, A 2021, 'Using critical realism and abduction to navigate theory and data in operations and supply chain management research', *Supply Chain Management*, vol. 26, no. 2, pp. 224–239.
- Ervits, I 2023, 'CSR reporting in China's private and state-owned enterprises: A mixed methods comparative analysis', *Asian Business and Management*, vol. 22, no. 1, pp. 55–83.
- Essex, A, Subramanian, N, & Gunasekaran, A 2016, 'The relationship between supply chain manager capabilities and performance: Empirical evidence', *Production Planning and Control*, vol. 27, no. 3, pp. 198–211.
- Essuman, D, Boso, N, & Annan, J 2020, 'Operational resilience, disruption, and efficiency: Conceptual and empirical analyses', *International Journal of Production Economics*, vol. 229, no. April, p. 107762.
- Fahimnia, B, Jabbarzadeh, A, & Sarkis, J 2018, 'Greening versus resilience: A supply chain design perspective', *Transportation Research Part E: Logistics and Transportation Review*, vol. 119, no. October, pp. 129–148.
- Fajgelbaum, PD & Khandelwal, AK 2022, 'The Economic Impacts of the US-China Trade War', *Annual Review of Economics*, vol. 14, pp. 205–228.
- Falasca, M & Zobel, CW 2011, 'A two-stage procurement model for humanitarian relief supply chains', *Journal of Humanitarian Logistics and Supply Chain Management*, vol. 1, no. 2, pp. 151–169.
- Falasca, M, Zobel, CW, & Cook, D 2008, 'A decision support framework to assess supply chain resilience', *Proceedings of ISCRAM 2008 - 5th International Conference on Information Systems for Crisis Response and Management*, , no. May 2008, pp. 596–605.
- Fan, H, Hu, Y, & Tang, L 2021, 'Labor costs and the adoption of robots in China',

- Journal of Economic Behavior and Organization*, vol. 186, pp. 608–631.
- Fan, Y & Fang, C 2020, 'Circular economy development in China-current situation, evaluation and policy implications', *Environmental Impact Assessment Review*, vol. 84, no. April, p. 106441.
- Fang, J et al. 2020, 'Dynamic Planning Method for Drug Distribution in Earthquake Response Based on Sliding Time Window Series', *IEEE Access*, vol. 8, pp. 160697–160710.
- Farooq, MU et al. 2021, 'Supply chain operations management in pandemics: A state-of-the-art review inspired by covid-19', *Sustainability (Switzerland)*, vol. 13, no. 5, pp. 1–33.
- Fath, BD, Dean, CA, & Katzmair, H 2015, 'Navigating the adaptive cycle: An approach to managing the resilience of social systems', *Ecology and Society*, vol. 20, no. 2.
- Fatorachian, H & Kazemi, H 2021, 'Impact of Industry 4.0 on supply chain performance', *Production Planning and Control*, vol. 32, no. 1, pp. 63–81.
- Feizabadi, J, Gligor, DM, & Alibakhshi, S 2021, 'Examining the synergistic effect of supply chain agility, adaptability and alignment: a complementarity perspective', *Supply Chain Management*, vol. 26, no. 4, pp. 514–531.
- Felsberger, A et al. 2022, 'The impact of Industry 4.0 on the reconciliation of dynamic capabilities: evidence from the European manufacturing industries', *Production Planning and Control*, vol. 33, no. 2–3, pp. 277–300.
- Feng, Y, Zhu, Q, & Lai, KH 2017, 'Corporate social responsibility for supply chain management: A literature review and bibliometric analysis', *Journal of Cleaner Production*, vol. 158, pp. 296–307.
- Fernandes, AC et al. 2017, 'Supply chain management and quality management integration: A conceptual model proposal', *International Journal of Quality and Reliability Management*, vol. 34, no. 1, pp. 53–67.
- Ferreira, G & Critelli, J 2022, 'China's Global Monopoly on Rare-Earth Elements', *Parameters*, vol. 52, no. 1, pp. 57–72.
- Festing, M & Eidems, J 2011, 'A process perspective on transnational HRM systems - A dynamic capability-based analysis', *Human Resource Management Review*, vol. 21, no. 3, pp. 162–173.
- Feyissa, TT, Sharma, RRK, & Lai, KK 2019, 'The impact of the core company's

- strategy on the dimensions of supply chain integration', *International Journal of Logistics Management*, vol. 30, no. 1, pp. 231–260.
- Fiala, P 2005, 'Information sharing in supply chains', *Omega*, vol. 33, no. 5, pp. 419–423.
- Fidler, DS & Kleinknecht, RE 1977, 'Randomized response versus direct questioning: Two data-collection methods for sensitive information', *Psychological Bulletin*, vol. 84, no. 5, pp. 1045–1049.
- Figueiredo, P, Silveira, G, & Sbragia, R 2008, 'Risk sharing partnerships with suppliers: The case of Embraer', *Journal of Technology Management and Innovation*, vol. 3, no. 1, pp. 27–37.
- Fischer-Preßler, D et al. 2020, 'Information technology and risk management in supply chains', *International Journal of Physical Distribution and Logistics Management*, vol. 50, no. 2, pp. 233–254.
- Fletcher, D & Sarkar, M 2013, 'Psychological resilience: A review and critique of definitions, concepts, and theory', *European Psychologist*, vol. 18, no. 1, pp. 12–23.
- Folke, C et al. 2010, 'Resilience thinking: Integrating resilience, adaptability and transformability', *Ecology and Society*, vol. 15, no. 4.
- Fonseca, LM & Azevedo, AL 2020, 'COVID- 19 : outcomes for Global Supply Chains', *Management & Marketing. Challenges for the Knowledge Society*, vol. 15, no. January 2020, pp. 424–438.
- Forkmann, S et al. 2016, 'Supplier relationship management capability: a qualification and extension', *Industrial Marketing Management*, vol. 57, pp. 185–200.
- Franca, RB et al. 2010, 'Multi-objective stochastic supply chain modeling to evaluate tradeoffs between profit and quality', *International Journal of Production Economics*, vol. 127, no. 2, pp. 292–299, viewed 23 April 2020.
- Frederico, GF et al. 2020, 'Supply Chain 4.0: concepts, maturity and research agenda', *Supply Chain Management*, vol. 25, no. 2, pp. 262–282.
- Frederiksen, DJ & Kringelum, LB 2021, 'Five potentials of critical realism in management and organization studies', *Journal of Critical Realism*, vol. 20, no. 1, pp. 18–38.
- Freeman, RE, Dmytriiev, SD, & Phillips, RA 2021, 'Stakeholder Theory and the Resource-Based View of the Firm', *Journal of Management*, vol. 47, no. 7, pp. 1757–1770.

Friedrich, A, Lange, A, & Elbert, R 2022, 'Make-or-buy decisions for industrial additive manufacturing', *Journal of Business Logistics*, vol. 43, no. 4, pp. 623–653.

Fu, X et al. 2015, 'Low cost carrier competition and route entry in an emerging but regulated aviation market - The case of China', *Transportation Research Part A: Policy and Practice*, vol. 79, pp. 3–16.

Galli-Debicella, A 2021, 'How SMEs Compete Against Global Giants Through Sustainable Competitive Advantages', *Journal of Small Business Strategy*, vol. 31, no. 5, pp. 13–21.

Galvin, P, Rice, J, & Liao, TS 2014, 'Applying a Darwinian model to the dynamic capabilities view: Insights and issues', *Journal of Management and Organization*, vol. 20, no. 2, pp. 250–263.

Galvin, P, Rice, J, & Liao, TS 2015, 'Can a Darwinian nomenclature help reconcile alternative perspectives of the dynamic capabilities view?', *Journal of Management and Organization*, vol. 21, no. 5, pp. 695–700.

Galy, N & Germain, L 2007, 'Market Competition and Share Prices : The Case of', *Business Week*, no. July 2003, pp. 1–29.

Gapp, R, Fisher, R, & Kobayashi, K 2008, 'Implementing 5S within a Japanese context: An integrated management system', *Management Decision*, vol. 46, no. 4, pp. 565–579.

García-Flores, R & Xue, ZW 1998, 'A multi-agent system for chemical supply chain simulation and management support', *Journal of Allergy and Clinical Immunology*, vol. 130, no. 2, p. 556.

García-Reyes, H, Avilés-González, J, & Avilés-Sacoto, SV 2022, 'A Model to Become a Supply Chain 4.0 Based on a Digital Maturity Perspective', *Procedia Computer Science*, vol. 200, no. 2019, pp. 1058–1067.

Gaweł, A, Mroczek-Dąbrowska, K, & Pietrzykowski, M 2023, *Digitalization and Its Impact on the Internationalization Models of SMEs*.

Georgise, FB, Thoben, K-D, & Seifert, M 2012, 'Adapting the SCOR Model to Suit the Different Scenarios: A Literature Review & Research Agenda', *International Journal of Business and Management*, vol. 7, no. 6, pp. 2–17.

Ghadge, A et al. 2017, 'Using risk sharing contracts for supply chain risk mitigation: A buyer-supplier power and dependence perspective', *Computers and Industrial Engineering*, vol. 103, pp. 262–270.

- Ghoris, T 2007, 'Becoming Qualitative Researchers: An Introduction [Book Review]', in, *Qualitative Research Journal*, Pearson, Boston, MA, p.[203]-204.
- Gibbons, DW, Serfontein, JPL, & van der Merwe, AF 2021, 'Mapping the path to certification of metal laser powder bed fusion for aerospace applications', *Rapid Prototyping Journal*, vol. 27, no. 2, pp. 355–361.
- Gligor, D et al. 2019, 'Distinguishing between the concepts of supply chain agility and resilience: A multidisciplinary literature review', *International Journal of Logistics Management*, vol. 30, no. 2, pp. 467–487.
- Gligor, D et al. 2020, 'The triple-a supply chain and strategic resources: developing competitive advantage', *International Journal of Physical Distribution and Logistics Management*, vol. 50, no. 2, pp. 159–190.
- Goh, E & Loosemore, M 2017, *The impacts of industrialization on construction subcontractors: a resource based view*, *Construction Management and Economics*, vol. 35, no. 5, pp. 288–304, viewed 16 April 2020.
- Goh, PG & Chou, MC 2022, 'Global Supply Chains in a Glocal World', *Global Supply Chains in a Glocal World*.
- Golgeci, I, Makhmadshoev, D, & Demirbag, M 2021, 'Global value chains and the environmental sustainability of emerging market firms: A systematic review of literature and research agenda', *International Business Review*, vol. 30, no. 5, p. 101857.
- Goncalves, C & Kokkolaras, M 2017, 'Modeling the relationship between aviation original equipment manufacturers and maintenance, repair and overhaul enterprises from a product-service system perspective', *Proceedings of the International Conference on Engineering Design, ICED*, vol. 3, no. DS87-3, pp. 389–398.
- Gonçalves, LAPJ & Ribeiro, PJG 2020, 'Resilience of urban transportation systems. Concept, characteristics, and methods.', *Journal of Transport Geography*, vol. 85, no. May, p. 102727.
- Gössling, S 2020, 'Risks, resilience, and pathways to sustainable aviation: A COVID-19 perspective', *Journal of Air Transport Management*, vol. 89, no. May, pp. 0–3.
- Grassia, M et al. 2022, '(Unintended) Consequences of export restrictions on medical goods during the Covid-19 pandemic', *Journal of Complex Networks*, vol. 10, no. 1, pp. 1–14.
- Greene, RR, Galambos, C, & Lee, Y 2004, 'Journal of Human Behavior in the Social

