

THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

Enhancing Structural Flexibility of Supply Chains under Frequent Disruptions

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CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden 2026

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ABSTRACT

Due to frequent disruptions, companies have developed a stronger interest in resilience and how to achieve it through various capabilities. One key capability is supply chain flexibility. While supply chain flexibility has traditionally been regarded as reactive, companies increasingly design supply chains with structural options to make them more adaptable. This subtype of supply chain flexibility, referred to as structural flexibility, is recognized as vital for future supply chains.

The purpose of this licentiate thesis is to contribute to flexibility, dual sourcing, and adaptive supply network design literature by analyzing how structural flexibility is formed through the design characteristics of dual sourcing and how practices are enabled, while also providing an understanding of how firms can deliberately enhance structural flexibility. Existing research has primarily focused on defining structural flexibility and identifying practices such as dual sourcing, rather than explaining how structural flexibility is formed through these practices. Moreover, limited attention has been given to how such practices are enabled through specific requirements.

The thesis builds on two papers, both based on multiple case studies. The first paper investigates how structural flexibility is formed through the design characteristics of dual sourcing, particularly through variation in integration depth and utilization breadth. The second paper examines how practices of structural flexibility are enabled through meeting strategy-based, dependency-based, and practice-specific requirements across different states referred to as ex-ante, ex-post, and ex-diem. The research follows a qualitative design based on abductive reasoning, systematically combining empirical observations and theoretical development.

The findings show that structural flexibility is formed through differences in how dual sourcing is integrated and utilized within the supply chain. These design characteristics determine which structural flexibility dimensions are formed and how they extend across the supply network. The results further demonstrate that structural flexibility is a multidimensional capability with a hierarchical structure, where different dimensions emerge depending on the level of integration. In addition, the findings show that practices are enabled through a hierarchical sequence of requirements and that enablement is dynamic, as practices can shift between ex-ante, ex-post, and ex-diem through re-evaluation.

Overall, the thesis advances the understanding of structural flexibility by explaining how it is formed through practice design and how practices are enabled through structured requirements. By doing so, it provides a more structured understanding of how firms can deliberately design and manage structurally flexible supply chains under conditions of repeated disruptions.

Keywords: Structural Flexibility, Dual Sourcing, Supply Chain Design, Resilience.

List of appended papers

Paper I Feist, E., Jonsson, P., Halldórsson, Á. (2025) “Forming structural flexibility dimensions with different design characteristics of dual sourcing: A multiple case study”. Accepted conference paper in the Proceedings of the 16th EDSI conference, 1- 4 June, Gothenburg.

An earlier version of this paper was presented at the 16th EDSI conference 2025.

Contributions: Main author with primary responsibility for conceptualization, data collection, and analysis. The main author led the writing of the paper and the interpretation of the findings.

Paper II Feist, E., Jonsson, P., Halldórsson, Á. (2025) “*Practices Enhancing Structural Flexibility of Supply Chains*”. Accepted conference paper in the Proceedings of the 33rd EurOMA conference, 13-18 June, Milan.

An earlier version of this paper was presented at the 33rd EurOMA conference 2025.

Contributions: Main author with primary responsibility for conceptualization, data collection, and analysis. The main author led the writing of the paper and the interpretation of the findings.

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This licentiate thesis marks the end of an important stage in my research journey. The process has challenged me to think more critically, to develop greater patience, and to trust the gradual nature of research. Completing this thesis has not only been about producing academic work, but also about growing more confident in my own voice as a researcher and, not least, becoming more flexible in both time management and thought processes. I would like to take this opportunity to express my gratitude to the people who have supported me and this development throughout the way.

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1. Introduction

Over the past years, supply chains have been exposed to frequent disruptions (Carranza, 2025). These disruptions have highlighted the vulnerability of supply chains and networks, increasing pressure on firms to maintain stable supply and production (Aratani, 2024). In response to this development, firms have a stronger interest in supply chain resilience and the capabilities required to cope with these disruptions (Saili, 2025). Among the different capabilities discussed in the literature, supply chain flexibility has received particular attention because it allows firms to change their operations, strategies, and networks when disruptions occur (Stevenson & Spring, 2007). One sub-type of flexibility that has gained increasing attention is structural flexibility, a capability that enables supply chains to reconfigure their architecture through structural options such as alternative suppliers, production sites, or distribution channels (Volberda, 1996; Christopher & Holweg, 2011; Sarma & Pramod, 2015). By creating such structural options, supply chains become adaptable in times of frequent disruptions (Christopher & Holweg, 2017).

1.1 Background and Problem Context

Following the COVID-19 pandemic and a series of subsequent disruptions, companies have developed a stronger interest in resilience and its capabilities (Alicke & Foster, 2024; Carranza, 2025). Due to the ongoing uncertain conditions, natural disasters, and geopolitical issues, the number of disruptions has increased (Hand, 2024). Disruptions such as the blockage of the Suez Canal, material and component constraints like semiconductors, increased cyberattacks, the war in Ukraine, and political conflicts regarding tariffs and regulations have heightened supply chain pressure over the last five years (Teophilo, 2025). As a consequence, supply chains have become fragile, leading to product scarcity (Aratani, 2024).

1.1.1 Manufacturing firms under frequent disruptions

Manufacturing companies are particularly exposed to disruptions because their operations rely on complex supply networks and critical materials (Lund et al., 2020). Modern manufacturing supply chains are often organized across multiple countries and involve a large number of specialized suppliers that provide components, technologies, and materials essential for production (Christopher & Holweg, 2011; Bode & Wagner, 2015). Many manufacturing firms rely on global suppliers that provide highly specialized and complex materials, which are difficult to substitute in the short term (Carranza, 2025). These specialized and complex materials comprise advanced components and technologies that are produced by only a limited number of suppliers worldwide. As a result, manufacturing supply chains have become increasingly interconnected and dependent on international sourcing networks (Wagner & Bode, 2008).

Due to this high level of interdependence, disruptions that occur at one supplier, transportation route, or production site can affect the whole supply chain and other firms and industries (Ivanov et al., 2014). Disruptions are therefore rarely restricted to a single firm but may generate ripple effects across multiple tiers of the supply chain, leading to production delays and material shortages (Craighead et al., 2007; Dolgui et al., 2018; Ivanov et al., 2014). For manufacturing companies, even short disruptions can have significant consequences, as production systems often rely on synchronized material

flows and just-in-time deliveries that leave little to no room for delays (Christopher & Peck, 2004; Wagner & Bode, 2008).

Swedish manufacturing companies operate in these global supply networks and are, therefore, highly exposed to these frequent disruptions (Svenskt Näringsliv, 2025). Many Swedish firms operate in technology-intensive industries such as automotive and telecommunications, which rely heavily on specialized components and globally distributed supplier bases.

1.1.2 Recent resilience strategies

In response to the increasing frequency of disruptions, firms have developed a stronger interest in supply chain resilience and the capabilities required to cope with uncertainty (World Economic Forum, 2024). As disruptions have become more frequent, companies have begun implementing various strategies intended to strengthen the resilience of their supply chains.

Many of these resilience strategies focus on improving the ability of companies to respond to disruptions once they occur. Common approaches include increasing safety stocks, building buffer capacity, strengthening monitoring and risk management systems, and improving collaboration with vital suppliers (Tang, 2006; Christopher & Holweg, 2011; Hohenstein et al., 2015). Other strategies attempt to decrease vulnerability of supply chains by using multiple suppliers or increasing transparency across supply networks (Ivanov et al., 2014). Through these measures, companies seek to mitigate the immediate impacts of disruptions and maintain the continuity of supply and production.

In addition, companies are increasingly investing in digital technologies and information systems that improve visibility and transparency across supply chains, enabling faster responses by spreading information (Ivanov et al., 2014). Digital tools, advanced analytics, and monitoring systems are intended to help companies detect disruptions earlier and coordinate responses more effectively across supply networks (Queiroz et al., 2022). As a result, many resilience strategies focus on strengthening a firm's capabilities to detect disruptions, react to disturbances, and recover operations and processes as soon as possible.

One of the capabilities companies need to achieve resilience is supply chain flexibility. Therefore, some managers seek to be and remain dynamic in the market through flexibility by maintaining the ability to respond quickly when disruptions occur. This type of flexibility is often used on demand when a specific disruption is detected, requiring companies to react by reallocating resources, adjusting production volumes, or switching suppliers (Hargreaves, 2024).

At the same time, companies are increasingly recognizing that reacting to disruptions alone may not be sufficient when disruptions occur repeatedly, and supply chains remain exposed to frequent disruptions. As a result, some companies are developing more flexible supply chain models that allow them to adjust their operations more easily in response to disruptions (Bergmeier & Gierhardt, 2025; Johnston, 2024). Instead of relying solely on reactive responses, firms start to consider how flexibility can be embedded into the design of their supply chains.

This shift moves supply chain flexibility from a purely dynamic or reactive capability toward a type of flexibility that is referred to as structural flexibility, a structurally embedded capability. To achieve this, companies begin to strategically adjust the structure of their supply chains and networks through certain practices, such as diversifying suppliers, distribution channels, and manufacturing sites, as well as collaborating with partners (Saili, 2025).

1.1.3 Current limitations of enhancing structural flexibility

The problem is that strategies to enhance structural flexibility primarily focus on the practices to be planned and used rather than on how they are enabled and form structural flexibility through the practices (Teophilo, 2025). The question, thereby, is whether the practices build the desired long-term structures to be structurally flexible. Simply planning and using these practices might not be enough, and companies still need to enhance the flexible structure with these practices. Currently, managers are trying to enhance structural flexibility with known practices (Saili, 2025), but do not know what is required to plan and use these practices to build a structure.

This raises the question of whether the use of these practices leads to structural flexibility or whether additional conditions are required for these practices to enhance structural flexibility. While companies increasingly adopt such practices to cope with disruptions, little is known about the requirements that must be fulfilled for these practices to effectively enhance structural flexibility. Without understanding how these practices must be planned and utilized, companies may adopt practices without enhancing structural flexibility.

Another problem that emerges after enabling these practices is whether the structural flexibility that forms is a consistent and therefore homogeneous kind of capability. This problem has its origin in the fact that managers form flexibility contextually through certain practices (Roggio, 2025) rather than through deliberately seeking to form a certain type of flexibility. Hence, while managers try to enhance structural flexibility through certain practices, they do not know what they form or whether structural flexibility is always the same kind of formation.

1.2 Theoretical Background

The managerial interest and motivation to enhance structural flexibility comes from the wish to increase the overall resilience within a supply chain. Resilience is a capacity that is increased by supply chains that adapt, withstand, and recover from disruptions (Christopher & Peck, 2004). Flexibility, agility, and adaptability are often described as capabilities that can obtain resilience, yet are described very similarly to each other (Benzidia & Makaoui, 2020; Christopher & Holweg, 2017; Phadnis, 2024). Research has shown that flexibility as a capability results in adaptability and agility, depending on the strategic approach that is taken (Christopher & Holweg, 2011). While often dynamic approaches were used to obtain resilience, new ways, such as enhancing structural flexibility, are necessary to obtain resilient supply chains (Christopher & Holweg, 2017).

1.2.1 Supply Chain Flexibility

Flexibility is an evolving term originally defined for manufacturing processes (Upton, 1994). It is defined as “[...] the ability to change or react with little penalty in time, effort,

cost, or performance” (Upton, 1994, p. 73). With rising interest, the term extended to supply chain flexibility, and researchers built the first frameworks defining flexibility as a capability concerning the entire supply chain (Vickery et al., 1999). Thereby, supply chain flexibility is a diverse capability through its applicability in every single process and operation, leading to the formation of different abilities which are called dimensions (Vickery et al., 1999). These formations refers to how flexibility emerges, and depending on its dimensional formation, the outcome of supply chain flexibility is potentially different (Duclos et al., 2003; Martínez Sánchez & Pérez Pérez, 2005; Stevenson & Spring, 2007). Up to 2011, research regarding supply chain flexibility was focused on the dimensions defining supply chain flexibility. Thereby, Stevenson and Spring (2007) finally reviewed the former literature and based on that presented a conceptual model. This model has been empirically underpinned, and it has been concluded that supply chain flexibility is not bound to a single supply chain but the supply chain network (Stevenson & Spring, 2009). As Manders, Caniëls and Ghijsen (2016) concluded, no unified definition can be made about supply chain flexibility as it is a diverse capability that can exist in any process and operation throughout the supply chain, forming different dimensions. Hence, supply chain flexibility is not a homogeneous capability that can result in very different outcomes depending on which dimensions are formed.

1.2.2 Structural Flexibility

Which attributes structural flexibility shares with supply chain flexibility, and whether structural flexibility forms specific flexibility dimensions, is not conceptualized. In contrast to supply chain flexibility, structural flexibility has a formal definition that focuses on the creation of structures capable of changing the architecture of a supply chain, leading to adaptable supply chains (Christopher & Holweg, 2011; Sarma & Pramod, 2015). Despite this definition and its conceptual relation to supply chain flexibility, the specific abilities that structural flexibility forms are not yet conceptualized. This concerns particularly the formation of structural flexibility in dimensions like those identified in supply chain flexibility research, and how such dimensions might form.

Research on supply chain flexibility has identified multiple dimensions that describe the abilities flexibility can provide across different system levels, ranging from operational to tactical to strategic to network-level dimensions (Stevenson & Spring, 2007; Manders et al., 2016; Rojo et al., 2018). However, these studies primarily focus on identifying flexibility dimensions rather than explaining how these dimensions are formed through specific supply chain structures or practices. As a result, it remains unexplored how flexibility dimensions form.

Understanding how structural flexibility emerges through the formation of certain dimensions becomes particularly relevant when companies attempt to deliberately design their supply chains to be adaptable to disruptions. Structural flexibility is typically enhanced through practices that create alternative structures or parallel options within the supply chain, such as multiple suppliers, distributed production sites, or alternative distribution channels (Volberda, 1996; Christopher & Holweg, 2011). However, how these practices need to be enabled and whether adopting these practices always leads to the enhancement of structural flexibility needs further clarification. In addition to that, these practices can be designed in different ways. Consequently, different designs of the practices might form different structural flexibility dimensions and therefore, enhance structural flexibility in different ways.

