THESIS FOR THE DEGREE OF DOCTOR OF ENGINEERING

Procurement adaptability in fast-changing environments

The case of automotive semiconductors and electronics

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CHALMERS UNIVERSITY OF TECHNOLOGY

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ABSTRACT

This thesis explores how buying firms can adapt their procurement activities to shifts in their business environments, both within their supply network and in the broader industrial and macroeconomic environments. This need for adaptation within procurement first became clear when buying firms struggled to respond to supply disruptions caused by the COVID-19 pandemic and has been reinforced by uncertainties caused by trade sanctions, wars, and rapid technology development that marked the first half of the 2020s. This is especially true for the automotive industry, and its supply network for semiconductors and electronics: the global shortage of semiconductors in the years 2020-2023 turned the automakers' procurement focus to increase resilience for semiconductor supply; at the same time, trends of automation, connectivity, and electrification maintain pressure on automakers' procurement to secure cost and innovation of electronics and semiconductors amid an uncertain business environment marked by geopolitical and technological developments.

To address this need for adaptation within procurement, this thesis applies the concept of adaptability from the social-ecological view of resilience, which focuses on learning, combining experience and knowledge, response adjustment, and continuous development. This view emphasizes that any system faces pressures from within and from an external environment under constant change and therefore, the system must "change in order not to be changed".

Procurement adaptability to environmental shifts is investigated through a case study of an automaker's quest to adjust its procurement to shifts in its business environment. Research was conducted in an industrial PhD project in the Procurement function of a commercial vehicle manufacturer in Sweden and leveraged the access to the case company to obtain in-depth data through internal documents, interviews, internal reports, and historical data. Of the papers presented in this thesis, findings from two of them are analyzed to characterize the supply network in relation to adaptability and findings from the other two are analyzed to shed light on how actions by the studied buying firm enhanced its procurement adaptability.

This thesis reveals that procurement adaptability is influenced by supply network characteristics that enable the acquisition of new knowledge and information flows, fast and effective response adjustment and the match between network structure and procurement focus. Building on the understanding of the supply network, this thesis also shows that a buying firm enhances its procurement adaptability by combining experience from internal functions and suppliers, adjusting activities, processes and interactions in the supply network, and making lasting changes in the scope of procurement activities. The findings contribute to our understanding of supply networks that face uncertain environmental shifts and how buying firms can enhance their procurement adaptability.

Keywords: procurement; semiconductors; automotive; adaptability

LIST OF APPENDED PAPERS

This thesis is based on the research reported in the following papers:

Paper I

Garcia, J. A. C., Arvidsson, A., & Jonsson, P. (2024). An analysis of automakers navigating an evolving semiconductor landscape. *International Journal of Physical Distribution & Logistics Management*, 54(6), 586-609. https://doi.org/10.1108/IJPDLM-11-2023-0412.

Contribution: main author; main responsible for conceptualization, data collection and analysis. Main part of the interpretation, writing of the paper, and responding to the review process.

Paper II

Arvidsson, A., Garcia, J. A. C., & Govik, L. (2026). Power dynamics in global supply networks at times of supply crisis. *Industrial Marketing Management*, 132, 61-75. https://doi.org/10.1016/j.indmarman.2025.11.012.

Contribution: part of the data collection and analysis; part of interpretation of the results, contributed to the writing of the method and findings section.

Paper III

Garcia, J.A.C.; Arvidsson, A; Jonsson, P. (2026) Building resilience amidst a crisis: An automaker's procurement journey to secure semiconductor supply. *Journal of Purchasing and Supply Management.* https://doi.org/10.1016/j.pursup.2026.101174.

Contribution: main author; main responsible for conceptualization, data collection and analysis, interpretation of the results, and writing of the paper.

Paper IV

Garcia, J.A.C.; Suurmond, R.; Arvidsson, A. (working paper) Crisis under Control: Supply Network Emergence and Control in the Automotive Sector.

Earlier versions of the paper were presented at the 34th IPSERA annual conference in 2025 and at WION Conference in 2026. The paper is currently in development for a journal submission.

Contribution: main author; main responsible for conceptualization, data collection and analysis, interpretation of the results, and writing of the paper.

ACKNOWLEDGEMENTS

As I focus on the last items in my to-do list to finish up my thesis, it is difficult to zoom out and think the big picture of my journey in the last almost five years. And somehow I realize that this last-minute rush, which I am sure is part of many other PhD students' journey, also represents how I have grown and changed during my PhD studies. More than two years ago I wrote in my licentiate thesis that I embraced the opportunity to learn about procurement, research and semiconductors. When I look back to these almost five years, I could not have imagined how much this journey would teach about myself, too. I am finishing my PhD and feeling proud of knowing a thing or two about procurement, something about how to investigate problems, but I am especially proud of the feeling that I can look at the world with new lenses, be even more comfortable with the idea that I do not know enough about a given topic, and embrace the journey to learn about it.

For my journey in my researcher education, I have much to thank my supervisor Ala Arvidsson. Ala, now we have worked together for more than six years and I feel that we have achieved a wonderful way of collaborating. I feel that you greatly understood how I work, what motivates me and what helps me stay focused, and what to say to remind me of the big picture of my PhD journey. It should go without saying that I would not be here without your support, but your empathy and humanity have been a big part of helping me learn how to navigate the academic life and who I am in it. Thank you so much!

I am also grateful for having Patrik Jonsson as my co-supervisor. Thank you for the time, guidance, and support you gave me, including evening paper readings and weekend calls to finish a paper review. To me, it is remarkable how you who often had insightful tips and remarks that clearly showed your knowledge and experience, and packed in a calm and clear way to communicate. Thank you also to my examiner Árni Halldorsson for your guidance and for always emphasizing the important things in a PhD project in a clear and objective way.

I already considered myself to have an exemplary supervision team and then Robert Suurmond came along. Thank you, Robert, for being such a big part of my last PhD year, for the deep and the not so deep talks that helped me reflect on my position as a researcher in an industrial context, and for the opportunity to spend some time at Maastricht University and work together.

I also want to thank my fellow doctoral students at TME. Despite the limited time we have spent together due to me not being there so often, you have always made me feel welcomed, and gave me the feeling of being part of the TME doctoral student community.

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Finally, thank you to my family and friends for their support. Thank you to my colleagues and friends at Maastricht University and the friends I have met through the IPSERA community, especially Jan, Aleksi, Fanny, and Dominik.

José Augusto Campos Garcia
Gothenburg, August 2026

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1. INTRODUCTION

Procurement has received increased attention and recognition as a strategic role in supporting a buying firm's organizational goals in an increasingly uncertain supply environment. As firms navigate changes in dynamic external business environments, procurement can leverage external resources and capabilities at suppliers to cope with change. However, after many decades of a comparatively favorable external business environment, the first half of the 2020s was characterized by supply disruptions and geopolitical tensions that challenged traditional procurement ways of working. In this context, the need for change and adaptation in procurement arises (Knight et al., 2022; Schoenherr et al., 2023).

The COVID-19 pandemic exposed buying firms' vulnerability to disruptions in their highly interconnected supply networks (Glas et al., 2021; Kähkönen & Patrucco, 2022), which calls for more resilient supply networks within the procurement research agenda (Gebhardt et al., 2022; van Hoek, 2020). As buying firms continue to face an uncertain environment (Carnovale et al., 2025), building such resilience must go beyond the return to a previous stable state after a disruption (Castillo, 2022; Scholten et al., 2025): uncertainty in supply, technology development, and cost require buying firms to do more than just prevent and react to shortages to maintain operations. In an environment of frequent and disruptive change, buying firms are required to find new ways of managing their supply network and procurement needs to adapt to the new reality of the global supply environment (Di Mauro et al., 2024; Knight et al., 2022).

In the automotive industry, successive shifts have happened in the external business environment and its supply network in the last three decades. Shifts in the external business environment have included new emissions and safety regulations, and technological development that led to a growing number of electronic functions in vehicles. These shifts have made automotive original equipment manufacturers (OEMs) more dependent on electronic components, on the semiconductors used inside electronic components, and on the complex network that supplies them. These shifts went largely unnoticed by many OEMs until the global shortage of semiconductors in 2020.

Semiconductors have been increasingly used in vehicles since their first use in electronic injection systems in the 1960s (Hitachi, 2026; Łukasiak & Jakubowski, 2010) and in many devices of our everyday life. They are technologically complex and produced in long and capital-intensive processes (Geng & Jiang, 2009; Mönch et al., 2018). While external and industrial shifts made semiconductors and electronics crucial for their products, OEMs have remained largely dependent on a Tier 1-centric supply network to handle these shifts. This dependence contributed to a lack of relationships with semiconductor producers and a lack of understanding of the semiconductor industry, which hindered OEMs' ability to secure supply of semiconductors for their vehicles. Vehicle production stops caused billions of euros of loss in the automotive industry (AlixPartners, 2021) and revealed that OEMs were unprepared to deal with their dependence on semiconductors to produce vehicles (King et al., 2021). The vulnerability of economies to semiconductor shortages motivated policy makers' efforts to strengthen the local technology development and supply of semiconductors (European Commission, 2023; U.S. Congress, 2022). Today, semiconductors and electronics are key for

innovation and cost of vehicles that are increasingly autonomous, connected and electrified. Therefore, OEMs must adapt their procurement to not only prevent a new shortage crisis, but also leverage these trends to secure the right innovation and cost of semiconductors and electronics.

In this thesis, I present the research from my doctoral research project and use the concept of adaptability from the social-ecological view of resilience (Adobor, 2020; Folke et al., 2010; Gunderson & Holling, 2002; Wieland et al., 2023) to frame the findings of my research in regards to how buying firms can adapt and adjust their procurement activities to changes in their external business environment. Beyond the ability to react to a previous stable state after a disruption (Ambulkar et al., 2015; Pettit et al., 2010; Sheffi & Rice Jr, 2005), this view emphasizes the need for continuous change and evolution as the environment around firms keeps on changing (Fath et al., 2015; Folke et al., 2010; Holling, 2001; Scholten et al., 2025). Through research conducted in an industrial PhD project at the procurement function of an automotive OEM (the focal OEM), this thesis reveals that procurement adaptability encompasses continuous review and development of processes, knowledge, strategic intent and supplier relationships.

1.1. Motivation

1.1.1. Empirical problem

Approximately six months into my PhD research project, my research proposal highlighted the main practical problem identified at that moment as the lack of knowledge about semiconductors within the focal OEM's procurement function in different aspects: market knowledge about the semiconductor industry, technical knowledge of the role played by semiconductors in vehicles, and knowledge of their production process. This lack of knowledge, together with low demand share for semiconductors and lack of relationships with semiconductor suppliers, placed the focal OEM and other OEMs in a weak position to secure supply of semiconductors during the global shortage crisis. They lacked the power and leverage that OEMs traditionally have over their suppliers.

As a result of the shortage crisis, OEMs, including the focal OEM, gave their Procurement functions the task to build resilient supply chains and avoid a new global shortage. The lack of semiconductor knowledge within the focal OEM's Procurement function, combined with the newly recognized strategic importance of semiconductors for the OEM's business, motivated the research done in my PhD project. As the research project unfolded and the problem was better understood, another underlying problem became clear: the lack of adaptation in the procurement function despite continuous change in its external business environment.

The increasing importance of semiconductors resulted from gradual changes in the external business environment and in the supply network during the two decades before the semiconductor shortage crisis. In the overall market, legal requirements (e.g., for enhanced safety, fuel efficiency, and reduced emissions) prompted the development and use of new semiconductor-based technologies in vehicles in the 2000s and 2010s. More recent features such as Advanced Driver Assistance Systems (ADAS), advanced infotainment, and vehicle autonomy (Verth, 2018) further increase vehicles' dependence on semiconductors.

Furthermore, characteristics of the supply network put in question the OEMs' sourcing model that largely relies on their Tier 1 suppliers. For instance, the mismatch in the automotive industry's demand and the semiconductor industry's supply availability (Attinasi et al., 2021; Zapp et al., 2012) overwhelmed Tier 1 suppliers' role to coordinate supply and demand in the network. Moreover, semiconductor suppliers increasingly offer more complex and complete solutions, capturing part of the value previously created by Tier 1 suppliers and reshaping the value creation landscape in the supply network (Meissner et al., 2020).

These gradual changes in the external environment were not reflected in changes in the OEMs' procurement. Through their reliance on Tier 1 suppliers to manage sub-suppliers, including semiconductor suppliers, OEMs failed to look beyond Tier 1 suppliers. They overlooked the increasing strategic relevance of semiconductors, and did not build required knowledge and supplier relationships in the upstream supply network. Without being attentive to their supply network structure, the automotive OEMs shaped their supply network in a way that prevented them from identifying change in their external environment and made them vulnerable to disruptions in the semiconductor industry. Once the supply of semiconductors became constrained at the end of 2020, the consequences of this vulnerability became clear: without semiconductors, OEMs could not produce and deliver vehicles.

Today, OEMs continue to face this risk of supply disruptions due to geopolitical tensions (European Commission, 2026a; Tewari, 2025), bans on imports of automotive electronics and semiconductors (U.S. Department of Commerce, 2025), and threats of new shortages and price hikes for memory chips (Shepardson, 2026). As previous gradual external changes become more disruptive and frequent, lack of knowledge of the supply network (e.g., the actors in the network, their roles and connections between them) can cost OEMs precious time to identify how changes in the external environment can affect their procurement. Moreover, the disconnect between the external environment and their procurement can again prevent OEMs from identifying future changes in the external environment and adapting their procurement.

1.1.2. Theoretical background

For buying firms exposed to changing environments, procurement can play an important role in navigating changes and handling instability, as it connects the buying firm with its external supply markets (Ellram et al., 2020, p. 3). To secure the firm's needs in terms of supply, cost, and innovation (Van Weele & Rozemeijer, 2022), procurement processes and activities relate to actively selecting and managing a number of suppliers from which it sources its needs (Choi & Krause, 2006). The more uncertain the external environment, the greater the need for a high level of strategic procurement (Akin Ateş & Memiş, 2021; Patrucco et al., 2023).

This role to secure the buying firm's needs is reshaped by recent supply crises and the pace of technological advancement. Disruptions at lower-tier suppliers show a need for mapping and understanding of the supply network beyond Tier 1 suppliers (Finkenstadt & Handfield, 2021; Spieske et al., 2022a). This need for understanding the supply network is extended to the sourcing of technology and innovation, particularly in the choice between delegation and intervention in sub-supplier selection (Johnsen, 2011) and the involvement of sub-suppliers in New Product Development (Suurmond et al., 2020). However, without the tools and techniques

to map and understand the characteristics of their supply networks (Knight et al., 2022), buying firms may not be able to identify critical suppliers for supply assurance, cost, and innovation.

To address this problem, my research applied two theoretical lenses to characterize a buying firm's supply network: Social Network Analysis supports the analysis of the supply network structure, the links in it, and the roles of its actors (Borgatti & Li, 2009; Kim et al., 2011). Through Resource Dependence Theory (RDT), it is possible to assess the dependences and power dynamics in the supply network and in relation to the external environment (Hillman et al., 2009; Kähkönen & Virolainen, 2011; Pfeffer & Salancik, 2015).

Social Network Analysis (SNA) examinates the structure of the supply network through metrics such as network size, centralization and density, and the analysis of a firm's role in the network through its centrality (e.g., degree, closeness and betweenness centrality) (Borgatti & Li, 2009; Kim et al., 2011). For instance, the firm's position in the supply network can influence its exposure to supply and cost risks (Borgatti & Li, 2009; Kim et al., 2011), and its ability to access supplier innovation (Kim et al., 2020). The use of SNA metrics can help characterize the supply network, the roles of firms in it, and explain the implications of the network structure for the buying firm's Procurement.

Resource Dependence Theory (RDT) suggests that people and organizations are interdependent with other people and organizations, and that the dependence on resources controlled by other organizations influences a firm's power position. For instance, this position comprises buyer-supplier dependences (Caniëls & Gelderman, 2005), the buying firm's position and role in its supply network, and relationships with suppliers (Kähkönen & Virolainen, 2011). Suppliers' market power and expertise and high supplier switching costs can cause a buying firm's weak power position (Caniëls & Gelderman, 2005). Therefore, RDT provides a lens to understand how power dynamics influences the role of procurement to manage the supply network (Marttinen & Kähkönen, 2022).

Understanding a buying firm's supply network structure is important for the firm's sourcing model and reaction to environmental shifts. For instance, the sourcing model of automotive OEMs has been traditionally built around their reliance on Tier 1 suppliers (Lamming, 1993). This sourcing model emphasizes a cost-efficient management of the supply base (Doran, 2004) but makes the supply network vulnerable to disruptions (Brintrup et al., 2015).

Beyond the understanding of the supply network, the influence of the external business environment is important for procurement and the understanding of environmental influences helps to position the role of procurement to adapt to and navigate environmental shifts (Essuman et al., 2022; González-Benito et al., 2010; Hoffmann et al., 2013; Patrucco et al., 2023). Therefore, my research applied two theoretical lenses to investigate how a buying firm changes its procurement in response to environmental changes: the social-ecological view of resilience (Adobor, 2020; Holling & Gunderson, 2002; Wieland & Durach, 2021).

The social-ecological view of resilience was chosen because it emphasizes a system's exposure to environmental shifts and the consequent need for continuous adaptation (Holling & Gunderson, 2002; Wieland & Durach, 2021), instead of viewing resilience as "bouncing back to normal" after a disruption (Peck, 2006; Sheffi & Rice Jr, 2005). In a supply network context,

the ability to adapt and transform is increasingly important (Wieland et al., 2023) and prevents firms from focusing only on high efficiency, which can undermine the network's ability to adapt to external changes (Adobor, 2020; Holling, 2001).

To understand change and adaptation to environmental shifts, the Complex Adaptive Systems (CAS) perspective proposes that a system evolves through its interaction with the external environment (Choi et al., 2001). A supply network is an adaptive system, in which individual agents self-organize as they try to maximize their fit and performance among environmental changes and a buying firm manages its supply network by combining ways to control outcomes in the network (i.e., control) and to allow for suppliers' innovation and self-organization (i.e., emergence) (Choi et al., 2001). As a buying firm adjusts its level and type of control over the supply network in response to environmental changes (Jacobides et al., 2016; Sting et al., 2019), these adjustments can be a powerful representation of the buying firm's procurement response to environmental shifts.

To summarize and analyze the findings of my research in relation to a buying firm's ability to change and adapt its procurement to environmental shifts, this thesis applies the concept of adaptability from the resilience thinking framework proposed by Folke et al. (2010) based on the social-ecological view of resilience (Holling, 2001; Walker et al., 2004). The framework consists of three elements – resilience, adaptability, and transformability. Resilience is defined as an overarching concept, as the ability of a system to "absorb disturbance and reorganize while undergoing change" so as to remain operational (Walker et al., 2004, p. 4). Adaptability and transformability are essential pre-requisites for resilience and are distinguished by the extent of change that they entail: adaptability refers to adjustments to the current system and is defined as the social actors' ability to influence resilience through learning, combining experience and knowledge, response adjustment and continuous development (Folke et al., 2010); transformability refers to the capacity to create a fundamentally new system when ecological, economical, or social structures make the existing system untenable (Walker et al., 2004, p. 4).

I chose to use the concept of adaptability because it breaks the larger concept of resilience down into constructs that can be observed in a buying firm's response to environmental shifts: learning, combining experience and knowledge, response adjustment and continuous development (Folke et al., 2010). This conceptual choice places adaptability as an essential ingredient for resilience and aim to contribute to the knowledge on how firms build resilience in supply network contexts (Carnovale et al., 2025; Castillo, 2022; Kähkönen et al., 2023; Scholten et al., 2025; Wieland et al., 2023).

Building adaptability and continuously adjusting procurement to external conditions is not an easy task. Procurement's direct influence on cost and the firm's profitability can motivate focus on short-term gains and curtail long-term adaptability (Aldrighetti et al., 2021; Carnovale et al., 2025). In this context, an adaptive view of resilience emphasizes that a balance between short-term stability and long-term adaptability is essential (Gunderson & Holling, 2002), but the existing literature does not address how a firm should achieve this balance in managing its supply network or how to account for the links between firms in the supply network and the influences of the external environment.