- Environment Resilience Theory', *Journal of Human Behavior in the Social Environment*, vol. 8, no. 4, pp. 75–91.
- Gregson, S et al. 2015, 'Supply chains, maintenance and safety in the Australian airline industry', *Journal of Industrial Relations*, vol. 57, no. 4, pp. 604–623.
- Grimme, W, Maertens, S, & Bingemer, S 2022, 'The role of very large passenger aircraft in global air transport - A review and outlook to the year 2050', *Transportation Research Procedia*, vol. 59, pp. 76–84.
- Grötsch, VM, Blome, C, & Schleper, MC 2013, 'Antecedents of proactive supply chain risk management - A contingency theory perspective', *International Journal of Production Research*, vol. 51, no. 10, pp. 2842–2867.
- Gu, M et al. 2023, 'The effect of high-involvement human resource management practices on supply chain resilience and operational performance', *Journal of Management Science and Engineering*, vol. 8, no. 2, pp. 176–190.
- Gualandris, J et al. 2021, 'The association between supply chain structure and transparency: A large-scale empirical study', *Journal of Operations Management*, vol. 67, no. 7, pp. 803–827.
- Gulley, AL, McCullough, EA, & Shedd, KB 2019, 'China's domestic and foreign influence in the global cobalt supply chain', *Resources Policy*, vol. 62, no. March, pp. 317–323.
- Gunasekaran, A, Subramanian, N, & Rahman, S 2015, 'Supply chain resilience: Role of complexities and strategies', *International Journal of Production Research*, vol. 53, no. 22, pp. 6809–6819.
- Gupta, H, Kusi-Sarpong, S, & Rezaei, J 2020, 'Barriers and overcoming strategies to supply chain sustainability innovation', *Resources, Conservation and Recycling*, vol. 161, no. June, p. 104819.
- Gupta, V & Ivanov, D 2020, 'Dual sourcing under supply disruption with risk-averse suppliers in the sharing economy', *International Journal of Production Research*, vol. 58, no. 1, pp. 291–307.
- Gurtu, A & Johnny, J 2021, 'Supply chain risk management: Literature review', *Risks*, vol. 9, no. 1, pp. 1–16.
- Hajami, N El & Chinoperekweyi, J 2019, 'A Global Analysis of the Role of Offsets in Aerospace Industry', *Saudi Journal of Business and Management Studies*, vol. 4(1), no. January, pp. 147–163.

Hajda, J, Jakuszewski, R, & Ogonowski, S 2021, 'Security challenges in industry 4.0 plc systems', *Applied Sciences (Switzerland)*, vol. 11, no. 21.

Halkier, B 2011, 'Methodological practicalities in analytical generalization', *Qualitative Inquiry*, vol. 17, no. 9, pp. 787–797.

Halpern, N et al. 2021, 'Ready for digital transformation? The effect of organisational readiness, innovation, airport size and ownership on digital change at airports', *Journal of Air Transport Management*, vol. 90, no. September 2020, p. 101949.

Han, Y, Skibniewski, MJ, & Wang, L 2017, 'A market equilibrium supply chain model for supporting self-manufacturing or outsourcing decisions in prefabricated construction', *Sustainability (Switzerland)*, vol. 9, no. 11.

Harris, D 2019, *Research practice*.

Harrison, H et al. 2017, 'Case study research: Foundations and methodological orientations', *Forum Qualitative Sozialforschung*, vol. 18, no. 1.

Hart, D 2022, *Transition and Opportunity*.

He, S, Hipel, KW, & Kilgour, DM 2017, 'Analyzing market competition between Airbus and Boeing using a duo hierarchical graph model for conflict resolution', *Journal of Systems Science and Systems Engineering*, vol. 26, no. 6, pp. 683–710.

He, Y 2017, 'Supply risk sharing in a closed-loop supply chain', *International Journal of Production Economics*, vol. 183, no. September 2016, pp. 39–52.

He, Z et al. 2023, 'Building organizational resilience with digital transformation', *Journal of Service Management*, vol. 34, no. 1, pp. 147–171.

Healy, M & Perry, C 2000, 'Comprehensive criteria to judge validity and reliability of qualitative research within the realism paradigm', *Qualitative Market Research: An International Journal*, vol. 3, no. 3, pp. 118–126.

Hedström, P & Ylikoski, P 2010, 'Causal mechanisms in the social sciences', *Annual Review of Sociology*, vol. 36, pp. 49–67.

Helo, P & Hao, Y 2022, 'Artificial intelligence in operations management and supply chain management: an exploratory case study', *Production Planning and Control*, vol. 33, no. 16, pp. 1573–1590.

Hepher, T 2017, 'Values of PW1100 Powered A320neos Remain Unchanged - For Now', *Aircraft Value News*, pp. 1–3.

Hinkin, TR, Tracey, JB, & Enz, CA 1997, *Scale construction: Developing reliable and valid measurement instruments*.

- Hitt, MA, Carnes, CM, & Xu, K 2016, 'A current view of resource based theory in operations management: A response to Bromiley and Rau', *Journal of Operations Management*, vol. 41, no. February, pp. 107–109.
- Hobbs, JE 2021, 'Food supply chain resilience and the COVID-19 pandemic: What have we learned?', *Canadian Journal of Agricultural Economics*, vol. 69, no. 2, pp. 189–196.
- Hock-Doepgen, M et al. 2021, 'Knowledge management capabilities and organizational risk-taking for business model innovation in SMEs', *Journal of Business Research*, vol. 130, no. March 2019, pp. 683–697.
- Hohenstein, NO et al. 2015, 'Research on the phenomenon of supply chain resilience: A systematic review and paths for further investigation', *International Journal of Physical Distribution and Logistics Management*, vol. 45, no. 2005, pp. 90–117.
- Hollnagel, E, Woods, DD, & Leveson, N 2012, 'Resilience engineering: Concepts and precepts', in, *Resilience Engineering: Concepts and Precepts*, pp.1–397, viewed 19 May 2020.
- Horgos, D & Tajoli, L 2015, 'How Offshoring Can Affect the Industries' Skill Composition', *Economies*, vol. 3, no. 2, pp. 72–99.
- Hosseini, S, Ivanov, D, & Dolgui, A 2019, 'Review of quantitative methods for supply chain resilience analysis', *Transportation Research Part E: Logistics and Transportation Review*, vol. 125, no. December 2018, pp. 285–307.
- Hughes, WJ 2022, 'Guidelines for Formulating and Writing Process Control Documents and Process Specifications for Advanced Materials', no. October.
- Huo, B et al. 2015, 'The effect of high-involvement human resource management practices on supply chain integration', *International Journal of Physical Distribution and Logistics Management*, vol. 45, no. 8, pp. 716–746.
- Iacus, SM et al. 2020, 'Estimating and projecting air passenger traffic during the COVID-19 coronavirus outbreak and its socio-economic impact', *Safety Science*, vol. 129, pp. 1–17.
- IBISWorld 2021, *Biggest Industries by Revenue in Australia in 2021*, , p. 1.
- Ibrahim, T a 2003, 'Supply Chain Risks, Resilience and Firm Performance: an Empirical Study', *System*, vol. d, no. Chapter 6.
- ICAO n.d., 'Inspector Manual Inspector Qualifications', *Cooperative Development of*

Operational Safety and Continuing Airworthiness.

Iflaifel, M et al. 2020, 'Resilient Health Care: A systematic review of conceptualisations, study methods and factors that develop resilience', *BMC Health Services Research*, vol. 20, no. 1, pp. 1–21.

Iftikhar, A et al. 2022, 'The impact of supply chain complexities on supply chain resilience: the mediating effect of big data analytics', *Production Planning and Control*, vol. 0, no. 0, pp. 1–21.

International Air Transport Association (IATA) 2020, *IATA - Air transport supports 65.5 million jobs and \$2.7 trillion in economic activity*, IATA Press Release No: 56, p. <https://www.iata.org/en/pressroom/pr/2018-10-02-01>, viewed 4 May 2020,

International Air Transport Association (IATA) 2023, 'Industry statistics', *International Air Transport Association Global Outlook for Air Travel*, pp. 1–2.

International Civil Aviation Organization 2013, *No Title, World Aviation and the World Economy*.

Islami, X, Mustafa, N, & Topuzovska Latkovikj, M 2020, 'Linking Porter's generic strategies to firm performance', *Future Business Journal*, vol. 6, no. 1, pp. 1–15.

Ismail, HS, Poolton, J, & Sharifi, H 2011, 'The role of agile strategic capabilities in achieving resilience in manufacturing-based small companies', *International Journal of Production Research*, vol. 49, no. 18, pp. 5469–5487.

Israelsson, JL 2016, 'What are the minimum requirements of numbers used in a good case study?', *School of Business, Engineering and Science, Halmstad University*.

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*, vol. 136, no. March, p. 101922.

Ivanov, D 2021a, 'Supply Chain Viability and the COVID-19 pandemic: a conceptual and formal generalisation of four major adaptation strategies', *International Journal of Production Research*, vol. 59, no. 12, pp. 3535–3552.

Ivanov, D 2021b, 'Digital Supply Chain Management and Technology to Enhance Resilience by Building and Using End-to-End Visibility During the COVID-19 Pandemic', *IEEE Transactions on Engineering Management*, vol. PP, pp. 1–11.

Ivanov, D 2022, 'Viable supply chain model: integrating agility, resilience and

sustainability perspectives—lessons from and thinking beyond the COVID-19 pandemic’, *Annals of Operations Research*, vol. 319, no. 1, pp. 1411–1431.

Jain, V et al. 2017, ‘Supply chain resilience: model development and empirical analysis’, *International Journal of Production Research*, vol. 55, no. 22, pp. 6779–6800.

Jamehshooran, BG, Shaharoun, AM, & Haron, HN 2015, ‘Assessing supply chain performance through applying the SCOR model’, *International Journal of Supply Chain Management*, vol. 4, no. 1, pp. 1–11.

Jang, J, Jo, WM, & Kim, JS 2020, ‘Can employee workplace mindfulness counteract the indirect effects of customer incivility on proactive service performance through work engagement? A moderated mediation model’, *Journal of Hospitality Marketing and Management*, vol. 29, no. 7, pp. 812–829.

Japan Aircraft Development Company 2019, ‘Worldwide Market Forecast 2019-2034’, *Japan Aircraft Development Company*, , no. March, p. 20.

Jasiūnas, J, Lund, PD, & Mikkola, J 2021, ‘Energy system resilience – A review’, *Renewable and Sustainable Energy Reviews*, vol. 150, no. June.

Jennings, PA et al. 2013, ‘Improving classroom learning environments by cultivating awareness and resilience in education (CARE): Results of a randomized controlled trial’, *School Psychology Quarterly*, vol. 28, no. 4, pp. 374–390.

Jessin, TA, Rajeev, A, & Rajesh, R 2023, ‘Supplier selection framework to evade pseudo-resilience and to achieve sustainability in supply chains’, *International Journal of Emerging Markets*, vol. 18, no. 6, pp. 1425–1452.

Jia, F et al. 2018, ‘Sustainable supply chain management in developing countries: An analysis of the literature’, *Journal of Cleaner Production*, vol. 189, pp. 263–278.

Jia, F & Lamming, R 2013a, ‘Cultural adaptation in Chinese-Western supply chain partnerships: Dyadic learning in an international context’, *International Journal of Operations and Production Management*, vol. 33, no. 5, pp. 528–561, viewed 16 April 2020.

Jia, F & Lamming, R 2013b, ‘Cultural adaptation in Chinese-Western supply chain partnerships: Dyadic learning in an international context’, *International Journal of Operations and Production Management*, vol. 33, no. 5, pp. 528–561.

Jia, X et al. 2020, ‘The role of social capital on proactive and reactive resilience of organizations post-disaster’, *International Journal of Disaster Risk Reduction*, vol.

48, no. April, p. 101614.

Jiang, F & Kim, KA 2020, 'Corporate governance in China: A survey', *Review of Finance*, vol. 24, no. 4, pp. 733–772.

Jin, F & Chen, Z 2019, 'Evolution of transportation in China since reform and opening up: Patterns and principles', *Journal of Geographical Sciences*, vol. 29, no. 10, pp. 1731–1757.