1.3 Purpose and Research Questions

While structural flexibility is increasingly acknowledged as important for coping with frequent disruptions (Christopher & Holweg, 2017; Sarma & Pramod, 2015), existing research provides limited insight into structural flexibility as a subtype of supply chain flexibility. In practice, companies increasingly introduce practices enhancing structural flexibility, such as multiple suppliers, production sites, postponement, or collaboration to make their supply chains more adaptable to disruptions (Bergmeier & Gierhardt, 2025; Johnston, 2024). However, while these practices are supposed to enhance structural flexibility, it remains unclear what kind of structural flexibility formations result from these practices, as part of this enhancement. Without understanding which dimensions structural flexibility shares with supply chain flexibility, it becomes difficult to frame structural flexibility theoretically and managerially to form structural flexibility according to certain objectives. While structural flexibility can be enhanced through multiple practices such as collaboration, postponement, and diversification (Volberda, 1996; Christopher & Holweg, 2011), this thesis focuses analytically on dual sourcing for this specific problem. The reason is that dual sourcing offers a large range of variation in design characteristics described in the literature (Huang et al., 2018; Jakšič & Fransoo, 2018; Li et al., 2011, 2023). By examining these variations within a single, theoretically grounded diversification practice, it becomes possible to determine how different design characteristics contribute to the formation of structural flexibility.

Furthermore, literature provides limited insights into enabling the practices that are meant to enhance structural flexibility. Prior studies have mainly focused on identifying individual practices associated with structural flexibility (Volberda, 1996; Christopher & Holweg, 2011), while paying less attention to requirements that enable these practices to become structurally embedded in supply chains. For companies attempting to adopt such practices, this creates uncertainty regarding which requirements must be fulfilled for these practices to enhance structural flexibility or whether they enhance structural flexibility at all by the simple adoption of these practices.

Hence, the purpose of this licentiate thesis is to contribute to flexibility, dual sourcing, and adaptive supply network design literature by analyzing how structural flexibility is formed through the design characteristics of dual sourcing and how practices are enabled, while also providing an understanding of how firms can deliberately enhance structural flexibility.

First, as structural flexibility remains an under-theorized concept, particularly in terms of its formation, this thesis explores which dimensions may form through design characteristics of dual sourcing. By identifying and conceptualizing such dimensions, the thesis seeks to refine the theoretical and managerial understanding of structural flexibility and clarify how different dimensions of structural flexibility form from different design characteristics of dual sourcing to enhance structural flexibility. Hence, the first research question (RQ) is:

RQ 1: How does dual sourcing form structural flexibility?

In this thesis, formation refers to how structural flexibility emerges from the design characteristics of dual sourcing and forms different flexibility dimensions.

The second question framing this thesis is to understand how structural flexibility is enhanced through the practices. Thereby, this question is supposed to identify the requirements that enable the adoption of practices. By focusing on the enablement of practices, this thesis seeks to contribute to an understanding of how structural flexibility is enhanced. Therefore, the second question is:

RQ 2: How are practices of structural flexibility enabled?

In this thesis, enablement refers to how practices of structural flexibility are made possible through fulfilling certain requirements.

Third, recognizing that structural flexibility does not represent a homogenous capability, this thesis seeks to examine the insights into the formation of structural flexibility dimensions and enablement of practices to guide firms in deliberately enhancing structural flexibility. The last research question intends to support interpretation by showing how the insights can add to the understanding of enhancing the structural flexibility of supply chains. Therefore, the last research question is:

RQ3: How do the formation of structural flexibility dimensions and the enablement of practices support firms in deliberately enhancing structural flexibility?

Here, enhancing refers to strengthening structural flexibility, while deliberately refers to doing so through the intentional formation and enablement of practices.

1.4 Paper Presentation

The following section introduces the papers that are attached to this thesis.

1.4.1 Paper I

This paper examines how different design characteristics of dual sourcing form structural flexibility dimensions in supply chains and relates to RQ 1 and 3. Dual sourcing is increasingly used as a practice to enhance resilience by enhancing structural flexibility, yet existing literature provides limited insight into what dimensions of structural flexibility result from different dual sourcing design characteristics. While prior research acknowledges that dual sourcing forms flexibility, it remains unclear how design characteristics form structural flexibility.

Based on a qualitative multiple case study of six dual sourcing strategies across two companies, the article investigates how dual sourcing is designed under disruptive conditions. The analysis focuses on three key design characteristics: the type of dual sourcing, the depth of integration of dual sourcing into organizational structures and processes, and the breadth of utilization across components, products, and categories. By comparing cases that vary along these characteristics, the study examines how different dual sourcing practices lead to different structural flexibility dimensions.

The findings show that dual sourcing does not uniformly form structural flexibility. Instead, the formation of structural flexibility dimensions depends on how deeply the strategy is integrated and how broadly it is utilized. Deeper integration forms higher-level structural flexibility dimensions related to relationships, network structure, and

reconfiguration, while superficial integration limits flexibility to more basic strategic-level dimensions. Broader utilization increases the scope and number of structural flexibility dimensions formed, whereas narrow utilization confines structural flexibility to limited parts of the supply chain. By linking dual sourcing design characteristics to specific structural flexibility dimensions, the article contributes to a more nuanced understanding of how structural flexibility is formed through dual sourcing in supply chains facing repeated disruptions.

1.4.2 Paper II

This paper examines how practices enhancing structural flexibility are enabled in supply chains under frequent disruptions and relates to RQ 2 and 3. Structural flexibility is increasingly recognized as a crucial capability for adaptability and resilience; however, existing research offers limited insight into how practices that enhance structural flexibility are enabled by meeting specific requirements.

Based on a qualitative multiple case study, this article investigates several practices enhancing structural flexibility as cases, including dual sourcing, dual design, dual transportation modes, dual manufacturing sites, and dual supply hubs. The analysis focuses on how these practices are planned, utilized, and routinized across different states, referred to as ex-ante, ex-post, and ex-diem, and how practices are enabled.

The findings show that structural flexibility is not enhanced from individual practices in isolation, but often from a network of practices. Enhancing structural flexibility requires enabling or fulfilling an ordered set of requirements that can be grouped into strategy-based, dependency-based, and practice-specific requirements. Thereby, practices can shift in the states and can therefore change the state they are in. By explaining what practices enhancing structural flexibility require, and how these requirements are met, the article contributes to a clearer understanding of how structural flexibility is enhanced in supply chains.

1.5 Outline of This Thesis

Following the introduction, the theoretical framework presents and analyzes the key theories that frame this thesis. This chapter reviews and positions the literature on supply chain flexibility and structural flexibility, designing adaptive supply networks, and clarifies the conceptual foundations guiding the research.

The methodology chapter then outlines the overall methodological approach of the thesis. In addition to describing the research design, data collection, and data analysis, this chapter presents the methodological choices made in each of the two included papers.

The findings and discussion chapter synthesizes the most important empirical findings from both papers. This chapter highlights the key insights that are relevant for answering the research questions and shows how the findings from the two studies complement each other. In addition, this chapter analyzes how the findings address the research questions and discusses the theoretical and managerial contributions of the thesis.

Finally, the conclusion chapter presents the main conclusions of the thesis. It summarizes the knowledge gained through the research, outlines the overall contributions of this knowledge, and discusses the limitations and future research possibilities of the study.

2. Theoretical Framework

In the next paragraph, the literature framing this licentiate regarding supply chain flexibility, structural flexibility, and designing adaptive supply networks will be presented.

2.1. Supply Chain Flexibility

Over the years, supply chain flexibility has become well-understood from various perspectives. Starting with manufacturing flexibility, different dimensions have been found that define the abilities that flexibility can form in different operations, but also based on tactical concerns in manufacturing (Chen et al., 1992; Slack, 1983; Upton, 1994; Vokurka & O’Leary-Kelly, 2000). In the late 90’s and the following 00’s, flexibility has been defined within the supply chain context, leading to more dimensions that enable flexibility strategically as well throughout the whole network (Duclos et al., 2003; Pujawan, 2004; Vickery et al., 1999; Vokurka & O’Leary-Kelly, 2000). Afterwards, research has focused on finding unified definitions for supply chain flexibility. The authors developed conceptual frameworks that consist of multiple dimensions systemically organized into different levels (Manders et al., 2016; Martínez Sánchez & Pérez Pérez, 2005; Rojo et al., 2018; Stevenson & Spring, 2007, 2009). The levels are of a hierarchical nature, and while operational and tactical levels encompass dimensions of short-term changes, strategic and network levels encompass dimensions of long-term changes (Martínez Sánchez & Pérez Pérez, 2005; Stevenson & Spring, 2007). Because of the number of frameworks that exist around the definition of supply chain flexibility, a synthesis of these definitions and dimensions can be seen in Table 1:

Table 1: Summary of all Supply Chain Flexibility Levels and Dimensions.

Level	Description of Level	Examples of Dimensions	Authors
Operational level	Is concerned with the short-term changes in operations and material flow.	Machine Flexibility, Labor Flexibility, Material handling Flexibility, Operation Flexibility.	(Manders et al., 2016; Rojo et al., 2018; Stevenson & Spring, 2007)
Tactical level	Is concerned with the short-term internal relationships of the supply chain, mediating operations, and strategic interests.	Product/modification Flexibility, Volume Flexibility, Delivery Flexibility, Production Flexibility, Quality Flexibility.	(Manders et al., 2016; Slack, 1983; Stevenson & Spring, 2007; Upton, 1994).
Strategic level	Is concerned with long-term customer relationships, and to distribute as fast as possible.	New Design, Market Flexibility, Launch Flexibility, Access Flexibility, Supply & Sourcing Flexibility, Purchasing Flexibility.	(Manders et al., 2016; Pujawan, 2004; Rojo et al., 2018; Stevenson & Spring, 2007; Vokurka & O’Leary-Kelly, 2000)

Network level	Is concerned with long-term network structures	Reconfiguration Flexibility, Robustness Flexibility, Relationship Flexibility, Logistic Flexibility.	(Lummus et al., 2005; Malhotra & Mackelprang, 2012; Manders et al., 2016; Rojo et al., 2018; Stevenson & Spring, 2007)
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2.2 Structural Flexibility as a Type of Supply Chain Flexibility

Christopher and Holweg (2011) argue that structural flexibility, together with dynamic flexibility, is a type of supply chain flexibility. While dynamic flexibility aims to establish control over a disruptive situation as a reactive short-term option, structural flexibility embraces disruptions by enabling the company to prepare for such turbulences through building structures. Structural flexibility facilitates long-term changes, making the supply chain more adaptable (Sarma & Pramod, 2015). Dynamic flexibility facilitates the supply chain to be agile (Phadnis, 2024). Forming both types of flexibility comes with a cost; however, the cost associated with dynamic flexibility originates from its short-term needs, while the cost of structural flexibility stems from the structure that is built (Christopher & Holweg, 2011). Hence, building this structure makes sense when companies experience frequent new disruptions (Christopher & Holweg, 2017).

Based on the differences between the two types and their relation to supply chain flexibility as an umbrella term, it can be questioned whether the different types of supply chain flexibility generate distinct dimensions as well. Examining the synthesis of the frameworks, the hierarchy is based on short-term and long-term changes, with both types manifesting either short-term or long-term flexibility (Christopher & Holweg, 2011; Phadnis, 2024). Based on the fact that structural flexibility has a long-term nature (Sarma & Pramod, 2015), it would form dimensions that enable the supply chain to change permanently, such as at the strategic and network levels of the frameworks. Additionally, it can be argued that some dimensions may belong to the tactical level, as these mediate between long-term and short-term dimensions. However, dimensions of the tactical level, which mediate short- and long-term interests, mainly focus on how long-term dimensions align with short-term dimensions, enabling reactive adjustments. Hence, long-term dimensions can be found at the strategic and network levels, and therefore, it can be assumed that structural flexibility forms dimensions within these two levels.

2.2.1 Practices enhancing structural flexibility

The literature identifies several practices through which structural flexibility can be embedded in supply chains and organizations. Across these practices, the common principle is the deliberate creation of alternative structures, parallel capacities, or configurable arrangements that allow adaptation when conditions change. These practices can broadly be grouped into three categories: collaboration, postponement, and diversification (Volberda, 1996; Christopher & Holweg, 2011). Collaboration enhances structural flexibility by establishing internal and external relational arrangements that extend access to complementary resources and capabilities. Volberda (1996) highlights multifunctional teams, adaptive units, and modified control systems as internal mechanisms that support structural adaptability, while also emphasizing partnerships and alliances as external forms of collaboration. Christopher and Holweg (2011) complement this view by pointing to asset sharing and interorganizational cooperation as structural supply chain practices. Postponement enhances structural flexibility by delaying

commitment to final configurations. Christopher and Holweg (2011) propose separating predictable base demand from volatile surge demand, allowing firms to manage efficiency and flexibility simultaneously. By holding base materials or modules and completing final assembly against actual orders, firms embed adaptability into the supply chain structure. Diversification practices enhance structural flexibility by intentionally creating parallel structural options. Dual sourcing, multiple manufacturing sites, dispersed production, flexible labor arrangements, and outsourcing are examples of such practices (Christopher & Holweg, 2011). These practices reduce dependency on single structures and embed substitution possibilities into supply chain design.

2.3 The Potential Formation of Structural Flexibility Dimensions by Dual Sourcing

Discussing the formation of potential structural flexibility dimensions leads to the question of how these are formed through structural flexibility. Former research, which investigated the supply chain flexibility dimensions, concluded that these dimensions are formed (Martínez Sánchez & Pérez Pérez, 2005; Rojo et al., 2018; Stevenson & Spring, 2007), but not how they are formed, and whether this formation can be managed.

Going back to structural flexibility and its potential formation, one can say that the enhancement of structural flexibility comes from certain practices (Volberda, 1996; Christopher & Holweg, 2011). Evidence can be found from research on dual sourcing, which concluded that dimensions such as delivery and supply flexibility are formed through this practice (Glock, 2012; Sawik, 2014). Therefore, dual sourcing, as a practice of structural flexibility, forms flexibility dimensions. Managing these formations becomes interesting when a firm wants to deliberately form, for example, only certain kinds of dimensions reflecting the resulting abilities that are made possible through supply chain flexibility. Choosing and deliberately forming supply chain flexibility dimensions might as well help to deliberately form one type of supply chain flexibility, building a short-term or long-term capability.