1.2. Scope and Purpose

The aim of this thesis is to develop knowledge on how a buying firm can enhance its procurement adaptability to fast-changing external business environments. It presents the research conducted within my Industrial PhD project in a collaboration between Chalmers and the Procurement function of a Swedish commercial vehicle OEM (the focal OEM). The project idea was initiated in May, 2021, during the first months of the global semiconductor crisis and research continued throughout and after the crisis. Embeddedness within the focal OEM's procurement ensured the practical relevance of the research conducted after the crisis ended. Since January 2025, the PhD project has been part of a research project on the automotive supply network of electronics and semiconductors, in a consortium led by Chalmers Technical University and containing another OEM, Tier 1 suppliers, and a research institute.

1.3. Research questions

This thesis addresses two research questions, the first one (RQ1) focusing on how supply network characteristics affect procurement adaptability and the second one (RQ2) focusing on how a buying firm enhances its procurement adaptability.

The first research question explores the influence of supply network characteristics on procurement adaptability:

> RQ1: How do the supply network characteristics affect a buying firm's procurement adaptability in fast-changing environments?

This question addresses the empirical problem of a buying firm's lack of knowledge and understanding of the supply network. In the empirical context of my research, there were indications that the OEMs' ability to adapt their procurement was limited by their supply networks: they lacked connections to upstream suppliers, were dependent on their Tier 1 and did not have visibility of the supply network. However, the exact mechanisms behind this limitation were not well understood. Theoretically, while the need and importance of supply network mapping has been argued for decades (Choi et al., 2021; Kim et al., 2011; Pichler et al., 2023), the literature lacks tools and methods to map and characterize a supply network (Di Mauro et al., 2024; Knight et al., 2022). This research question addresses both this gap by exploring how a buying firm can map its supply network and how it can interpret its characteristics to influence adaptability.

To address how a buying firm can characterize its supply network, this thesis applies SNA metrics such as network size, density, centralization, and node centrality (Borgatti & Li, 2009; Kim et al., 2011) and RDT through power dynamics, based on sources of power in the network, power imbalances between actors, and how power distribution is affected by a high-impact supply crisis (Caniëls & Gelderman, 2007; Kähkönen & Virolainen, 2011). By addressing RQ1, this thesis combines static and dynamic views of the supply network through the evolution of the supply network structure over almost three decades, the power dynamics observed at the beginning of a high-impact supply crisis, and shifts of power distribution caused by this crisis. Particularly, the dynamic element of this characterization reveals the influences of the external environments on changes in the network structure and power distribution.

Building on this characterization of the supply network and its relation to the external environment, the second research question addresses how a buying firm enhances its procurement adaptability to cope with and leverage shifts in the external environment.

> RQ2: How does a buying firm enhance its procurement adaptability in fast-changing environments?

Buying firms' ability to adapt and cope with change has been emphasized since the COVID-19 pandemic. In procurement research, resilience has been investigated through several angles: procurement response to the COVID-19 pandemic (Dube et al., 2022; Küffner et al., 2022; van Hoek, 2021; Vega et al., 2022), the role of procurement capabilities (Gebhardt et al., 2022; Kähkönen et al., 2023) and procurement digitalization (Harju et al., 2023) to build resilience, and the gaps in theory and practice for resilience in procurement (Glas et al., 2021; van Hoek, 2020). However, research is still needed to understand procurement role to support resilience as an ability to continuously adapt to change rather than focusing on the reaction to an environmental shift (Adobor, 2020; Wieland et al., 2023). Through the concept of adaptability from social-ecological resilience, this research question explores the buying firm's ability to influence resilience and remain adaptable to change in the long term through learning, combining experience and knowledge, response adjustment, and continuous development amidst environmental shifts (Folke et al., 2010).

Section 1.4 describes the connection between the papers and this thesis.

1.4. Connection between the thesis and appended papers

The research conducted in my doctoral research project consisted of four papers. Figure 1 summarizes the connection between the papers and this thesis: the papers are presented on the upper part of the figure, while the lower part of the figure shows how the papers contribute to answering the research questions in this thesis.

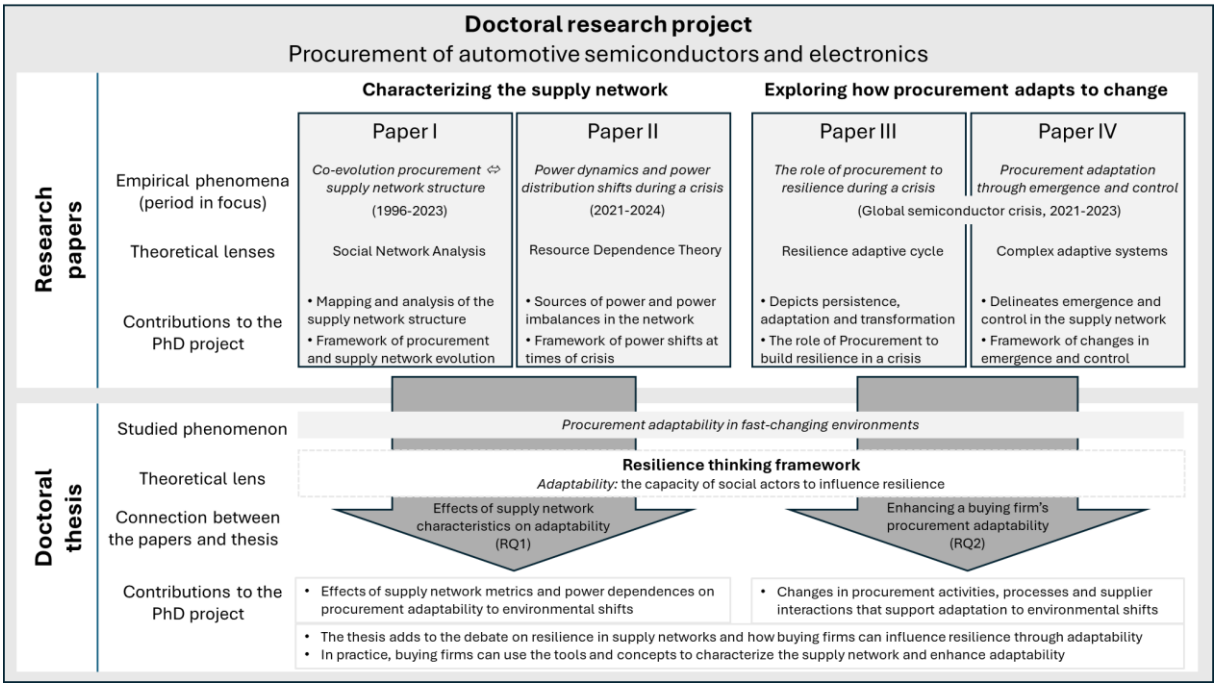


Figure 1: Connection between the papers and the thesis in my doctoral research project.

Papers I and II addressed the characterization of the supply network. Paper I investigated the interaction between procurement focus and supply network structure to understand how they co-evolve and how mismatches between them can hinder a buying firm's ability to react to shifts in the external environment. Paper II investigated the power position of a buying firm through the sources of power that affect this power position in a changing environment and how procurement copes with power imbalances and shifts in power distribution. In this thesis, the findings of these papers were analyzed through an adaptability lens to answer RQ1 on how supply network characteristics affect a buying firm's adaptability.

Papers III and IV empirically investigated procurement endeavors to ensure change amid a high-impact supply disruption: the global semiconductor crisis of 2020-2023. In this empirical context of a crisis that exceeded the OEM's supply disruption preparedness, Paper III investigated the role of procurement to build resilience during a crisis through disruption response measures. Paper IV investigated changes in a buying firm's control over the supply network beyond first-tier suppliers through in the supply network. In this thesis, the findings of Papers III and IV were analyzed to answer RQ2 on how a buying firm enhances procurement adaptability through disruption response measures and changes in control over the network.

By bringing together the findings from these four papers, this thesis extends our knowledge of how a buying firm can enhance its procurement adaptability to environmental shifts.

1.5. Thesis outline

The thesis is structured as follows: section 2 presents the frame of reference of this thesis. Section 3 presents the research design and methods adopted in the different studies. Section 4 contains a summary of the findings of the appended papers. Section 5 discusses the findings related to the aim and research questions. Section 6 presents the practical implementation of findings at the focal OEM. Finally, Section 7 presents conclusions and limitations.

2. THEORETICAL FRAMEWORK

This thesis adopts the theoretical framework presented in Figure 2. The theoretical lenses from the appended papers are used as supporting lenses (left-hand side of Figure 2) in this thesis and provide concepts that are central for the analysis. The middle section of Figure 2 shows how the findings from the papers are analyzed through the primary lens of the resilience thinking framework (Folke et al., 2010). The right-hand side of Figure 2 shows that the concept of adaptability is applied to procurement and supply management and uses the existing knowledge in the Procurement and Supply Management (PSM) field.

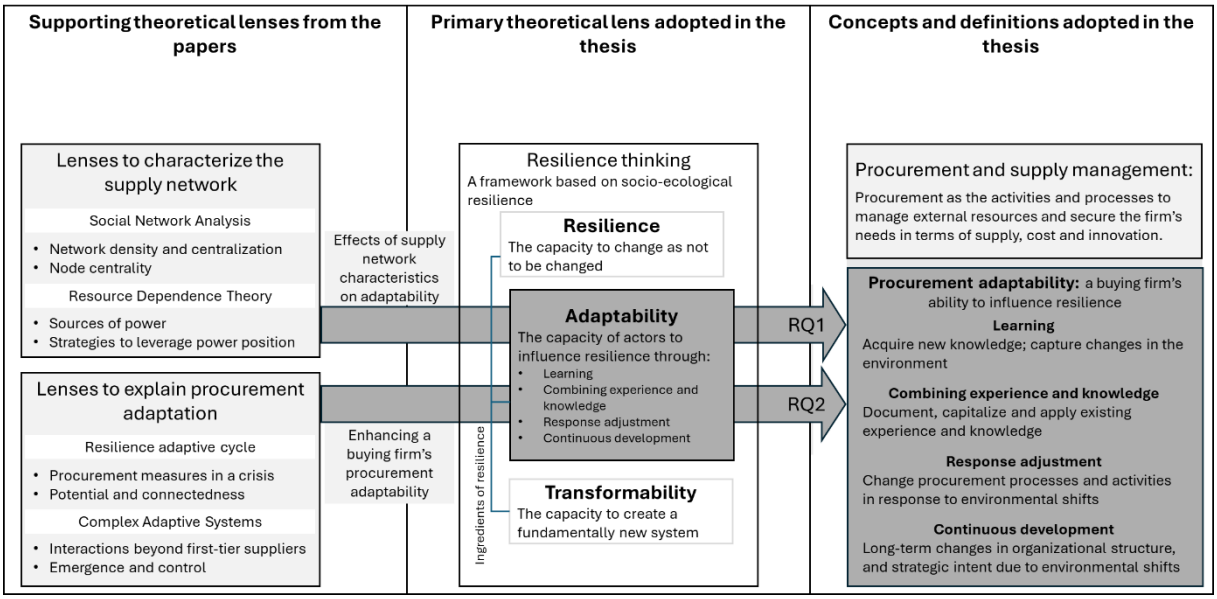


Figure 2: Theoretical framework adopted in this thesis.

The framework defines procurement as the set of activities and processes to manage the firm's external resources and secure the firm's needs in terms of supply, cost and innovation (see section 2.1). To explore procurement adaptability, this thesis applies the Resilience Thinking framework by Folke et al. (2010) based on the social-ecological view of resilience (Walker et al., 2004), further described in section 2.2. The operationalization of adaptability in a procurement context is made by applying the definition from Folke et al. (2010) and on further details on each aspect of adaptability provided in Berkes et al. (2002).

2.1. Procurement and supply management

A firm depends on external resources to obtain the products, knowledge and services needed to run its operations. For that purpose, procurement encompasses the management of the buying firm's external resources through the definition of needs, supplier selection, contracting, ordering, expediting, and follow up (Van Weele & Rozemeijer, 2022). Different definitions consider procurement as a set of activities and processes while other definitions consider procurement as the function responsible for these activities (Ellram et al., 2020). In the present thesis, I consider procurement to be the set of activities and process performed by the buying firm to manage its external resources. This choice makes the definition applicable to firms where the function responsible for procurement has other names and also takes into consideration that such activities are at times performed by other functions.

In managing an organization's external resources, procurement seeks to strike a balance between the objectives of cost savings, supply assurance, and value enhancement through innovation (Van Weele & Rozemeijer, 2022). Among procurement objectives, cost is the most predominant in procurement research (Wynstra et al., 2019) and has been a traditional part of the identity of procurement (Murfield et al., 2021). This can be accomplished through sourcing strategies such as demand pooling, product optimization, pricing evaluation, and supplier relationship enhancement (Schiele, 2007). Cost savings are important because of the high cost share of outsourced products for buying firms (Schiele, 2019). Achieving cost savings requires procurement professionals with a set of skills including commercial, technical, and supply market knowledge (Schütz et al., 2020).

Procurement activities can also help to drive innovation by involving suppliers in New Product Development (NPD) and cultivating relationships that are aligned with technology roadmaps (Arvidsson et al., 2022; Schiele, 2010). Some companies might intervene in sub-supplier selection for critical components, but in many cases the responsibility for this selection is given to direct suppliers because of a lack of resources to manage sub suppliers (Johnsen, 2011). Procurement's contribution to innovation is linked to several factors, including closer integration with other organizational functions and a comprehensive skill set of technical and market knowledge (Blome et al., 2013; Legenvre & Gualandris, 2018; Luzzini & Ronchi, 2011). Research on procurement involvement in NPD has focused primarily on dyadic relationships with the involvement of direct suppliers, and the role of procurement in involving suppliers that are further in the supply network remains unexplored (Johnsen, 2022).

Ensuring the availability of goods and services is part of the role of procurement and is essential to meet the demands of internal customers and support the company's operations (Monczka et al., 2020). As supply shortages can be far costlier than the components themselves, ensuring supply becomes one of the main priorities of procurement (Schiele, 2019), and the urgency of supply disruptions can require fast adaptation from procurement. A certain level of disruption preparedness can be achieved before a disruption happens (Sengupta et al., 2025) through risk management practices, robust supplier selection, and supply network mapping (Choi et al., 2020; Dabhilkar et al., 2016; Gebhardt et al., 2022; Pereira et al., 2020). However, disruptions can require procurement to adapt and reconfigure resources through disruption response measures (Ambulkar et al., 2015; Dabhilkar et al., 2016; Glas et al., 2021; Kähkönen et al., 2023). Another important part of adaptation is the capitalization of learnings after a disruption (Gebhardt et al., 2022; Kähkönen & Patrucco, 2022).

Between supply, cost, and innovation, a buying firm's procurement focus is frequently reviewed and adjusted to changes in the external environment, and this also influences the managerial attention given to procurement. Historically, the focus and relevance of procurement have been subject to changes in the external environment: supply scarcity during World Wars I and II gave high attention to procurement to secure supply; a more stable supply environment in the 1920s meant lesser attention for procurement; and management interest in procurement revamped again through cost-cutting focus during economic recessions in the 1950s and 1960s as well as the oil embargo of the 1970s (Heberling, 1993). This shows that the role of procurement and relevance within a firm are subject to changes in the external environment. More recently, procurement has stood under the spotlight after the supply

disruptions of the early 2020's placed supply networks around the world under heightened stress (Di Mauro et al., 2024; Tate et al., 2022). As geopolitical tensions and regulatory pressure maintains heightened uncertainty in firms' external business environment (Carnovale et al., 2025; Rogers et al., 2024), this raises the question as to how procurement can adapt to environmental shifts.

Moreover, recent disruptions emphasize the importance of upstream suppliers (Gebhardt et al., 2022; Küffner et al., 2022; Spieske et al., 2022b), which reinforces long-existing calls for mapping and understanding supply networks beyond first-tier suppliers (Carter et al., 2015; Choi & Linton, 2011). However, as mapping a supply network can easily become complex and expensive, finding appropriate ways to improve visibility and understanding of the supply network remains a challenge understood by practitioners, researchers and policy makers (Choi et al., 2020; European Commission, 2026b; The White House, 2021), and calls for research that uses new ways to characterize supply networks and increase firms' awareness of their supply networks (Carter et al., 2015; Knight et al., 2022).

2.2. Resilience thinking: a framework for resilience in social-ecological systems

The resilience thinking framework was proposed by Folke et al. (2010) as a framework to study the dynamics of social-ecological systems. The framework builds on previous research and publications on resilience of social-ecological systems (SES), accounting for the dynamic nature of a complex adaptive system as it adapts to changes in its environment (Folke, 2006; Folke et al., 2021; Walker et al., 2004). The framework integrates the concepts of resilience, adaptability and transformability. Particularly, through its focus on the continuous adaptation to shifts in the environment, the resilience thinking framework emphasizes adaptability and transformation as core prerequisites for resilience (Folke et al., 2010).

The central concept in the framework, resilience, has been defined in several ways. Among different definitions, the one that expresses well the meaning that I adopt in this thesis is a short one provided by Folke et al. (2010, p. 3): "the capacity to change in order to maintain the same identity". This capacity is reflected in the system's ability to absorb disruptions and reorganize to retain the same function, structure, identity, and feedbacks (Walker et al., 2004). While simple, this definition encapsulates the idea that as environmental conditions change, adaptation is essential for a system to maintain its function and goes beyond the idea of return to a previous stable state after a disruption (Holling, 1996).

Another important element of the theory on the resilience of SES is the resilience adaptive cycle. The adaptive cycle is a heuristic model that suggests that an SES goes through phases of slow and gradual alternated with rapid and disruptive change (Folke, 2006). The adaptive cycle, its constituting phases and elements are further described in section 2.4.2. The adaptive cycle and the resilience thinking framework are two separate but complementary heuristics in SES resilience that explain how a system interacts with cycles of gradual and rapid changes that it goes through (Folke et al., 2010; Walker et al., 2004).

In supply chain contexts, the concepts and heuristics from social-ecological resilience have been conceptually translated and provide promising insights for the study of supply networks (Adobor & McMullen, 2018; Novak et al., 2021; Wieland & Durach, 2021; Wieland et al.,

2023). For instance, the resilience adaptive cycle, which is used in Paper III and further explained in section 2.4.2, supports the understanding of constant change in supply chains (Adobor, 2020; Wieland, 2021). Similarly, the extension of the resilience thinking framework to a supply chain context has inspired the definition of supply chain resilience as the supply chain's ability to persist, adapt and transform (Wieland & Durach, 2021; Wieland et al., 2023).

In the resilience thinking framework, adaptability and transformability are two essential prerequisites of resilience (Folke et al., 2010). Adaptability relates to the human component of this interaction, through the actions of the system's actors to influence resilience (Walker et al., 2004). Adaptability enables a system to face change and maintain its configuration. Conversely, transformability refers to the ability to create a fundamentally new system when new environmental conditions deem the current system configuration undesirable (Folke et al., 2010; Walker et al., 2004). As social-ecological resilience deals with the interaction between human and natural systems, these two characteristics become essential for a system that faces change, to either adapt to remain in the same intended development path or transform into a new desirable development path (Folke, 2006).

Within resilience thinking, adaptability is composed of four elements: learning, combining experience and knowledge, response adjustment, and continuous development (Folke et al., 2010). In a supply chain context, adaptability has been highlighted, together with agility and alignment, as characteristics of supply chains necessary to create competitive advantage and navigate uncertain environments (Lee, 2004; Patrucco & Kähkönen, 2021). While both definitions stem from the same need to continuously adapt to environmental shifts, the definition in the resilience thinking provides a broader basis that emphasizes learning as an important element of adaptability (Folke et al., 2010).