Jinjin, Y, Haiyang, Y, & Zubair, A 2014, 'Forecasting methods and ICAOs Vision of 2011-2033 Global Air Traffic', *Journal of Air Transport Studies*, vol. 5, no. 1, pp. 1–23.

John-Eke, EC & Eke, JK 2020, 'Strategic Planning and Crisis Management Styles in Organizations: a Review of Related Literature', *Journal of Strategic Management*, vol. 5, no. 1, pp. 36–46.

Johnson, RB et al. 2013, 'JohnsonMixedmethods2004', *American Educational Research Association*, vol. 33, no. 7, pp. 14–26.

Jones, D 2023, 'Policy Paper the roles and responsibilities of personnel involved in aircraft line and base maintenance', no. December 2015, p. 12.

Jones, R 2008, 'The production of knowledge', in C Elman, J Gerring, & J Mohoney (eds.), *Nature Nanotechnology*, Cambridge, pp.448–449.

Junko, K et al. 2020, 'The perseverance of resilient leadership', *Deloitte*, p. 16.

Jüttner, U & Maklan, S 2011, 'Supply chain resilience in the global financial crisis: An empirical study', *Supply Chain Management*, vol. 16, no. 4, pp. 246–259.

Kamalahmadi, M & Parast, MM 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*, vol. 171, pp. 116–133.

Kamalahmadi, M, Shekarian, M, & Mellat Parast, M 2022, 'The impact of flexibility and redundancy on improving supply chain resilience to disruptions', *International Journal of Production Research*, vol. 60, no. 6, pp. 1992–2020.

Kamble, SS & Gunasekaran, A 2020a, 'Big data-driven supply chain performance measurement system: a review and framework for implementation', *International Journal of Production Research*, vol. 58, no. 1, pp. 65–86 .

Kamble, SS & Gunasekaran, A 2020b, 'Big data-driven supply chain performance measurement system: a review and framework for implementation', *International Journal of Production Research*, vol. 58, no. 1, pp. 65–86.

Kapoor, M & Aggarwal, V 2020, 'Tracing the economics behind dynamic capabilities

theory', *International Journal of Innovation Science*, vol. 12, no. 2, pp. 187–201.

Karimi, F, Monfared, JH, & Keramati, M 2022, 'The effect of strategic supply chain management on the performance and orientation of the supply chain by analyzing the mediating role of resilience (A case study of the offshore sector of the oil industry)', *Journal of value creation in business management*, vol. 2, no. 3, pp. 61–81.

Kaufman, BE 2015, 'The RBV theory foundation of strategic HRM: Critical flaws, problems for research and practice, and an alternative economics paradigm', *Human Resource Management Journal*, vol. 25, no. 4, pp. 516–540.

Kaur, H & Singh, SP 2022, 'Disaster resilient proactive and reactive procurement models for humanitarian supply chain', *Production Planning and Control*, vol. 33, no. 6–7, pp. 576–589.

Kazancoglu, I et al. 2022, 'Role of flexibility, agility and responsiveness for sustainable supply chain resilience during COVID-19', *Journal of Cleaner Production*, vol. 362, no. May, p. 132431.

Kegenbekov, Z & Jackson, I 2021, 'Adaptive supply chain: Demand-supply synchronization using deep reinforcement learning', *Algorithms*, vol. 14, no. 8, pp. 1–14.

Ketchen, DJ, Tomas, G, & Hult, M 2011, 'Building theory about supply chain management: Some tools from the organizational sciences', *Journal of Supply Chain Management*, vol. 47, no. 2, pp. 12–18.

Khan, O, Daddi, T, & Iraldo, F 2021, 'Sensing, seizing, and reconfiguring: Key capabilities and organizational routines for circular economy implementation', *Journal of Cleaner Production*, vol. 287, p. 125565.

Kiyabo, K & Isaga, N 2020, 'Entrepreneurial orientation, competitive advantage, and SMEs' performance: application of firm growth and personal wealth measures', *Journal of Innovation and Entrepreneurship*, vol. 9, no. 1.

Klein, R et al. 2020, 'A review of revenue management: Recent generalizations and advances in industry applications', *European Journal of Operational Research*, vol. 284, no. 2, pp. 397–412.

Klosterhalfen, ST, Willems, SP, & Dittmar, D 2023, 'Safety stock placement in supply chains with expediting', *European Journal of Operational Research*, vol. 307, no. 2, pp. 745–757.

- Kobayashi, M 2014, 'Relational View', *Annals of Business Administrative Science*, vol. 13, no. 2, pp. 77–90.
- Kochan, CG & Nowicki, DR 2018, 'Supply chain resilience: a systematic literature review and typological framework', *International Journal of Physical Distribution and Logistics Management*, vol. 48, no. 8, pp. 842–865.
- Kong, Q et al. 2021, 'Trade openness and economic growth quality of China: Empirical analysis using ARDL model', *Finance Research Letters*, vol. 38, no. February 2020, p. 101488.
- Kouvelis, P & Milner, JM 2002, 'Supply chain capacity and outsourcing decisions: The dynamic interplay of demand and supply uncertainty', *IIE Transactions (Institute of Industrial Engineers)*, vol. 34, no. 8, pp. 717–728.
- Kovács, G & Falagara Sigala, I 2021, 'Lessons learned from humanitarian logistics to manage supply chain disruptions', *Journal of Supply Chain Management*, vol. 57, no. 1, pp. 41–49.
- Kowalska, A, Budzyńska, A, & Białowas, T 2022, 'Food export restrictions during the COVID-19 pandemic: Real and potential effects on food security', *International Journal of Management and Economics*, vol. 58, no. 4, pp. 409–424.
- Krause, DR, Scannell, T V., & Calantone, RJ 2000, 'A structural analysis of the effectiveness of buying firms' strategies to improve supplier performance', *Decision Sciences*, vol. 31, no. 1, pp. 33–55.
- Kumar, B & Sharma, A 2021, 'Managing the supply chain during disruptions: Developing a framework for decision-making', *Industrial Marketing Management*, vol. 97, no. July, pp. 159–172.
- Kumari, P & Aithal, PS 2020, 'An Overview of the Aviation Industry in India with Special Emphasis on Privatization', *International Journal of Case Studies in Business, IT, and Education*, vol. 4, no. 2, pp. 220–228.
- Kump, B et al. 2019, 'Toward a dynamic capabilities scale: Measuring organizational sensing, seizing, and transforming capacities', *Industrial and Corporate Change*, vol. 28, no. 5, pp. 1149–1172.
- Kurth, MH et al. 2019, 'Defining resilience for the US building industry', *Building Research and Information*, vol. 47, no. 4, pp. 480–492.
- de la Tour, A, Glachant, M, & Ménière, Y 2011, 'Innovation and international technology transfer: The case of the Chinese photovoltaic industry', *Energy Policy*,

vol. 39, no. 2, pp. 761–770, viewed 23 March 2020.

Laaksonen, O & Peltoniemi, M 2018, 'The Essence of Dynamic Capabilities and their Measurement', *International Journal of Management Reviews*, vol. 20, no. 2, pp. 184–205.

Lan, P 2018, 'A review of advantages and disadvantages of three paradigms : positivism , interpretivism and critical inquiry', *The University of ADELAIDE*, no. April, pp. 0–7.

Lanzolla, G & Markides, C 2021, 'A Business Model View of Strategy', *Journal of Management Studies*, vol. 58, no. 2, pp. 540–553.

Larson, PD & Gammelgaard, B 2001, 'JOURNAL OF BUSINESS LOGISTICS, Vol.22, No. 2, 2001 27', *Journal of Business Logistics*, vol. 22, no. 2, pp. 27–50.

Lau, VMY & Tovstiga, G 2015, 'Exploration of relational factors: Sino-foreign joint venture partnering', *Journal of Strategy and Management*, vol. 8, no. 2, pp. 191–202.

Lay, J, Bender, A, & Strohmayer, A 2022, 'Layout and testing of a serial hybrid electric powertrain for a light twin demonstrator platform', *IOP Conference Series: Materials Science and Engineering*, vol. 1226, no. 1, p. 012068.

Lee, KL et al. 2022, 'The effect of digital supply chain on organizational performance: An empirical study in Malaysia manufacturing industry', *Uncertain Supply Chain Management*, vol. 10, no. 2, pp. 495–510.

Lee, SH, Peña-Mora, F, & Park, M 2006, 'Dynamic planning and control methodology for strategic and operational construction project management', *Automation in Construction*, vol. 15, no. 1, pp. 84–97.

Lenaerts, B, Allroggen, F, & Malina, R 2021, 'The economic impact of aviation: A review of the role of market access', *Journal of Air Transport Management*, p. 13.

Lengnick-Hall, CA, Beck, TE, & Lengnick-Hall, ML 2011, 'Developing a capacity for organizational resilience through strategic human resource management', *Human Resource Management Review*, vol. 21, no. 3, pp. 243–255.

Lenjani, A et al. 2020, 'A resilience-based method for prioritizing post-event building inspections', *Natural Hazards*, vol. 100, no. 2, pp. 877–896.

Lewis, S 2015, 'Qualitative Inquiry and Research Design: Choosing Among Five Approaches', *Health Promotion Practice*, vol. 16, no. 4, pp. 473–475.

Li, J & Yu, D 2018, 'The path to innovation: The antecedent perspective of intellectual capital and organizational character', *Frontiers in Psychology*, vol. 9, no.

DEC, pp. 1–18.

Li, JH, Anderson, AR, & Harrison, RT 2003, 'Total quality management principles and practices in China', *International Journal of Quality and Reliability Management*, vol. 20, no. 9, pp. 1026–1050.

Li, L 2018, 'China's manufacturing locus in 2025: With a comparison of "Made-in-China 2025" and "Industry 4.0"', *Technological Forecasting and Social Change*, vol. 135, no. February 2017, pp. 66–74.

Li, M et al. 2021, 'Role of trade openness, export diversification, and renewable electricity output in realizing carbon neutrality dream of China', *Journal of Environmental Management*, vol. 297, no. May, p. 113419.

Li, T & Trani, AA 2014, 'A model to forecast airport-level General Aviation demand', *Journal of Air Transport Management*, vol. 40, pp. 192–206.

Liao, MY 2015, 'Safety Culture in commercial aviation: Differences in perspective between Chinese and Western pilots', *Safety Science*, vol. 79, pp. 193–205.

Lima-Junior, FR & Carpinetti, LCR 2016, 'Combining SCOR® model and fuzzy TOPSIS for supplier evaluation and management', *International Journal of Production Economics*, vol. 174, pp. 128–141.

Lin, J et al. 2023, 'How to build supply chain resilience: The role of fit mechanisms between digitally-driven business capability and supply chain governance', *Information and Management*, vol. 60, no. 2, p. 103747.

Lin, W & Ai, Q 2020, '"Aerial Silk Roads": Airport Infrastructures in China's Belt and Road Initiative', *Development and Change*, vol. 51, no. 4, pp. 1123–1145.

Lindgren, BM, Lundman, B, & Graneheim, UH 2020, 'Abstraction and interpretation during the qualitative content analysis process', *International Journal of Nursing Studies*, vol. 108.

Lindkvist, C, Stasis, A, & Whyte, J 2013, 'Configuration management in complex engineering projects', *Procedia CIRP*, vol. 11, pp. 173–176.

Linkov, I et al. 2018, 'Tiered approach to resilience assessment', *Risk Analysis*, vol. 38, no. 9, pp. 1772–1780.

Linkov, I et al. 2020, 'The case for value chain resilience', *Management Research Review*, vol. 43, no. 12, pp. 1461–1476.