However, dual sourcing, as one prominent example of practices enhancing structural flexibility, is described as a homogeneous practice in resilience and flexibility literature. Its design characteristics shape how it is used, integrated, and utilized, and thereby potentially form different structural flexibility dimensions. These design characteristics influence how much dual sourcing becomes part of the supply chain structure. Consequently, practices such as dual sourcing might not automatically result in one specific form of structural flexibility. Rather, depending on how it is designed, different design choices may potentially form different dimensions of structural flexibility. This suggests that the outcome of practices is linked to their design, and that understanding their design characteristics is essential to explain how structural flexibility forms.

2.3.1 Temporal dual sourcing types in resilience and flexibility literature

The literature on resilience and flexibility commonly distinguishes between emergency and long-term dual sourcing (Li et al., 2023). Emergency dual sourcing is activated reactively when a primary supplier fails to deliver (Han et al., 2023). It is typically applied under supply uncertainty or known vulnerabilities (Huang et al., 2018). Although it provides short-term responsiveness, it is often associated with higher administrative and operational costs, as well as increased risk due to untested suppliers and insufficient

infrastructure for parallel sourcing (Huang et al., 2018; Kouki et al., 2018). In such cases, the flexible structure must be built or activated under time pressure.

Long-term dual sourcing, in contrast, refers to a planned and continuous allocation of volumes between two or more suppliers (Li et al., 2023). It is a regular sourcing routine, reducing coordination burdens and enabling cost efficiencies (Huang et al., 2018). Because suppliers are selected in advance, the sourcing structure becomes more stable. Here, flexibility is not activated reactively but is a routine in the supply chain.

2.3.2 Integration mechanisms

Dual sourcing also involves various integration mechanisms that shape its design characteristics. Integration refers to the alignment and coordination of processes within and across organizational boundaries (Power, 2005). In the context of dual sourcing, integration is achieved through administrative routines, product design choices, technological systems, and supplier positioning decisions.

Administrative adjustments are required to manage split volumes, forecasting systems, and inventory policies (Xiong et al., 2022). Contracts often need to be renegotiated to retain sourcing rights and ensure flexibility (Luo et al., 2015). Operational processes must align quality standards and material specifications when suppliers differ (Lu et al., 2011). Logistics configurations may need to be integrated better to enable variation in delivery frequencies and production start times (Glock, 2012).

Product substitution further shapes dual sourcing. When products or components are designed to be substitutable or need to be redesigned for dual sourcing, firms can reallocate supply across variants in case of disruption (Lu et al., 2011; Wu et al., 2020). This design characteristic gives the freedom to use both suppliers for a certain product. However, high demand and technical feasibility may reduce the benefits and require adjustments in sourcing design (Lu et al., 2011).

Technological systems are another integration mechanism. Information transparency enables diversification decisions and reduces supply risk (Yang et al., 2012). Technologies such as blockchain can increase visibility and coordination across suppliers (Liu et al., 2019), while broader information sharing supports the dualization of sourcing strategies (Chen & Liu, 2024; Wang et al., 2010).

Combining nearshore and offshore suppliers allows firms to balance lead time advantages with cost efficiency and supply continuity (Jakšič & Fransoo, 2018; Wang et al., 2010). Geographic diversification thereby becomes a structural design mechanism rather than a purely operational choice. Hence, supplier positioning is another mechanism of integration.

2.3.3 Utilization

Beyond the types of dual sourcing expressing the temporality and integration, the extent to which dual sourcing is utilized shapes this practice. Extensive utilization enables sequential decision-making, demand adjustment, and constraint management at the system level (Song et al., 2017). Spreading capacity across multiple suppliers reduces

dependency and balances risk (Davarzani et al., 2011). Therefore, utilization intensity may also alter the nature of the sourcing structure and the type of flexibility it generates.

2.4 Structural Flexibility as a Capability of Adaptable Supply Chains

Structural Flexibility has been conceptualized as a capability that leads to adaptable supply chains, and that is enhanced through certain practices (Christopher & Holweg, 2011). It is an important capability for future supply chains, which are mostly defined by disruptions and uncertainty (Christopher & Holweg, 2017). Christopher and Holweg (2011) describe that supply chain flexibility, in comparison to dynamic flexibility, would be a more effective cost saving over time in disruptive environments. With that, this conceptualization describes the possible effects and advantages of choosing structural flexibility as a capability to achieve in the future supply chain. However, how to enhance structural flexibility aside from using these practices remains underconceptualized. One reason for that is that it is never stated how to enable these practices, which requirements are bound to that enablement, and how these are enabled through the requirements.

2.4.1 Known requirements of structural flexibility

To be able to enhance structural flexibility, companies need to meet certain requirements. Such requirements are network capabilities, relationship management and collaboration, multi-purpose resources, risk management, and have an adaptive structure (Iravani et al., 2005; Christopher & Holweg, 2011; Sarma & Pramod, 2015; Majid et al., 2019). These requirements are not conceptualized but are more mentioned. However, the literature does not connect these requirements with the practices that are enhancing structural flexibility. Additionally, although these requirements have not been conceptualized, comparing the requirements with the practices of structural flexibility, certain named requirements, such as multi-purpose resources, are tautological. Additionally, having adaptive structures as a requirement to build something that is supposed to result in adaptability seems illogical. Therefore, to enhance structural flexibility through certain practices, the requirements enabling the practices need to be revealed.

2.5 Jury Rigging and Designing an Adaptive Supply Network

To understand how supply networks can be designed to cope with disruptions that cannot be anticipated, Kauffman et al. (2018) introduce the concepts of tinkering and jury rigging. Drawing from biological evolution as a process of tinkering, they argue that complex adaptive systems survive by recombining existing elements in novel ways when confronted with unforeseen conditions. In this perspective, adaptation does not always result from pre-planned optimization but from the creative reconfiguration of existing structures.

Kauffman et al. (2018) reflect this logic in supply networks. They define unknown-unknowns as disruptions that have no prior occurrence and no known probability distribution. Such events only become visible in their realization and therefore cannot be addressed through traditional risk mitigation or probabilistic planning. In response, they propose jury-rigging as an adaptive mechanism. Jury-rigging describes the ability of a supply network to recombine suppliers, relationships, and capabilities in non-prespecified ways to address unexpected events. It implies that suppliers are not fixed in narrowly defined roles but can assume new functions when required.

This perspective differs from traditional supply chain risk management approaches that focus on efficiency, redundancy, or predefined contingencies (Hohenstein et al., 2015; Tang, 2006). Instead, it views adaptive capacity as something that can be designed in the network structure itself. Kauffman et al. (2018) distinguish between ex-ante and ex-post as states and are different responses to uncertainty. Ex-ante refers to anticipating a disruption and preparing a plan for an adapted supply network before the disruption materializes. Ex-post refers to reacting after a disruption has occurred and making immediate changes to adapt the network accordingly. Ex-post responses are often regarded as insufficient for building adaptive and resilient supply networks, as they are reactive rather than proactive (Feizabadi et al., 2023). However, when following the logic of designing an adaptive network, ex-post actions can also be interpreted as a starting point for structural change. A reactive adjustment may, over time, lead to more permanent flexible structures once the disruption has passed. In this sense, ex-post does not necessarily contradict structural adaptation but may initiate it.

In addition to these states, Kauffman et al. (2018) identify “rewiring” as a key requirement for both ex-ante and ex-post states. Rewiring refers to reconnecting nodes within the supply network after a new practice or actor has been introduced. The concept has been criticized for implying random reconnection of existing nodes within a fixed network structure (Hearnshaw & Wilson, 2013). However, rewiring does not necessarily imply a static system. While some nodes may already exist, others may be newly introduced, and even existing nodes may perform new practices or roles in ex-ante and ex-post states (Kauffman et al., 2018). Nodes in supply networks can be understood as actors positioned on the supplying or receiving end (Zhao et al., 2011). When practices such as dual sourcing, postponement, or collaboration are adopted, both supplying and receiving nodes often need to be reconnected or newly integrated. In this research, rewiring is therefore interpreted as a systematic and growing process of reconnecting and extending the network rather than a random re-linking of fixed elements.

The perspective of Kauffman et al. (2018) has been chosen because it directly addresses the structural conditions, such as rewiring and the states under which adaptive responses become possible. While much of the flexibility literature focuses on dimensions or practices, jury rigging provides a network-level explanation of how adaptive capacity is designed. It shifts attention from isolated practices to the underlying architecture, relationships, and decision rights that design adaptation under uncertainty. As this thesis investigates how to enable practices that enhance structural flexibility, the jury-rigging perspective offers a suitable theoretical foundation to analyze how this structure is designed by ex-ante and ex-post to be adaptable.

However, Kauffman et al.’s framework was developed in a context of relative stability, where disruptions were less frequent and often treated as exceptional events. Under such conditions, distinguishing between ex-ante and ex-post was sufficient to explain adaptive responses. However, current supply chain environments are characterized by frequent and overlapping disruptions, including geopolitical tensions, pandemics, and climate-related catastrophes (Collins, 2025). In such conditions, practices may not remain in one state, and new practices are added. Instead, they may move from ex-ante to ex-post and may persist beyond the disruption as part of daily routines in sight of long-term dual sourcing strategies. This raises further questions, particularly whether the requirements for practices change when practices transition between states.

2.6 Synthesis of the literature

Structural flexibility has increasingly been described as a crucial capability for supply chains operating under frequent disruptions (Christopher & Holweg, 2011, 2017). Despite its growing relevance, structural flexibility remains conceptually underdeveloped. As illustrated in Figure 1, this thesis positions structural flexibility at the intersection of three literature streams: flexibility, dual sourcing, and adaptive supply network design. While each stream provides important insights, they remain only partially connected. In particular, the formation of structural flexibility through practices and the enablement of these practices are insufficiently theorized.

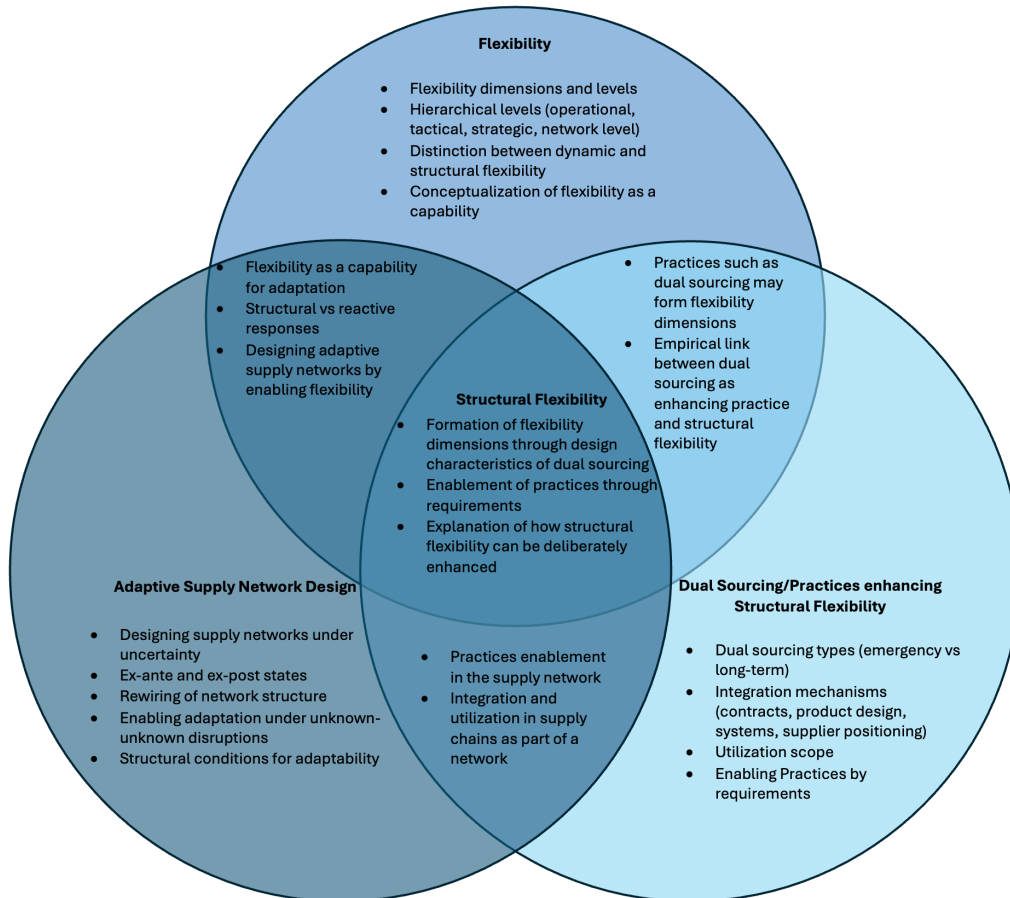


Figure 1: Positioning of structural flexibility in the literature.

To clarify its conceptual positioning, insights from supply chain flexibility as seen in Figure 1 provide an important theoretical reference. Flexibility has been extensively categorized across hierarchical system levels ranging from operational to network levels (Manders et al., 2016; Rojo et al., 2018; Stevenson & Spring, 2007). These frameworks distinguish between short-term change and long-term structures. From a structural flexibility perspective, this hierarchy suggests that structural flexibility is primarily associated with strategic and network-level dimensions regarding reconfiguration and relationships. However, while supply chain flexibility literature identifies dimensions, it does not explain whether and how structural flexibility specifically forms these dimensions, nor whether different ways of adopting certain practices to enhance structural flexibility may lead to different dimensional formations. In this thesis, supply chain flexibility therefore serves as a theoretical frame to interpret potential formations of structural flexibility rather than as the primary object of investigation.

The literature further indicates that structural flexibility is enhanced through practices such as collaboration, postponement, and diversification (Volberda, 1996; Christopher & Holweg, 2011). Yet these practices are rarely examined from a structural flexibility perspective. Instead, they are often analyzed individually, focusing on cost, efficiency, or risk mitigation. At the same time, practices are not homogeneous. As illustrated in Figure 1, design characteristics of dual sourcing such as emergency versus long-term orientation (Li et al., 2023), degrees of integration (Power, 2005), product substitutability (Lu et al., 2011), technological transparency (Liu et al., 2019), supplier positioning (Jakšič & Fransoo, 2018), and intensity of utilization (Song et al., 2017) shape how deeply a practice becomes embedded in the supply chain structure. These design characteristics suggest that structural flexibility may not form uniformly but rather depends on how practices are configured and developed.