In this thesis, I apply the resilience thinking framework, along with its definitions of resilience, adaptability, and transformability, as the theoretical lens to analyze a buying firm's need for change and continuous adaptation in its procurement as it is influenced by its external business environment. The framework aligns with a view of resilience as the capacity to change so as not to be changed (Walker, 2020). As it moves beyond the persistence and reaction to external perturbations that is common to many definitions of supply chain resilience (Peck, 2006; Sheffi & Rice Jr, 2005), it portraits a rather proactive role that a buying firm can take to identify, cope with and shape change in its environment (Wieland et al., 2023). Particularly, the concept of adaptability provides a lens to explore how a buying firm can enhance its ability to recognize and continuously adapt to environmental shifts through its procurement. A crucial benefit of applying the resilience thinking framework and the operationalization of adaptability - as the buying firm's ability to learn, combine experience and knowledge, adjust its response to external drivers, and continuously develop its procurement – is that it allows an analysis of how the buying firm can actively influence resilience in its procurement.

2.3. Theoretical lenses on the characterization of the supply network

2.3.1. Social Network Analysis

Social Network Analysis (SNA) is the application of Network Theory to the social sciences as a strategy for investigating social structures (Otte & Rousseau, 2002). In Network Theory,

which is the theoretical perspective behind SNA (Borgatti & Halgin, 2011), a network is a set of actors (also called nodes) connected by a set of connections (also called ties) and the arrangement of these connections constitutes the network structure. Network Theory concerns the interaction between the network structure and given processes to generate outcomes for nodes and the whole network (Borgatti & Halgin, 2011).

SNA has diverse applications and has also been applied in Supply Chain Management (SCM), as researchers recognized the value of the network perspective to analyze supply chains (Borgatti & Li, 2009; Carter et al., 2007). SNA's relevance in Operations and Supply Chain Management (OSCM) extends to aspects such as supply chain relationships, innovation (Wichmann & Kaufmann, 2016), resilience (Kim et al., 2015; Li et al., 2020), robustness (Brintrup et al., 2015) and risk propagation (Basole & Bellamy, 2014; Garvey et al., 2015). Such an analysis offers an exploration of the roles of the nodes depending on their position in the network and of how the network structure influences the performance of firms and of the whole network (Kim et al., 2011).

SNA can analyze both the hard (e.g., financial and material flows) and soft (e.g., information sharing) ties between firms in a supply network, making it a suitable approach for SCM studies. Aided by a qualitative analysis of ties, it can provide strong insights into supply network collaboration and performance (Borgatti & Li, 2009; Han et al., 2020). As summarized in Table 1, SNA metrics can be used to characterize the supply network and implications at the node and network levels (Kim et al., 2011).

Table 1: SNA metrics for the supply network structure (Kim et al., 2011).

Supply network characteristic	**Metric**	**Implications of a high score for the procurement context**
Node centrality	Degree centrality	Coordinator role: To reconcile differences of firms and align their opinions with the greater supply network goals
	Closeness centrality	Navigator role: To explore, access, and collect various information with greater autonomy in the supply network
	Betweenness centrality	Broker role: To mediate dealings between network members and turn them into an advantage
Network centralization	Centralization	Lack of interactions between central and peripheral firms. Decoupled relationships between firms at different tiers
Network complexity	Complexity	More firms involved in transferring information Active interactions at a local level Slow relaying of communications

Node centrality refers to a node's position and relative importance in the network (Borgatti & Li, 2009; Kim et al., 2011). In supply networks, a high degree of centrality (the node's number of connections) represents a firm's rich access to resources and information, with the ability to integrate and allocate material flows and to influence other firms' operations and

decisions. A high betweenness centrality (being on the shortest path between other firms in the network) gives a firm the role to control the flows of materials and information between suppliers and customers as well as the ability to control interactions between firms. Firms with a high betweenness centrality become critical for the network, as their failure can slow down the whole network and impact cost, quality, and lead times (Borgatti & Li, 2009; Kim et al., 2011). Finally, high closeness centrality (related to the node's average distance to all other nodes in the network) suggests a firm's independence through its ability to reach other firms quickly. A firm with low closeness centrality might face information distortion, disruption risk, and cost increases (Borgatti & Li, 2009; Kim et al., 2011).

As a complement to node-level metrics, network-level metrics concern the structure and operation of the entire network. For instance, network complexity is described based on network size (i.e., number of nodes in the network) and density (degree of interdependency between nodes): a larger network size can indicate longer information paths, more time needed to reach other firms (Borgatti & Li, 2009; Kim et al., 2011) and additional operational effort to manage suppliers (Akin Ateş & Memiş, 2021; Choi & Krause, 2006). Network centralization, in turn, represents the concentration of power in a few central nodes, which can cause hinder responsiveness and effectiveness in decision-making (Kim et al., 2011).

SNA is applied in this thesis because it can reveal characteristics of the supply network that have implications for a buying firm's procurement adaptability, by supporting or hindering the firm's ability to adapt to and leverage these shifts (Borgatti & Li, 2009).

2.3.2. Power dynamics in the supply network and power position of the buying firm

Power dynamics in a supply network can occur at three levels: the micro (intrafirm), macro (interfirm and supply network), and meso (external environment) levels. According to resource dependence theory (RDT), a firm's dependence on external resources controlled by others significantly influences its power within a network of organizations (Caniëls & Gelderman, 2007; Pazirandeh & Norrman, 2014; Pfeffer & Salancik, 2015).

At the micro (intrafirm) level, a buying company's power position is influenced by factors such as resources, specialized capabilities, demand share, and reputation (Kähkönen & Virolainen, 2011; Pazirandeh & Norrman, 2014; Pfeffer & Salancik, 2015).

At the meso (supply network) level, power is influenced by dyadic interfirm relationships. In each relationship, power imbalances can arise due to control over critical information, negotiation skills, and supplier substitutability (Pazirandeh & Norrman, 2014; Pfeffer, 1981). As buying firms depend on suppliers and their complex supply networks (Xiao et al., 2019), the power position of the buying firm can also be influenced by local power imbalances in the supply network and the overall supply network structure.

Finally, changes in the macro (external environment) level can affect the power balances and a buying firm's power position. These changes can be broader economic trends and global market shifts (Cox et al., 2001) as well as geopolitical and global disruptions and regulations (McNamara & Newman, 2020; Pazirandeh & Norrman, 2014).

Similarly, improving a buying firm's power position in the network can require approaches at different levels. At the micro level, such actions include increasing customer attractiveness, gaining supplier attention (Pulles et al., 2019; Schiele & Vos, 2015) and replacing assets in the supply network with others of higher value (Cox et al., 2001). Approaches at the meso level can include strengthening supplier relationships (Eisenhardt & Schoonhoven, 1996) and increasing customer attractiveness to gain a supplier's preferred customer status (Goldberg & Schiele, 2020; Pellegrino et al., 2020). At the macro level, the buying firm's actions aim to recognize and engage with changes in external forces (Pfeffer & Salancik, 1977).

In this thesis, RDT is applied for the analysis of the power dynamics in the supply network, as it can reveal how supplier dependences and changes in power distribution affect a buying firm's ability to adapt to the ongoing environmental shifts (Caniëls & Gelderman, 2005), which complements the analysis of the supply network structure through SNA.

2.4. Theoretical lenses on adaptability

2.4.1. Supply networks as complex adaptive systems

This thesis views the supply network as a complex adaptive system (CAS), which was first proposed by Choi and colleagues as they applied the underlying dynamics in CASs to supply networks through three main foci: internal mechanisms, environment and co-evolution (Choi et al., 2001, p. 353). A revision of Choi and colleagues' framework by Nair and Reed-Tsochas (2019) is shown in Figure 3. The latter framework provides a distinction of the enacted and external environments and the existence of emergent system properties that result from the co-evolution between the system and its environment. This section explores the characteristics of supply networks as a CAS based on the framework by Nair and Reed-Tsochas (2019).

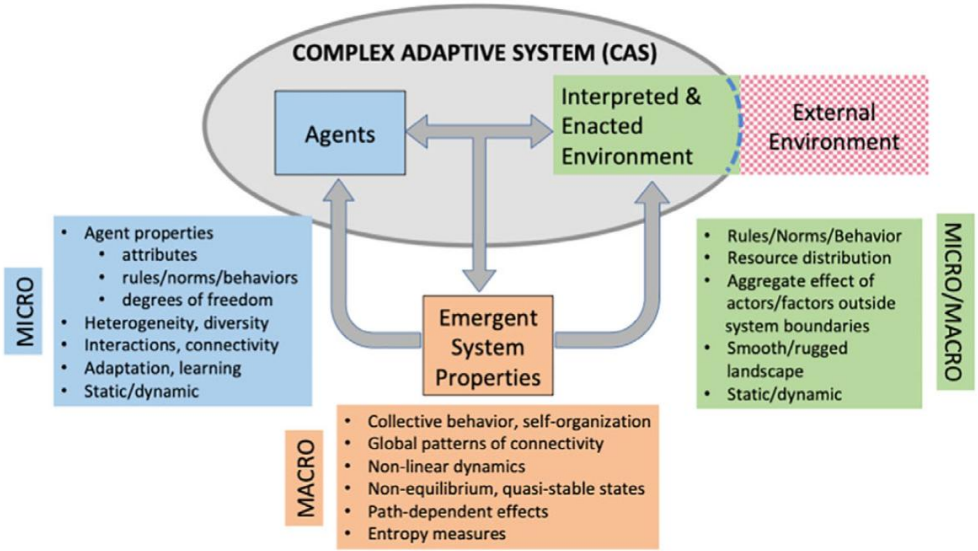


Figure 3: Conceptual framework of complex adaptive systems. Source: Nair and Reed-Tsochas (2019).

The block of agents within a CAS contain the entities that are part of the system, such as the individual firms that are part of a supply network (Choi et al., 2001). Agents are characterized through their connectivity, rules of behavior (i.e., beliefs and values that each agent holds and

influence their behavior), levels of autonomy, diversity, the ability to learn and adapt as well as dynamicity (Nair & Reed-Tsochas, 2019). Each agent aims to increase its own fit through actions to control other agents, which can increase predictability of the system, but reduce the autonomy of the controlled agent (Nair & Reed-Tsochas, 2019).

The enacted environment is co-created by the interaction between the agents and the external environment (Nair & Reed-Tsochas, 2019), such as industry dynamics and patterns in relationships between agents in a supply network. Conversely, the external environment lies outside of the supply network's boundaries but still influence the network (Nair & Reed-Tsochas, 2019), such as the macroeconomic landscape, natural disasters, and geopolitical developments. The environment is characterized by the tight coupling between its components (i.e., rugged landscapes), its dynamism (Choi et al., 2001), and environmental norms and rules that are imposed on the agents (Nair & Reed-Tsochas, 2019).

Emergent system properties in a CAS are a result of the interaction and co-evolution between the agents and the environment (Choi et al., 2001; Nair & Reed-Tsochas, 2019). These properties represent patterns that manifest between firms without the control of a single firm, such as the collective behavior of groups of firms and self-organization (Nair & Reed-Tsochas, 2019). Quasi-stable or quasi-equilibrium states represent the balance between order and complete disorder, as the balance between the stability of operations in a supply network at the same time that it is exposed to perturbations from the external environment that can create disorder in operations (Choi et al., 2001; Nair & Reed-Tsochas, 2019).

Based on the application of the CAS theory to supply networks, Choi et al. (2001) propose that firms should define how much of the supply network to control and how much to let emerge. As the co-evolution between the network and the environment cause non-linear changes in the network, firms that can balance emergence and control are expected to outperform those that manage their supply network by emergence or control alone (Choi et al., 2001).

In this thesis, CAS theory provides useful concepts for characterizing the system within its environment and a buying firm's ability to adapt and co-evolve with the environment (Choi et al., 2001). To investigate procurement adaptability, the use of CAS theory can reveal how the interaction between supply network and its environment places demands for procurement adaptability and how these demands are reflected on changes in the buying firm's attempts to control the supply network.

2.4.2. The resilience adaptive cycle

The adaptive cycle, presented in the seminal work by Gunderson and Holling (2002) and reproduced in Figure 4, is composed of four phases (exploitation, conservation, release, and reorganization) and three interconnected elements (resilience, potential and connectedness) (Adobor, 2020; Wieland & Durach, 2021) that describe the resilience of complex adaptive systems (Adobor, 2020; Holling, 2001). A system goes through the four phases in the cycle and its resilience varies contingent on the varying levels potential and connectedness (Holling, 2001).

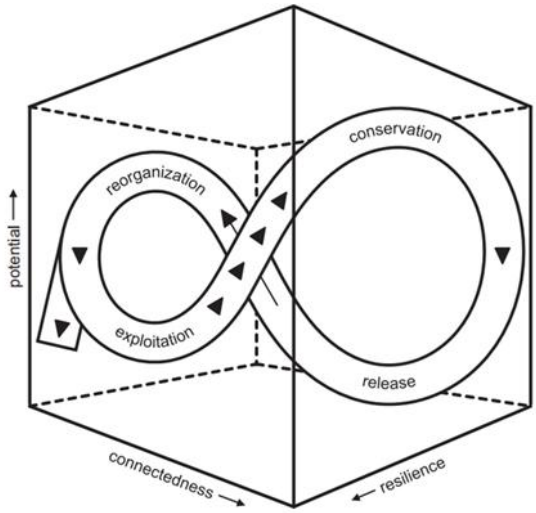


Figure 4: The adaptive cycle representing the phases of social-ecological resilience. Source: Wieland and Durach (2021).

Holling and Gunderson's (2002, p. 33) framework only describes potential and connectedness as general properties of a complex system and their translation to supply networks has been mainly conceptual (Adobor, 2020). Potential refers to the accumulated resources over time that can enable change, such as financial and social capital, while connectedness represents the degree of flexibility or rigidity of controlling variables and processes (Holling & Gunderson, 2002). For a supply network, connectedness is influenced by aspects such as the number of suppliers in the supply network, the number of ties between them, and the amount of controlling variables and processes (Adobor, 2020). The third element of the adaptive cycle, resilience, represents the system's adaptive capacity (Holling, 2001).

Resilience, potential, and connectedness vary with the transitions in the adaptive cycle. Two main transitions in the adaptive cycle concern the front and back loops. The front loop is the transition from exploitation to conservation, in which resources in the system are mostly disconnected and new connections lead to increased potential and connectedness (Adobor, 2020; Wieland, 2021). A supply network in the conservation phase is efficient but vulnerable. If a disruption exceeds the coping capability of a supply network in conservation, this causes the network to move from conservation into the release and organization phases, in which old resources and rules are released, giving space for the formation of new, innovative configurations (Fath et al., 2015; Holling, 2001).

In supply chain management, social-ecological resilience based on the adaptive cycle has been conceptually translated as the supply chain's ability to persist, adapt, and, transform (Wieland & Durach, 2021), and has been advocated as a perspective to deal with the non-linear nature of supply networks and the more frequent disruptive changes (Adobor, 2020; Wieland et al., 2023). Inspired by these conceptual works, in this thesis I adopt the resilience adaptive cycle the view of the supply network as a dynamic system and emphasize a buying firm's adaptation to changes in its supply network and external environment.

3. METHODS

This section describes the research design adopted in this thesis, starting with ontological and epistemological considerations, the research approach and method, the case, and data collection and analysis methods. Some considerations and reflections on the choice of methods are presented at the end of this section.

3.1. Research setting: industrial PhD project

The research in this thesis was conducted in the setting of an Industrial PhD project between Chalmers University of Technology and the procurement function of the focal OEM. The project idea was my initiative when a master's thesis project (for which I was the industrial supervisor) in early 2021 revealed the contrast between the lack of strategic consideration of semiconductors at the focal OEM's procurement and the increasing importance of semiconductors made evident by the semiconductor crisis, which was then in its early days.

The research started officially in January, 2022 and during almost 4.5 years I was part of the semiconductor procurement team at the focal OEM, working from the Procurement organization's office and participating in the team's daily activities. The physical placement at the Procurement organization gave me real time access to issues faced by the procurement teams, the possibility to discuss ideas, verify events, present findings and listen to questions. For example, it is gratifying to realize how the question "How much of our supply chain shall we control?", which I heard many times in the office, converged with the research interest in control and emergence in supply networks that inspired Paper IV.

Prior to my PhD, I worked for two years as a purchaser for electronic components. This experience gave me the advantage of knowing relevant people, relevant data sources, the OEM's experience during the semiconductor crisis, and having a basic technical understanding of semiconductors and electronic components. This experience caused two distinct types of effects. On the one hand, this prior knowledge allowed me to start the investigation in each paper from a more advanced point, for example by not needing to understand the focal OEM's procurement organization, its main suppliers and the magnitude of the semiconductor crisis. On the other hand, this experience came with preconceptions and established views that I had to acknowledge and address in my research. For example, I acknowledged my previous views of why the OEMs had a weak position in the supply network that were based on my experience as a purchaser and challenged those views by interviewing informants from other OEMs and from suppliers to gain more knowledge of the phenomenon.

My connection to the focal OEM also created challenges in the data collection when suppliers' participation in the research was influenced by their interest in obtaining new business with the focal OEM or influenced by negative events in their relationship with the OEM. In such cases, it was important to make clear the neutral character of the research project and the lack of connection to business decisions. In cases when the supplier was unwilling to contribute due to the relationship with the focal OEM, the solution was to obtain other contact persons within the same company that were not affected by the business decision but still had knowledge of the investigated phenomena.

The connection between the research project and the focal OEM was kept through an industrial supervision committee. This committee contained 4 to 6 members from the focal OEM's procurement (the number varied over time due to organizational changes), including hierarchical levels from purchaser to senior vice president. Meetings in this committee took place every six to twelve months and were used for presentations of research results, discussion of implications and finding implementation possibilities as well as future research.

3.2. Ontology and epistemology

In business research, ontology and epistemology are crucial philosophical assumptions that reflect the views of researchers in their consideration of reality and how knowledge about reality can be gained (Bell et al., 2022). As Burell and Morgan (1979) argue, all researchers possess such views on the nature of the social world and how it ought to be investigated, that is, ontological and epistemological positions.

The research presented in this thesis has been characterized by a critical realist view of reality, understanding that there is a reality happening out there independent of human observation and that my role as a researcher is to devise methods to observe and capture as much of this reality as possible and necessary to ensure research rigor (Bell et al., 2022; Burell & Morgan, 1979). In my research context, this position assumes that the supply network and the interactions between firms exist, and so do the environmental influences that prompt change in the network and in the interactions between firms, even if I cannot observe them.

This position is strongly connected to the sentiment I had during my experience in the practice, which motivated me to do research: an interest to "know the truth beyond what I can see and understand based on my experience". Particularly, I have always thought that there was more to the truth than what I could see through my experience in practice and that what we (as practitioners in the automotive OEM's procurement) see from our perspective is only the part of the supply network that we control, the actions that we take towards the network, and the things that the other supply network actors convey in their interactions with us.

In line with a critical realist position, I recognize that there are limitations in the human capability to objectively measure and observe, as proposed in the critical realist approach (Bhaskar, 1975). Using the three domains of the critical realist approach in my research context (Bhaskar & Hartwig, 2016), my view assumes that there are real, objective mechanisms (the domain of *Real*) that characterize buying firms' interaction with their external environment and influence their procurement adaptability. These mechanisms manifest through events (the domain of *Actual*) that may or may not be recognized by all the social actors in the system. My critical realist position allowed to acknowledge this limitation of the human observation while still recognizing the need to obtain evidence (the domain of *Empirical*) of these events.

My critical realist position was reflected in my methodological choices in the papers, through the use of multiple data sources and data triangulation, additional data validation to verify data from interviews, and data collection procedures that combined several steps of data collection to allow gradual identification of the events, objects and structures behind the phenomena under investigation in each study (Easton, 2010).