Liu, T et al. 2017, 'Sharing the Big Risk: Assessment Framework for Revenue Risk Sharing Mechanisms in Transportation Public-Private Partnerships', *Journal of*

- Construction Engineering and Management*, vol. 143, no. 12, pp. 1–12.
- Liu, Y et al. 2021, 'Analysis of the influencing factors of organizational resilience in the ISM framework: An exploratory study based on multiple cases', *Sustainability (Switzerland)*, vol. 13, no. 23.
- Lockamy, A 2017, 'An examination of external risk factors in Apple Inc.'s supply chain', *Supply Chain Forum*, vol. 18, no. 3, pp. 177–188.
- Lockström, M et al. 2010, 'Antecedents to supplier integration in the automotive industry: A multiple-case study of foreign subsidiaries in China', *Journal of Operations Management*, vol. 28, no. 3, pp. 240–256.
- Lorentz, H et al. 2013, 'Priorities and determinants for supply chain management skills development in manufacturing firms', *Supply Chain Management: An International Journal*, vol. 18, no. 4, pp. 358–375.
- Lotfi, M & Larmour, A 2022, 'Supply chain resilience in the face of uncertainty: how horizontal and vertical collaboration can help?', *Continuity & Resilience Review*, vol. 4, no. 1, pp. 37–53.
- Lu, Q, Wang, X, & Wang, Y 2023, 'Enhancing supply chain resilience with supply chain governance and finance: the enabling role of digital technology adoption', *Business Process Management Journal*, vol. 29, no. 4, pp. 944–964.
- Lucas, SR 2014, 'Beyond the existence proof: Ontological conditions, epistemological implications, and in-depth interview research', *Quality and Quantity*, vol. 48, no. 1, pp. 387–408.
- Luna, J et al. 2018, 'Assessment of an emerging aerospace manufacturing cluster and its dependence on the mature global clusters', *Procedia Manufacturing*, vol. 19, pp. 26–33.
- Lundberg, J & Johansson, BJ 2015, 'Systemic resilience model', *Reliability Engineering and System Safety*, vol. 141, pp. 22–32.
- Luo, L et al. 2021, 'An integrated strategic and tactical optimization model for forest supply chain planning', *Forest Policy and Economics*, vol. 131, no. March, p. 102571.
- MacDonald, C 2012, 'Understanding PAR: A Qualitative Research Methodology', *Canadian Journal of Action Research*, vol. 13, no. 2, pp. 34–50.
- Machado, MC et al. 2020, 'Performance measurement for supply chain management and quality management integration: A systematic literature review', *Benchmarking*,

vol. 27, no. 7, pp. 2130–2147.

MacPherson, A & Pritchard, D 2007, 'Boeing's diffusion of commercial aircraft technology to Japan: Surrendering the U.S. industry for foreign financial support', *Journal of Labor Research*, vol. 28, no. 3, pp. 552–566.

Madni, AM & Jackson, S 2011, 'Towards a conceptual framework for resilience engineering', *IEEE Engineering Management Review*, vol. 39, no. 4, pp. 85–102.

Magnusson, D & Pettersson, K 2019, 'Improvement of a Qualification Process in the Aerospace Industry'.

Mahajan, RP 2010, 'Critical incident reporting and learning', *British Journal of Anaesthesia*, vol. 105, no. 1, pp. 69–75.

Makarius, EE & Srinivasan, M 2017, 'Addressing skills mismatch: Utilizing talent supply chain management to enhance collaboration between companies and talent suppliers', *Business Horizons*, vol. 60, no. 4, pp. 495–505.

Mallak, L 1998, 'Putting organizational resilience to work', *Industrial Management (Norcross, Georgia)*, vol. 40, no. 6 NOV./DEC., pp. 8–13.

Man, M 2009, 'The Relationship between Distinctive Capabilities, Strategy Types, Environment and the Export Performance of Small and Medium-Sized Enterprises of the Malaysian', *Management (18544223)*, vol. 4, no. 1, pp. 205–223.

Mandal, S et al. 2016, 'Achieving supply chain resilience: The contribution of logistics and supply chain capabilities', *International Journal of Disaster Resilience in the Built Environment*, vol. 7, no. 5, pp. 544–562.

Mangan, J & Christopher, M 2005, 'Management development and the supply chain manager of the future', *The International Journal of Logistics Management*, vol. 16, no. 2, pp. 178–191.

Mann, S 2011, 'A critical review of qualitative interviews in applied linguistics', *Applied Linguistics*, vol. 32, no. 1, pp. 6–24.

Mantik, J, Sulaeman, MM, & Harsono, M 2021, 'Supply Chain Ontology: Model Overview and Synthesis', *Jurnal Mantik*, vol. 5, no. 2, pp. 790–799.

Manyena, B, Machingura, F, & O'Keefe, P 2019, 'Disaster Resilience Integrated Framework for Transformation (DRIFT): A new approach to theorising and operationalising resilience', *World Development*, vol. 123, p. 104587.

Mark, CK 2017, 'To "educate" Deng Xiaoping in capitalism: Thatcher's visit to China and the future of Hong Kong in 1982', *Cold War History*, vol. 17, no. 2, pp. 161–180.

- Marra, M, Ho, W, & Edwards, JS 2012, 'Supply chain knowledge management: A literature review', *Expert Systems with Applications*, vol. 39, no. 5, pp. 6103–6110.
- Martin, J & Hofmann, E 2019, 'Towards a framework for supply chain finance for the supply side', *Journal of Purchasing and Supply Management*, vol. 25, no. 2, pp. 157–171.
- Mason, M 2010, 'Sample size and saturation in PhD studies using qualitative interviews', *Forum Qualitative Sozialforschung*, vol. 11, no. 3.
- Masteika, I & Čepinskis, J 2015, 'Dynamic Capabilities in Supply Chain Management', *Procedia - Social and Behavioral Sciences*, vol. 213, pp. 830–835.
- Matysiak, L, Rugman, AM, & Bausch, A 2018, 'Dynamic Capabilities of Multinational Enterprises: The Dominant Logics Behind Sensing, Seizing, and Transforming Matter!', *Management International Review*, vol. 58, no. 2, pp. 225–250.
- Maulini, Y et al. 2022, 'Knowledge integration and entrepreneurial capabilities for sustainable competitive advantage through supply chain management', *Uncertain Supply Chain Management*, vol. 10, no. 2, pp. 333–344.
- May, B 2020, 'World Economic Prospects Monthly Overview : Bumping along the bottom Economist World Economic Prospects Monthly | Overview Major forecast changes this month', no. May 2006.
- McAvoy, J & Butler, T 2018, 'A critical realist method for applied business research', *Journal of Critical Realism*, vol. 17, no. 2, pp. 160–175.
- McDonnell, R 2020, 'Customs Capacity Study within Service Providers', no. March.
- Mckinnon, A 2014, 'BUILDING SUPPLY CHAIN RESILIENCE: A Review of Challenges and Strategies', *International Transport Forum Discussion Papers*, , no. 2014–06, pp. 1–23.
- Medina-Serrano, R et al. 2020, 'Strategic sourcing: Developing a progressive framework for make-or-buy decisions', *Journal of Industrial Engineering and Management*, vol. 13, no. 1, pp. 133–154.
- Meijer, MS 2022, 'Optimization and Coordination in High-tech Supply Chains', , vol. 1, no. 2022.
- Mensah, P & Merkuryev, Y 2014, 'Developing a Resilient Supply Chain', *Procedia - Social and Behavioral Sciences*, vol. 110, pp. 309–319.
- Meuwissen, MPM et al. 2019, 'A framework to assess the resilience of farming systems', *Agricultural Systems*, vol. 176, no. May, p. 102656.

- Meyer, M, Glas, AH, & Eßig, M 2021, 'Systematic review of sourcing and 3D printing: make-or-buy decisions in industrial buyer–supplier relationships', *Management Review Quarterly*, vol. 71, no. 4, pp. 723–752.
- Mezmir, EA 2020, 'Qualitative Data Analysis: An Overview of Data Reduction, Data Display and Interpretation', *Research on Humanities and Social Sciences*, vol. 10, no. 21, pp. 15–27.
- Mhalla, M 2020, 'The Impact of Novel Coronavirus (COVID-19) on the Global Oil and Aviation Markets', *Journal of Asian Scientific Research*, vol. 10, no. 2, pp. 96–104.
- Mhlanga, O 2017, 'Impacts of deregulation on the airline industry in South Africa: A review of the literature', *African Journal of Hospitality, Tourism and Leisure*, vol. 6, no. 3, pp. 1–14.
- Miles, RE & Snow, CC 2007, 'Organization theory and supply chain management: An evolving research perspective', *Journal of Operations Management*, vol. 25, no. 2, pp. 459–463.
- Min, H 2019, 'Blockchain technology for enhancing supply chain resilience', *Business Horizons*, vol. 62, no. 1, pp. 35–45.
- Min, S, Zacharia, ZG, & Smith, CD 2019, 'Defining Supply Chain Management: In the Past, Present, and Future', *Journal of Business Logistics*, vol. 40, no. 1, pp. 44–55.
- Mishra, D et al. 2016, 'Bridging and buffering: Strategies for mitigating supply risk and improving supply chain performance', *International Journal of Production Economics*, vol. 180, pp. 183–197, viewed 3 May 2020.
- Mishra, JL et al. 2022, 'Extending dynamic capabilities towards lean thinking in humanitarian supply chains', *Production Planning and Control*, vol. 33, no. 6–7, pp. 655–675.
- Mishra, RK 2020, 'The “Silk Road”: Historical Perspectives and Modern Constructions', *Indian Historical Review*, vol. 47, no. 1, pp. 21–39.
- Modarress Fathi, B, Ansari, AI, & Ansari, Alexander 2023, 'Green Commercial Aviation Supply Chain—A European Path to Environmental Sustainability', *Sustainability (Switzerland)*, vol. 15, no. 8.
- Mohammed, A 2020, 'Towards “gresilient” supply chain management: A quantitative study', *Resources, Conservation and Recycling*, vol. 155, no. January, p. 104641.
- Mohsin, A 2021, 'A Manual for Selecting Sampling Techniques in Research.', *Munich*

Personal RePEC Archive, , no. 2016, pp. 1–56.

Monostori, J. 2023, 'Robustness-oriented analysis, (re)design and management of supply chains'.

Monostori, J 2018, 'Supply chains robustness: Challenges and opportunities', *Procedia CIRP*, vol. 67, pp. 110–115.

Moons, K, Waeyenbergh, G, & Pintelon, L 2019, 'Measuring the logistics performance of internal hospital supply chains – A literature study', *Omega (United Kingdom)*, vol. 82, pp. 205–217.

Moosavi, J, Fathollahi-Fard, AM, & Dulebenets, MA 2022a, 'Supply chain disruption during the COVID-19 pandemic: Recognizing potential disruption management strategies', *International Journal of Disaster Risk Reduction*, vol. 75, no. February, p. 102983.

Moosavi, J, Fathollahi-Fard, AM, & Dulebenets, MA 2022b, 'Supply chain disruption during the COVID-19 pandemic: Recognizing potential disruption management strategies', *International Journal of Disaster Risk Reduction*, vol. 75, no. September 2021, p. 102983,.

Morash, EA & Lynch, DF 2002, 'Public policy and global supply chain capabilities and performance: A resource-based view', *Journal of International Marketing*, vol. 10, no. 1, pp. 25–51.

Morrish, SC & Jones, R 2020, 'Post-disaster business recovery: An entrepreneurial marketing perspective', *Journal of Business Research*, vol. 113, no. March 2019, pp. 83–92.

Mouatasim, A El & Hadid, IH Al 2020, *Edited by Evon Abu-Taieh, Abdelkrim El Mouatasim and Issam H. Al Hadid*, E Abu-Taieh (ed.), IntechOpen, London, UK.

Munir, M et al. 2020, 'Supply chain risk management and operational performance: The enabling role of supply chain integration', *International Journal of Production Economics*, vol. 227, no. March 2019, p. 107667.