Although several studies mention requirements associated with structural flexibility, such as network capabilities, collaboration, multi-purpose resources, and adaptive structures (Iravani et al., 2005; Majid et al., 2019; Sarma & Pramod, 2015), these requirements are neither systematically conceptualized nor clearly linked to the practices that are expected to enhance structural flexibility. In some instances, requirements appear circular, for example, when adaptive structures are treated as prerequisites for adaptability. This indicates a lack of explanation regarding how practices enhancing structural flexibility are enabled while being a part of an adaptive supply network (Figure 1). By looking into designing adaptive supply networks by Kauffman et al. (2018), the literature might clarify how practices are *ex-ante* planned or *ex-post* utilized, and what kind of requirements enabling these practices result from that.

Because structural flexibility remains underconceptualized, several sections of this frame of reference synthesize dispersed literature streams to construct a coherent analytical foundation. The synthesis of supply chain flexibility dimensions clarifies where structural flexibility may be positioned hierarchically and what kind of formations can be expected. The synthesis of practice literature illustrates how different design characteristics may connect to the formation of structural flexibility. The integration of jury rigging theory (Kauffman et al., 2018) provides a network-level explanation of how adaptability needs to be designed and enabled, and systematic rewiring under unknown-unknown disruptions. Hence, these literature streams move the discussion from a descriptive definition of structural flexibility to its enhancement through formation and practice enablement.

Hence, the frame of reference reveals three interconnected challenges: First, the formation of structural flexibility by the enhancing practices remains sufficiently specified. Second, the practices themselves, and how these can be enabled to enhance structural flexibility. Third, addressing what these challenges require, moving toward an analysis of how structural flexibility is deliberately enhanced by the formation of dimensions and the enablement of practices combining the knowledge of formation and practice enablement.

3. Methodology

This chapter explains the adoption of a qualitative approach and the methodological choices of the study that form the foundation for two articles and this dissertation. Additionally, this chapter seeks to explain the case selection, research process, data collection, and analysis, describing the research process and the choices that led up to this licentiate seminar. The chapter closes with a reflection of the decisions that were made through this process.

3.1 Overall Research Design

This thesis adopts a qualitative research design grounded in an interpretivist epistemological position and guided by abductive reasoning, characterized by systematic combining between empirical observations and theoretical development (Bryman et al., 2015; Dubois & Gadde, 2002). Hence, the overall ambition is theory development and conceptual refinement of structural flexibility.

Structural flexibility is described in prior research as a long-term capability enabling supply chains to adapt through building flexible structures (Christopher & Holweg, 2011; Sarma & Pramod, 2015). Despite its increasing relevance in turbulent environments (Christopher & Holweg, 2017), it remains conceptually underdeveloped. The literature does not clearly explain how practices that enhance structural flexibility are enabled, especially which requirements are connected to that enablement, nor which structural flexibility dimensions may form as a result of practices such as dual sourcing. While supply chain flexibility research provides hierarchical categorizations of flexibility dimensions (Martínez Sánchez & Pérez Pérez, 2005; Rojo et al., 2018; Stevenson & Spring, 2007), it does not specify how structural flexibility as a distinct type is formed or how it relates to those dimensions. This theoretical fragmentation requires an exploratory and theory-building research approach (Eisenhardt, 1989). A qualitative approach is therefore appropriate, as it enables in-depth exploration of how actors design, interpret, and embed practices intended to build structural flexibility in real-world supply chain settings (Miles et al., 2020b; Yin, 2018c). A quantitative approach would have required established operationalizations of structural flexibility dimensions and practice requirements (Edmondson & McManus, 2007). However, statistical testing would presuppose a level of construct maturity that the literature does not yet provide.

Furthermore, the overall research design builds on two multiple case studies to capture variation in how structural flexibility is formed and practices enabled. Multiple cases allow comparison across the two companies, different practices or practice designs, and thereby strengthen theory development (Eisenhardt, 1989). Thereby, both companies that were participating in the studies provided a suitable empirical setting because both adopted several practices to build a flexible structure and regularly face disruptions in their whole supply network. These characteristics make structural flexibility particularly relevant and observable in practice. Furthermore, this thesis consists of two empirical papers that address complementary aspects of enhancing structural flexibility. The first paper investigates how structural flexibility is formed through the design characteristics of dual sourcing. The second paper examines how practices that enhance structural flexibility are enabled. Together, the papers explain both the enhancement of structural flexibility, the first one by understanding the outcome of forming structural flexibility

dimensions as the enhancement, and the second, how to enable the practice to enhance structural flexibility.

From an epistemological perspective, this research understands structural flexibility as a capability that is embedded in routines, relationships, structural arrangements, and managerial decisions (Volberda, 1996; Iravani et al., 2005; Christopher & Holweg, 2011; Sarma & Pramod, 2015; Majid et al., 2019). Structural flexibility is enhanced through practices such as dual sourcing, collaboration, postponement, and diversification (Volberda, 1996; Christopher & Holweg, 2011). Understanding such a phenomenon requires insights into organizational processes, interpretations, and design choices as they unfold in practice (Yin, 2018a). Structural flexibility cannot be meaningfully reduced to predefined constructs without first clarifying its conceptual structure.

The research follows an abductive reasoning, characterized by iterative movement between theory and empirical material (Alvesson & Kärreman, 2007; Dubois & Gadde, 2002). The reason is that an abductive approach allows the research to refine theoretical concepts while remaining grounded in empirical observations of structural flexibility, practices, and dimensional formation. Existing literature on structural flexibility, supply chain flexibility, and dual sourcing provided an initial conceptual framing that informed data collection and analysis. However, empirical observations were not treated as confirmations of prior theory. Instead, emerging patterns and inconsistencies prompted refinement and extension of the theoretical understanding. Through an iterative comparison between empirical findings generated from the interviews and the literature on supply chain flexibility, structural flexibility, dual sourcing, and adaptive supply network design, the research moves back and forth between data and theory. Initial interpretations of the empirical material were confronted with existing concepts, which led to the refinement of categories such as integration depth, utilization breadth, and enabling requirements. These refined concepts were then revisited in the empirical material to assess their explanatory fit and to identify variations across cases. This iterative process supported the development of a more structured explanation of how practices of structural flexibility are enabled, how structural flexibility forms through dual sourcing, and how different structural design choices relate to different dimensional outcomes. Abductive reasoning is particularly appropriate for under-theorized phenomena, as it combines theoretical sensitivity with openness to empirical complexity (Timmermans & Tavory, 2012), such as with structural flexibility.

3.2 Methodological Choices

Building on the overall qualitative and abductive research design, this thesis applies a multiple case study strategy in both included papers. While both studies investigate structural flexibility as a capability, they approach the phenomenon from different analytical angles and therefore differ in unit of analysis and empirical focus. The methodological choices in each paper reflect these differences while remaining consistent with the overarching aim of developing and refining the conceptual understanding of structural flexibility. The specific design characteristics of each study are outlined below, and an overview of these is provided in Table 2.

3.2.1 Methodological choices for paper I

In Paper I, a multiple case study design was adopted to understand how different design characteristics of dual sourcing form structural flexibility dimensions. The study comprises six cases of dual sourcing practices adopted to increase adaptability under disruption. The unit of analysis consists of structural flexibility dimensions as outcomes formed through different configurations of integration and utilization. Data collection was cross-sectional in timing but process-oriented in content, as respondents described how dual sourcing strategies were practiced. Case selection was theoretically motivated, focusing on dual sourcing practices deliberately designed to enhance flexibility rather than solely to reduce costs or stimulate competition. The phenomenon studied is structural flexibility as a capability that can form differently depending on how a specific practice is structurally configured. The analysis combines within-case and cross-case approaches (Bryman et al., 2015; Miles et al., 2020c), enabling identification of patterns linking integration depth and utilization breadth to the hierarchical formation of structural flexibility dimensions.

3.2.2 Methodological choices for paper II

In Paper II, a multiple case study design was employed to understand how structural flexibility is enhanced through different practices and how the associated requirements are enabled. The study includes eleven cases of structural flexibility practices that were either planned or actively utilized with the intention of becoming or remaining flexible under disruption. The unit of analysis consists of the requirements linked to enhancing structural flexibility through these practices. As in Paper I, the data collection was cross-sectional in structure but captured retrospective accounts of planning, utilizing, and routinization. Case selection was theoretically driven, focusing on organizations that deliberately adopt structural flexibility practices beyond short-term reactive responses. The phenomenon studied is structural flexibility as a capability that organizations seek to enhance through the fulfillment and enablement of specific requirements. The analysis combines within-case influenced by the phases of reflexive thematic analysis proposed by Braun and Clarke and cross-case approaches (Braun & Clark, 2006; Bryman et al., 2015; Miles et al., 2020c). This allowed systematic comparison across practices and refinement of the conceptual understanding of how the structural flexibility is enabled by meeting certain requirements.

Table 2: Methodological Design Choices

Methodological Design Choice	Paper I	Paper II
Case Study Type	Multiple Case Study:	Multiple Case Study:
Number of Cases	Six Cases of dual sourcing cases.	Eleven Cases of different structural flexibility practices.
Unit of Analysis	Structural Flexibility Dimensions.	Requirements of enhancing structural flexibility by different practices.
Temporal dimension	Cross-Sectional in retro perspective	Cross-Sectional in retro perspective
Motivation for case selection	Dual sourcing used to become more flexible.	Structural Flexibility practices planned or utilized to be or become more flexible.

Phenomenon studied	Structural Flexibility as a capability that can be formed differently as an outcome of practicing dual sourcing.	Structural Flexibility as a capability that wants to be enhanced by certain practices.
Analysis Approach	Within-case and cross case analysis (Bryman et al., 2015; Miles et al., 2020c).	Within-case influenced by the phases of reflexive thematic analysis proposed by Braun and Clarke (Braun & Clarke, 2006) and cross case analysis (Bryman et al., 2015; Miles et al., 2020c).

3.3 Case Selection per Paper

Case selection in this thesis follows a purposive and theoretically informed sampling strategy consistent with qualitative case study research (Miles et al., 2020a; Yin, 2018b). The objective was not statistical representativeness but transferability. Cases were selected based on their theoretical relevance to the phenomenon of structural flexibility and their potential to extend, contrast, and refine conceptual understanding.

Following Yin (2018b), case selection was guided by replication logic rather than sampling logic in a statistical sense. Cases were chosen to either predict similar results under different structural conditions or to produce contrasting results for theoretically explainable reasons. This approach strengthens transferability and supports theory development. In line with Miles, Huberman, and Saldaña (2020a), sampling boundaries were defined before case inclusion to ensure conceptual clarity and internal coherence of the empirical material.

Across both papers, boundary conditions were applied to ensure alignment with the theoretical framing of structural flexibility as a long-term capability embedded in supply chain structures (Christopher & Holweg, 2011; Sarma & Pramod, 2015). Only cases in which practices were explicitly connected to enhancing or building structural flexibility under disruption were included. Hence, practices adopted purely for cost efficiency, competitive bidding, or short-term operational optimization without a structural flexibility ambition were excluded. Furthermore, cases were selected to allow credibility, dependability, and transferability of findings, consistent with qualitative quality criteria in logistics research (Halldórsson & Aastrup, 2003)

In Paper I, the sampling strategy focused specifically on dual sourcing practices. Cases were selected based on their ability to illustrate variation in theoretically relevant design characteristics, particularly in type, integration depth, and utilization breadth. This aligns with a variable-oriented comparative strategy (Miles et al., 2020a), where cases are chosen to capture meaningful contrasts along analytically significant dimensions. The six selected cases represent different dual sourcing practices to enhance flexibility under disruption. The variation across cases enabled within-case analysis and cross-case comparison, supporting explanation building and theoretical refinement.

In Paper II, the sampling strategy was broader and included eleven cases representing different structural flexibility practices beyond dual sourcing. The intention was to capture variation in how structural flexibility is enhanced through different practices and how associated requirements are fulfilled. Consistent with theoretical sampling principles (Miles et al., 2020a), cases were selected to extend or challenge emerging explanations

and to cover variation in maturity level, degree of routinization, and contextual conditions. This allowed examination of how enabling requirements are interpreted and operationalized across different organizational settings, strengthening analytical depth and conceptual abstraction.

3.4 Data Collection

Data for this thesis were collected between September 2024 and September 2025. Across both papers, the primary data source consisted of semi-structured interviews with managers directly involved in sourcing, supply chain management, product development, and operational planning. Thereby, several interviews contributed as a data source for both papers, as seen in Table 3, especially the ones regarding dual sourcing as a practice. The overall data collection strategy was designed to capture how structural flexibility practices were adopted in two Swedish manufacturing firms.

Table 3: Interviews and Shared Data Collection Paper I and II

No	Interview Topic	Company	Date	Use in Papers
1	Reactive dual sourcing adoption	A	11.09.2024	Paper I & II
2	Reactive dual transportation adoption	A	02.10.2024	Paper II
3	Routinized diversification of supply hubs and manufacturing sites	B	04.12.2024	Paper II
4	Routinized dual sourcing adoption	B	05.12.2024	Paper I & II
5	Routinized diversification of supply hubs and manufacturing sites	B	13.12.2024	Paper II
6	Planned and routinized dual transportation adoption	A	20.12.2024	Paper II
7	Planned dualization of transportation routes, suppliers and manufacturing sites	B	01.04.2025	Paper I & II
8	Newly routinized dual sourcing adoption	A	05.05.2025	Paper I & II
9	Reactive dualization of product design	B	15.05.2025	Paper II
10	Reactive dualization of product design	B	15.09.2025	Paper II
11	Planned dualization of suppliers	A	23.09.2025	Paper I & II

Semi-structured interviews were chosen because the phenomenon under study, structural flexibility as an organizational capability, is context-dependent (Miles et al., 2020c). Interviewing allowed access to managerial interpretations, decision rationales, and descriptions of integration mechanisms that are not visible in formal documents. The interview guides were theory-informed, drawing on literature on supply chain flexibility, structural flexibility, and flexibility-enhancing practices. At the same time, they remained open enough to allow exploration of unexpected themes, consistent with the abductive research logic.

In Paper I, data collection focused specifically on dual sourcing design characteristics. Six cases of dual sourcing were examined across two Swedish manufacturing firms.

Interviews were conducted with sourcing managers, procurement managers, supply chain managers, and engineering representatives involved in the design of dual sourcing. The interview questions explored the disruption context, the motivation for adopting dual sourcing, integration mechanisms such as supplier qualification and internal coordination, utilization patterns across components and product categories, and the perceived structural flexibility outcomes. The interviews were conducted via video conferencing, recorded with consent, and transcribed verbatim. Follow-up questions were asked where clarification was needed, and some cases were discussed in more than one meeting to ensure depth and internal consistency. The data captured both ongoing practices and retrospective accounts of how dual sourcing was designed.