In my research context, it is important to recognize the investigated phenomena are influenced by people's views, motivations, and interpretations of events (e.g., supplier selection decisions, reactions to supply chain risks, and supplier relationship management). This entails that investigating and explaining these phenomena requires understanding their motivations, interpretations and meanings. While this might seem to lean towards interpretivism, I do not see that it shapes me as an interpretivist. Rather, I still see that reality is objective, as phenomena in the supply network happen independent of my observation. However, subject aspects of people's views, motivations, and interpretations influence the events (such as decisions, interfirm interactions, material and information flows) that are part of the *actual* domain of reality. Therefore, devising ways to explore the meanings and motivations related to these interactions is a way for me as a researcher to obtain evidence (i.e., in the *empirical* domain) to understand and explain these events. Thus, recognizing the importance of people's views of the empirical context helped me to devise better ways to capture informants' meanings and motivations to explain the phenomena that I aimed to observe, understand, and explain.

In addition, my own views of the supply network and the investigated phenomena were shaped by my experience in practice. Having pre-shaped views and at the same time wishing to go beyond these views influenced my relation to the empirical context of my research. On the one hand, I was part of the empirical context, possessed experience of previous events, and participated in decisions that shaped events in that context. On the other hand, I was a researcher, wishing to observe the empirical context as if I were looking at it from the outside. To address this conflict, I often made a mental exercise to reflect on how I would approach my research had I known nothing about the context. However, I often realized that that was not possible and not even desirable, because my previous experience allowed me to critically assess information and data I collected. For example, in some occasions I received information that contradicted my own experience of events, as if the informant claimed to have taken action X, but I was part of the event and saw that action Y was taken. I would describe my reasoning process in such circumstances as first letting the practitioner experience step in and inform my interpretation of the topic being discussed. The second step was to regain a researcher perspective and ask myself some questions as a distant observer:

a. What is it that actually happened? How can I find out more about the event?
b. What if the informant really sees from their perspective that they did X? How can I understand their perspective better? Does it reveal a gap in the informant's knowledge or a difference in interpretation that is relevant to my phenomenon of interest?
c. What if there is more to this event than what I know about it?
d. And if they know that they did Y, what motivates them to say that they did X? What is their underlying motivation and could this motivation be relevant to my phenomenon of interest?

The questions in points a) and c) relate to how I used my previous experience to inform my quest to better understand the phenomena of interest. The questions in points b) and d) relate to how I treated informants' meanings, interpretations of events, and motivations. As I study a social context, I consider that meanings, motivations, and interpretations are factors that shape how people make decisions, build relationships, and interact with others in the supply network.

As such, understanding these factors is an essential part of explaining phenomena in the supply network. For example, understanding the reasons for early semiconductor supplier selection (e.g., in the late 1990' and early 2000's) was important to explain how these decisions shaped the supply network structure in Paper I. Similarly, understanding procurement practitioners' intentions behind supply disruptions measures was important to explain the measures' contribution to resilience in Paper III (e.g., persistence, adaptation or transformation).

That is why I identified well with the critical realist view and with its separation of the real, actual, and empirical domains. It resonated with my view that there was likely more to the phenomena than what I could see and, as a researcher, my role was to devise ways that would allow me to observe and make sense of these phenomena.

One example of the influence of my critical realist view is present in paper I, in which the investigation of historical phenomena back to 1996 raised challenges, such as the risk of interviewees misremembering events and finding reliable data sources. My co-authors and I acknowledged the limitations in observing these events to gain knowledge about the studied phenomena. This prompted further reflection and the collection and triangulation of different types of data, in which interview data was verified through news articles and internal documents, internal documents were verified and further clarified in interviews, and preliminary findings were validated with employees of the focal OEM.

3.3. Research approach

Connected to the empirical context in which the research project originated (especially the lack of knowledge about semiconductors) and the theoretical gap about how a buying firm could enhance its procurement adaptability, the present thesis adopted a predominantly qualitative exploratory research approach. This background aligns with the purpose and motivation of an exploratory research approach: to generate knowledge and enhance our understanding of a topic about which there is little scientific knowledge but there is a reason to explore it (Stebbins, 2001). A qualitative research approach is appropriate for generating new knowledge, especially when placed in the natural settings of organizations (Bluhm et al., 2011).

As defined by Ketokivi and Choi (2014), qualitative research addresses the meaning and interpretation of concepts in their specific context of inquiry. A qualitative research approach allowed the exploration of the meanings and implications of the investigated phenomena within their empirical context. For example, the use of different types of qualitative data enabled proximity to aspects such as the reasons behind decisions and actors' motivation, which would not have been possible through quantitative approaches.

The only exception to the overall qualitative approach is the use of SNA metrics in Paper I, in which SNA provided quantitative metrics to observe the supply network evolution and explain its characteristics on network and node levels and their implications for procurement.

The purpose of my doctoral research project was addressed through four studies and each study resulted in one paper. In particular due to the exploratory character of the research, these studies were not planned from the beginning of the project, but were rather empirically guided by the findings of the earlier papers and further questions that they posed.

Sections 3.3.1 and 3.3.2 provide more details on the timing and my contribution to each of the papers as well as their connection to theory.

3.3.1. Research process and my contribution to the papers

The timeline of the research process is summarized in Figure 5.

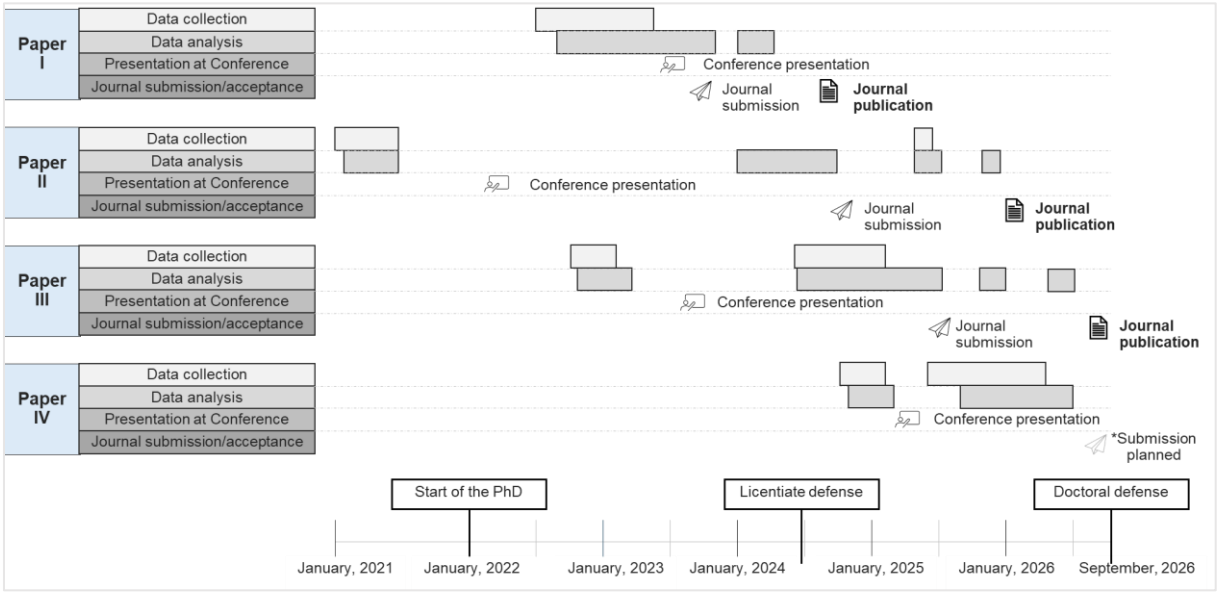


Figure 5: Timeline of the research process.

Papers I and II constitute the more exploratory part of this thesis, connected to the need to better understand the supply network that motivated my project. Chronologically, the study for Paper II was the first one to be conducted and data collection started during the first months of the semiconductor crisis (January–May, 2021). The identification of relevant problems, supply network actors and data sources was strongly informed by the ongoing crisis in its early phase.

In the study for Paper II, I contributed to the definition of the practical problem and identification of relevant interview informants, and collected secondary data; part of the data analysis; part of the writing of the methods and findings sections, and review of the final paper during the peer review process. My supervisor Ala was the main author of this paper and submitted it to a special issue of Industrial Marketing Management that focused on power dynamics.

The early findings of Paper II on the OEMs' weak power position in the supply network, as presented at the IPSERA conference in April 2022, raised questions about what led to such a position. These questions motivated the historical investigation of the supply network evolution in the period 1996-2023 that resulted in Paper I (data collection and analysis took place between September, 2022 and March, 2024). Even though the research for Paper I started later, it is presented here in this thesis as the first paper due to its historical character, telling the story of the supply network evolution in the period prior to the power dynamics observed in Paper II. I had a leading researcher role in this paper, from conceptualization, through data collection and analysis, writing, and peer review process. The paper was submitted to the NOFOMA conference, which was selected due to the opportunity to receive detailed feedback in the peer review process. The paper presented at the NOFOMA conference in 2023 was invited for

submission to the IJPDLM special issue for the conference, to which it was later accepted. Both the conference and journal submissions were decided among the authorship team.

For Paper III, data collection and analysis took place between November, 2022 and December, 2025. Paper III built on the findings of Papers I and II to explore how the focal OEM counteracted the weak power position and unfavorable supply network structure it faced. This was done by investigating the disruption response measures adopted by the focal OEM's procurement during the semiconductor crisis. I had a leading researcher role in this paper, from conceptualization, through data collection and analysis, writing, and in the peer review process. This paper was intended for the IPSERA Conference and the Journal of Purchasing and Supply Management (both in the PSM field) since the beginning of the research, due to its focus on procurement measures and the role of procurement during a crisis. The paper was presented at IPSERA 2023 and accepted for journal publication in July, 2026.

Finally, Paper IV addresses a problem identified by Paper I: the level of control exercised by OEMs in contrast to the emergence of supply network structures. Paper I showed negative implications of emergent structures that were not known the OEMs before the crisis, but the exploration of these emergent structures and the OEMs' control was beyond the scope of Paper I. Thus, research is ongoing to address the question of how much control and emergence a buying firm shall exercise in its supply network, which will be published in Paper IV. Also in this paper, I had a leading researcher role from conceptualization, through data collection and analysis, writing, and peer review process during conference submissions. The intended outlet for this paper is a journal in the operations management field, due to its focus on the interactions and transactions in the supply network and the connection to the theory on supply networks as complex adaptive systems that has been historically published in this journal.

3.3.2. Connection between research approach and contribution to theory

The research presented in this thesis addressed theory generation and theory elaboration to varying levels in each paper. Figure 6 presents an overview of the interaction between theory and the empirical context that shaped each paper's contribution to theory (Ketokivi & Choi, 2014). In the figure, the thickness of the arrows represents the relative balance between theory and empirical data.

In Paper I, the departing point of the research was a practical question about how the studied supply network had evolved into the structure it had at the beginning of the semiconductor crisis. Theoretically, existing literature had addressed conceptually (Borgatti & Li, 2009) and empirically (Choi & Hong, 2002; Kim et al., 2011) the implications of the supply network structure and node characteristics for the firms in the network. SNA was used to provide the lens, metrics, and concepts to understand the supply network evolution.

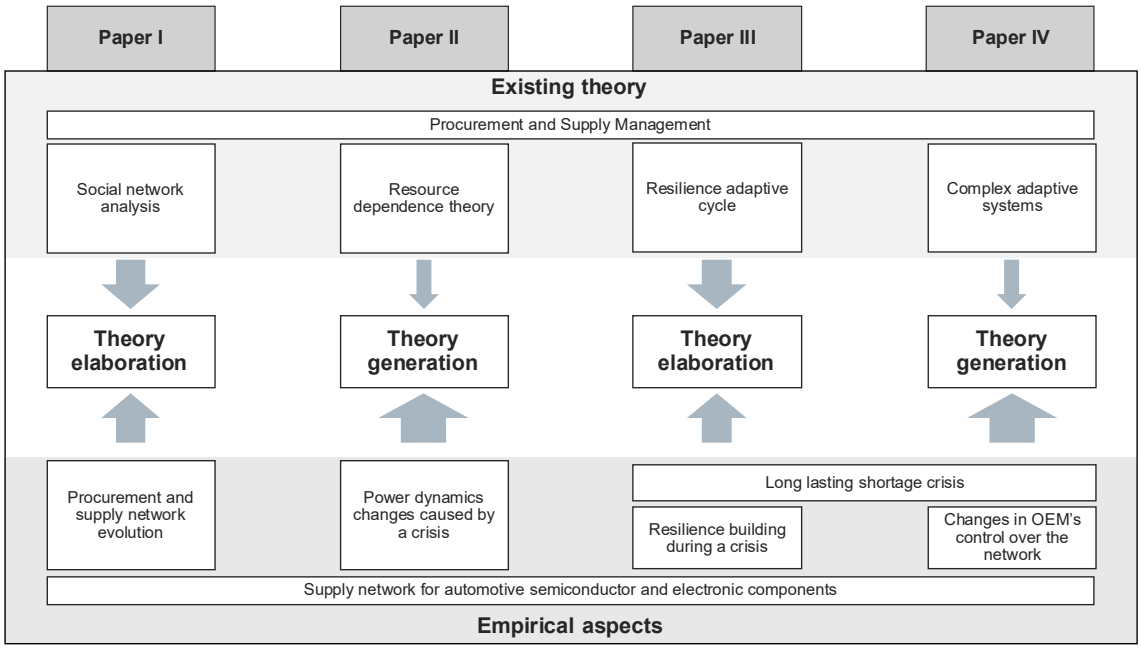


Figure 6: Interaction between theory and empirical context in each paper in this thesis. Source: adapted from Ketokivi and Choi (2014).

Paper I contributed with elaboration of the theory in Procurement and Supply Management by revealing a longitudinal account of the implications of procurement focus on the supply network structure and vice-versa. One limitation of the use of SNA is the need for large networks for the metrics to be calculated, which was not possible due to the lack of data from the focal OEM. To address this limitation, the scope of the network analyzed (the ego network) was limited to the suppliers for the most important electronic components and the most important type of semiconductor component, based on empirical evidence that emphasized the relevance of these components. This delimitation of the scope of the studied network was decided on after consultations with a researcher with long experience in the use of SNA in a course I attended and with other SNA scholars to make sure the studied network was relevant and representative. Further addressing this limitation, qualitative data from the interviews was used to validate the findings from the analysis of SNA metrics. This also provided a contribution to the SNA theory by showing how contextual data can aid the analysis of SNA metrics.

Paper II had as its main aim to generate knowledge on the power shifts caused by high-impact supply disruptions. Empirically, this aim was motivated by the perceived OEMs' lack of power in the supply network, despite their traditionally strong power position. While previous literature had shown the appropriateness of RDT as a theoretical lens to understand the implications of power in procurement settings (Caniëls & Gelderman, 2007; Kähkönen & Virolainen, 2011; Pazirandeh & Norrman, 2014), this shift caused by a supply disruption revealed a new facet of these implications. Thus, RDT was used to provide the theoretical lens and concepts such as sources of power and strategies to manage power in the network.

Paper II contributed with theory generation on the implications of disruption-driven power shifts for procurement. The investigation of power dynamics on different levels of analysis (micro, meso, and macro) was an important step that extended the understanding of a buying

firm's power position from the dyadic buyer-supplier relationships to a view that considers the supply network and the overall business environment.

A major shift in the research approach took place in the study for Paper III. Empirically, the question "how can procurement build resilience?" is often asked in practice and motivated my interest. Theoretically, research on the role of procurement to build resilience had largely contributed to an engineering-based view of resilience (Jüttner & Maklan, 2011; Pereira et al., 2020; Pettit et al., 2010), with a few exceptions (e.g., Küffner et al., 2022; Vega et al., 2022). The social-ecological resilience view caught my attention for its focus on long-term resilience and continuous adaptation to environmental shifts (Carpenter et al., 2001; Walker et al., 2004; Wieland & Durach, 2021), but an empirical exploration of this view was missing. Therefore, departing from a theoretical background of well-studied procurement practices to build engineering-based resilience on the one side and a rising debate on social-ecological resilience in supply network contexts on the other, Paper III intended to build on these two existing streams of literature to elaborate theory on the role of procurement to build resilience from a social-ecological view of resilience. As presented in Figure 6, this contribution was also possible due to the in-depth exploration of the empirical context through the use of several types of data that ensured contextual richness needed for the application of social-ecological resilience concepts.

Finally, Complex Adaptive Systems theory was selected for Paper IV because it directly connects to concepts of emergence and control in supply networks (Choi et al., 2001; Nair & Reed-Tsochas, 2019). However, one limitation of this theory is the lack of detail in the definitions of emergence and control, how they take place in practice and how firms shall go about devising strategies to balance them. Thus, the paper adopts the loosely defined concepts of emergence and control, to investigate changes in control patterns by a buying firm through interactions in the network. In this study, the empirical context of the semiconductor crisis provided rich contextual account of changes in the interactions between firms in the network as the crisis forced the focal OEM to adjust its priority between suppliers as supply constraints from each supplier dynamically changed over time.

For Paper IV, the lack of more detailed definitions of emergence and control in the theory generate several questions about how to analyze and code the data. Questions such as "how do we know that this interaction is really a form of control?" or "how do we define more control or less control?" have been common in the data analysis process. This has prompted the need for structured data analysis procedures and building a trail of evidence in the data structure that makes the analysis of emergence and control transparent. As a result, the identification of how emergence and control take place in a real life supply network setting is expected to contribute with generation of new theory for the literature on supply networks as complex adaptive systems and on the adjustment of control amidst environmental shifts.

3.4. Case study method in my research

This section addresses the use of the case study method in my research. It addresses the choice of case study as an appropriate method for my research approach, context, and questions as well as its implementation through data collection and analysis.

In my doctoral research project, the case study method was adopted as the overall method throughout my research and also for the individual papers. From the start of my research project, case study was a strong candidate among research methods for my research due to its fit with my research approach: it explores contemporary phenomena in their context (Halinen & Törnroos, 2005) as well as historical phenomena (Wieland et al., 2024), it leverages contextual richness (Piekkari & Welch, 2018), and it is appropriate to investigate questions of "how" and "why" (Yin, 2018).

During my research project, I have come in contact with several definitions or even traditions of case study research and have always felt some discomfort when trying to identify with any of those traditions. Rather, I have reflected on and applied elements of these traditions in my research. My use of the case study was guided from the beginning by a positivistic view, for example in the role of explanations and the importance of case study protocols (Yin, 2018) and the aim to build theory through a structured process for case research (Eisenhardt, 1989). However, as I progressed in my research education and understood the differences between the types of case study proposed by Yin and Eisenhardt, I also identified conflicts between their descriptions of an ideal case study and my own views on epistemology, such as Yin's rigid use of theory and Eisenhardt's focus on multiple cases and replication. In this process, my view of case study research was influenced by reviews of the case study method that go beyond the positivistic view and argue for diversity in case research, such as Ketokivi and Choi (2014) and Piekkari and Welch (2018). Furthermore, my research is aligned with a critical realist view of case research, highlighting the strength of single cases to explore causal relationships through iteration and combination of multiple data sources (Easton, 2010). This use of multiple data sources reflects a critical realist view of a researcher's ability to observe phenomena, which highlights the importance of the researcher's strategy to interact with the empirical context and obtain relevant data in several iterations.

Despite the fitting characteristics of the case study method, I have explored other methods in my research. During courses such as "Research in Technology Managements and Economics" (an introductory course in my department at Chalmers) and "Qualitative Research Methods", I developed great interest in Action Research and the Delphi method. I became interested in Action Research due to the possibility to combine academic contribution and practical relevance (Alfaro-Tanco et al., 2021) and to execute rigorous interventions in the empirical context (Näslund et al., 2010). I still plan to use Action Research in a future study, for example for the implementation of my research findings to other purchased products than electronics and semiconductors. Similarly, I plan to conduct a study on the capabilities needed for the procurement of automotive electronics and semiconductors in the future, for which the Delphi method is planned to be used to collect experts' input on future trends (Rowe & Wright, 1999). However, during my doctoral research project, my co-authors and I have chosen to prioritize the papers that are appended to this thesis.