Munir, M, Jajja, MSS, & Chatha, KA 2022, 'Capabilities for enhancing supply chain resilience and responsiveness in the COVID-19 pandemic: exploring the role of improvisation, anticipation, and data analytics capabilities', *International Journal of Operations and Production Management*, vol. 42, no. 10, pp. 1576–1604.

Muñoz-Pascual, L & Galende, J 2020, 'Ambidextrous relationships and social capability as employee well-being: The secret sauce for research and development

and sustainable innovation performance', *International Journal of Environmental Research and Public Health*, vol. 17, no. 9, pp. 1–23.

Musa Ardo, F et al. 2022, 'A review in redressing challenges to produce sustainable hydrogen from microalgae for aviation industry', *Fuel*, vol. 330, no. June, p. 125646.

Nagy, J & Foltin, P 2022, 'Increase supply chain resilience by applying early warning signals within big-data analysis', *Ekonomski vjesnik*, vol. 35, no. 2, pp. 467–481.

Namcheol Moon 2015, 'Plant Locations and Production Networks of the European Civil Aviation Industry: Focus on the Airbus', *Journal of the Economic Geographical Society of Korea*, vol. 18, no. 3, pp. 267–280.

Namdar, J et al. 2021, 'Business continuity-inspired resilient supply chain network design', *International Journal of Production Research*, vol. 59, no. 5, pp. 1331–1367.

Näslund, D & Hulthen, H 2012, 'Supply chain management integration: A critical analysis', *Benchmarking*, vol. 19, no. 4, pp. 481–501.

Nazam, M et al. 2020, 'Modeling the key barriers of knowledge management adoption in sustainable supply chain', *Journal of Enterprise Information Management*, vol. 33, no. 5, pp. 1077–1109.

Negri, M et al. 2021, 'Integrating sustainability and resilience in the supply chain: A systematic literature review and a research agenda', *Business Strategy and the Environment*, vol. 30, no. 7, pp. 2858–2886.

Nematollahi, M, Tajbakhsh, A, & Mosadegh Sedghy, B 2021, 'The reflection of competition and coordination on organic agribusiness supply chains', *Transportation Research Part E: Logistics and Transportation Review*, vol. 154, no. June 2020, p. 102462.

Nemeth, CP & Herrera, I 2015, 'Building change: Resilience Engineering after ten years', *Reliability Engineering and System Safety*, vol. 141, pp. 1–4.

Nguyen, HL & Akerkar, R 2020, 'Modelling, measuring, and visualising community resilience: A systematic review', *Sustainability (Switzerland)*, vol. 12, no. 19, pp. 1–26.

Nicolaescu, SS et al. 2020, 'Human capital evaluation in knowledge-based organizations based on big data analytics', *Future Generation Computer Systems*, vol. 111, pp. 654–667.

Nikookar, E & Yanadori, Y 2022, 'Preparing supply chain for the next disruption beyond COVID-19: managerial antecedents of supply chain resilience', *International*

- Journal of Operations and Production Management*, vol. 42, no. 1, pp. 59–90.
- Norris, G & Wagner, M 2005, *Airbus A380 Superjumbo for the 21st century*.
- O.Nyumba, T et al. 2018, 'The use of focus group discussion methodology: Insights from two decades of application in conservation', *Methods in Ecology and Evolution*, vol. 9, no. 1, pp. 20–32.
- Oliffe, JL et al. 2021, 'Zoom Interviews: Benefits and Concessions', *International Journal of Qualitative Methods*, vol. 20, pp. 1–8.
- Oliva, FL et al. 2019, 'The integration between knowledge management and dynamic capabilities in agile organizations', *Management Decision*, vol. 57, no. 8, pp. 1960–1979.
- Olivares-Aguila, J & Vital-Soto, A 2021, 'Supply Chain Resilience Roadmaps for Major Disruptions', *Logistics*, vol. 5, no. 4.
- Oman, PA of CA of 2019, 'Public Authority for Civil Aviation AIRWORTHINESS PROCEDURES MANUAL', no. November.
- Orr, S & Jadhav, A 2018, 'Creating a sustainable supply chain: the strategic foundation', *Journal of Business Strategy*, vol. 39, no. 6, pp. 29–35.
- Oschman, JJ 2019, 'A conceptual framework implementing an AS9100 quality management system for the aerospace industry', *South African Journal of Industrial Engineering*, vol. 30, no. 2, pp. 1–16.
- Oyewobi, LO et al. 2016, 'Relationship between competitive strategy and construction organisation performance: The moderating role of organisational characteristics', *Management Decision*, vol. 54, no. 9, pp. 2340–2366.
- Pacho, T 2015, 'Exploring Participants' Experiences Using Case Study', *International Journal of Humanities and Social Science*, vol. 5, no. 4, pp. 44–53.
- Pagh, JD & Cooper, MC 1998, 'Supply Chain Postponment and Speculation Strategies How to Choose the right strategy by Janus D.Pagh And Martha C Cooper', *Journal of Business Logistics*, vol. 19, no. 2, pp. 13–32.
- Papanagnou, CI 2022, 'Measuring and eliminating the bullwhip in closed loop supply chains using control theory and Internet of Things', *Annals of Operations Research*, vol. 310, no. 1, pp. 153–170.
- Park, Jongkyung et al. 2010, 'An integrative framework for supplier relationship management', *Industrial Management and Data Systems*, vol. 110, no. 4, pp. 495–515.

- Park, SY 2021, 'Reliability Analysis of Boeing ' s Dreamlifter Large Cargo Freighter', no. 2015.
- Park, WY 2018, 'Managing hazards of the make-buy decision in the face of radical technological change', *Industrial Management and Data Systems*, vol. 118, no. 7, pp. 1345–1364.
- Patrucco, A et al. 2022, 'Managing triadic supplier relationships in collaborative innovation projects: a relational view perspective', *Supply Chain Management*, vol. 27, no. 7, pp. 108–127.
- Paulraj, A 2011, 'Understanding the relationships between internal resources and capabilities, sustainable supply management and organizational sustainability', *Journal of Supply Chain Management*, vol. 47, no. 1, pp. 19–37.
- Pečený, L et al. 2020, 'Optimisation in Transport and Logistic Processes', *Transportation Research Procedia*, vol. 44, no. 2019, pp. 15–22.
- Peng, DX, Schroeder, RG, & Shah, R 2008, 'Linking routines to operations capabilities: A new perspective', *Journal of Operations Management*, vol. 26, no. 6, pp. 730–748.
- Perkmann, M et al. 2013, 'Academic engagement and commercialisation: A review of the literature on university-industry relations', *Research Policy*, vol. 42, no. 2, pp. 423–442.
- Perry, C 1998a, 'A Structured Approach for Presenting Theses', *Australasian Marketing Journal*, vol. 6, no. 1, pp. 63–85.
- Perry, C 1998b, 'Processes of a case study methodology for postgraduate research in marketing', *European Journal of Marketing*, vol. 32, no. 9–10, pp. 785–802.
- Perry, C 1998c, 'Processes of a case study methodology for postgraduate research in marketing', *European Journal of Marketing*, vol. 32, no. 9–10, pp. 785–802.
- Peter, S & Park, LS-C 2018, 'Changing research methodology: Two case studies of Critical Realism informing social work doctoral research', *Aotearoa New Zealand Social Work*, vol. 30, no. 1, pp. 65–70.
- Peters, MA 2021, 'The ancient Silk Road and the birth of merchant capitalism', *Educational Philosophy and Theory*, vol. 53, no. 10, pp. 955–961.
- Peterson Institute 2008, 'China's Response to the Global Crisis', *Peterson Institute*, , no. February 2009.
- Petrescu, RVV et al. 2017, 'Home at Airbus', *Journal of Aircraft and Spacecraft*

Technology, vol. 1, no. 2, pp. 97–118.

Petroni, G et al. 2013, 'Strategies and determinants for successful space technology transfer', *Space Policy*, vol. 29, no. 4, pp. 251–257.

Pettit, TJ, Croxton, KL, & Fiksel, J 2019, 'The Evolution of Resilience in Supply Chain Management: A Retrospective on Ensuring Supply Chain Resilience', *Journal of Business Logistics*, vol. 40, no. 1, pp. 56–65.

Pettit, TJ, Fiksel, J, & Croxton, KL 2010, 'Ensuring Supply Chain Resilience: Development of a Conceptual Framework', *Journal of Business Logistics*, vol. 31, no. 1, pp. 1–21.

Pfadenhauer, M 2009, 'At Eye Level: The Expert Interview — a Talk between Expert and Quasi-expert', *Interviewing Experts*, pp. 81–97.

Phan, AC et al. 2019, 'Impact of supply chain quality management practices on operational performance: empirical evidence from manufacturing companies in Vietnam', *Supply Chain Management*, vol. 24, no. 6, pp. 855–871.

Philipsen, S & Littrell, RF 2011, *Manufacturing quality and cultural values in China*, viewed 24 April 2020.

Piercy, NF 2009, 'Strategic relationships between boundary-spanning functions: Aligning customer relationship management with supplier relationship management', *Industrial Marketing Management*, vol. 38, no. 8, pp. 857–864.

Piller, I, Zhang, J, & Li, J 2020, 'Linguistic diversity in a time of crisis: Language challenges of the COVID-19 pandemic', *Multilingua*, vol. 39, no. 5, pp. 503–515.

Pimentel, CL 2018, 'Problems and issues related to teaching japanese to students with disabilities: Lessons learned', *Journal of Language Teaching and Research*, vol. 9, no. 1, pp. 1–6.

Pitelis, CN 2022, 'Dynamic capabilities, the new multinational enterprise and business model innovation: A de/re-constructive commentary', *Journal of International Business Studies*, vol. 53, no. 4, pp. 741–753.

Polyviou, M, Croxton, KL, & Knemeyer, AM 2020, 'Resilience of medium-sized firms to supply chain disruptions: the role of internal social capital', *International Journal of Operations and Production Management*, vol. 40, no. 1, pp. 68–91.

Ponomarov, SY & Holcomb, MC 2009a, 'Understanding the concept of supply chain resilience', *The International Journal of Logistics Management*, vol. 20, no. 1, pp. 124–143, viewed 3 May 2020.

- Ponomarov, SY & Holcomb, MC 2009b, 'Understanding the concept of supply chain resilience', *The International Journal of Logistics Management*, vol. 20, no. 1, pp. 124–143.
- Popenoe, R et al. 2021, 'A practical guide to data analysis in general literature reviews', *Nordic Journal of Nursing Research*, vol. 41, no. 4, pp. 175–186.
- Popper, K 1993, 'Evolutionary Epistemology, Rationality, and the Sociology of Knowledge', in, Open Court, Chicago, Illinois, USA.
- Pournader, M, Kach, A, & Talluri, S 2020, 'A Review of the Existing and Emerging Topics in the Supply Chain Risk Management Literature', *Decision Sciences*, vol. 51, no. 4, pp. 867–919.
- Prajogo, D, Oke, A, & Olhager, J 2016, 'Supply chain processes: Linking supply logistics integration, supply performance, lean processes and competitive performance', *International Journal of Operations and Production Management*, vol. 36, no. 2, pp. 220–238.
- Pretorius, OR et al. 2022, 'Developing resilient supply chains in the Southern African Development Community: Lessons from the impact of COVID-19', *Journal of Transport and Supply Chain Management*, vol. 16, pp. 1–12.
- Pritchard, D & Macpherson, A 2004, 'Industrial Subsidies and the Politics of World Trade: The Case of the Boeing 7e7', *The Industrial Geographer*, vol. 1, no. 2, pp. 57–73.
- Punzo, G et al. 2020, 'Engineering Resilient Complex Systems: The Necessary Shift Toward Complexity Science', *IEEE Systems Journal*, vol. 14, no. 3, pp. 3865–3874.
- Purvanova, RK 2014, 'Face-to-face versus virtual teams: What have we really learned?', *Psychologist-Manager Journal*, vol. 17, no. 1, pp. 2–29.
- Queiroz, MM et al. 2019, 'Industry 4.0 and digital supply chain capabilities: A framework for understanding digitalisation challenges and opportunities', *Benchmarking*, vol. 28, no. 5, pp. 1761–1782.
- Queiroz, MM et al. 2022, 'Supply chain resilience in the UK during the coronavirus pandemic: A resource orchestration perspective', *International Journal of Production Economics*, vol. 245, no. December 2021, p. 108405.
- Rahi, S & Reiter, B 2017, 'Research Design and Methods: A Systematic Review of Research Paradigms, Sampling Issues and Instruments Development', *International Journal of Economics & Management Sciences*, vol. 06, no. 02.