In Paper II, data collection was broader and covered eleven cases of different structural flexibility practices. These included several diversification practices such as dual sourcing or dual design adopted to enhance flexibility. Interviews were conducted with managers responsible for adopting or coordinating these practices. The focus was on understanding how the practices were planned or utilized, which requirements had to be fulfilled, how integration into organizational routines occurred, and how the practices transitioned from initial intention to more routinized use. Similar to Paper I, interviews were semi-structured, recorded, and transcribed. The data collection captured both utilized, planned, and routinized practices, allowing examination of structural flexibility practices across different maturity stages.

Across both papers, data collection was cross-sectional in timing but process-oriented in substance. Respondents described the adoption of practices, allowing reconstruction of temporal development even though interviews were conducted at specific points in time. The repeating nature of data collection allowed refinement of questions as theoretical understanding evolved. Early interviews informed subsequent interviews, enabling deeper probing into emerging themes such as integration depth, utilization breadth, and enabling requirements.

Ethical considerations were addressed throughout the research process. Participation was voluntary, informed consent was obtained from all interviewees, and anonymity was ensured in reporting. The combination of multiple cases, multiple respondents across functional areas, and systematic documentation strengthened credibility and allowed triangulation across perspectives.

3.5 Data Analysis

The data analysis across both papers followed a structured qualitative approach consistent with abductive reasoning. Analysis moved back and forth between empirical material and theoretical concepts to refine the conceptual understanding of structural flexibility. The process combined theory-informed coding with inductive pattern identification, allowing both analytical structure and openness to emerging insights (Miles et al., 2020a, 2020b).

In both papers, the analysis began with a within-case examination. Each case was first analyzed individually to preserve contextual richness and understand the internal logic of how practices were adopted. Interview transcripts were coded systematically using a coding structure derived from the theoretical framework. Initial coding categories were informed by literature on supply chain flexibility dimensions (Stevenson & Spring, 2007), structural flexibility (Christopher & Holweg, 2011; Sarma & Pramod, 2015), and

structural flexibility-enhancing practices such as dual sourcing. This deductive structure provided an analytical lens to identify relevant mechanisms, outcomes, and enabling conditions.

At the same time, coding remained open to inductive refinement. As transcripts were analyzed, recurring empirical patterns that were not fully captured by existing theoretical categories were identified. These patterns were compared within and across cases, leading to refinement of categories and development of higher-order themes. This process reflects abductive reasoning, where empirical observations challenge, extend, or nuance existing theoretical assumptions.

In Paper I, the analytical focus was on how different design characteristics of dual sourcing form structural flexibility dimensions. Within-case analysis identified integration mechanisms, utilization patterns, and the resulting flexibility dimensions. The coding process was influenced by phases of reflexive thematic analysis, allowing systematic identification of themes within each case before abstraction (Bryman et al., 2015; Miles et al., 2020c). After within-case analysis, a variable-oriented cross-case comparison was conducted (Miles et al., 2020a). Cases were compared along analytically relevant dimensions, particularly integration depth and utilization breadth. Through systematic comparison, recurring configurations were identified, leading to the conceptualization of different structural flexibility formation patterns.

In Paper II, the analytical focus was on how structural flexibility practices are enabled through specific requirements. Within-case analysis identified the requirements linked to each practice, how these were fulfilled, and how practices shifted from planning to utilization and routinization. The coding structure initially reflected theoretical concepts such as the known requirement of structural flexibility and designing adaptive supply networks. However, during analysis, it became evident that requirements can be categorized and were fulfilled in certain sequences, leading to refinement of the conceptual framing. Cross-case comparison allowed identification of recurring enabling patterns and differences across practice types and maturity levels. This comparison supported abstraction from individual cases toward a more general explanation of how structural flexibility is enhanced by enabling the practices.

Across both papers, cross-case analysis played a central role in abstraction. By systematically comparing similarities and differences across cases, the analysis moved from descriptive case narratives to conceptual explanation. The comparative logic allowed identification of structural configurations, hierarchies, and patterns of enablement that would not have been visible in single-case analysis.

Throughout the analysis, transparency and rigor were maintained by documenting coding decisions, maintaining clear links between empirical evidence and conceptual categories, and continuously revisiting theoretical assumptions, considering empirical findings. The repeating movement between theory and data ensured that conceptual development remained grounded in empirical material while contributing to theoretical refinement.

3.6 Research Process

The research process began in August 2023 with the start of the doctoral studies. At that time, research on supply chain flexibility was already extensive, with a strong focus on

defining flexibility in increasingly fine-grained detail. Numerous frameworks categorize flexibility into dimensions and hierarchical levels, yet empirical studies examining how flexibility is formed in practice have been comparatively limited. At the same time, the COVID-19 pandemic, the Semiconductor scarcity, and the Ukraine war have intensified the discussion around resilience and the need for supply chains to cope with repeated and overlapping disruptions. While resilience was frequently discussed as an objective, the underlying mechanisms through which companies could deliberately enhance flexibility remained ambiguous.

Early engagement with the literature revealed conceptual ambiguity in supply chain flexibility. Definitions of supply chain flexibility varied significantly, and the distinction between different types of flexibility was not always clearly articulated. Supply chain flexibility theories were often systemic and abstract, describing what flexibility is rather than how it is formed. They rarely captured the situational and configurational nature of supply chain flexibility in real organizational settings.

In early 2024, initial meetings with companies further highlighted a practical problem. Companies did not necessarily describe themselves as “flexible,” yet they actively used practices intended to cope with disruptions. Many companies adopted practices such as dual sourcing, collaboration, or supplier diversification without explicitly conceptualizing them as structural flexibility mechanisms. At the same time, companies increasingly expressed a need for a more structured and deliberate approach to becoming flexible, particularly as disruptions became more frequent. Identifying flexibility in practice proved challenging, as companies that did not explicitly frame their actions as flexibility-enhancing often struggled to articulate what they were doing and what outcomes were achieved. The gap between textbook definitions of flexibility and the knowledge regarding flexibility in the participating companies became increasingly evident.

These observations shifted the focus from supply chain flexibility in general to structural flexibility as a more precise analytical lens. Structural flexibility appeared more closely aligned with the companies’ need for long-term adaptability rather than short-term responsiveness. However, this shift generated new questions, particularly regarding the practices through which structural flexibility is formed. Companies often adopt practices situationally, without fully understanding the requirements attached to them or the structural outcomes they might form. The question, therefore, became not what structural flexibility is, but how it is enabled by practices and how different design characteristics of these practices lead to different formations of structural flexibility.

Paper I emerged from the theoretical observation that structural flexibility is frequently described as a subtype of supply chain flexibility, yet its dimensional formation remains unclear. Based on the literature on supply chain flexibility and structural flexibility, the central question became whether structural flexibility always leads to the same flexibility outcomes or whether, similar to supply chain flexibility, it can form different dimensions depending on how it is configured. This question gained practical relevance as companies struggled to form flexibility in a target-oriented manner aligned with their strategic objectives. Dual sourcing was selected as a practice because it is a well-established supply chain practice explicitly linked to structural flexibility by the literature, yet it can be designed and integrated in very different ways. Data collection for Paper I was conducted between September 2024 and September 2025. The purpose was to understand how

structural flexibility forms as an outcome of different design characteristics of a specific practice.

Paper II was developed from a deeper engagement with Company A's dual sourcing practices. Due to the regulatory nature of Company A's products, it became evident that adopted structural flexibility practices require fulfilling specific organizational, relational, and technical requirements. Some of these requirements were not clearly articulated in the literature, nor were they systematically understood within companies. The involvement of Company B, which demonstrated a more structured and mature approach to flexibility practices, further highlighted that structural flexibility can be achieved in a deliberate and target-oriented manner when requirements and standards are consciously addressed. This observation shifted the focus toward the enablement process of structural flexibility practices and the requirements necessary for their adoption. Data collection for Paper II was conducted between September 2024 and September 2025. The study investigates how structural flexibility is enhanced through practices and how associated requirements are fulfilled across different organizational contexts.

Throughout the research process, the interaction between theory and empirical observation remained constant. Initial theoretical ambiguities led to empirical exploration, and empirical insights led to a refinement of the theoretical framing. The two papers thus reflect complementary analytical perspectives: one examines structural flexibility as a formation of a specific practice, and the other investigates how structural flexibility practices are enabled. Together, they respond to the overarching ambition of clarifying how structural flexibility is enhanced.

3.7 Reflection on Methodological Approach

The qualitative and abductive research design adopted in this thesis was chosen in response to the underconceptualized nature of structural flexibility. Structural flexibility is described in the literature as a capability that enables supply chains to reconfigure their architecture through structural options. Studying such a phenomenon required a research design capable of capturing context, interpretation, and variation in supply chain structures.

One strength of this approach lies in its ability to capture variation in how structural flexibility is formed. Structural flexibility does not form in the same way across organizations. It depends on how the practices are designed. A qualitative design enabled close examination of these mechanisms. Rather than treating flexibility as a predefined construct measured through indicators, the research traced how structural flexibility was enhanced within two companies. Studying multiple cases allowed comparison across organizational contexts and helped identify recurring patterns and boundary conditions. This comparison reduced the risk that conclusions were shaped by a single organizational context or based on certain disruptive events.

At the same time, the methodological approach relies on the interpretation of managerial accounts. The empirical material consists mainly of semi-structured interviews with managers responsible for adopting or coordinating structural flexibility practices. Such accounts are retrospective and shaped by managerial sensemaking. Respondents describe how they understand their actions and outcomes, which may not fully capture informal routines or unintended structural consequences. The analysis, therefore, relies on interpreted representations of organizational practice rather than direct observation of

behavior. This limitation was addressed through systematic cross-case comparison, documentation of analytical decisions, and repeated revisiting of empirical material to ensure that interpretations remained grounded in the data.

Another methodological consideration concerns the temporal dimension of the research. Data collection was cross-sectional, although practices are shifting in the states. The cases included retrospective descriptions of planning, utilization, and routinization of practices, allowing reconstruction of how practices shifted the states. However, the study does not observe structural flexibility longitudinally across disruption cycles. A fully longitudinal design might have provided deeper insight into how structural flexibility practices shift the states and develop. Nevertheless, the retrospective process perspective allowed comparison across cases at different states and made this observation.

Research quality was addressed through credibility, dependability, transferability, and confirmability, following the adaptation of qualitative quality criteria proposed by Halldórsson and Aastrup (2003). While earlier frameworks, such as those proposed by Yin, provide foundational criteria for case study research, Halldórsson and Aastrup adapt these principles to logistics and supply chain management research, where complex organizational processes and interorganizational relationships play a central role.

Credibility was supported through triangulation, cross-case comparison, and continuous confrontation of emerging interpretations with empirical data. Dependability was addressed through transparent documentation of coding structures, category development, and analytical procedures.

Transferability was approached cautiously. The study does not aim for statistical generalization. Structural flexibility is strongly context-dependent and embedded in industry conditions. Instead, detailed case descriptions and explicit boundary conditions allow readers to assess contextual similarity.

Confirmability was strengthened through explicit linkage between empirical evidence and conceptual interpretation, ensuring that conclusions remained grounded in the empirical material.

Reflexivity regarding the researcher's role was also considered. Collaboration with industrial partners provided access to rich organizational insights but also required awareness of potential alignment with managerial perspectives. The analysis, therefore, emphasized distinguishing intended flexibility from empirically observable structural mechanisms.

Finally, the theoretical lens evolved during this journey. The initial focus on supply chain flexibility revealed definitional ambiguity and gradually shifted attention toward structural flexibility as a more specific phenomenon. This development reflects the abductive logic of the research, where theoretical framing evolves through interaction with empirical insights rather than remaining fixed on the theoretical insights

4. Summary of Papers

The two empirical papers that form the foundation of this licentiate thesis are summarized below. Together, they examine the enhancement of structural flexibility from different perspectives. Table 4 provides an overview and information about these two papers.

Paper I investigates how structural flexibility forms through the design characteristics of dual sourcing. The purpose of the study is to understand how different design characteristics of dual sourcing form structural flexibility dimensions. By examining multiple cases of dual sourcing practices, the paper analyzes how variation in design characteristics leads to different structural flexibility dimensions.

Paper II examines structural flexibility from the perspective of enablement rather than formation. The purpose of the study is to understand the requirements that need to be met to enable practices of structural flexibility. Through multiple case analyses, the paper investigates how practices in ex-ante, ex-post, and ex-diem enable the practices through meeting certain requirements.

Table 4: Summary of Papers.

Paper	Research Question	Empirical focus	Data sources	Analytical approach	Theoretical lens	Analytical output
I	Research Question 1	Design characteristics of dual sourcing forming structural flexibility	Interviews with sourcing and supply chain managers; company documents	Cross-case comparison of design characteristics and sourcing practices	Supply chain flexibility dimensions; dual sourcing literature	Structural flexibility dimensions and their hierarchical formation.
II	Research Question 2	Requirements enabling structural flexibility practices	Interviews; company documents; archival material	Thematic analysis of requirements and dependencies between practices	Structural flexibility literature; adaptive supply network perspective (Kauffman et al., 2018)	Framework explaining the requirements enabling structural flexibility practices.
I & II	Research Question 3	Integration of formation and enablement findings	Findings from Paper I and Paper II	Conceptual synthesis of empirical findings	Structural flexibility and supply network design literature	Proposed framework illustrating how firms can enhance structural flexibility.

4.1 Paper I: “Forming structural flexibility dimensions with different design characteristics of dual sourcing: A multiple case study”.

Paper I is situated in the ongoing debate on supply chain flexibility and structural flexibility. While dual sourcing is widely discussed as a resilience-enhancing strategy, existing literature largely treats it as a homogeneous practice associated with risk reduction and sourcing flexibility. At the same time, structural flexibility has been defined, yet its dimensional formation remains insufficiently specified. The paper

addresses this by investigating how different design characteristics of dual sourcing form structural flexibility.

The main findings demonstrate that dual sourcing varies along two central design characteristics: integration depth and utilization breadth. Integration depth reflects how extensively dual sourcing is embedded into contracts, product design, coordination routines, and technological systems. Utilization breadth reflects how widely dual sourcing is applied across components and products. Different combinations of these characteristics are linked with the formation of different structural flexibility dimensions. Superficial integration and narrow utilization primarily enhance strategic-level flexibilities, whereas deep integration and broad utilization contribute to higher network-level dimensions such as reconfiguration and relationship flexibility.