3.5. Case selection and description

In this thesis, following the purpose to generate knowledge on how a buying firm can enhance its procurement adaptability, the selected case is the focal OEM, a leading European commercial vehicle manufacturer. More specifically, within the focal OEM, this thesis

investigates the adaptability in the procurement of semiconductors and electronics. Conversely, the empirical context refers to the context in which the case firm is immersed: the focal OEM's supply network for electronics and semiconductors. Besides the focal OEM, this empirical context includes Tier-1 suppliers, electronics manufacturing service (EMS) companies, semiconductor suppliers, authorized distributors, other OEMs that share the same suppliers and the external environment that influences the supply network. While the cases across each individual paper varied, they were all selected within this empirical context.

In the studied supply network, OEMs develop, manufacture, and provide services for commercial and passenger vehicles. They outsource the development and production of most components used in their products, including electronic components (e.g., electronic control units, sensors and actuators). Electronic control units (ECUs) are electronic devices programmed to control a certain function of a vehicle, such as lights, engine, or stability control. The development and manufacturing of electronics are outsourced, and typically every electronic component has only one Tier 1 supplier, because high development costs make multisource financially unfeasible. Each electronic component can contain up to 1000 subcomponents, including semiconductors, passive (resistors, transistors, and others) and electromechanical (printed circuit board, screws, connectors, cables, among others) parts. The Tier 1 supplier is responsible for selecting and procuring all subcomponents needed to produce an electronic component, including semiconductors.

The focal OEM is a representative case of buying firms that were forced to adapt to environmental shifts and had the potential to be a revelatory case (Yin, 2018). In addition, the focal OEM represented a case in which the existing theories in the PSM field could not explain the challenges faced by buying firms and therefore constituted an interesting case for research (Ridder, 2017). As Dubois and Gibbert (2010) argue, a fit between theory, the case method and the phenomena must be achieved. Thus, the selected case is justified by the strategic position of procurement at the focal OEM, the complexity of the supply network, the exposure to a fast-changing environment, and the its need to adapt its procurement due to environmental shifts. The revelatory potential of the unique access to data and to experienced informants within the focal OEM and its suppliers was crucial to generate an in-depth understanding of how procurement interacts with the external environment (section 3.1 explores the advantages and limitations posed by the industrial PhD project). This unique access to data allowed data collection and analysis to happen in iterations to build a gradual understanding of events and mechanisms within the supply network (Easton, 2010).

Despite sharing the same empirical context, each paper had distinct empirical problem and research questions, which motivated the selection of different cases. In Paper I, to address the evolution of the supply network in interplay with procurement focus, the studied case was the focal OEM's supply network for semiconductors and electronics. Accordingly, data collection involved the focal OEM, two other OEMs in its holding group and actors from the semiconductor industry, in order to enhance generalizability of findings. In contrast, Paper II investigated how environmental shifts affected the power position of an OEM, and therefore had the focal OEM as the case, while the supply network was assumed as part of the analytical levels (i.e., other OEMs belonged to the micro level and suppliers belonged to the meso level).

Papers III and IV share the focal OEM as the case: a case of an OEM that had to build resilience and of an OEM that adjusted its levels of emergence and control during a crisis in Paper IV, respectively. Consequently, Paper III used data only from the focal OEM to obtain an in-depth understanding of the role of procurement to build resilience during a crisis, while Paper IV employed three sub-cases including supplier to focus on interactions with suppliers.

In sum, the case study adopted in my research is characterized by the consistency of the empirical context and the variation in the cases in each paper. This methodological variety sets the limits of its generalizability of this thesis's findings to other contexts with similar characteristics of a complex supply network and fast changes in the external environment.

3.6. Data sampling and collection

The research in this thesis employed a variety of data sources, depending on the nature of the empirical problem, aim and research questions addressed in each paper. Using the focal OEM's semiconductor and electronics supply network as the empirical context throughout the thesis, different network actors were included in the data collection in each paper.

Table 2 presents an overview of the data sources of each paper.

Table 2: Overview of data sources and data collected in each paper.

	Paper I	**Paper II**	**Paper III**	**Paper IV**
Empirical motivation	Causes of the buying firm's weak position in the supply network	A buying firm's lack of power to secure supply in a crisis	A buying firm's need to build resilience during a crisis	A buying firm's difficulty to define what to control in the supply network
Companies included in the data collection	Three OEMs One semiconductor supplier Semiconductor industry experts	Three OEMs Three Tier 1 suppliers Independent distributors External market experts	The Focal OEM	*The supply chains for three ECUs:* The Focal OEM Three Tier 1 suppliers Three semiconductor suppliers One EMS company
Collected data * Additionally, 3 interviews from Paper I were used in Paper II ** Additionally, 20 interviews from Paper II were used in Paper III	19 interviews Focal OEM's E/E architecture drawings and supplier lists 15 news articles	20 interviews* 14 internal documents (5 presentations; 2 emails; 2 process descriptions; 1 supplier contract; 2 supplier and parts lists; 2 letters to suppliers and policy makers)	Participatory observation 3 interviews** 167 taskforce reports 23 internal documents (13 process documents; 8 emails; 1 meeting report and 1 presentation)	13 interviews 36 internal documents from the Focal OEM 10 supplier contracts and agreements 22 meetings with suppliers 6 emails 3 price offers and 3 technical presentations

A common characteristic of my research is the iteration between interviews and internal documents from the OEM. For example, in Paper I, interviews were used to build an understanding of the motivations behind the OEMs' procurement focus, while internal documents such as E/E architecture drawings and supplier lists were used to map the evolution

of the supply network and validate interview data. In contract, in Paper III internal documents were the main source of data, including taskforce reports and internal presentations, while interviews were used for data validation and complementation.

In total, 73 internal documents were collected and 55 interviews were conducted across the four studies. Out of those, 31 interviews were conducted with the focal OEM for all four papers, of which 11 were for paper I, 11 were for Paper II, three were for Paper III, and six were for paper IV. In addition, five Tier 1 suppliers, two semiconductor suppliers, two independent distributors, and five market/industry experts were interviewed.

The study design of each paper relied more or less on the use of each data source type depending on the aims and problems addressed by each paper. In this regard, the participation in daily business of the focal OEM's procurement organization gave me the opportunity to identify events, involved people, documents, and what possibilities were available for research to obtain and use data. For example, in Paper I, the exploratory character of the study benefited from identifying experts with 20+ years of experience at the focal OEM who could provide broad accounts of the evolution of procurement focus in the 27-year period. Similarly, for Paper III, my participation in the crisis taskforce at the focal OEM made me aware of the existence of the taskforce reports published throughout the crisis. Upon discussion with my co-authors, we agreed that these reports were a better source of detailed evidence of the measures adopted by the OEM's procurement than any interview could be. Therefore, the data collection procedure for each paper explored the strengths of the available data as it identified what types of information were most appropriate for each study's aim.

Paper I used a mix of data sources to ensure the validity of its retrospective perspective. Two other OEMs in the same holding group as the focal OEM were added to the data sampling to increase the validity of our understanding of the phenomena that took place in the considered time span. Interviews with individuals from the three OEMs were intended to identify their procurement focus during the studied period, while secondary data such as news articles, network maps, and supplier lists were used to validate and complete the historical view. In addition, interviews with one semiconductor supplier and two experts in the supply network were aimed at considering the external perspective in the study.

In Paper II, the data collection gathered perspectives on the OEMs' power position in the supply network and the power shifts that were caused by the semiconductor crisis. To ensure these perspectives, data were collected through interviews with informants from three automotive OEMs and Tier 1 suppliers to those OEMs to ensure a supplier perspective in this paper. The lack of semiconductor suppliers in the data sampling reflects the lack of access to semiconductor suppliers during this phase of data collection (January–May 2021).

Paper III used the focal OEM's internal process descriptions and crisis taskforce reports generated during the semiconductor process to identify measures adopted by the focal OEM's procurement to secure component supply of semiconductors and electronics. This data was complemented by internal documents such as emails, meeting invitations, minutes of meetings and purchasing orders obtained through my participatory observation. Finally, the data was validated through interviews with the three main employees involved in the measures adopted by the focal OEM before and during the crisis.

Finally, Paper IV first used the focal OEM's internal documents to obtain a first map of changes in emergence and control towards three Tier 2 suppliers before, during, and after the crisis. Furthermore, data from further documents and from interviews with members of the focal OEM's procurement, three Tier 1 suppliers, and two Tier 2 suppliers are being analyzed to further delineate the emergence and control that were identified in the internal documents.

3.7. Data analysis

Table 3 shows the data analysis techniques and conceptual codes used in each of the papers.

Table 3: Overview of data analysis techniques and conceptual codes used in each paper.

	Paper I	**Paper II**	**Paper III**	**Paper IV**
Studied phenomena	Co-evolution procurement focus ⇔ supply network structure	Power distribution shifts during a crisis	Procurement contribution to resilience during a crisis	Changes in emergence and control due to environmental shifts
Procurement-related concepts	Procurement objectives: supply, cost, and innovation	Strategies to improve power position	Procurement measures to build resilience	Procurement objectives: supply, cost, and innovation
Theoretical perspective	Social Network Analysis	Resource Dependence Theory	Resilience adaptive cycle	Supply networks as complex adaptive systems
Supporting concepts adopted	Network size, density and centralization Node centrality (degree, closeness and betweenness)	Sources of power, power position of a buying firm; power imbalances; power distribution shifts	Persistence, adaptation and transformation Potential and connectedness	Emergence and control Supply network cognizance
Main data analysis techniques	Inductive open coding and pattern coding of interviews using Nvivo and an Excel table Calculation of SNA metrics using SNA software Pajek	Timeline of case events Pattern coding of sources of power Display in mega matrices and grouping of similar codes	Multi-stage data coding in Excel table Categorization of procurement measures Analysis of changes in potential and connectedness	Within-case analysis of internal documents and interviews in an Excel table Cross-case analysis of modes of change in control and emergence
Main analysis codes	Procurement focus, supply network structure, external and internal environments	Sources of power Procurement strategies to improve power position	Procurement disruption response measures Persistence, Adaptation, Transformation Potential Connectedness	Emergence Control Interactions in the supply network Modes of change in emergence and control

The table shows that a common characteristic of the data analysis across the papers was the use of open coding techniques to code the qualitative data from interviews and internal documents. This open coding was done using Excel tables that organized the data from interviews and internal documents to allow the identification of the analysis codes (only Paper

II did not use an Excel table in the coding procedure). However, these tables were used in different ways: in Paper I, interviews were first inductively using NVivo software and only later all quotes were transferred to an Excel table to be matched with the analysis codes; in Paper III, an Excel table was used from the beginning to gather all taskforce reports and several columns were used to match each report with the analysis codes; and in Paper IV, an Excel table was first used as a catalogue of all collected documents and later used to code interviews and internal documents based on the analysis codes. The common use of Excel tables across the papers reflects my preference as a researcher to have a data structure to code qualitative data. This is a preference that I have developed during my doctoral research and used to a larger extent in the later studies, also due to the knowledge of the empirical context at the beginning of each study. For example, in Paper I it was only possible to develop a data structure after the three first expert interviews and the first round of data analysis that identified the main themes in the data and relevant concepts from the literature. Conversely, in Paper IV an analytical structure was already used in the first phase of coding of internal documents and then expanded for the coding of interviews.

3.7.1. Data analysis in the papers

In Paper I, the data analysis was divided into three phases, allowing iterations between the theoretical background and empirical observations to elaborate upon theory (Dubois & Gibbert, 2010). This included two phases of open coding and pattern coding (Eisenhardt, 2021) of interviews and secondary data, the representation of supply network maps and the calculation of supply SNA metrics using the software Pajek (De Nooy et al., 2018), and the analysis of node centrality as well as network centralization and complexity (Kim et al., 2011). After the codes from the first analysis phases were matched with the relevant concepts from the literature, observations were once again coded to identify the interaction between procurement focus, supply network structure, and external and internal environmental factors. Similar instances of interaction were grouped into categories (Schreier, 2014).

In Paper II, pattern coding (Eisenhardt, 2021) was used to identify sources of power (based on a combination of sources of power and as perceived by the respondents), and the impact of procurement strategies on the OEM's power position. The analyses were shared with the case representatives for feedback and input and to increase the validity of the findings. Codes from pattern coding were displayed in mega matrices and grouped into themes.

In Paper III, data from the focal OEM's taskforce process descriptions was coded to identify measures adopted by the focal OEM's procurement. This initial list of measures was validated through validation interviews (Pawson, 1996) and used as a basis to code taskforce reports. Additional procurement measures named by the informants during and after the validation interviews were included in the list of measures. The taskforce reports were coded in an Excel file in which each report was analyzed to identify what measures were reported, along with contextual aspects such as involved network actors, motivation, purpose, timing and related environmental uncertainties. These measures were analyzed for their contribution to resilience through changes in potential and connectedness as well as their contribution to the system's ability to persist, adapt, and transform. Additional documents such as emails and internal presentations were used to complement and validate the data from the other sources.

In Paper IV, all transcripts, reports, notes, and presentations were compiled in a spreadsheet and used to map the interactions between the actors in each supply chain (OEM, Tier 1 supplier and semiconductor supplier). The data was first analyzed within-case by coding the interactions between the actors and developing maps of the interactions within each supply chain and each period (before, during, and after crisis). Each interaction was coded into either control (if the interaction showed the OEM's attempt to exert control over the network) or emergence (if the interaction represented the emergence of interactions beyond the OEM's control). The analysis also revealed interactions that increased the OEM's visibility into the supply network but did not increase the OEM's control, and these actions were also coded as "visibility". The maps for each supply chain and period were used to build timelines of the evolution of emergence and control in each supply chain (for an example, see Figure 8 or see Paper IV for more details). These timelines were used to identify patterns in the evolution of emergence and control through cross-case comparison and to identify how the post-crisis levels of emergence and control relate to the interactions in the network in the previous periods.

3.7.2. Data analysis in the thesis

For this thesis, the analysis used the findings from each of the four papers to answer the thesis's research questions. To answer RQ1, the findings from Papers I and II were analyzed to identify how supply network characteristics affect each aspect of adaptability (learning, combining experience and knowledge, response adjustment, and continuous development). To answer RQ2, the findings from Papers III and IV were used to analyze how a buying firm enhances adaptability through each of its aspects. Similar to the papers, in the data analysis for the thesis I used an Excel table to structure the coding and matching of the papers findings with the four aspects of adaptability, following the steps described in Table 4. The coding used the definitions of each aspect of adaptability that are provided in Figure 2.

Table 4: Data analysis structure to answer the thesis's research questions.

Analysis step	RQ1		RQ2	
	Paper I	Paper II	Paper III	Paper IV
Step 1	Review paper findings List implications of SNA metrics for each aspect of adaptability	Review paper findings List implications of power dynamics for each aspect of adaptability	Review paper findings List implications of measures for each aspect of adaptability	Review paper findings List implications of each mode of change for each aspect of adaptability
Step 2	Group implications by type of SNA metric	Group implications by aspect of power dynamics	Group implications by type of measure	Group modes with similar types of implications
Step 3	Synthesize implications for each aspect of adaptability	Synthesize implications for each aspect of adaptability	Synthesize implications for each aspect of adaptability	Synthesize implications for each aspect of adaptability
Step 4	Organize implications per network characteristic and for each aspect of adaptability (see Table 6)		Organize implications per measure and mode and per aspect of adaptability (see Table 7)	

3.8. Reflection on methodological quality and ethical considerations

In this section, I present my reflections on the quality and ethical considerations of my research. Quality considerations follow the assessment of trustworthiness, for which my reflections are based on the works of Guba (1981), and Lincoln and Guba (1985) that define criteria such as credibility, transferability, dependability, and confirmability and on the reflections by Pratt et al. (2020) on transparency as a criterion for trustworthiness.

Credibility is the extent to which the findings reliably and accurately account the experiences of informants and the investigated phenomenon. In my research, this was addressed through the collection of different types of data from several actors in the network, including multiple OEMs, Tier 1 and semiconductor suppliers and even external actors such as market experts. In addition, to address the limitations in informants' accounts of events in the distant past, different data sources such as archival documents and news articles were used, together with triangulation between sources and validation of findings through validation interviews.

Transferability questions whether the findings can be applied to other contexts. In the present thesis, the in-depth character of the investigation risks compromising the generalizability of the findings. As suggested in Lincoln and Guba (1985), the assessment of transferability relies on thick descriptions to show the reader the findings and give the reader the possibility to compare the findings with other contexts (Pratt et al., 2020). For this purpose, each paper and this thesis identify the contextual factors that delimitate the transferability of findings to other contexts. For example, in this thesis, environmental shifts, the frequency of disruptions, and the strategic role of procurement are essential factors to qualify the transfer of the findings to another context. In addition, the transferability of findings has been discussed and reflected on through their implementation in practice at the focal OEM. These implementation initiatives have shown that some of the findings are specific to electronics and semiconductors, such as high speed of innovation and the capital intensity of semiconductors productors. However, other findings are applicable to most parts of procurement, such as Tier 1-centric supply networks and the need to map the supply network and power dependences.

Dependability refers to the consistency of the data, especially across time. In this regard, dependability was ensured through the detailed description of the research methods, the creation of data structure overviews to ensure alignment between purpose, research questions and data collection and analysis within each paper, followed by continuous review of data collection and analysis in the research teams involved in each study.

Finally, confirmability refers to the use of a process to verify the data and ensure that the findings reflect the data and participants' views rather than the researcher's (Pratt et al., 2020). In my research, my direct involvement in the procurement function of the focal OEM (see sections 3.1 and 3.2 for more details) created an ever bigger need for transparency of methods and of how the raw data and participants' views were analyzed. This need was addressed through triangulation between data sources, data validation, and repeated exchanges with the participants to ensure accuracy of interpretations. As encouraged by Easterby-Smith et al. (2008), these procedures focused on ensuring accuracy of informants' views through close engagement with the empirical context rather than through independence from the phenomena.

Besides quality of research, ethical considerations are important to ensure research objectivity, as ethical transgressions can lead to erroneous or biased research (Shamoo & Resnik, 2022). In the present thesis, especially given its close connection with industry and the author's dual role as researcher and practitioner, the following main issues arise: conflict of interest, bias, continuous consent in interviews and potential to harm people. As Shamoo and Resnik (2022) argue, education and mentoring are the two main strategies to prevent ethical misconduct and this has been applied through courses in research ethics and research methods, as well as through the mentoring in the PhD research project. Further reflections on each of identified issues are presented in the next paragraphs.

Regarding bias and conflict of interest, many questions and findings in the present thesis are connected to my previous and current positions at the focal OEM. As the research findings could have interpretations of whether past strategies and decisions were "right", this can create conflicts of interest and affect scientific objectivity (Shamoo & Resnik, 2022) and bias based on my previous experience. The first step in addressing this issue has been the awareness to recognize it and reflect on it. My motivation to develop research is a general interest in developing knowledge and learn from past experiences, no matter if that reveals past wrong decisions. Moreover, objectivity of the research questions, methods and findings has been guaranteed through open discussions with the academic supervisors and in an industrial supervision committee within the focal OEM (see section 6 for more details). This follows the rule from the Swedish Research Council (2017, p. 10) to "openly account for my interests and other associations".

Similarly, the use of interviews as the main data collection technique requires consent of interviewees for the use of information they provide (Allmark et al., 2009). An important step taken in every interview was to inform at the beginning of interviews about how the data will be used and ask for consent for recording and transcribing. However, Allmark et al. (2009) highlight that as interviewees start reporting on historical events, they might reveal more details than they had intended at the beginning of the interview. To deal with this issue, interviewees were asked during and after the interviews whether there was any sensitive information that would require confidential treatment. For content identified as sensitive, interviewees and a point of contact within the company were asked to review the data before publication in papers.

Finally, the research of past events and decisions comes with the risk of harm to the reputation of people involved in those events. In line with the rule from the Swedish Research Council (2017, p. 10) to "strive to conduct my research without doing harm to people, animals or the environment", this concern has been actively dealt with through clear communication of research aim: to develop knowledge and understanding for the future, and not to revisit questions such as what should have been done in the past. Interview questions and presentations have been phrased accordingly to prevent harm to people who have been involved in the investigated phenomena.