- Raj, R et al. 2015, 'Measuring the resilience of supply chain systems using a survival model', *IEEE Systems Journal*, vol. 9, no. 2, pp. 377–381.
- Rajesh, R 2022, *A novel advanced grey incidence analysis for investigating the level of resilience in supply chains*, Springer US,.
- Ramanatt, PR, Natarajan, K, & Shobha, KR 2020, 'Challenges in implementing a wireless avionics network', *Aircraft Engineering and Aerospace Technology*, vol. 92, no. 3, pp. 482–494.
- Ramos, E et al. 2020, 'Inventory management model based on lean supply chain to increase the service level in a distributor of automotive sector', *International Journal of Supply Chain Management*, vol. 9, no. 2, pp. 113–131.
- Ramzy, N et al. 2022, 'SENS: Semantic Synthetic Benchmarking Model for integrated supply chain simulation and analysis', no. Ecis 2022, pp. 1–15.
- Razali, MN et al. 2020, 'Big data analytics for predictive maintenance in maintenance management', *Property Management*, vol. 38, no. 4, pp. 513–529.
- Rebolledo, C & Nollet, J 2011, 'Learning from suppliers in the aerospace industry', *International Journal of Production Economics*, vol. 129, no. 2, pp. 328–337.
- Redondi, R, Malighetti, P, & Paleari, S 2011, 'New Routes and Airport Connectivity', *Networks and Spatial Economics*, vol. 11, no. 4, pp. 713–725.
- Reed, IA 2017, 'Cultural sociology as research program: Post-positivism, meaning, and causality', in CJ Alexander, RN Jacobs, & P Smith (eds.), *The Oxford Handbook of Cultural Sociology*, Oxford University Press, pp.27–45.
- Reichardt, U, Ulfarsson, GF, & Pétursdóttir, G 2018, 'Volcanic ash and aviation: Recommendations to improve preparedness for extreme events', *Transportation Research Part A: Policy and Practice*, vol. 113, no. January, pp. 101–113.
- Remko, van H 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 and Production Management*, vol. 40, no. 4, pp. 341–355.
- Ren, L et al. 2021, 'A review of CO2 emissions reduction technologies and low-carbon development in the iron and steel industry focusing on China', *Renewable and Sustainable Energy Reviews*, vol. 143, no. March, p. 110846.
- Ren, X et al. 2020, 'Challenges towards hydrogen economy in China', *International Journal of Hydrogen Energy*, vol. 45, no. 59, pp. 34326–34345.

- Rezapour, S, Farahani, RZ, & Pourakbar, M 2017, 'Resilient supply chain network design under competition: A case study', *European Journal of Operational Research*, vol. 259, no. 3, pp. 1017–1035.
- Riccardo, A, Daria, B, & Dmitry, I 2021, 'Increasing supply chain resilience through efficient redundancy allocation: A risk-averse mathematical model', *IFAC-PapersOnLine*, vol. 54, no. 1, pp. 1011–1016.
- Riley, JM et al. 2016, 'How internal integration, information sharing, and training affect supply chain risk management capabilities', *International Journal of Physical Distribution and Logistics Management*, vol. 46, no. 10, pp. 953–980.
- Roberts, JM 2014, 'Critical Realism, Dialectics, and Qualitative Research Methods', *Journal for the Theory of Social Behaviour*, vol. 44, no. 1, pp. 1–23.
- Robinson, CJ & Malhotra, MK 2005, 'Defining the concept of supply chain quality management and its relevance to academic and industrial practice', *International Journal of Production Economics*, vol. 96, no. 3, pp. 315–337.
- Rodríguez, ADR 2023, *Systematic reviews in education?*
- Roh, J, Hong, P, & Min, H 2014, 'Implementation of a responsive supply chain strategy in global complexity: The case of manufacturing firms', *International Journal of Production Economics*, vol. 147, no. PART B, pp. 198–210, viewed 16 April 2020.
- Rosenthal, M 2016, 'Qualitative research methods: Why, when, and how to conduct interviews and focus groups in pharmacy research', *Currents in Pharmacy Teaching and Learning*, vol. 8, no. 4, pp. 509–516.
- Rowland, DR 2013, 'Reviewing the Literature: A Short Guide for Research Students', *International Journal of Accounting Information System*, vol. 4, no. 2, pp. 1–13.
- Rowley, J 2012, 'Conducting research interviews', *Management Research Review*, vol. 35, no. 3–4, pp. 260–271.
- Rozhkov, M et al. 2022, 'Adapting supply chain operations in anticipation of and during the COVID-19 pandemic', *Omega (United Kingdom)*, vol. 110, p. 102635.
- Russo, D, Montecchi, T, & Ying, L 2012, 'Functional-based search for patent technology transfer', in, *Proceedings of the ASME Design Engineering Technical Conference*, pp.529–539, viewed 11 January 2020.
- Sá, MM de et al. 2020, 'Supply chain resilience: the whole is not the sum of the parts', *International Journal of Operations and Production Management*, vol. 40, no. 1, pp. 92–115.

- Sabahi, S & Parast, MM 2020a, 'Firm innovation and supply chain resilience: a dynamic capability perspective', *International Journal of Logistics Research and Applications*, vol. 23, no. 3, pp. 254–269.
- Sabahi, S & Parast, MM 2020b, 'Firm innovation and supply chain resilience: a dynamic capability perspective', *International Journal of Logistics Research and Applications*, vol. 23, no. 3, pp. 254–269.
- Sacchi, R et al. 2023, 'How to make climate-neutral aviation fly', *Nature Communications*, vol. 14, no. 1, pp. 1–17.
- Sadler, GR et al. 2010, 'Recruitment of hard-to-reach population subgroups via adaptations of the snowball sampling strategy', *Nursing and Health Sciences*, vol. 12, no. 3, pp. 369–374.
- Saidi, S, Shahbaz, M, & Akhtar, P 2018, 'The long-run relationships between transport energy consumption, transport infrastructure, and economic growth in MENA countries', *Transportation Research Part A: Policy and Practice*, vol. 111, no. March, pp. 78–95.
- Samuel, KE et al. 2011, 'Knowledge management in supply chain: An empirical study from France', *Journal of Strategic Information Systems*, vol. 20, no. 3, pp. 283–306.
- Sangwan, KS, Bhakar, V, & Digalwar, AK 2018, 'Sustainability assessment in manufacturing organizations: Development of assessment models', *Benchmarking*, vol. 25, no. 3, pp. 994–1027.
- Santra, S 2021, 'Contingent workforce management: a holistic overview', *Strategic HR Review*, vol. 20, no. 6, pp. 199–205.
- Saraçyakupoğlu, T 2020, 'The Manufacturing and Qualification Methodology of the Aviation-Grade Parts', , pp. 32–36.
- Saragih, J et al. 2020, 'Supply chain operational capability and supply chain operational performance: Does the supply chain management and supply chain integration matters?', *International Journal of Supply Chain Management*, vol. 9, no. 4, pp. 1222–1229.
- Sarkis, J 2021, 'Supply chain sustainability: learning from the COVID-19 pandemic', *International Journal of Operations and Production Management*, vol. 41, no. 1, pp. 63–73.
- Sawyer, E & Harrison, C 2020, 'Developing resilient supply chains: lessons from

- high-reliability organisations', *Supply Chain Management*, vol. 25, no. 1, pp. 77–100.
- Scherer, C 2019, 'Airbus Global Market Forecast 2019-2038', *Airbus market forecast 2019-2039*, pp. 33–44.
- Schiele, H 2010, 'Early supplier integration: The dual role of purchasing in new product development', *R and D Management*, vol. 40, no. 2, pp. 138–153.
- Schmelzle, U & Mukandwal, PS 2023, 'The impact of supply chain relationship configurations on supplier performance: investigating buyer–supplier relations in the aerospace industry', *International Journal of Logistics Management*, vol. 34, no. 5, pp. 1301–1321.
- Schmidt, S 2009, 'Shall We Really Do It Again? The Powerful Concept of Replication Is Neglected in the Social Sciences', *Review of General Psychology*, vol. 13, no. 2, pp. 90–100.
- Schmitt, AJ & Singh, M 2012, 'A quantitative analysis of disruption risk in a multi-echelon supply chain', *International Journal of Production Economics*, vol. 139, no. 1, pp. 22–32.
- Schmuck, R 2020, 'Global supply chain quality integration strategies and the case of the Boeing 787 Dreamliner development', *Procedia Manufacturing*, vol. 54, no. 2019, pp. 88–94.
- Schniederjans, DG, Curado, C, & Khalajhedayati, M 2020a, 'Supply chain digitisation trends: An integration of knowledge management', *International Journal of Production Economics*, vol. 220, no. November 2018, p. 107439.
- Schniederjans, DG, Curado, C, & Khalajhedayati, M 2020b, 'Supply chain digitisation trends: An integration of knowledge management', *International Journal of Production Economics*, vol. 220, no. June 2019, p. 107439.
- Schoch, K 2009, '6: Three Case Studies', pp. 119–137.
- Scholten, K, Sharkey Scott, P, & Fynes, B 2019, 'Building routines for non-routine events: supply chain resilience learning mechanisms and their antecedents', *Supply Chain Management*, vol. 24, no. 3, pp. 430–442.
- Schrag, F 1992, 'In Defense of Positivist Research Paradigms', *Educational Researcher*, vol. 21, no. 5, pp. 5–8.
- Seidl, R & Turner, MG 2022, 'Post-disturbance reorganization of forest ecosystems in a changing world', *Proceedings of the National Academy of Sciences of the United States of America*, vol. 119, no. 28, pp. 1–10.

- Sharma, M et al. 2022, 'Developing a framework for enhancing survivability of sustainable supply chains during and post-COVID-19 pandemic', *International Journal of Logistics Research and Applications*, vol. 25, no. 4–5, pp. 433–453.
- Shekarian, M & Mellat Parast, M 2021, 'An Integrative approach to supply chain disruption risk and resilience management: a literature review', *International Journal of Logistics Research and Applications*, vol. 24, no. 5, pp. 427–455.
- Shen, ZM & Sun, Y 2023, 'Strengthening supply chain resilience during COVID-19: A case study of JD.com', *Journal of Operations Management*, vol. 69, no. 3, pp. 359–383.
- Shi, X, Liu, W, & Lim, MK 2023, 'Supply chain resilience: new challenges and opportunities', *International Journal of Logistics Research and Applications*, pp. 1–28.
- Shishodia, A et al. 2023, 'Supply chain resilience: A review, conceptual framework and future research', *International Journal of Logistics Management*, vol. 34, no. 4, pp. 879–908.
- Shuaib, KM, He, Z, & Song, L 2021, 'Effect of organizational culture and quality management on innovation among Nigerian manufacturing companies: The mediating role of dynamic capabilities', *Quality Management Journal*, vol. 28, no. 4, pp. 223–247.
- Simatupang, TM & Sridharan, R 2002, 'the Collaborative Supply Chain Simatupang.Pdf', *International Journal of Logistics management*, vol. 13, no. 1, pp. 15–30.
- Singamneni, S et al. 2019, 'Additive Manufacturing for the Aircraft Industry: A Review', *Journal of Aeronautics & Aerospace Engineering*, vol. 08, no. 01.
- Singh, CS, Soni, G, & Badhotiya, GK 2019, 'Performance indicators for supply chain resilience: review and conceptual framework', *Journal of Industrial Engineering International*, vol. 15, no. s1, pp. 105–117.
- Singh, D & Verma, A 2018, 'Inventory Management in Supply Chain', *Materials Today: Proceedings*, vol. 5, no. 2, pp. 3867–3872.
- Singh, S et al. 2021, 'Impact of COVID-19 on logistics systems and disruptions in food supply chain', *International Journal of Production Research*, vol. 59, no. 7, pp. 1993–2008.
- Singh, SKM 2023, 'Application of Blockchain in Supply Chain Management',

International Journal For Multidisciplinary Research, vol. 5, no. 2.