Paper I advances the thesis by demonstrating that structural flexibility does not form homogeneously from a given practice. Instead, its formation depends on how the practice is integrated and utilized within the supply chain. By analyzing integration depth and utilization breadth across six dual sourcing cases, the paper explains how similar practices may lead to different structural flexibility formations. This provides a conceptual bridge between practice design and clarifying how structural flexibility forms through specific design characteristics. In addition, the paper contributes to the understanding of how structural flexibility can be formed to managerial objectives and contextual conditions. The paper shows that certain dual sourcing designs can be aligned with strategic objectives such as robustness, responsiveness, or cost-efficiency. Structural flexibility is therefore positioned as a contingent outcome formed by design characteristics that can be chosen based on aligning with objectives and contextual conditions.

4.2 Paper II: “Practices Enhancing Structural Flexibility of Supply Chains”.

Paper II is positioned within the literature on structural flexibility and designing adaptive supply networks. Although prior research identifies practices such as collaboration, postponement, and diversification as practices enhancing structural flexibility, limited attention has been given to the requirements necessary for these practices to be enabled. By investigating how structural flexibility practices are planned, utilized, and routinized, the study conceptualizes structural flexibility as a capability that is enhanced through deliberate enablement across different states.

The findings reveal that structural flexibility practices require the enablement or fulfillment of specific requirements. These requirements can be categorized and can differ depending on the state the practices were adopted into, the kind of practice, and its dependencies. The analysis also shows that practices may shift the states that can make them structurally embedded routines. Structural flexibility is enhanced by systematically enabling and fulfilling requirements in a certain hierarchical sequence.

Paper II advances the thesis by explaining the enabling requirements behind structural flexibility practices. Rather than assuming that practices automatically enhance structural flexibility, the study identifies certain categories of requirements that must be enabled or fulfilled in a certain hierarchical sequence to enhance structural flexibility. This deepens the understanding of structural flexibility as an actively enhanced capability. Furthermore, the paper contributes to enhancing structural flexibility in relation to managerial objectives and contextual conditions. By showing that enabling requirements differ depending on strategy, dependencies, and the practice itself, it shows that to enhance structural flexibility, firms must actively enable the practices to adopt such practices. Structural flexibility is thus conceptualized as a capability that can be enhanced by practices by enabling these through certain requirements

5. Findings and Discussion

The following paragraphs present first the findings regarding the formation of structural flexibility through dual sourcing design characteristics, and the practices are enabled by certain underlying requirements in 5.1. Afterwards, the answers to each of the three research questions are discussed in 5.2

5.1 *The Findings*

The purpose of this thesis is to contribute to flexibility, dual sourcing, and adaptive supply network design literature by analyzing how structural flexibility is formed through the design characteristics of dual sourcing and how practices are enabled, while also providing an understanding of how firms can deliberately enhance structural flexibility. Through the two papers, the understanding of how structural flexibility is formed and how structural flexibility is enabled has been advanced by the results.

Paper I, shows that structural flexibility dimensions are not inherent outcomes of dual sourcing but are formed through variation in integration depth and utilization breadth. The theoretical implication lies in conceptualizing structural flexibility as configurational and hierarchical, where different design characteristics produce distinct dimensional outcomes.

Paper II shows that structural flexibility practices are enabled through strategy-based, dependency-based, and practice-specific requirements that must be fulfilled in a structured sequence.

5.1.1 *Formation of structural flexibility*

The findings show that structural flexibility dimensions do not form automatically from dual sourcing. Although in all six cases, dual sourcing was practiced, the structural flexibility formations differed significantly. Structural flexibility was therefore not solely practice-driven but was formed by how dual sourcing was designed in the supply chain. Across the cases, two central characteristics explain the variation in structural flexibility formation: the depth of integration and the breadth of utilization. These characteristics are two spectra rather than categories, positioning the cases differently in terms of structural integration and scope. The findings demonstrate that structural flexibility forms due to integration and utilization. The same practice leads to the formation of different structural dimensions depending on how deeply it is integrated and how broadly it is utilized. Structural flexibility is therefore not a homogeneous capability, but a design-dependent outcome formed by integration and utilization of dual sourcing.

The formation of structural flexibility with integration and utilization

The cross-case analysis identifies two central design characteristics of dual sourcing that shape the formation of structural flexibility: the depth of integration and the breadth of utilization. These characteristics explain how the same practice can form different structural flexibility dimensions.

Integration depth refers to the degree to which dual sourcing was embedded into routines, design and engineering processes, supplier qualification procedures, contractual arrangements, IT systems, and cross-functional coordination. Hence, integration depth

captures how strongly dual sourcing is embedded within organizational and supply chain structures. With deep integration, dual sourcing was not only practiced when disruptions occurred but also functioned as an institutionalized part of sourcing. Superficial integration was characterized by conceptual planning, limited supplier qualification, and the absence of routines. In such cases, dual sourcing primarily theoretically forms structural flexibility. In contrast, deep integration involved systematic supplier qualification, product redesign, formalized procedures, IT-enabled coordination, and continuous relationship management. These cases consistently formed a broader and higher-level set of structural flexibility dimensions. Hence, superficial integration, in contrast, was marked by conceptual planning, limited qualification efforts, and the absence of embedded routines. In these setups, dual sourcing existed more as an option than as a structurally embedded capability.

The findings show that integration depth primarily determines the system level of structural flexibility that can be formed. Cases with superficial integration formed lower-level structural flexibility dimensions mainly on the strategic level, while deeply integrated cases formed higher-level structural flexibility dimensions on the network level. Deep integration embedded dual sourcing, which connects it not only to sourcing arrangements but also to product design, supplier coordination, and structural reconfiguration possibilities.

Utilization breadth refers to how widely dual sourcing was applied across components and product categories. Narrow utilization confined the formed structural flexibility to a limited product line. Broad utilization extended structural flexibility formation across multiple components and categories, increasing the number of formed structural flexibility dimensions. However, broad utilization alone does not guarantee the formation of structural flexibility; without deep integration, utilization primarily expands formation rather than forming higher-level dimensions.

Integration depth primarily determines the system level at which structural flexibility forms, whereas utilization breadth determines the scope and extension of these dimensions. Deeper integration consistently formed more network-level structural flexibility dimensions. Broader utilization increased the overall number of formed structural flexibility dimensions within the structural level achieved through integration. Looking into these spectra, integration depth and utilization breadth represent four characteristic types of dual sourcing: (1) deep and narrow, (2) deep and broad, (3) superficial and narrow, and (4) superficial and broad. These types of dual sourcing are not only descriptive but also explain the variation in the formation of structural flexibility dimensions.

Dimensions belonging to structural flexibility and their hierarchy

As presented in Figure 2, beyond identifying which dimensions belong to structural flexibility, the findings show that the formation of structural dimensions differs in their quantity and level within the supply chain. When positioning the empirically observed structural flexibility dimensions within established flexibility frameworks, a clear pattern emerges across the cases.

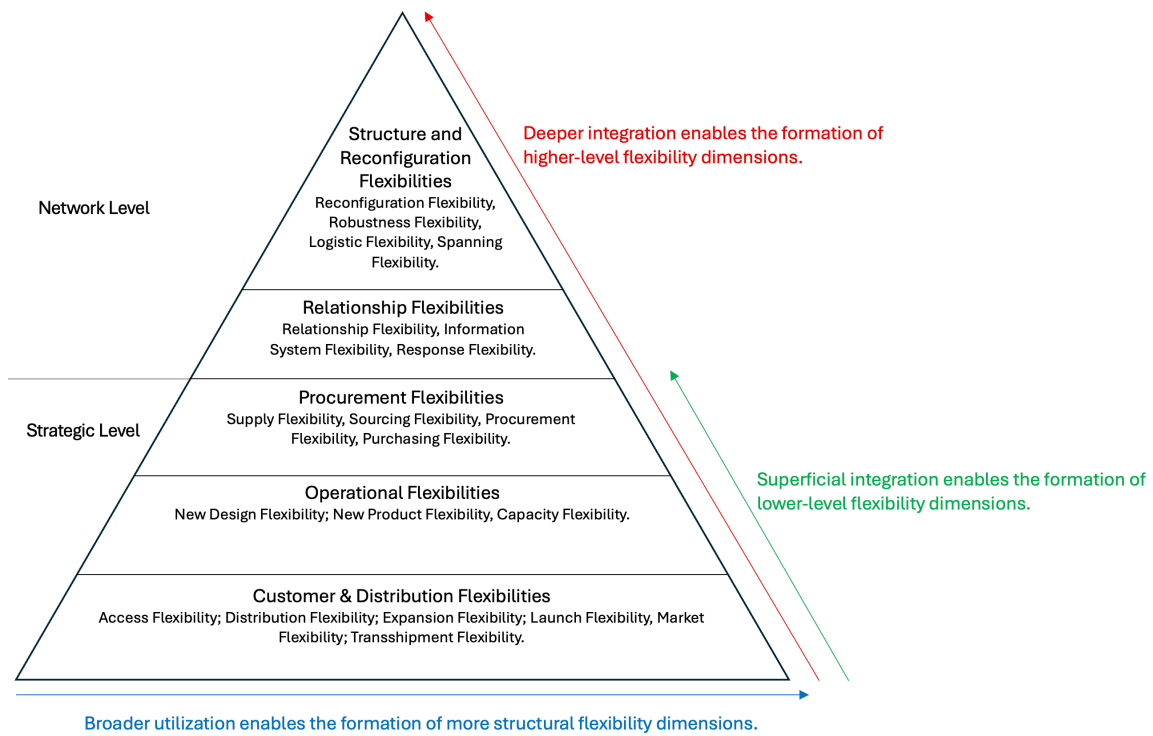


Figure 2: Structural Flexibility Dimensions and their hierarchy.

As presented in Figure 2, structural flexibility dimensions formed primarily at the strategic level when dual sourcing practices were superficially integrated. At this level, the most consistently formed dimensions were customer & distribution flexibilities, such as access flexibility and distribution flexibility, which were present across almost all cases. Distribution flexibility and expansion flexibility were formed in cases characterized by deeper integration, while launch flexibility appeared particularly where regulatory preparation or regional responsiveness had been planned. Operational flexibilities such as new design flexibility, new product flexibility, and capacity flexibility were also observed, particularly where interchangeable components and product redesign were integrated into engineering routines. Within procurement flexibilities, sourcing flexibility and supply flexibility were widely formed across the cases, even when integration was superficial. In cases with broader utilization and deeper integration, procurement flexibility and purchasing flexibility were additionally formed. These strategic level dimensions reflect the ability to access alternative sources, adjust volumes, introduce products, and respond to demand changes through structurally integrated sourcing practices.

Network level dimensions, in contrast, formed primarily in cases characterized by deep integration, often combined with broader utilization. Relationship flexibility was formed where supplier relationships were systematically maintained and integrated into routines. Information system flexibility appeared in cases where IT systems were explicitly configured to support multi-supplier coordination. Response flexibility formed in cases with managed supplier pools and continuous coordination. Reconfiguration flexibility and robustness flexibility were formed in cases where supplier pools, interchangeable designs, and coordinated systems enabled structural shifting of sourcing configurations. Logistic flexibility was formed in one deeply integrated case where flow and transport paths could be adjusted cost-effectively. Spanning flexibility was formed in one case with

particularly advanced supplier coordination. In contrast, dimensions such as interorganizational flexibility and organizational flexibility were not empirically observed across the cases. These network level dimensions reflect a more advanced integration that forms dimensions that coordinate, reconfigure, and stabilize the supply network.

The hierarchy shown in Figure 2, therefore, does not describe a strict sequence between individual dimensions. Rather, it reflects increasing integration depth in the supply chain. The depth of integration determines whether structural flexibility forms at the strategic level or extends into the network level, whereas the breadth of utilization determines how widely these dimensions are formed within one system level in the supply chain.

5.1.2 Requirements of planning and utilizing practices of structural flexibility

The findings show that practices of structural flexibility do not enhance structural flexibility simply by being introduced. Instead, they are enabled through a structured set of requirements. Across different practices such as dual sourcing, dual transportation, dual manufacturing sites, dual design, and dual supply hubs, three categories of requirements consistently shaped whether the practice was in ex-ante, ex-post, or ex-diem.

The results further demonstrate that requirements vary depending on whether practices are planned, activated in reaction to disruption, or routinized over time. However, despite differences in timing and intensity, the underlying enabling logic remains stable. Structural flexibility is therefore progressively enabled through meeting layered requirements rather than emerging automatically from practice adoption.

The practices in ex-ante, ex-post, and ex-diem

Practices were observed in three states: ex-ante, ex-post, and ex-diem. These states differ in timing, uncertainty, and degree of routinization, but they follow the same structural logic.

Ex-ante practices are forward-looking and planning oriented. In this state, firms prepare structural options before disruptions occur. Risk mitigation plans are developed, contracts are negotiated, products are validated, and collaboration structures are aligned in advance. Requirements are enabled so that the practice can be activated if necessary. The focus lies on preparedness and strategic positioning.

Ex-post practices are reactive and action oriented. Here, a disruption triggers immediate activation. Requirements must be fulfilled under time pressure. Strategic prioritization, cross-functional coordination, technical feasibility, and regulatory approval become central. In this state, requirements need to be directly fulfilled as the ex-post practice is used directly. Thereby, ex-post is not solely about the reactive utilization of a practice, but to build a preliminary structure to utilize the practice.

Ex-diem practices are routinized and continuously maintained. In this state, the practice is institutionalized as part of daily operations. Strategic positioning is based on ongoing risk awareness or regional logic. Dependencies are stabilized through established collaboration, and practice-specific requirements such as volume levels, system capabilities, equipment flexibility, and staff training are continuously sustained.

Structural flexibility in this state becomes fully embedded in the supply chain network. Thereby, requirements are enabled continuously, so the practice can be used regularly.

The categories of requirements and their hierarchy

Three categories of requirements enable practices of structural flexibility: strategy-based requirements, dependency-based requirements, and practice-specific requirements.

Strategy-based requirements define why and to what extent a practice is pursued and are defined by the states ex-ante, ex-post, and ex-diem. Depending on the state, these include risk assessment, prioritization of critical products, customer focus, regionalization decisions, and long-term structural positioning. They establish direction and determine the intended level of flexibility. Without strategic alignment, practices remain isolated and lack structural coherence. Hence, across practices and states, strategy-based requirements are addressed first. Firms initially define the strategic intent of the practice, whether in response to disruption, as part of mitigation planning, or as a routinized positioning decision. Without this strategic framing, subsequent requirements lack coherence.