4. FINDINGS

This section presents the findings of the research in my PhD project, both from each individual paper and their connection to this thesis. To this purpose, section 4.1 presents a brief overview of how the findings from each paper are applied to this thesis. Subsections 4.1.1 to 4.1.4 present more details on the findings of each paper.

4.1. Summary of findings from the appended papers in regards to the thesis's research questions

To explore how supply network characteristics influence procurement adaptability, the findings from Papers I and II are the foundation of this exploration. These findings show how characteristics such as low network density, low node closeness centrality, and dependence on the knowledge of suppliers contributed to the focal OEM's lack of knowledge of the supply network and hindered its ability to recognize shifts in the external environment. Based on these findings, this thesis also explores what characteristics can help a buying firm to reverse that problem.

The findings of Papers III and IV are the foundation of this thesis's contribution to understanding how a buying firm can enhance its procurement adaptability. They show how the buying firm learns, adjusts responses, combines experience and knowledge, and continuously develops its procurement to adapt to shifts in the external business environment. Particularly, Paper III shows how a buying firm enhances its procurement adaptability through measures to build resilience during a crisis that exceeds its disruption preparedness. Further, Paper IV shows how a buying firm adapts to environmental shifts by adjusting the balance between emergence and control.

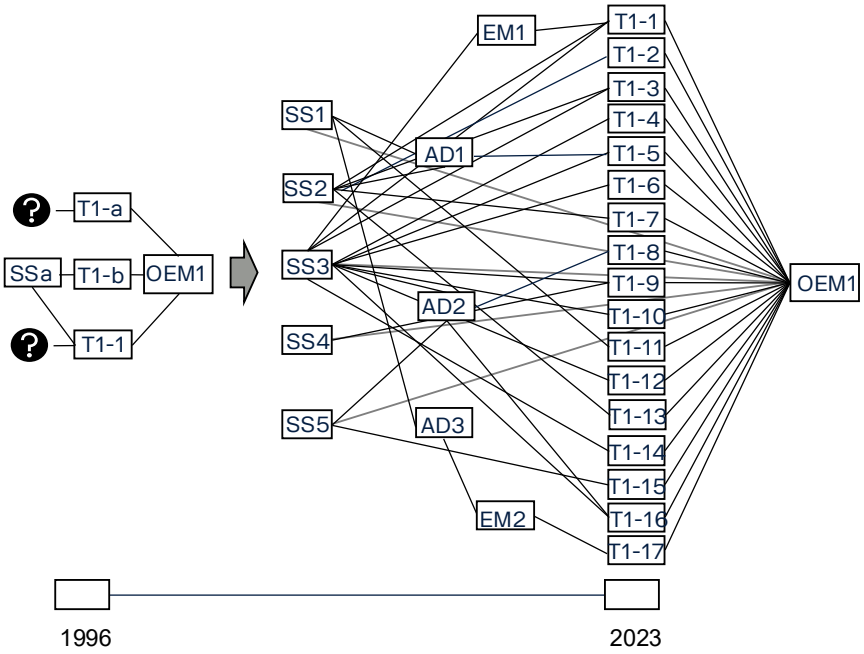
4.1.1. Coevolution of OEMs' procurement focus and supply network structure (or lack thereof)

The coevolution of procurement focus and supply network structure in the context of automotive semiconductors and electronics was marked by the following main elements: OEMs' procurement focus on cost and Tier 1 supplier relationships enforcing a Tier 1-centric supply network in the period 1996–2020; the focus on semiconductor innovation by OEMs' R&D in this period, prompting direct but informal connections with semiconductor suppliers with no procurement involvement; and a change from a previous lack of supply assurance focus in which supply was assured through Tier 1 suppliers (1996–2020) to a strong supply assurance focus in the period 2020–2023, supported by direct connections through procurement with semiconductor suppliers, and an increase in the OEMs' centrality and in the network's density.

For most of the studied period (1996–2020), OEMs' focus on cost and on Tier 1suppliers was matched by the evolution of a Tier 1-centric supply network. This was a result of the OEMs' decision to focus on relationships with Tier 1 suppliers, to focus on core competence, and to increase cost efficiency, supported by an external environment of stable supplies.

The mapping of the supply network evolution between 1996 and 2023 showed growth in network size (especially in the number of Tier 1 suppliers) because of the addition of new electronics, which increased network centralization and decreased density (see Paper I for the

SNA metrics). Despite OEMs' attempts to reduce complexity in their supply network, the SNA metrics show split results: a lower network density indicates lower network complexity, but a larger network size indicates greater network complexity. Figure 7 illustrates this evolution of the supply network through maps of the network in 1996 and 2023. The evolution of a hub-centric network is further supported by the decreasing closeness centrality of the OEMs (representing greater distance to all actors beyond Tier 1 suppliers in the network) despite their increasing degree centrality (i.e., increasing number of direct connections with Tier 1 suppliers).



(?): The supplier could not be identified
SS: Semiconductor Supplier; AD: Authorized Distributor;
EMS: Electronics Manufacturing Services; T1: Tier 1 supplier

Figure 7: Maps of an OEM's supply network for electronics and semiconductors in 1996 and 2023.

The analysis of the network maps, together with data from interviews, showed that Tier 1 suppliers maintained a central position over the years in controlling information flows, supplies and coordinating innovation in the supply network, especially until 2020. Relying on Tier 1 suppliers to this extent prevented OEMs from developing technical and market knowledge about semiconductors and approaches to secure semiconductor supply.

The long-lasting match between the OEMs' cost focus and a cost-efficient Tier 1-centric supply network was opposed by a mismatch with the procurement objectives of supply and innovation. First, when OEMs decided to increase their control over the software used in their vehicles but innovation could not be obtained in a timely manner from Tier 1 suppliers, OEMs' R&D departments established informal but direct contacts with semiconductor suppliers in the late 1990s and early 2000s. These direct contacts increased OEMs' understanding of the latest semiconductor technologies available in the market needed to meet new legal requirements and reduce time-to-market for new vehicle features. Despite R&D's recognition of the increased relevance of semiconductors, direct connections with semiconductor suppliers did not involve

the OEMs' procurement, largely due to resource limitations at procurement, lack of knowledge about semiconductors, and a strong position of R&D in making decisions on semiconductors.

The second instance of mismatch refers to the lack of semiconductor supply assurance focus by the OEMs' procurement in contrast with the increasing OEM dependence on semiconductors throughout the period 1996–2020. Despite the increasing value of semiconductors and the occurrence of disruptions that affected other OEMs (e.g., semiconductor supply disruptions caused by an earthquake and tsunami in Fukushima, Japan in 2011), the studied OEMs did not change their sourcing model of reliance on Tier 1 suppliers until 2020. As explained by an OEM purchaser: "At that time, we did not know much about semiconductor industry and for us, it was more the focus on the price (…) and not how we can really secure our supply because from our perspective, the Tier 1 is handling it and he has to secure our supplies" (OEM Semiconductor Purchaser, interview, November 2022). It was only in 2021, when a major crisis impacted the automotive OEMs, that their procurement functions sought to establish direct connections with semiconductor suppliers and other measures to secure component supply.

Finally, the findings reveal the implications of a Tier 1-centric supply network for OEMs' procurement. The delegation of semiconductor-related responsibilities to Tier 1 suppliers and the reliance on them prevented OEMs from developing familiarity with semiconductors. The resulting lack of knowledge and detachment from the semiconductor industry contributed to the OEMs' unawareness of the complexity of the semiconductor production. From a Tier 1 supplier's perspective, the excessive delegation of responsibilities caused an overload on these suppliers' ability to coordinate supply and demand in the supply network, which contributed to a generalized disruption in the network.

4.1.2. Empirical description of the power dynamics in the supply network and the OEMs' power position

In the supply network, sources of power include incudes internal (micro level) factors such as the OEMs' customer attractiveness because of their technical sophistication and drive of innovation; supply network-related (meso level) factors such as high switching costs due to long and costly development times, low but stable long-term volumes; and global market-related (macro level) factors, such as competition with other industries and industry regulations. In particular, OEMs perceived as premium brands attract Tier 1 suppliers' interest to work with them. In regards to volumes, passenger vehicle OEMs are attractive to Tier 1 suppliers because of their higher volumes, while commercial vehicle OEMs are attractive to Tier 1 suppliers because of their long-lasting and more stable volumes. Further, the early involvement and selection of suppliers, the use of single sourcing models, and the long development times for electronic components create a lock-in position for OEMs as they become dependent on a specific Tier 1 supplier the only one that can supply a given electronic component. Finally, semiconductor suppliers have become increasingly attracted to the increasing volumes of automotive OEMs because of the shift toward electrification.

Tier 1 suppliers' relationships with semiconductor suppliers are largely affected by their size and purchased volume of semiconductors. High volumes are important to semiconductor suppliers due to the semiconductor industry's high capital intensity and high investments for

semiconductor production. Tier 1 suppliers with larger volumes maintain direct relationships with semiconductor suppliers; in contrast, if Tier 1 suppliers' volumes are not large enough to be purchased directly from semiconductor suppliers, ordering and logistics management may be outsourced to authorized distributors.

The findings of Paper II reveal that the supply disruptions at semiconductor suppliers shifted the power distribution towards them and away from OEMs. This shift also left Tier 1 suppliers in a difficult position that included pressure from OEMs, little influence over semiconductor suppliers and the task to coordinate tight semiconductor supply with increasing automotive demands. These changes in power dynamics exacerbated the OEMs' weak position and required measures to minimize power imbalances across the network.

In order to minimize the power imbalances in the supply network and secure supply of semiconductors and electronics, the OEMs adopted measures across levels such as collaboration between OEMs and creating routines and knowledge in their procurement organizations (micro level); increasing collaboration with Tier 1 suppliers at the same time as expanding relationships beyond them in the supply network (meso level); and engaging with actors outside the automotive industry such as companies in other industries and policy makers (macro level). These measures counteracted power imbalances across the network and the higher levels of power imbalance created by supply disruptions.

4.1.3. The role of procurement to build resilience during a crisis

The findings of Paper III depict the role of procurement to build resilience during a crisis. This role is described related to the pre-crisis procurement measures that build disruption preparedness, the measures adopted during a crisis that alter PSM's potential and connectedness to build resilience, and finally the measures that are kept in the system after the crisis to support future preparedness. The measures help procurement to persist, adapt, and transform in a crisis. An overview of procurement measures and their contribution to resilience is presented in Table 5, which is a simplified version of Appendix C in Paper III.

Part of the buying firm's first response to the crisis consisted of procurement measures focused on persisting and maintaining operations. These measures leveraged the existing pre-crisis preparedness based on internal cross-functional collaboration, supply assurance processes focused on Tier 1 suppliers, and long-term collaboration with Tier 1 suppliers. However, high connectedness (e.g., dependence on Tier 1 suppliers and rigid requirements) and low potential (e.g., resource and capability limitations) limited the buying firm's ability to deploy first-response measures and persist (see Paper III for more details). These findings reveal how a disruption can exhaust pre-crisis preparedness and require adaptation in procurement.

Once first-response measures based on preparedness were exhausted, the buying firm adopted measures across the supply network to adapt and transform the supply management system. Through measures that adjusted potential and connectedness, procurement mitigated the risk that excessive rigidity in the system could prevent it from adapting to new conditions caused by the crisis (see Paper III for further elaboration on this risk, called rigidity trap risk). These adjustments emphasize how a buying firm can adapt its procurement to promote change in response to a disruption that exceeds its preparedness. Furthermore, measures focused on

transformation portray a change in the buying firm's strategic procurement of semiconductors, which ensures that new knowledge, processes, and resources acquired during the crisis were incorporated in procurement after the crisis. Through these measures, the buying firm mitigated the risk that the lack of resources and connections could force its procurement back to its pre-crisis configuration (see Paper III for further elaboration on this risk, called poverty trap risk).

Table 5: Overview of procurement measures to build resilience in a crisis.

Main contribution to resilience	**Procurement measure and contribution to resilience**
Internal measures within the OEM	
Persistence	***Cross-functional taskforce:*** Coordinated information flows towards involved stakeholders and supported fast decision making ***Decentralized decision making:*** Gave purchasers and first line managers decision mandate to support fast decision making ***External trainings about semiconductors:*** Provided purchasers with knowledge about semiconductors to address shortages
Adaptation	***Increasing buffer stocks of electronics:*** adjusted the OEM's buffer stock management principles according to new conditions to build protection against future disruptions ***Assembly of missing parts at the dealer:*** Changes in the vehicle production operations to allow vehicle production without the missing parts ***Adjustment of vehicle production schedules:*** Adapted vehicle production schedules according to the availability of electronic components
Transformation	***Dedicated semiconductor procurement team:*** Responsible for the shift to long-term strategic semiconductor procurement ***Internal trainings about semiconductors:*** Increased purchasers' knowledge about semiconductors to support strategic semiconductor procurement
Tier 1 supplier-related measures	
Persistence	***Shortage meetings with Tier 1 suppliers:*** Increased information flows on semiconductor availability; enabled discussions of solutions to shortages; ensured Tier 1s' priority ***Capacity information requests to Tier 1 suppliers:*** Increased information flows on semiconductor availability and potential future shortages
Adaptation	***Technical changes to electronic components:*** Allowed technical changes in an electronic component so that it could be produced without the missing semiconductor ***Extended volume forecasts to Tier 1 suppliers:*** Changes the OEM's volume forecast process to adapt to longer planning horizons for semiconductors
Supply network measures involving actors beyond Tier 1 suppliers	
Persistence	***Coordination in the OEM-Group:*** Used influence and relationship of the OEM-Group holding to obtain attention and priority of Tier 1 and semiconductor suppliers ***3-n party meetings:*** Increase information flows; ensured priority from other actors in the network
Adaptation	***Spot market semiconductor purchases:*** Allocated internal resources to establish contact with independent distributors and execute spot purchasers ***Establish relationships with semiconductor suppliers:*** Established relationships with semiconductor suppliers that were previously seen as out of the OEM's procurement scope

4.1.4. How procurement adjusts emergence and control to cope with and leverage environmental shifts

This section presents preliminary findings from the ongoing data analysis of Paper IV. These findings show that the level of control over the supply network beyond Tier 1 suppliers is influenced by shifts in the external environment, by internal priorities between procurement objectives, and contextual factors in the relationship with each Tier 2 supplier.

The first part of the findings of Paper IV reveal the interactions between actors in the supply network that constitute emergence and control in the network from the point of view of the OEM. This analysis is done for each of the supply chains studied (SC-A, SC-B, and SC-C). Figure 8 is an example of this mapping Supply Chain A and shows the interactions between the OEM, the Tier 1 supplier (T1-A) and the semiconductor supplier (SS-A).

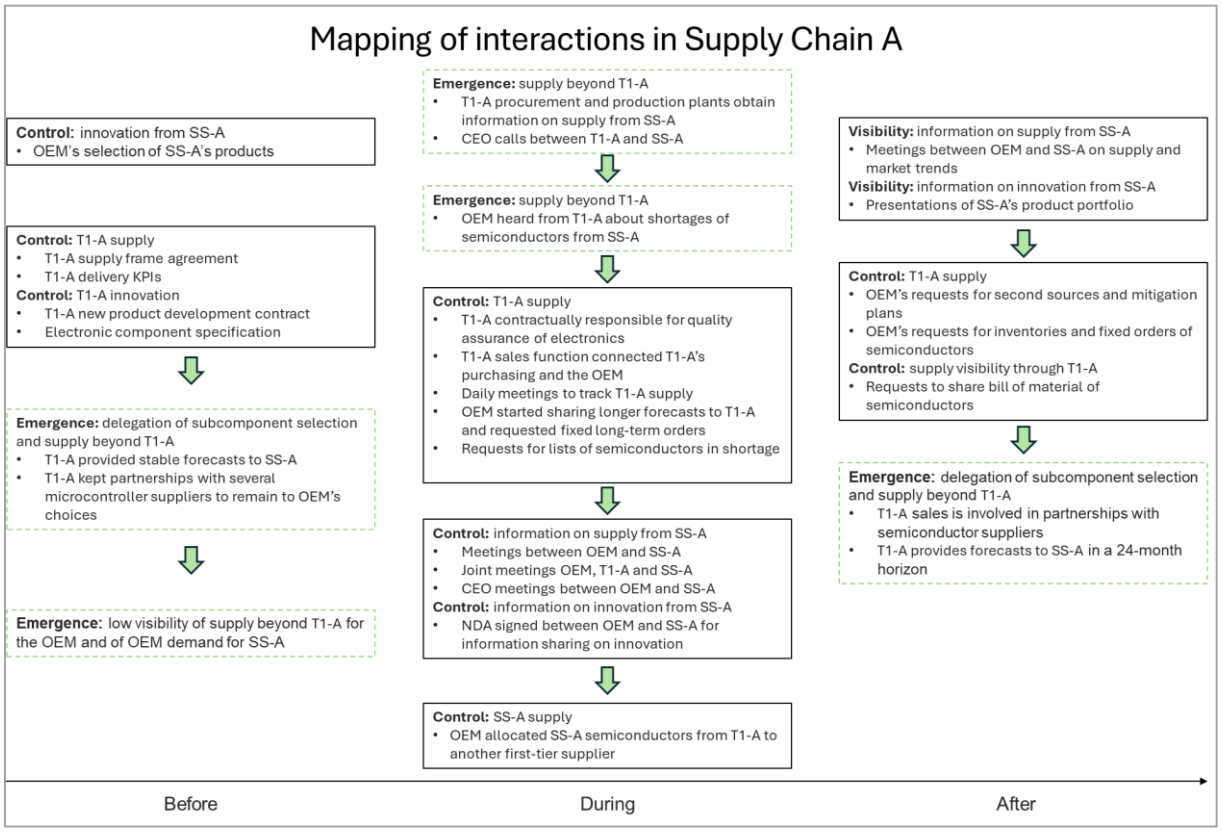


Figure 8: Mapping of interactions that form emergence and control in the supply network.

In the three studied supply chains, the mapping of interactions shows a pattern of OEM control before the crisis through contracts with its Tier 1 suppliers. These contracts establish delivery terms and performance indicators to control supply as well as terms for new product development to control innovation. These same contracts delegated responsibilities to Tier 1 suppliers for supply and innovation of subcomponents, including semiconductors. This delegation led to emergence across the procurement objectives of supply, cost and innovation in all three supply chains. The main exception to the predominant emergence was the OEM's R&D department's interactions with the semiconductor supplier "SS-A" that resulted in the selection of the supplier's semiconductor products for use in the OEM's vehicles.

During the crisis, the type of control interactions with Tier 1 suppliers and also the level of control beyond Tier 1 suppliers changed. As shown in the middle section of Figure 8 for Supply

Chain A, the control over Tier 1 suppliers shifted to frequent meetings to track deliveries, requests for visibility of components in shortage and high management involvement. At the same time, the control beyond Tier 1 suppliers was realized through direct meetings between the OEM and SS-A including high management, and allocation of supply of a SS-A product from T1-A to another Tier 1 supplier. The findings also show that the focus on supply assurance came in detriment to focus on the other two procurement objectives. Even though there was interest from all three semiconductor suppliers in exchanges about innovation, these exchanges had to wait until the crisis was over due to resource limitations.

After the crisis, the preliminary findings of Paper IV reveal a return to control over Tier 1 suppliers based on contracts with new requirements for higher levels of inventories, visibility of bills of materials, and risk mitigation plans. Beyond the Tier 1 suppliers, the interactions with semiconductor suppliers are less frequent and only focus on overall market trends, which reveal a return to high levels of emergence.

A comparison between supply chains shows that the levels of emergence and control across suppliers and procurement objectives are more varied after the crisis than they were before the crisis. Higher levels of control were influenced by the formalization of the relationship between the OEM and the semiconductor supplier SS-B with an innovation focus, which resulted from the selection of SS-B's products for one of the OEM's projects based on technological features. This selection also caused higher level of control over supply of the selected SS-B products. Conversely, the relationships with SS-A and SS-C were not formalized through contracts and higher emergence reflects the OEM's focus on assurance of supply through the Tier 1 suppliers.