Sinnaiah, T, Adam, S, & Mahadi, B 2023, 'A strategic management process: the role of decision-making style and organisational performance', *Journal of Work-Applied Management*, vol. 15, no. 1, pp. 37–50.

Skilton, PF 2014, 'Value Creation, Value Capture, and Supply Chain Structure: Understanding Resource-Based Advantage in a Project-Based Industry', *Journal of Supply Chain Management*, vol. 50, no. 3, pp. 74–93.

Sobieralski, JB 2020, 'COVID-19 and airline employment: Insights from historical uncertainty shocks to the industry', *Transportation Research Interdisciplinary Perspectives*, vol. 5, p. 100123.

Von Soest, C 2023, 'Why Do We Speak to Experts? Reviving the Strength of the Expert Interview Method', *Perspectives on Politics*, vol. 21, no. 1, pp. 277–287.

Sohal, A & Morrison, M 1995, 'TQM and the learning Organization', *Managing Service Quality: An International Journal*, vol. 5, no. 6, pp. 32–34.

Sokolov, B et al. 2016, 'Structural quantification of the ripple effect in the supply chain', *International Journal of Production Research*, vol. 54, no. 1, pp. 152–169.

Song, JF et al. 2016, 'Three novel Cu₆S₆ cluster-based coordination compounds: Synthesis, framework modulation and the sensing of small molecules and Fe³⁺ ions', *Dalton Transactions*, vol. 45, no. 29, pp. 11883–11891.

Song, M et al. 2022, 'How to enhance supply chain resilience: a logistics approach', *International Journal of Logistics Management*, vol. 33, no. 4, pp. 1408–1436.

Soshkin, M 2016, 'The US aerospace industry: A manufacturing powerhouse', *Business Economics*, vol. 51, no. 3, pp. 166–180.

Southwick, SM et al. 2014, 'Resilience definitions, theory, and challenges: Interdisciplinary perspectives', *European Journal of Psychotraumatology*, vol. 5.

Spicer, A 2020, 'Organizational Culture and COVID-19', *Journal of Management Studies*, vol. 57, no. 8, pp. 1737–1740.

Sprecher, B et al. 2015, 'Framework for resilience in material supply chains, with a case study from the 2010 rare earth crisis', *Environmental Science and Technology*, vol. 49, no. 11, pp. 6740–6750.

Sreedevi, R & Saranga, H 2017, 'Uncertainty and supply chain risk: The moderating role of supply chain flexibility in risk mitigation', *International Journal of Production Economics*, vol. 193, no. July, pp. 332–342.

- Ståhl, D, Hallén, K, & Bosch, J 2017, 'Achieving traceability in large scale continuous integration and delivery deployment, usage and validation of the eiffel framework', *Empirical Software Engineering*, vol. 22, no. 3, pp. 967–995.
- Stanton, MCB & Roelich, K 2021, 'Decision making under deep uncertainties: A review of the applicability of methods in practice', *Technological Forecasting and Social Change*, vol. 171, no. October 2020, p. 120939.
- Stevenson, M & Spring, M 2007, 'Flexibility from a supply chain perspective: Definition and review', *International Journal of Operations and Production Management*, vol. 27, no. 7, pp. 685–713.
- Stratton, R & Warburton, RDH 2003, 'The strategic integration of agile and lean supply', *International Journal of Production Economics*, vol. 85, no. 2, pp. 183–198.
- Su, D et al. 2015, 'Government-driven university-industry linkages in an emerging country: the case of China', *Journal of Science and Technology Policy Management*, vol. 6, no. 3, pp. 263–282, viewed 8 January 2020.
- Su, HC & Linderman, K 2016, 'An Empirical Investigation in Sustaining High-Quality Performance', *Decision Sciences*, vol. 47, no. 5, pp. 787–819.
- Sudusinghe, JI & Seuring, S 2022, 'Supply chain collaboration and sustainability performance in circular economy: A systematic literature review', *International Journal of Production Economics*, vol. 245, no. December 2021, p. 108402.
- Sun, X, Wandelt, S, & Zhang, A 2022, 'Aviation under COVID-19 Pandemic: Status Quo and How to Proceed Further?', *SSRN Electronic Journal*.
- Surbier, L, Alpan, G, & Blanco, E 2014, 'A comparative study on production ramp-up: State-of-the-art and new challenges', *Production Planning and Control*, vol. 25, no. 15, pp. 1264–1286.
- Suryawanshi, P & Dutta, P 2022, 'Optimization models for supply chains under risk, uncertainty, and resilience: A state-of-the-art review and future research directions', *Transportation Research Part E: Logistics and Transportation Review*, vol. 157, no. November 2021, p. 102553.
- Tamvakis, P & Xenidis, Y 2012, 'Resilience in Transportation Systems', *Procedia - Social and Behavioral Sciences*, vol. 48, pp. 3441–3450.
- Tan, Y & Davis, CL 2023, 'The Limits of Liberalization: WTO Entry and Chinese State-Owned Firms', *International Studies Quarterly*, vol. 67, no. 3.
- Tang, J et al. 2023, 'The impact of international air routes on tourism', *Annals of*

Tourism Research, vol. 101, p. 103583.

Tarigan, ZJH et al. 2021, 'The effect of competency management on organizational performance through supply chain integration and quality', *Uncertain Supply Chain Management*, vol. 9, no. 2, pp. 283–294.

Teece, DJ 2007, 'Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance', *Strategic Management Journal*, vol. 28, no. 13, pp. 1319–1350.

Teece, DJ 2014, 'The foundations of enterprise performance: Dynamic and ordinary capabilities in an (economic) theory of firms', *Academy of Management Perspectives*, vol. 28, no. 4, pp. 328–352.

Teece, DJ 2016, 'Dynamic capabilities and entrepreneurial management in large organizations: Toward a theory of the (entrepreneurial) firm', *European Economic Review*, vol. 86, pp. 202–216.

Teece, DJ & Augier, M 2008, 'Dynamic capabilities and multinational enterprise: Penrosean insights and omissions', *Technological Know-How, Organizational Capabilities, and Strategic Management: Business Strategy and Enterprise Development in Competitive Environments*, vol. 47, no. January 2006, pp. 69–86.

Teece, DJ, Pisano, G, & Shuen, A 2009, 'Dynamic capabilities and strategic management', *Knowledge and Strategy*, vol. 18, no. April 1991, pp. 77–116.

Teegavarapu, S, Summers, JD, & Mocko, GM 2008, 'Case study method for design research: A justification', *Proceedings of the ASME Design Engineering Technical Conference*, vol. 4, no. January, pp. 495–503.

Tellis, W 1997, 'Application of a Case Study Methodology', *The Qualitative Report*, vol. 3, pp. 1–19.

Terluin, IJ 2003, 'Differences in economic development in rural regions of advanced countries: An overview and critical analysis of theories', *Journal of Rural Studies*, vol. 19, no. 3, pp. 327–344.

Tomlinson, PR & Fai, FM 2016, 'The impact of deep vertical supply chain relationships upon focal-firm innovation performance', *R and D Management*, vol. 46, pp. 277–290.

Tonn, G et al. 2021, 'U.S. transportation infrastructure resilience: Influences of insurance, incentives, and public assistance', *Transport Policy*, vol. 100, no. April 2020, pp. 108–119.

- Tracey, M, Lim, JS, & Vonderembse, MA 2005, 'The impact of supply-chain management capabilities on business performance', *Supply Chain Management*, vol. 10, no. 3, pp. 179–191.
- Tracht, K, Niestegge, A, & Schuh, P 2013, 'Demand planning based on performance measurement systems in closed loop supply chains', *Procedia CIRP*, vol. 12, pp. 324–329.
- Treuner, F et al. 2014, 'Supply Chain Resilience: A Survey of Disruptions in Aviation and Aerospace Supply - Chains and Increasing Resilience', *Supply Chain Management III*, pp. 7–12.
- Trif, R-C 2023, 'The attack of the Russian Federation on Ukraine – Approach regarding the land logistics support of military actions', *Bulletin of 'Carol I' National Defence University*, vol. 12, no. 1, pp. 143–153.
- Trunk, A & Birkel, H 2022, 'No Resilience Without Partners: A Case Study on German Small and Medium-Sized Enterprises in the Context of COVID-19', *Schmalenbach Journal of Business Research*, vol. 74, no. 4, pp. 537–574.
- Tsai, Y Te & Lasminar, RG 2021, 'Proactive and reactive flexibility: How does flexibility mediate the link between supply chain information integration and performance?', *International Journal of Engineering Business Management*, vol. 13.
- Tukamuhabwa, BR et al. 2015a, 'Supply chain resilience: Definition, review and theoretical foundations for further study', *International Journal of Production Research*, vol. 53, no. 18, pp. 5592–5623.
- Tukamuhabwa, BR et al. 2015b, 'Supply chain resilience: Definition, review and theoretical foundations for further study', *International Journal of Production Research*, vol. 53, no. 18, pp. 5592–5623.
- Tukamuhabwa, BR et al. 2015c, 'Supply chain resilience: Definition, review and theoretical foundations for further study', *International Journal of Production Research*, vol. 53, no. 18, pp. 5592–5623.
- Tummala, R & Schoenherr, T 2011, 'Assessing and managing risks using the Supply Chain Risk Management Process (SCRMP)', *Supply Chain Management*, vol. 16, no. 6, pp. 474–483.
- Uddin, M 2021, 'Blockchain Medledger: Hyperledger fabric enabled drug traceability system for counterfeit drugs in pharmaceutical industry', *International Journal of Pharmaceutics*, vol. 597, no. November 2020, p. 120235.

- Um, J & Han, N 2021, 'Understanding the relationships between global supply chain risk and supply chain resilience: the role of mitigating strategies', *Supply Chain Management*, vol. 26, no. 2, pp. 240–255.
- Umar, M, Wilson, M, & Heyl, J 2020, 'The structure of knowledge management in inter-organisational exchanges for resilient supply chains', *Journal of Knowledge Management*, vol. 25, no. 4, pp. 826–846.
- Urciuoli, L et al. 2014, 'The resilience of energy supply chains: A multiple case study approach on oil and gas supply chains to Europe', *Supply Chain Management*, vol. 19, no. 1, pp. 46–63.
- Usanova, K & Géraudel, M 2023, 'Talent turnover and the contagion effect: the case of the aerospace industry', *Human Resource Development International*, vol. 00, no. 00, pp. 1–23.
- Di Vaio, A & Varriale, L 2020, 'Blockchain technology in supply chain management for sustainable performance: Evidence from the airport industry', *International Journal of Information Management*, vol. 52, no. March 2019, p. 102014.
- Vardon, DR et al. 2022, 'Realizing “net-zero-carbon” sustainable aviation fuel', *Joule*, vol. 6, no. 1, pp. 16–21.
- Vegter, D, van Hillegersberg, J, & Olthaar, M 2021, 'Performance measurement systems for circular supply chain management: Current state of development', *Sustainability (Switzerland)*, vol. 13, no. 21.
- Vinet, L & Zhedanov, A 2011, A 'missing' family of classical orthogonal polynomials, *Journal of Physics A: Mathematical and Theoretical*, vol. 44, no. 8, pp. 1689–1699, viewed 16 November 2020.
- Vissak, T 2010, *Recommendations for using the case study method in international business research*, viewed 23 April 2020.
- Vonderembse, MA & Tracey, M 1999, 'The impact of supplier selection criteria and supplier involvement on manufacturing performance', *Journal of Supply Chain Management*, vol. 35, no. 2, pp. 33–39.
- Wan, N et al. 2019, 'Risk assessment in intelligent manufacturing process: A case study of an optical cable automatic arranging robot', *IEEE Access*, vol. 7, pp. 105892–105901.
- Wang-Lu, H & Valerio Mendoza, OM 2023, 'Job prospects and labour mobility in China', *Journal of International Trade and Economic Development*, vol. 32, no. 7, pp.