Second, dependency-based requirements are addressed. Once the strategic direction is clarified, firms ensure that necessary collaborations, structural linkages, and complementary practices are in place. This stage is about reconnecting practices in a supply network with each other to make it structurally feasible. Thereby, dependency-based requirements reflect structural interdependencies between practices and actors. Many practices depend on other practices, such as dual design, collaboration with suppliers and customers, regional sourcing structures, transportation capacity, or coordination across production sites. Collaboration emerges as a recurring dependency across practices, although its form differs depending on whether sourcing, design, production, or transport is involved. These dependencies demonstrate that structural flexibility practices are interconnected and often cannot function independently.

Lastly, practice-specific requirements are addressed, which is the category regarding technical feasibility. They define operational feasibility and vary depending on the nature of the practice. For sourcing-related practices, these include regulatory approvals, technical understanding of components, sufficient volume levels, cost balancing, supplier competence, quality standards, and administrative coordination. For transportation-related practices, cost, sustainability, packaging constraints, and system support are central. For manufacturing-related practices, equipment flexibility, regulatory requirements, volume thresholds, and employee training are decisive.

Meeting the requirements

Meeting these requirements comes with prior choices and with certain phases after the enablement or fulfillment of the requirements. The order of meeting these requirements can be seen in Figure 3.

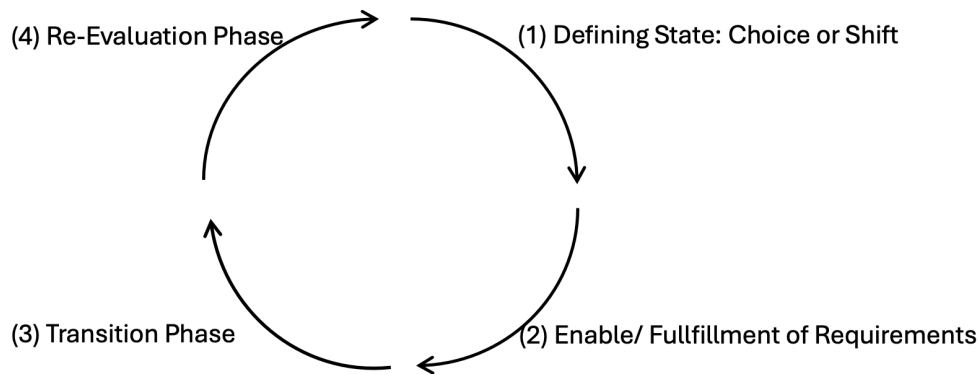


Figure 3: Meeting the Requirements to Enable Structural Flexibility.

Before the requirements are met, managers must decide whether they want to plan the practice ex-ante, whether they are reacting in ex-post, or whether they are routinizing a practice (1). This decision must be made as it defines the first category of strategy-based requirements. An alternative to this decision is that after one circle of use, the practice shifts to a different state.

Afterwards, the hierarchical sequence of meeting the requirements has been gone through, which is consistent in all three ex-ante, ex-post, and ex-diem states (2). What differs is whether they must be fulfilled or enabled. In ex-post situations, requirements must be fulfilled immediately as it is a reaction. In ex-ante situations, they are enabled in preparation. In ex-diem situations, they are continuously enabled, maintained, and refined.

After going through the sequence of requirements, practices may go through a transition phase (3) where the old practice and the new practice are used at the same time, and it is ensured that the new practice is rewired correctly in the supply network.

Then there is a potential use of the practice, followed by a re-evaluation phase (4), where, depending on the state, it is decided to stop the practice, continue with the practice, or eventually improve the use of the practice. Hence, after this re-evaluation phase, the practice can shift its state to another state or be stopped, which causes ex-ante or ex-post practices to become ex-diem after enabling or fulfilling these requirements.

5.2 Answering the Research Questions and Discussion

The results show that enhancing structural flexibility comes from the enablement of structural flexibility practices and is shaped through the formation of structural flexibility dimensions. Differences in integration depth and utilization breadth explained how dual sourcing practices formed different structural flexibility dimensions, while the hierarchical enablement of practices by strategy-based, dependency-based, and practice-specific requirements determined whether these practices became structurally integrated or remained reactions. Together, the findings demonstrate that structural flexibility is both a configurational outcome of design and a progressively enhanced and enabled capability shaped by deliberate structural decisions.

5.2.1 RQ 1: How does dual sourcing form structural flexibility?

The findings show that dual sourcing forms structural flexibility dimensions not by its mere presence, but through its integration and utilization in the supply chain design.

Although all six cases practiced dual sourcing, the formation of structural flexibility dimensions differed significantly, and the number of dimensions formed can be significantly lower with some design characteristics. Additionally, similar to former frameworks regarding supply chain flexibility, the structural flexibility dimensions form a hierarchy. Thereby, the results demonstrate that dual sourcing forms structural flexibility dimensions through two central design characteristics: integration depth and utilization breadth.

This finding addresses a limitation in supply chain flexibility literature, which has identified flexibility dimensions across system levels but has not explained how these dimensions are formed (Manders et al., 2016; Rojo et al., 2018; Stevenson & Spring, 2007). While prior research identifies flexibility dimensions across different system levels, it treats these dimensions as given outcomes rather than explaining how they are formed. The findings challenge this assumption by showing that flexibility dimensions do not emerge independently but are shaped through the design of practices. In particular, the results demonstrate that integration depth and utilization breadth determine which dimensions are formed, thereby providing a mechanism that is not specified in prior literature.

The findings further reveal that structural flexibility dimensions are hierarchically ordered. This hierarchical pattern aligns with the system-level differentiation in supply chain flexibility frameworks (Martínez Sánchez & Pérez Pérez, 2005; Stevenson & Spring, 2007) but extends them by demonstrating that these levels are not only conceptual categories but reflect increasing embedment of the practice.

The findings refine the definition of structural flexibility (Christopher & Holweg, 2011; Sarma & Pramod, 2015), as these illustrate what this definition entails in terms of dimensions. Hence, structural flexibility is not only the ability to reconfigure a supply chain's architecture through building a structure (Sarma & Pramod, 2015). It is a diverse, multi-dimensional capability that presents differently and can result in different long-term abilities depending on the practice's design characteristics. Hence, the formation of structural flexibility demonstrates that supply chain flexibility, as well as structural flexibility, can be deliberately formed and managed. The abilities resulting from the dimensions that can be aligned with a firm's focus on, e.g., customer & distribution, product design, or relationship building.

Since RQ 1 deals with design characteristics of dual sourcing, the findings support the literature in mentioning dual sourcing as a practice enhancing structural flexibility (Volberda, 1996; Christopher & Holweg, 2011). However, the sole adoption of dual sourcing does not necessarily lead to the enhancement of structural flexibility, as too superficial integration leads to a decrease in the formation of structural flexibility dimensions. This challenges the common assumption that adopting dual sourcing inherently enhances flexibility

In addition, this research contributes to dual sourcing literature. This practice is often described as either emergency or long-term sourcing in flexibility and resilience literature (Huang et al., 2018; Li et al., 2023). The findings challenge this temporal distinction between emergency and long-term sourcing. This clarifies how integration mechanisms (Power, 2005) as design characteristics like product substitutability (Lu et al., 2011),

information transparency (Yang et al., 2012), and supplier positioning (Jakšič & Fransoo, 2018), contribute to the formation of specific structural flexibility dimensions.

While one could argue that long-term dual sourcing translates into deep and emergency dual sourcing in superficial integration, the integration and utilization of dual sourcing practices is not only caused by temporality but also by the ability and need of the firm to deeply integrate and broadly utilize its dual sourcing practices. Firms that manufacture highly regulated products, such as those in healthcare, have no choice but to integrate their dual sourcing practice deep in their supply chain to oblige all regulations and, at the same time, test their products for functionality and safety reasons. The same with utilization: Firms that may produce several products with similar or the same components often have broader utilization, while smaller firms or firms working with highly regulated products have narrow utilization, as products do not share components, or every product receiving new components needs to be individually approved. Hence, temporality does not necessarily play a role in the integration and utilization of dual sourcing practices.

The findings show the theoretical distinction between strategic and network-level flexibility and demonstrate that integration depth determines whether dual sourcing remains at a strategy-oriented level or extends into the whole supply network. When dual sourcing remains superficially integrated, characterized by conceptual planning and limited embedding into routines, it primarily forms strategic-level dimensions aligning with the strategic level of supply chain flexibility described by Vokurka and O'Leary-Kelly (2000) and Stevenson and Spring (2007). Deep integration forms structural flexibility dimensions at the network level. Such dimensions correspond to the network-level described by several concepts regarding supply chain flexibility (Lummus et al., 2005; Malhotra & Mackelprang, 2012; Manders et al., 2016; Rojo et al., 2018; Stevenson & Spring, 2007). Hence, it explains how different levels of supply chain flexibility emerge in practice and shows that the distinction between strategic and network-level flexibility is not only conceptual but also depends on how dual sourcing is integrated. It further demonstrates that dual sourcing does not automatically lead to higher-level flexibility but requires deep integration to become a structural feature of the supply network.

Utilization breadth complements integration by determining the scope of formed structural flexibility dimensions. Narrow utilization confines structural flexibility to specific product lines, limiting its structural reach, which is also visible in the number of formations. Broader utilization extends structural flexibility across components, categories, or regions, increasing the number of formed dimensions within one system level formed by integration. However, the findings show that broad utilization without deep integration primarily expands potential flexibility rather than realized structural adaptability. This supports prior literature emphasizing that utilization intensity affects sourcing effectiveness (Davarzani et al., 2011; Song et al., 2017), while adding the insight that utilization alone is insufficient without structural integration to form structural flexibility.

However, by limiting the answers to dual sourcing, this research does not determine the formation of structural flexibility of other practices. Other diversification practices, collaboration, and postponement may enhance structural flexibility through the same or other design characteristics.

5.2.2 RQ 2: How are practices of structural flexibility enabled?

The findings show that practices of structural flexibility are enabled through meeting underlying requirements in a hierarchical sequence. Structural flexibility is not enhanced simply by adopting practices such as dual sourcing, dual manufacturing, collaboration, or postponement. Instead, practices that enhance structural flexibility can only be enabled when their strategy-based, dependency-based, and practice-specific requirements are systematically met. Enablement is therefore not inherent to the practice itself, but conditional upon meeting layered requirements in a specific sequence.

The results regarding the states refine Kauffman et al.'s distinction between ex-ante and ex-post (Kauffman et al., 2018). One extension is the introduction of another state, ex-diem, which is the routinization of practices. Ex-diem shows that adaptive networks nowadays do not only rely on ex-ante planning but also on the continuous routinization of structural options to be adaptable. The findings additionally challenge the static view of the framework by showing that practices can be added to the supply network and shift between states over time. A practice going through this sequence of requirements and different phases, such as the transition and re-evaluation phase, can lead to a shift and therefore a change of state. The phases thereby ensure that practices are rewired correctly and improved, and that technical feasibility is ensured. The framework from Kauffman et al. (2018) is extended by the understanding that a practice is not only adopted in ex-ante or ex-post and rewired but, in some cases, also controlled and improved by transition and re-evaluation phases.

In addition, states shift between ex-ante, ex-post, and ex-diem states. The use of a practice in ex-ante, ex-post, and ex-diem reactions can be re-evaluated and afterwards shift into routinized ex-diem practices, stagnate in the current state, or even be stopped and kept as an ex-ante plan for future disruptions. This demonstrates, on the one hand, that the enablement of practices is not totally static. On the other hand, it shows as well that while ex-post is not suitable for designing adaptable supply networks in itself (Feizabadi et al., 2023), it may initiate through its reaction to utilize a practice that might shift and afterwards enable structural flexibility. This challenges the view that ex-post reactions are only of a dynamic and short-term nature (Feizabadi et al., 2023).

The findings show that enablement begins with strategy-based requirements that can be different depending on the state that was chosen or the practice shifted to. Depending on whether a practice is in ex-ante, ex-post, or ex-diem, this category of requirements provides the direction for the structure that the practice intends to build. Without this strategic positioning, practices remain isolated operational adjustments rather than building structural options. This finding refines prior literature that mentions requirements such as risk management or adaptive structures but does not connect them explicitly to specific practices or to a sequence of enablement (Iravani et al., 2005; Majid et al., 2019; Sarma & Pramod, 2015).

Second, practices depend on one another. Dependency-based requirements reflect that structural flexibility practices rarely function independently in a supply network. For example, dual sourcing depends on dual design, collaboration, and sometimes regional sourcing. Thereby, collaboration is not only a practice but a dependency underlying multiple practices. These findings clarify that structural flexibility is enhanced from interconnected practices rather than from the isolated adaption of practices. This extends Volberda's (1996) view by empirically showing how interdependencies between

practices condition whether structural flexibility can be formed. In addition, dependency-based requirements make sure that rewiring the supply network is feasible, addressing Kauffmann et al. (2018) concept of designing adaptive supply networks. Thereby, this research shows that the dependencies often have a giving and receiving practice (Zhao et al., 2011), which needs to be rewired according to the dependencies.

Third, practice-specific requirements define operational feasibility. Regulatory approvals, volume thresholds, technical feasibility, cost considerations, sustainability constraints, system capabilities, and employee skills determine whether a practice can function. The findings show that these requirements represent the most concrete enabling requirements and form the practical boundary of adopting practices of structural flexibility. This addresses a limitation in prior literature, where requirements such as “multi-purpose resources” or “adaptive structures” are mentioned but remain tautological or abstract (Iravani et al., 2005; Christopher & Holweg, 2011).

Beyond identifying categories, the findings reveal a hierarchical sequence in how requirements are met. Strategy-based requirements are addressed first, dependency-based requirements second, and practice-specific requirements last. This sequence is stable across ex-ante, ex-post, and ex-diem states. What differs across states is not the order, but the intensity and timing of fulfillment. In ex-ante states, requirements are enabled in preparation. In ex-post states, they must be fulfilled immediately under time pressure. In ex-diem states, they must be continuously enabled, maintained, and refined. This provides a structured explanation of enablement that is not specified in prior literature.