The second part of the data analysis looks at the changes in the balance between emergence and control in three levels: between supply chains, between procurement objectives, and between periods. From this analysis, a mapping of possible modes of shifts between emergence and control across periods is being mapped (for more details, please see Paper IV). Figure 9 presents a preliminary summary of these shifts.

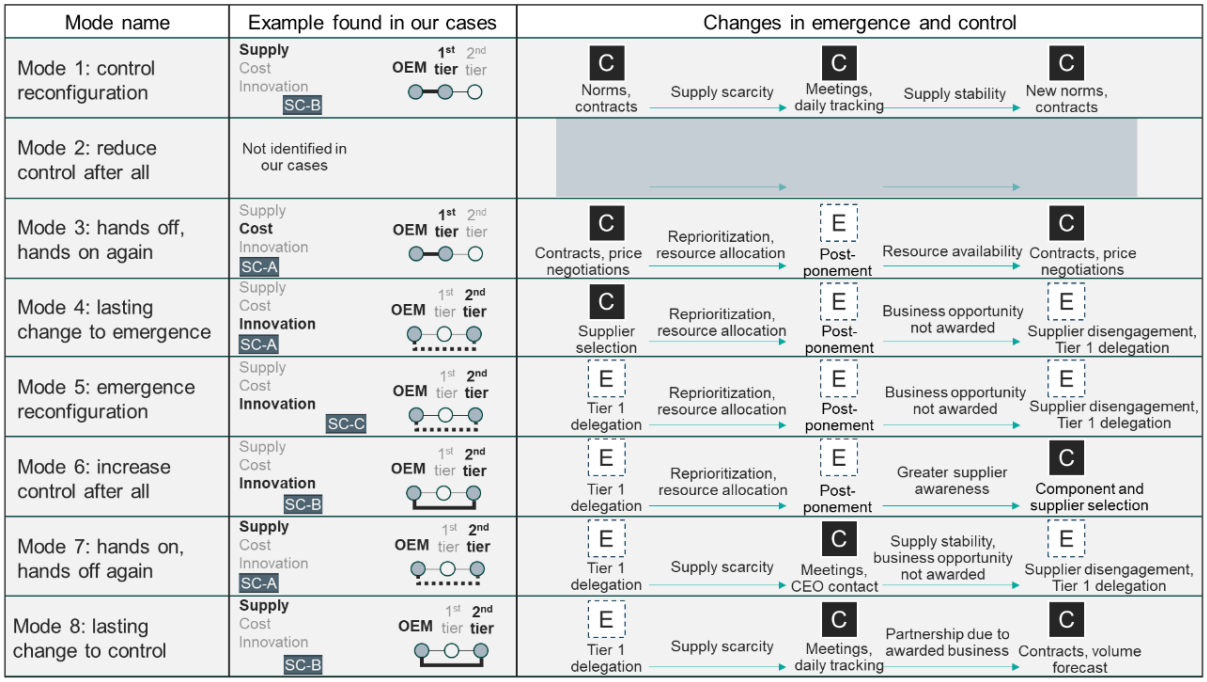


Figure 9: Summary of the modes of shifts between emergence and control.

5. DISCUSSION

This section analyzes the findings of the papers in relation to each research question (RQ1 in section 5.1 and RQ2 in section 5.2). The analysis is summarized in Figure 10.

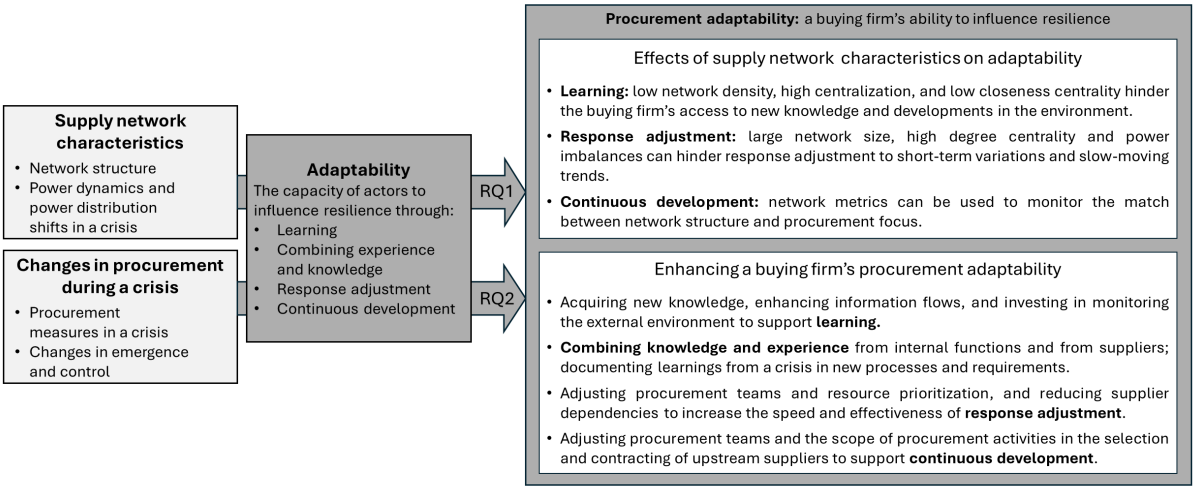


Figure 10: Summary of the answers to this thesis's research questions.

5.1. Supply network characteristics' effect on procurement adaptability

To answer RQ1, Table 6 presents an analysis of how supply network characteristics affect a buying firm's procurement adaptability. The findings of Papers I and II are distinguished between the supply network structure using SNA (node-level, network-level metrics and actors roles) and power dynamics in the supply network using RDT (sources of power, supplier dependences, and power distribution shifts).

Supply network characteristics affect a buying firm's adaptability by influencing the acquisition of new knowledge and learning about new developments in its environment; by influencing the coordination effort and effectiveness in response adjustment through the ability to reach all relevant suppliers; and by providing metrics for procurement to continuously shape and adapt the supply network structure to the procurement focus.

For learning, supply network connections influence the flow of information and the buying firm's acquisition of new knowledge. Low network density, high network centralization, and low node closeness centrality can hinder a buying firm's ability to acquire new knowledge and capture new developments in the environment. Particularly, monitoring slow-moving developments in the external environment is an essential part of resilience and adaptability (Holling, 2001) and buying firms face an increasing need for awareness of the external environment (Di Mauro et al., 2024; Knight et al., 2022). Using SNA (Borgatti & Li, 2009; Kim et al., 2011), these findings show how supply network characteristics can influence this awareness and extend the knowledge on how a buying firm can enhance learning by shaping its supply network in a way that enhances the flow of information and new knowledge that will help it identify and adapt to change. In line with the importance of learning in supply network contexts (Glas et al., 2021; Novak et al., 2021), these findings provide new concepts for future investigations of a buying firm's ability to learn.

Table 6: How supply network characteristics affect support procurement adaptability.

Supply network characteristics	**Contribution to adaptability**
Network-level metrics • Size • Density • Centralization	• **Learning** Low *network density* and *high centralization* can indicate the buying firm's lack of upstream supplier connections and dependence on few actors to receive information and learn about new developments in the network. The dependence on suppliers' knowledge can also prevent the buying firm from developing knowledge about upstream suppliers. • **Response adjustment** A large *network size* entails a large number of suppliers that can be affected by environmental shifts, while low *network density* entails that the buying firm is not able to reach different network tiers directly. Both factors increase the effort and hinder the speed of response to environmental shifts. • **Continuous development** Understanding and monitoring *network size* and *network density* can enable the buying firm to identify organizational burden, needed adjustments in the organizational structure and maintain a balance between a cost efficient network (not too dense) and ensuring cross-network connections and information flows.
Node-level metrics • Degree centrality • Betweenness centrality • Closeness centrality	• **Learning** An increase in *degree centrality* and *closeness centrality* through connections with upstream suppliers creates greater familiarity and knowledge about these suppliers and information about developments in the upstream network. • **Response adjustment** High *degree centrality* indicates a dependence on a high number of suppliers. Therefore, the buying firm needs to coordinate response adjustment actions towards several suppliers. High *betweenness centrality* reveals actors with "broker" roles that can become overloaded to handle variations in downstream needs and upstream availability, both of supply and innovation. The limited access to knowledge and information at upstream suppliers caused by low *closeness centrality* can delay the identification and response to environmental shifts.
Mapping and understanding the suppliers in the network	• **Learning** Mapping of the network increases the buying firm’s knowledge about critical suppliers for supply assurance and innovation. • **Response adjustment** Knowledge of critical suppliers and connections between suppliers can enable faster and more effective response to environmental shifts. • **Continuous development** Continuous monitoring of the network structure can allow a buying firm to continuously shape the network structure to match the procurement focus in response to environmental shifts.
Power dynamics in the network • Sources of power • Power imbalances • Power distribution shifts in a disruption	• **Learning** *Sources of power* such as dependence on supplier knowledge of the upstream supply network can make the buying firm dependent on its suppliers to acquire new knowledge and learn about developments in the environment. • **Response adjustment** Lack of control due to *sources of power* such as supplier dependences, low reputation or low volumes or due to local *power imbalances* across the supply network can hinder response to environmental shifts. The understanding of power imbalances across the network can help a buying firm to devise strategies to improve its power position. • **Continuous development** *Sources of power* at the macro level reflect the buying firm’s vulnerabilities to changes in the external environment through macroeconomic and cross-industry shifts. Understanding these sources can support monitoring of changes in the external environment and consequent *power distribution shifts*.

For response adjustment, the buying firm's connections, the overall network size, and power dependences influence the implementation of actions for response adjustment. Large network size and high node degree centrality can require higher response adjustment effort, while low network density, low node closeness centrality and lack of power can hinder effective response adjustment if the buying firm cannot reach the most relevant suppliers in the network. To build theory on how firms respond to supply disruptions (Glas et al., 2021) and other shifts in the external environment (Knight et al., 2022), these findings show that a buying firm needs to manage its supply network size and power dependences across the supply network to be able to implement actions for response adjustment, both for short-term variations and slow-moving trends.

For continuous development, supply network size and density influence the match between supply network structure and the procurement focus required by external conditions. Among network-level metrics, network density can be used to monitor the balance between cost efficiency (low density) and ensuring cross-network connections (high density). The pursuit of cost-efficient supply networks has historically built automotive OEMs' dependence on Tier 1 suppliers in the automotive industry (Doran, 2004; Hearnshaw & Wilson, 2013; Lamming, 1993), but this pursuit can increase the vulnerability to external changes (Adobor, 2020; Holling, 2001). These findings contribute to the debate on supply network complexity (Akin Ateş & Memiş, 2021) and exemplify the use of supply network size and density to measure complexity (Borgatti & Li, 2009; Kim et al., 2011): by monitoring and shaping the size and density of connections in its supply network, a buying firm can embrace network complexity to improve cross-network coordination of supply, cost, and innovation.

5.2. How a buying firm enhances its procurement adaptability

To answer RQ2, Table 7 presents the analysis of how a buying firm enhances its procurement adaptability, based on the findings of Papers III and IV and using concepts from the resilience adaptive cycle and supply networks as complex adaptive systems. This analysis shows that a buying firm enhances its procurement adaptability through disruption response measures and adjustment in control over the supply network during a crisis and also by maintaining new activities, knowledge, and processes after the crisis is over.

To enhance procurement adaptability through learning, a buying firm enhances information flows and knowledge that support situational awareness of the environmental shift at hand (Folke et al., 2010). This is done in part through persistence-oriented measures (i.e., measures aimed at sustaining operations and returning to a stable state) and temporary increase in control of upstream suppliers. In coping with a shift such as a long-lasting supply crisis, this situational awareness is crucial to adapt procurement response (Bode et al., 2011; Flynn et al., 2025). Another part of learning focuses on the long-term creation of knowledge and investments to monitor environmental shifts. This enhanced learning supports the response to new environmental shifts but some activities lose intensity (e.g., reduced intensity of relationships with second-tier suppliers) after the crisis is over, which can hinder learning capabilities for future environmental shifts. The fast pace of change since the COVID-19 pandemic has made it ever more important to accelerate learning both to respond to a disruption and to monitor and prepare for future disruptions (Glas et al., 2021; Knight et al., 2022). By analyzing learning as

an important aspect of adaptability (Folke et al., 2010), these findings highlight how a buying firm can enhance learning during and after an environmental shift, and that special attention is required to maintaining new forms of learning after a crisis is over.

To enhance procurement adaptability by combining experience and knowledge during a crisis, a buying firm gathers knowledge from different internal functions and from its supply network. A system's ability to adapt depends on its existing knowledge that can be used to cope with external perturbations (Fath et al., 2015; Holling, 2001), and in cases where this knowledge is spread across functions of the buying firm and among suppliers, it is critical that this knowledge is gathered and used for response adjustment. After a crisis, this combination of knowledge shifts focus onto documenting and applying the learnings from an environmental shift into new processes, new contractual requirements, and changes in the scope of procurement activities. This is an essential parts of capitalizing learnings from a crisis to ensure preparedness to future disruptions (Kähkönen & Patrucco, 2022). These findings align with and extend the principles of social-ecological resilience in supply network contexts (Wieland et al., 2023) and show that to continuously foster adaptability, a buying firm can devise ways to stimulate the combination of experience and knowledge also outside of crises, for example by creating cross-functional forums to monitor and review slow-moving variables.

Table 7: How a buying firm enhances its procurement adaptability.

Procurement measures during a crisis	**Contribution to adaptability**
Procurement measures that leveraged existing potential and connectedness in a disruption - Persistence-oriented measures	• **Learning** *Internal measures within the buying firm* enhance internal stakeholders' knowledge about affected products and access to information on new developments to handle environmental shifts. *Measures towards Tier 1 suppliers* and *towards the supply network* enhance information flows on new developments of the environmental shift. • **Combining knowledge and experience** *Internal and external measures* gather and combine knowledge and experience from different functions of the buying firm, Tier 1 suppliers and other firms in the network. • **Response adjustment** *Internal measures within the buying firm* enhance speed and cohesiveness in response adjustment. *Measures towards Tier 1 suppliers* and *towards the supply network* promote fast communication of response adjustment to other firms in the supply network and enhance the buying firm's portfolio of measures for response adjustment through coordination with other buying firms.

Procurement measures that altered potential and connectedness in a disruption - Adaptation-oriented measures - Transformation-oriented measures	• ***Learning*** *Internal measures within the buying firm* preserve and capitalize the created knowledge of the affected products and invest resources to monitor developments in the environmental shifts. *Measures towards Tier 1 suppliers* and *towards the supply network* increase suppliers' visibility of the buying firm's volume demands, increase information flows through first-hand contact with upstream suppliers and enhance the buying firm's knowledge of the supply market. • **Combining knowledge and experience** *Internal measures within the buying firm* document and apply knowledge and experience from a crisis into new processes and routines. *Measures towards Tier 1 suppliers* combine technical knowledge from the buying firm and suppliers to find solutions to cope with environmental shifts. • **Response adjustment** *Internal measures within the OEM* adjust rules and processes to increase the available time and range of possible actions to adjust its response to environmental shifts and the creation of dedicated procurement teams enhances speed and efficacy of responses to environmental shifts. *Measures towards the supply network* enhance fast and effective response to new environmental shifts based on information from upstream suppliers and greater knowledge of the supply market. • **Continuous development** A dedicated procurement team supports the creation of a long-term strategy for procurement of the affected products.
Changes in control and emergence	**Contributions to adaptability**
Update of control instruments Mode 1: control => control => control	• **Combining knowledge and experience** The update of control instruments translates experience from an environmental shifts into new contractual requirements. • **Response adjustment** New requirements enhance fast and effective response adjustment to new environmental shifts.
Temporary embedding and de-embedding Mode 3: control => emergence => control Mode 7: emergence => control => emergence	• **Learning** Increased temporary control (mode 7) increases awareness of developments in the environmental shift. • **Response adjustment** Temporary adjustments in the level of control (modes 3 and 7) adjusts the resource allocation for each procurement objective based on the needs caused by an environmental shift.
Lasting changes in control over an upstream supplier Mode 6: emergence => emergence => control Mode 8: emergence => control => control	• **Learning** Higher level of control during an environmental shift (mode 8) increased awareness of upstream suppliers and knowledge of their products. • **Combining knowledge and experience** Applied the learnings and new knowledge obtained during an environmental shift to adjust long-term levels of control. • **Response adjustment** Direct interactions with upstream suppliers supports capturing supplier innovation in new product development to meet new needs from the market and business environment (mode 6) and faster reaction to environmental shifts that affect supply availability (mode 8). • **Continuous development** Direct interactions with upstream suppliers influences the scope of a buying firm's procurement scope in the selection and contracting of upstream suppliers.

To enhance its procurement adaptability through response adjustment, a buying firm adjusts its organizational structure to coordinate fast response to changes, reduces dependencies in the supply network, and adjusts resource prioritization between procurement objectives. In cases when the lack of procurement practices such as multiple sourcing and connections with upstream suppliers (Choi & Linton, 2011; Choi et al., 2020; Dabhilkar et al., 2016) hinders adaptability during a crisis, response adjustment can seek to reduce dependences and increase the range of options available to respond to environmental shifts (Adobor, 2020; Holling, 2001). In the long run, improving response adjustment involves new contractual requirements and upstream supplier connections that enable faster reaction to environmental shifts. By showing responses to a specific disruption as well as the preparation for further environmental shifts, these findings expand the theory on procurement response to change (Glas et al., 2021; Kähkönen & Patrucco, 2022) by showing that preparedness and response to environmental shifts influence each other continuously as a buying firm continuously faces pressures from its environment (Folke et al., 2010; Wieland, 2021).

Finally, a buying firm enhances its procurement adaptability by nurturing continuous development as it adjusts its procurement organization and the scope of procurement activities in the selection and contracting of upstream suppliers. Adopting new strategic views and business models that are better suited for new environmental conditions can foster a transformation of the supply network (Wieland et al., 2023). In line with existing literature (Flynn et al., 2025; Holgado & Niess, 2023; Kähkönen & Patrucco, 2022), continuous development of procurement requires investments in knowledge, human resources, new supplier connections and the maintenance of processes and routines that proved beneficial during an environmental shift.

6. PRACTICAL IMPLEMENTATION OF FINDINGS

The findings from my research have been communicated to the focal OEM through recurring meetings with an Industrial Supervision Committee. Membership of the committee has ranged from four to six members (depending on organizational changes in the OEM's procurement) and had members that held positions as purchaser, manager, director and vice president related to semiconductors, electronics, and risk management within procurement. These meetings occurred every six to 10 months and were organized by me as soon as there were new relevant milestones in the PhD project to be discussed with the committee, such as the results of a study, plans for future studies, and the implementation of findings in practice. This section explores the implementation of findings within the focal OEM, while broader practical implications that could extend to other organizations are presented in section 7.2.

6.1. Initiatives connected to supply network structure and awareness

The first initiatives are inspired in the findings of Papers I and II, focused on spreading awareness of the importance of the supply network structure and the power position of the buying firm to buyers in different segments. Two different tools have been proposed and discussed with the Business Development teams of the focal OEM's procurement.

The first initiative is based on the findings of Paper I and emphasizes purchasers' knowledge of the supply network for the products they purchase. I developed an Excel-based tool that assesses the level of knowledge possessed by the purchaser or group of purchasers responsible for a category of parts. The tool contains questions aimed at addressing the four main elements of the empirical framework published in Paper I and presented in Figure 11.