991–1034.

Wang, J 2017, 'Did International Outsourcing Cause the Increase in China's Skill Premium?', *China and World Economy*, vol. 25, no. 1, pp. 109–126.

Wang, J, Yang, H, & Wang, H 2019, 'The evolution of China's international aviation markets from a policy perspective on air passenger flows', *Sustainability (Switzerland)*, vol. 11, no. 13.

War, UST, David, A, & College, R 2019, 'North America ' s Shifting Supply Chains : USMCA , ' , pp. 1–24.

Wasti, SN, Kozan, MK, & Kuman, A 2006, 'Buyer-supplier relationships in the Turkish automotive industry', *International Journal of Operations and Production Management*, vol. 26, no. 9, pp. 947–970.

Waxman, HC, Gray, JP, & Padron, YN 2003, 'Review of Research on Educational Resilience. Research Report', *Eric*, vol. 11, pp. 1–28.

Wendt, FT 2015, 'Masterarbeit Supply Chain Strategies in Aerospace Industry : Assessment of Approaches to Increase the Competitiveness and Profitability in a Global Environment Florian Tobias Wendt Supply Chain Strategies in Aerospace Industry : Assessment of Approaches t'.

Westby, C 2021, 'Resource Review', *Word of Mouth*, vol. 32, no. 5, pp. 10–12.

Widodo, AW et al. 2021, 'The impact of job stress on employee productivity during Covid-19 pandemic at the aviation industry', *IOP Conference Series: Earth and Environmental Science*, vol. 794, no. 1.

Wied, M, Oehmen, J, & Welo, T 2020, 'Conceptualizing resilience in engineering systems: An analysis of the literature', *Systems Engineering*, vol. 23, no. 1, pp. 3–13.

Wieland, A 2021, 'Dancing the Supply Chain: Toward Transformative Supply Chain Management', *Journal of Supply Chain Management*, vol. 57, no. 1, pp. 58–73.

Wieland, A & Durach, CF 2021, 'Two perspectives on supply chain resilience', *Journal of Business Logistics*, vol. 42, no. 3, pp. 315–322.

Wieland, A & Wallenburg, CM 2013, 'The influence of relational competencies on supply chain resilience: A relational view', *International Journal of Physical Distribution and Logistics Management*, vol. 43, no. 4, pp. 300–320.

Wilkinson, B et al. 2005, 'Human resource barriers to partnership sourcing in China', *International Journal of Human Resource Management*, vol. 16, no. 10, pp. 1886–1900.

- Wilson, AD, Onwuegbuzie, AJ, & Manning, LSP 2016, 'Using paired depth interviews to collect qualitative data', *Qualitative Report*, vol. 21, no. 9, pp. 1549–1573.
- Wollin-Giering, S & Hoffmann, M 2023, 'Automatic Transcription of English and German Qualitative Interviews', no. July.
- Woods, DD 2015, 'Four concepts for resilience and the implications for the future of resilience engineering', *Reliability Engineering and System Safety*, vol. 141, pp. 5–9.
- World Trade Organization 2020, '2020, World trade statistical review', *World trade organization*, p. 156.
- Wu, F et al. 2013, 'Supplier selection for outsourcing from the perspective of protecting crucial product knowledge', *International Journal of Production Research*, vol. 51, no. 5, pp. 1508–1519.
- Wübbecke, J et al. 2016, 'MADE IN CHINA 2025 The making of a high-tech superpower and consequences for industrial countries', *MERICS Papers on China*, , no. 2, p. 76.
- Xinqing, Z, Wenxia, Z, & Yandong, Z 2016, 'TRUST Equitable Research Partnerships: The Chinese Ethical Review System and its Compliance Mechanisms', , pp. 1–17.
- Xu, B & Albert, E 2016, 'China-Taiwan Relations', *Council on Foreign Relations*, pp. 1–6.
- Xu, L Da, Xu, EL, & Li, L 2018, 'Industry 4.0: State of the art and future trends', *International Journal of Production Research*, vol. 56, no. 8, pp. 2941–2962.
- Xu, W et al. 2021, 'Enhancing the resilience of the management of water resources in the agricultural supply chain', *Water (Switzerland)*, vol. 13, no. 12, pp. 1–22.
- Yang, G et al. 2020, 'Assessment of the effects of infrastructure investment under the belt and road initiative', *China Economic Review*, vol. 60, no. February, p. 101418.
- Yang, H, Zhang, Q, & Wang, Q 2018, 'Airline deregulation, market competition, and impact of high-speed rail on airlines in China', *Advances in Airline Economics*, vol. 7, pp. 79–101.
- Yang, M, Fu, M, & Zhang, Z 2021, 'The adoption of digital technologies in supply chains: Drivers, process and impact', *Technological Forecasting and Social Change*, vol. 169, no. January, p. 120795.
- Yang, Y & Jiang, Y 2023, 'Buyer-supplier CSR alignment and firm performance: A

- contingency theory perspective', *Journal of Business Research*, vol. 154, no. October 2022, p. 113340.
- Yarosan, EV et al. 2021, 'Advancing the understanding of pharmaceutical supply chain resilience using complex adaptive system (CAS) theory', *Supply Chain Management*, vol. 26, no. 3, pp. 323–340.
- Yin, RK 1981, 'The Case Study Crisis : Some Answers Author (s): Robert K . Yin Source : Administrative Science Quarterly , Vol . 26 , No . 1 (Mar . , 1981), pp . 58-65 Published by : Sage Publications , Inc . on behalf of the Johnson Graduate School of Management , C', *Journal of Marketing Research (JMR)*, vol. 26, no. 1, pp. 199–208.
- Yin, RK 2017, 'Case study research and applications : design and methods', in D Campbell (ed.), *Case study research and applications : design and methods*, SAGE Publications Inc., Los Angeles, California, p.219.
- Yin, W & Ran, W 2022, 'Supply Chain Diversification, Digital Transformation, and Supply Chain Resilience: Configuration Analysis Based on fsQCA', *Sustainability (Switzerland)*, vol. 14, no. 13.
- Yin, Y, Wang, Y, & Lu, Y 2019, 'Antecedents and outcomes of employee empowerment practices: A theoretical extension with empirical evidence', *Human Resource Management Journal*, vol. 29, no. 4, pp. 564–584.
- Yoo, SH, Rhim, H, & Park, MS 2019, 'Sustainable waste and cost reduction strategies in a strategic buyer-supplier relationship', *Journal of Cleaner Production*, vol. 237, p. 117785.
- Yrjölä, M et al. 2018, 'Inside-out and outside-in mental models: a top executive perspective', *European Business Review*, vol. 30, no. 5, pp. 529–553.
- Yuan, Y, Liu, Linlin, & Liu, Liu 2022, 'How does information integration enhance SMEs' credit quality: the mediating role of supply chain capabilities', *Industrial Management and Data Systems*, vol. 122, no. 2, pp. 544–561.
- Zakery, A & Saremi, MS 2021, 'Knowledge and intellectual capital in internationalizing SMEs, case study in technology-based health companies', *Journal of Intellectual Capital*, vol. 22, no. 2, pp. 219–242.
- Zavala-Alcívar, A, Verdecho, MJ, & Alfaro-Saiz, JJ 2020, 'A conceptual framework to manage resilience and increase sustainability in the supply chain', *Sustainability (Switzerland)*, vol. 12, no. 16.

Zeng, G, Liefner, I, & Si, Y 2011, 'The role of high-tech parks in China's regional economy: Empirical evidence from the IC industry in the Zhangjiang high-tech park, Shanghai', *Erdkunde*, vol. 65, no. 1, pp. 43–53, viewed 8 January 2020.

Zhang, G, Yang, Y, & Yang, G 2023, 'Smart supply chain management in Industry 4.0: the review, research agenda and strategies in North America', *Annals of Operations Research*, vol. 322, no. 2, pp. 1075–1117.

Zhang, L et al. 2011, 'A few measures for ensuring supply chain quality', *International Journal of Production Research*, vol. 49, no. 1, pp. 87–97.

Zhang, X et al. 2020, 'Strategies to trace back the origin of COVID-19', *Journal of Infection*, vol. 80, no. 6, pp. e39–e40.

Zhao, li et al. 2013, 'The impact of supply chain risk on supply chain integration and company performance: a global investigation', *Supply Chain Management: An International Journal*, vol. 18, no. 2, pp. 115–131.

Zhao, D et al. 2022, 'A High-Efficiency Technology for Manufacturing Aircraft Carbon Brake Discs with Stable Friction Performance', *Coatings*, vol. 12, no. 6.

Zhao, Y & Wan, J 2019, 'Analysis of development and evolution rules of civil aviation in China based on life cycle theory', *PLoS ONE*, vol. 14, no. 2, pp. 1–18.

Zhou, H et al. 2011, 'Supply chain integration and the SCOR model', *Journal of Business Logistics*, vol. 32, no. 4, pp. 332–344.

Zhu, H et al. 2017, 'Sustaining regional advantages in manufacturing: Skill accumulation of rural-urban migrant workers in the coastal area of China', *Sustainability (Switzerland)*, vol. 9, no. 1.

Zhu, Qingyun, Golrizgashti, S, & Sarkis, J 2021, 'Product deletion and supply chain repercussions: risk management using FMEA', *Benchmarking*, vol. 28, no. 2, pp. 409–437.

Zhu, Susan et al. 2021, 'Team Decision Making: The Dynamic Effects of Team Decision Style Composition and Performance via Decision Strategy', *Journal of Management*, vol. 47, no. 5, pp. 1281–1304.

Zhu, S, Yu, C, & He, C 2020, 'Export structures, income inequality and urban-rural divide in China', *Applied Geography*, vol. 115, no. September 2019, p. 102150.

Zhu, X & Wu, Y-J 2022, '¿Cómo afecta la resiliencia de la cadena de suministro al rendimiento de la cadena de suministro? El efecto mediador de la sostenibilidad', *Sustainability*, vol. 14, no. 21, pp. 1–19.

- Zighan, S & Ruel, S 2023, 'SMEs' resilience from continuous improvement lenses', *Journal of Entrepreneurship in Emerging Economies*, vol. 15, no. 2, pp. 233–253.
- Zimon, D & Madzik, P 2020, 'Standardized management systems and risk management in the supply chain', *International Journal of Quality and Reliability Management*, vol. 37, no. 2, pp. 305–327.
- Zimon, D, Madzik, P, & Sroufe, R 2019, 'Management systems and improving supply chain processes: Perspectives of focal companies and logistics service providers', *International Journal of Retail and Distribution Management*, vol. 48, no. 9, pp. 939–961.
- Zouari, D, Ruel, S, & Viale, L 2021, 'Does digitalising the supply chain contribute to its resilience?', *International Journal of Physical Distribution and Logistics Management*, vol. 51, no. 2, pp. 149–180.
- Zu, X & Kaynak, H 2012, 'An agency theory perspective on supply chain quality management', *International Journal of Operations and Production Management*, vol. 32, no. 4, pp. 423–446, viewed 23 April 2020.