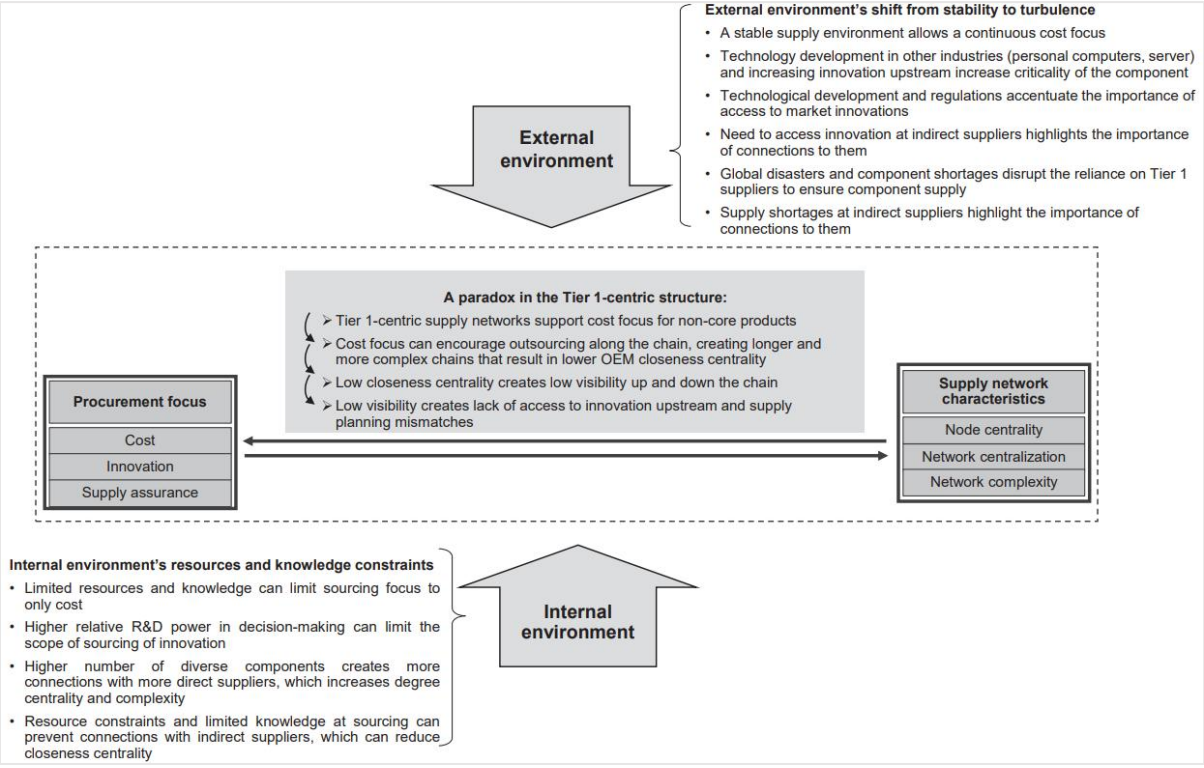


Figure 11: Empirical framework from Paper II used as a basis for self-assessment tool of purchasers' knowledge of the supply network.

Based on the elements in the framework in Figure 11, the tool supports the assessment of the "internal environment" element through the internal knowledge of the product's supply network. The questions are divided into different procurement objectives to enable a separate assessment of the relevance of each procurement objective (i.e., cost, supply, and innovation). The content of the questions addresses the elements "supply network characteristics" through questions on the sub-supplier structure as well as the "external environment" through questions on external trends, threats and opportunities for the purchased products. The result of the assessment showed the existing level of knowledge of the supply network and external environment compared to the required level of knowledge based on the relevance of the different aspects for the supply network.

I developed the tool and validated its applicability with managers within electronics procurement. I piloted the tool in three teams (responsible for three different types of electronic components) through a series of coaching-like meetings to guide each of the teams in how to apply the tool to assess the team's knowledge of the supply network. The results of the self-assessment pointed out the lacking knowledge on the external trends affecting one of the teams and resulted in an investigation of external trends being included in the team's strategic plan. For the other two teams, the results were highlighted risks due to the complexity of the supply networks beyond the Tier 1 suppliers and the lack of clarity of the critical suppliers for innovation and supply risks in the supply network, prompting further investigations and their inclusion in a larger assessment focused on supply chain resilience (see section 6.2).

I presented the tool to the focal OEM's procurement business development teams and proposed for it to be expanded for the whole procurement organization. However, more pilots were deemed necessary in order to assess the usefulness of the tool for other types of purchased products and to generalize the questions to make them accessible to purchasers with different levels of experience. Most recently, I handed over the content of the tool to a team in charge of developing a supply chain risk assessment tool for the whole procurement organization.

The second initiative uses the findings of Paper II on the sources of power that can create a vulnerable power position for a buying firm, as simplified as represented in Figure 12.

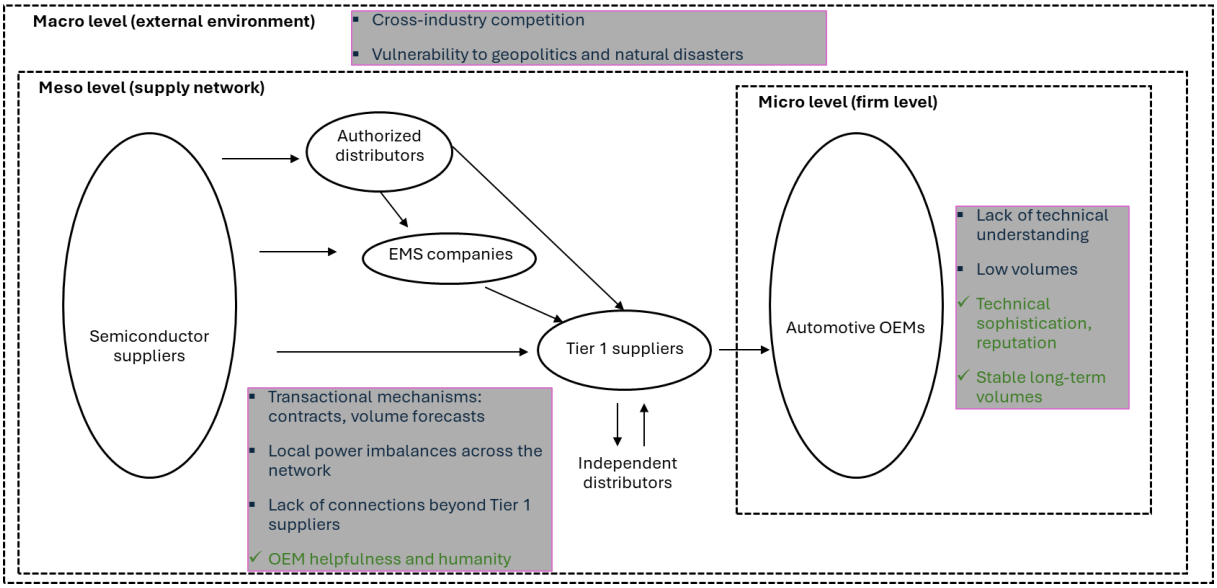


Figure 12: Representation of sources of power identified in Paper II used for implementation initiative at the focal OEM.

Even though the sources of power shown in Figure 12 may seem trivial, discussions in the Industrial Supervision Committee reinforced the understanding that these sources of power are not evident to purchasers involved in buyer-supplier relationships and therefore were not taken into consideration in their segment and supplier strategies. Particularly, the findings presented in Figure 12 emphasized the importance of the power position of Tier 1 suppliers towards semiconductor suppliers and the position of the automotive industry in the macro level.

Based on these findings and discussions, I have proposed the development of a framework that highlights the sources of power that can affect the focal OEM's power position for different types of products. This framework is based on the findings for electronics and semiconductors, but must be generalized for application by the broader group of purchasers at the focal OEM. Initial meetings have been held to present and discuss the idea of a tool with the focal OEM procurement business development teams, but I have so far not found a contact person that can support the development of the tool for the whole procurement organization.

6.2. Initiatives connected to supply chain resilience

The second set of initiatives is more recent and has used the theoretical framework of Paper III to establish an adaptive view of supply chain resilience for electronics and semiconductors. This framework is intended to be used by the teams responsible for sourcing these components at the focal OEM. This initiative expands the self-assessment based on the findings of Paper I (see section 6.1) by connecting the levels of internal environment, supply network structure, and external environment through the panarchical structure proposed by Holling (2001). A simplified representation of this structure is presented in Figure 13.

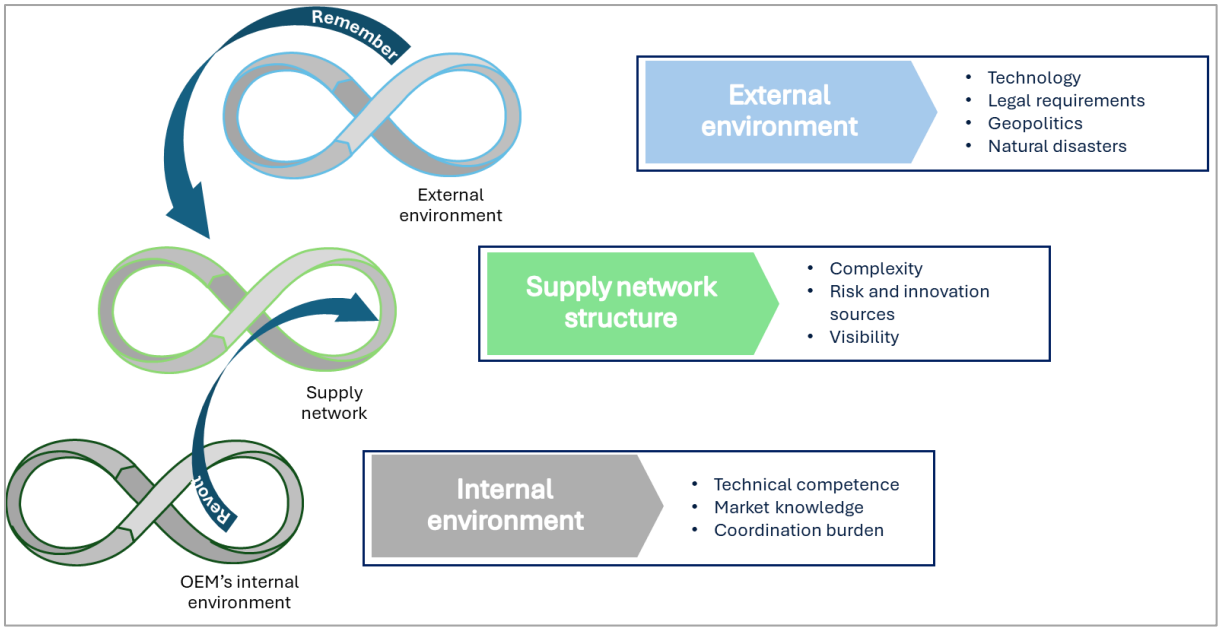


Figure 13: Simplified panarchical structure applying an adaptive view of resilience to electronics and semiconductor procurement. Source: author's creation based on Holling (2001).

The first aim of the initiative is to expand the view of supply chain resilience among purchasers from the more common "bounce back resilience" to an adaptive view that considers the supply network as part of and subject to the external environment. The initiative emphasizes the role of procurement beyond simply preparing for the next disruption, and focuses on the

buying firm's awareness of changes in the supply network and in the external environment. Through this awareness, procurement can promote proactive adaptation and transformation of internal structures and of the supply network to cope with and leverage environmental changes instead of waiting for disruptions and bouncing back from them.

I have presented the adaptive view of supply chain resilience by sharing the definition of resilience adopted in Paper III, a video with an explanation of resilience by Crawford Holling (Stockholm Resilience Centre, 2013), and the implications of these concepts for the procurement of electronics in four meetings with the respective procurement teams. Based on these presentations, I ran a team-building activity focused on assessing each category's ability to cope with changes in the supply network and in the external environment. More recently, I expanded the assessment tool presented in 6.1 with the panarchical structure presented in Figure 13 and ran focus exercises with two procurement teams responsible for two categories within electronics procurement. The assessment revealed one category's exposure to changes in technology driven by other industries and another category's exposure to changes in technologies within the automotive industry. For both categories, the assessment revealed risks connected to late adoption of new technologies and the need for a cross-functional assessment (i.e., together with R&D stakeholders) of ways to mitigate those risks.

7. CONCLUDING REMARKS

Motivated by early signs of a weak power position of automotive OEMs in their supply network, this thesis has aimed to enhance our understanding of how a buying firm can enhance its procurement adaptability. Through a case study of the automotive supply network for semiconductors and electronics, the answers to this thesis's research questions provide valuable insights for procurement theory and practice related to supply networks that face rapid change in their external environments. These contributions are explored in this section.

7.1. Theoretical contributions

This thesis contributes to the literature in the PSM field with the effects of supply network characteristics on a buying firm's procurement adaptability. Following calls for better tools and frameworks to enhance firms' knowledge of their supply networks (Di Mauro et al., 2024; Knight et al., 2022), this thesis demonstrates how firms can characterize their supply networks in terms of network structure (Borgatti & Li, 2009; Kim et al., 2011) and power dynamics (Caniëls & Gelderman, 2007; Pazirandeh & Norrman, 2014; Pfeffer & Salancik, 2015) to enhance adaptability. The combination of static and dynamic characterizations of the supply network reveals implications of the supply network for a specific environmental shift (e.g., a supply crisis) and for the long-term development of procurement within the buying firm's external environment.

The extension of these implications beyond the studied empirical context is subject to contextual factors such as critical upstream suppliers and stability of the business environment. In other supply network contexts, a stable environment can decrease the need for strategic procurement (González-Benito et al., 2010; Akin Ateş & Memiş, 2021) and the importance of especially learning and response adjustment. Nevertheless, the concept of adaptability can still be applied to such contexts and further research can investigate how environmental stability influences the need for adaptability and the effect of supply network characteristics.

The second contribution of this thesis to the PSM field is the application of the resilience thinking framework and the exploration of adaptability as proposed by Folke et al. (2010) in a procurement context to reveal the mechanisms that enable a buying firm to adapt its procurement. More frequent environmental shifts raise calls for an adaptive view of supply chain resilience (Novak et al., 2021; Wieland et al., 2023) and the use of new theoretical lenses in procurement research (Knight et al., 2022). This thesis reveals that investments in learning, reducing supplier dependencies, and connections to upstream suppliers can contribute to procurement adaptability in fast-changing environments. It must be noted that the need to learn about and connect to upstream suppliers is highly connected to the existence of critical upstream suppliers in the studied context. In other contexts, buying firms might be required to ensure other ways of learning (e.g., through participation in relevant industry forums) and the connection to other relevant actors (e.g., customers, policy makers, and industry associations) to enhance their procurement adaptability.

The third contribution of this thesis is that it supports the ongoing expansion of PSM focus beyond Tier 1 suppliers and to upstream supply network tiers and the external environment. The literature highlights a previous focus by buying firms, especially in the automotive

industry, on their Tier 1 suppliers and the risks caused by over delegation of responsibilities (Choi & Linton, 2011; Lamming, 1993). If new environmental conditions require firms to extend their procurement focus to the upstream supply network and the external environment (Di Mauro et al., 2024; Glas et al., 2021; Knight et al., 2022), tools and practices supporting this focus must be understood. This thesis summarizes four years of research on the management of upstream suppliers and contributes to the understanding of the pre-requisites for this extended role of procurement: investments in learning and new knowledge, changes in procurement teams, and the focus on long-term resilience through continuous adaptation. These contributions are especially valuable for other supply networks in which upstream suppliers are critical for supply, cost, and innovation. Nevertheless, for buying firms that choose not to or cannot expand their focus onto the upstream supply network, the findings on the adaptation of interactions with Tier 1 suppliers can also be valuable.

Finally, the findings presented in this thesis suggest that the continuous review of procurement knowledge, activities, and processes can be a central part of the scope of procurement for buying firms that face fast-changing environments. As specific skillsets are needed to secure cost savings (Schütz et al., 2020; Schiele, 2019) and contribute to innovation (Blome et al., 2013; Legenvre & Gualandris, 2018; Luzzini & Ronchi, 2011), these skillsets must be continuously reviewed as environmental conditions change and technology advances. Similarly, procurement activities and processes must be matched to the environment in which the buying firms operates. Thus, the findings in this thesis suggest that "Procurement Excellence" teams can play a central role in supporting adaptability by adjusting activities and processes in line with changes in a buying firm's external environment.

7.2. Practical implications

This thesis addresses the empirical problem of lack of procurement adaptation to external environmental shifts. These shifts pose challenges to buying firms in the studied context but can be extended to other organizations that are exposed to high pace of technological development and exposure to environmental shifts. This section presents the practical implications of the presented findings, beyond the practical implications for the focal OEM that were presented in section 6. The findings of this thesis have implications for the importance of adopting a supply network perspective, for shaping the supply network structure to enhance adaptability, and for seeing continuous adaptation as an important feature of a buying firm's procurement to cope with and leverage external environmental shifts.

First, the findings presented in this thesis show the importance for buying firms to look beyond their immediate suppliers and expand their attention to the upstream supply network and their external environment. Through the empirical application of the selected theoretical lenses (i.e., SNA, RDT, social-ecological resilience, and CAS), this thesis highlights the influence of the external environments on procurement and how knowledge of the supply network and awareness of the environment can help a buying firm adapt to changes in the environment. For practitioners working in multi-tier supply networks and facing fast pace of environmental change, this thesis proposes that mapping the supply network, identifying critical suppliers and monitoring developments in the external environment are essential to adapt to environmental shifts. It remains highly important to monitor changes in demand patterns and

technological development in other industries, as for instance the demand for memory chips for Artificial Intelligence-related applications causes longer lead times and higher prices for automotive applications at the time of the writing of the thesis.

Second, by knowing their supply network, practitioners can influence supply network characteristics that support adaptability to environmental shifts. In recent decades, shaping the supply network for cost efficiency has been a common practice among buying firms, but this practice can make buying firms unable to access new knowledge in the supply network and oblivious to new developments in the external environment. This thesis shows that, to adapt to environmental shifts, buying firms need to ensure learning through new knowledge acquisition and access to information, fast and effective response adjustment, and continuous development through a match between supply network structure and procurement focus.

Finally, this thesis provides procurement practitioners with concrete measures that can enhance adaptability of their buying firm's procurement. Beyond the reaction to crises, this thesis highlights the importance of practices to continuously monitor the external environment; document and preserve learnings from a crisis to prepare for future disruptions; adjust team structures and resource allocation to respond to environmental shifts; and monitor the continuous development of procurement in line with new environmental conditions.

7.3. Limitations and opportunities for future research

As with any research work, the present thesis has limitations, which on the one hand reflect choices made in the course of my research, and on the other hand present opportunities for future research. These limitations arise from the research scope, the adopted OEM perspective, and the contemporary focus on supply assurance. Scope limitations include the adoption of a single case study and a specific supply network.

The scope limitation refers to the focus on one supply network and on procurement. This choice was made due to the representative and revelatory potential of the selected case, but it has limitations for the generalizability of the findings. While the findings are expected to be applicable in other contexts with rapid environmental changes affecting the network, further research can explore procurement adaptability in the procurement of other types of products or even in other industries.

The adopted OEM perspective is justified by the challenges faced by automotive OEMs in the studied supply network, but it is reasonable to expect that other firms in the supply network face similar challenges or could have different challenges. For example, this thesis indicates Tier 1 suppliers' challenges to coordinate OEMs' needs and semiconductor suppliers' offerings in regards to supply and innovation, but an exploration of these challenges is out of the scope of this thesis. Therefore, future research can explore the concept of adaptability in the context of suppliers' procurement or even in other functions such as R&D and sales.

Finally, although data access was greatly supported by the direct access to the focal OEM's procurement activities for all the studied procurement objectives, the research was conducted during a time of increased focus on supply assurance due to the global semiconductor crisis (2020-2023) and later initiatives to enhance supply chain resilience and avoid a new crisis. However, even in those periods, it is possible to recognize the importance of procurement in

ensuring innovation in the supply network. Future research can explore procurement adaptability as an ability that enables OEMs' procurement to secure innovation amidst uncertain technological change. Further studies could focus on procurement capabilities and collaboration with R&D that enable the role of procurement in supporting innovation.

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