This hierarchical enablement directly relates to the jury rigging perspective proposed by Kauffman et al. (2018). Jury rigging emphasizes the ability of supply networks to recombine existing elements when confronted with unknown-unknown disruptions. However, such recombination is only possible if the practices in the network have been enabled ex-ante. The present findings specify what this enablement entails. Strategy-based requirements position the network for adaptation. Dependency-based requirements establish the structural linkages that allow rewiring. Practice-specific requirements ensure that technical and operational feasibility support recombination. In addition to that specification, it challenges jury rigging as ex-post reactions can combine new elements in terms of practices in the supply network.

This research advances the literature on structural flexibility as a capability. Christopher and Holweg (2011) conceptualize structural flexibility as a long-term capability that prepares supply chains for disruption. However, while the literature identifies practices such as collaboration, postponement, and dualization, it remains underconceptualized how these practices are enabled. The present findings respond to this gap by demonstrating that practices require structured enablement before they can enhance structural flexibility. In addition, the findings extend the literature by showing that practices are not used individually but function as an interconnected system enabling structural options.

In relation to structural flexibility as a capability for future supply chains (Christopher & Holweg, 2017), the findings clarify how this capability is enhanced by the practices. Structural flexibility is not achieved simply by adopting redundancy or multiple options. Its practices are progressively enabled through layered requirements that align strategic intent, structural interdependencies, and operational feasibility. This also explains that

practices, even if they could enhance structural flexibility, can also remain reactive and short-term, resembling, while others evolve into sustained structural changes. The difference lies not in the practice alone, but in whether certain requirements are enabled to build the practice as long-term options.

5.2.3 RQ 3: How do the formation of structural flexibility dimensions and the enablement of practices support firms in deliberately enhancing structural flexibility?

The combined findings explain how firms can deliberately enhance structural flexibility, moving beyond ad hoc diversification and reactive adjustments. Structural flexibility enhances neither automatically from adopting practices nor solely from responding to disruptions. Instead, it develops through deliberate design and progressive enablement. The results show that deliberate enhancement requires firms to address two interrelated dimensions: the formation of structural flexibility and the enablement of structural flexibility practices. This provides firms with a structured approach to enhance structural flexibility, rather than relying on isolated practices or reactive responses.

Formation of structural flexibility

The findings demonstrate that structural flexibility dimensions differ in depth and therefore the structural change they enable. Hence, firms need to define the abilities they want to form through structural flexibility dimensions. Strategic-level dimensions such as access, sourcing, and market flexibility enable continuity and a basic flexible structure. Network-level dimensions such as reconfiguration and robustness flexibility enable a more long-term and permanent architectural change that makes a supply network inherently flexible. However, aside from the levels, it needs to be considered as well that the dimensions that are formed reflect the abilities of structural flexibility. Hence, if the objective is flexibility in customer and distribution, deeper integration is not required. In contrast, relationship or reconfiguration flexibility requires deeper integration.

Enhancing structural flexibility, therefore, requires firms to decide whether the objective is of a strategic or broader network kind. Integration depth becomes a vital parameter after this decision regarding the objectives. If firms seek higher-level network flexibility dimensions, practices must be deeply embedded in product design, IT systems, supplier qualification, contractual routines, and cross-functional coordination. Superficial integration may form structural flexibility dimensions, however, on a lower level.

Beyond the integration, firms must consider utilization. Utilization breadth determines how widely structural flexibility extends across components and products. Narrow utilization limits structural flexibility to isolated parts of the supply base. Broader utilization extends structural options across the supply chain. However, the findings show that utilization must build upon integration. Broad utilization without deeper integration expands potential but does not form in itself structural flexibility dimensions. Hence, firms must ensure integration depth before scaling utilization breadth.

Not all firms can or need to achieve deep integration. The required level depends on regulatory constraints, resource availability, and product characteristics. This depends on the firm itself, how much it can integrate a certain practice, and the resources it might have, such as testing, product development, and volume to have extensive relationships with, e.g., suppliers. In addition, firms that produce highly regulated products and

therefore must ensure the safety, technical feasibility, and functionality of the product may have to automatically deeper integrate the practice than other companies. The same applies to utilization, as smaller firms may not have a large product range to extend utilization breadth.

Enabling practices through requirements

Choosing a state, namely whether to plan in ex-ante, to react in ex-post, or to routinize a practice in ex-diem, is a very contextual decision based on risk assessments, feasibility for a firm, and the firm's focus on customers, stakeholders, and technological advancement. A practice may initially emerge in ex-post, but to become a structural option, it must shift to ex-ante or be sustained in ex-diem.

Because practices may shift between states, the re-evaluation phase is important, as it does not evaluate the importance of the practice but improvements in how to practice. Ex-ante can be a suitable state when risks for new disruptions are still there, but the firm is not extremely reliant on the practice, or if the practice is used for lower volumes, while ex-diem enables the practice to be a continuous structural option that can form structural flexibility, but comes with maintaining the enablement of the practice regularly. Hence, structural flexibility is only enhanced when practices are adopted in ex-ante or sustained in ex-diem, although it may be initiated in ex-post.

While the sequence indicates the order in which requirements are addressed, their importance differs. Practice-specific requirements determine technical feasibility, while dependency-based requirements ensure structural feasibility. Strategy-based requirements are the first to be met; they are defined by the state that was chosen. Thereby, it is vital to understand that firms are supposed to choose the state that is most feasible to them and is aligning to their objectives. However, practice-specific requirements are most important as they represent the technical feasibility of adopting a practice. Dependency-based requirements, on the other hand, are the second most important as they must be met to reconnect all vital parts of the supply network, ensuring that a practice is not only technically but structurally feasible to adopt.

In Figure 4, the proposed framework represents the possible deliberate enhancement of structural flexibility through the formation of structural flexibility, and on the right side, the enablement of the practices. On the left side, firms must (I) choose the structural flexibility formations they want and need to align with their objectives. (II) Depending on the choice of formations, the firm must design its practice to form the desired formation. Thereby, the firms must reflect on the feasibility of their objectives regarding the integration and utilization that the firm can maintain. The formations enhance structural flexibility depending on how integrated and utilized the practice is. On the right side, (1) shows a possible initiation with an ex-post reaction, utilizing the practice directly. (2) To enhance structural flexibility, this practice must shift. Thereby, this shift (3) can only be to either ex-ante or ex-diem to enhance structural flexibility. The practice can thereby even shift from ex-ante to ex-diem; the enablement of practices is not static. This framework provides a structured approach for firms to move from reactive practices to deliberately enhance structural flexibility by linking practice design and enablement.

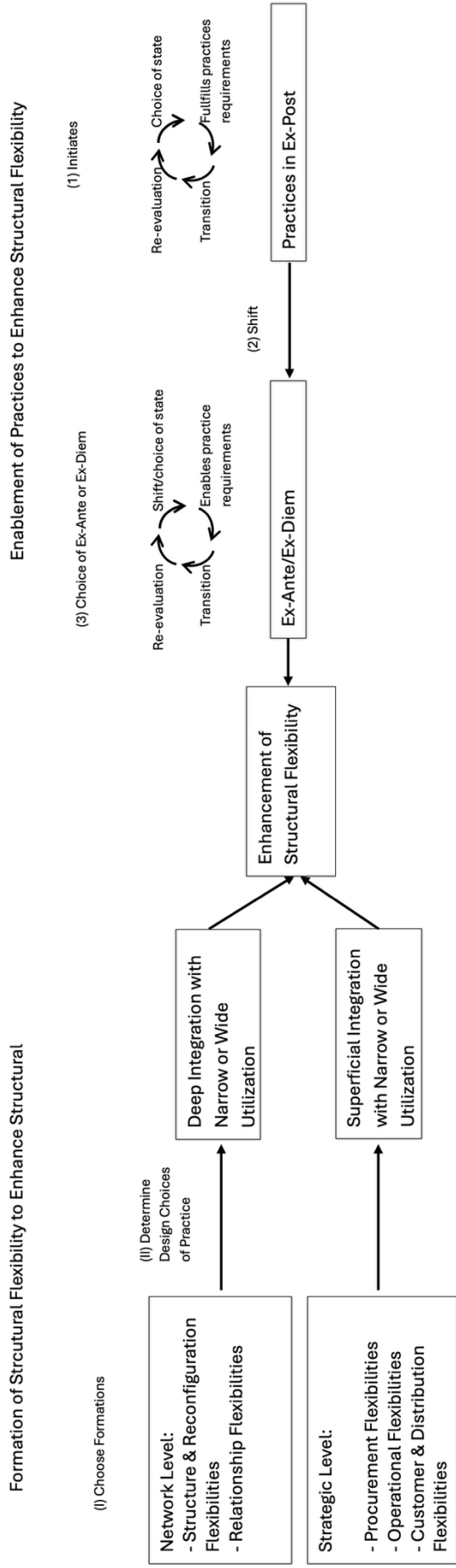


Figure 4: Proposed Framework on Deliberately Enhancing Structural Flexibility.

5.2.4 Synthesis of the discussion

Bringing the findings back to the theoretical positioning in Chapter 2, Figure 1 presents the three literature streams and their intersections, which this thesis contributes to.

Regarding flexibility, the findings confirm the hierarchical nature of flexibility dimensions across operational, tactical, strategic, and network levels (Manders et al., 2016; Martínez Sánchez & Pérez Pérez, 2005; Rojo et al., 2018; Stevenson & Spring, 2007). The results further support that structural flexibility can be associated with long-term dimensions at the strategic and network levels. However, while prior research identifies such dimensions, it does not explain how they are formed. The findings address this by showing that flexibility dimensions form from the design of practices, demonstrating that structural flexibility is not a homogeneous capability but a multidimensional one shaped by certain design characteristics.

At the intersection of flexibility and dual sourcing, the findings confirm that dual sourcing practices enhance flexibility in this case, structural flexibility. However, prior literature does not explain how such practices form specific flexibility dimensions. The results extend this understanding by showing that dual sourcing forms structural flexibility dimensions through integration depth and utilization breadth. This explains how practices form specific flexibility outcomes rather than assuming that structural flexibility emerges automatically.

Regarding dual sourcing literature, the findings confirm its role as a sourcing strategy used to manage risk and ensure supply continuity (Huang et al., 2018; Li et al., 2023) by flexibility. At the same time, the findings extend this view by positioning dual sourcing as a structural flexibility practice. Its structural flexibility enhancement depends on the enablement and how the practice is designed, shifting the understanding of dual sourcing from a sourcing decision toward a structural design mechanism that can deliberately form structural flexibility dimensions.

At the intersection of dual sourcing and adaptive supply network design, the findings clarify how practices become integrated and enabled in network structures. While prior research acknowledges integration and coordination, it does not explain how practices are enabled structurally. The results show that practices are enabled through a hierarchical sequence of requirements, linking practice design to network-level feasibility and adaptation. In addition, the findings show that deep integration does enhance structural flexibility, leading to the design of an adaptive supply network.

Regarding adaptive supply network design, the findings confirm that adaptability depends on how supply networks are structured and prepared for disruptions (Kauffman et al., 2018). The results support the distinction between ex-ante and ex-post responses and the importance of enabling requirements. This research adds ex-diem as a state of routinization, showing that nowadays firms design adaptive networks not only by ex-ante but by routinizing the practices due to frequent disruptions. At the same time, showing how practices shift between states, it demonstrates that adaptability also depends on maintaining and re-evaluating practices over time.

At the intersection of flexibility and adaptive supply network design, the findings connect flexibility with adaptability as a capability that can be enhanced by the enablement of practices and the formation of structural flexibility dimensions. While prior literature

treats the design of adaptive supply networks and flexibility separately; the results show that practices of structural flexibility, the formation of structural flexibility dimensions, and network design are linked.

6. Conclusions

The purpose of this licentiate thesis is to contribute to flexibility, dual sourcing, and adaptive supply network design literature by analyzing how structural flexibility is formed through the design characteristics of dual sourcing and how practices are enabled, while also providing an understanding of how firms can deliberately enhance structural flexibility. Through two papers, the thesis investigated structural flexibility as a capability enhanced by both the formation of practice design and by the enablement of practices. The findings show that structural flexibility forms through variation in integration depth and utilization breadth, and practices are enabled through meeting strategy-based, dependency-based, and practice-specific requirements in a hierarchical sequence. The enhancement of structural flexibility is therefore both designed and enabled. Enhancement results from deliberate integration, utilization, and enablement of practices by meeting their underlying requirements in a certain sequence.

6.1 Theoretical Contributions

This thesis contributes to the literature on supply chain flexibility, dual sourcing, and supply network design.

First, the thesis advances the understanding of how structural flexibility is formed. While prior research has identified flexibility dimensions across different system levels, it has rarely explained how these dimensions form through the design of practices. The findings show that structural flexibility dimensions are formed through the design characteristics of dual sourcing, particularly through integration depth and utilization breadth. This demonstrates that structural flexibility is not a homogeneous capability but a multidimensional one, where different dimensions reflect different structural abilities. The results further show that these dimensions follow a hierarchical structure across strategic and network levels, where some dimensions can be formed through more superficial integration, while others require deeper integration within the supply network.

Second, the thesis refines the understanding of dual sourcing. While dual sourcing has traditionally been described as a sourcing strategy based on the use of multiple suppliers, its role in enhancing flexibility has often been assumed rather than explained. The findings show that dual sourcing only contributes to structural flexibility when it is deliberately designed. The formation of structural flexibility depends on how the practice is integrated and utilized, rather than on the traditional distinction between emergency and long-term dual sourcing.

Third, the thesis contributes to adaptive supply network design by explaining how structural flexibility practices are enabled. While prior research highlights the importance of designing adaptive supply networks, it provides a limited explanation of how such practices are systematically enabled. The findings show that practices are enabled through a hierarchical sequence of requirements, consisting of strategy-based, dependency-based, and practice-specific requirements. In addition, the results show that practices shift across ex-ante, ex-post, and ex-diem states, and that enablement is not static. This provides a more structured understanding of how adaptive supply networks by enhancing structural flexibility.

6.2 Managerial Implications

The thesis contributes to managerial implications by explaining how firms can deliberately enhance structural flexibility through the formation and enablement of practices. The findings guide how firms can design practices to form specific structural flexibility dimensions and align these formations with their strategic objectives. Rather than treating flexibility as a general capability, the results show that firms can actively decide which structural abilities they want to achieve and design their practices accordingly.

In particular, the findings highlight the role of integration depth and utilization breadth in forming structural flexibility. Integration depth determines the structural level at which flexibility is formed, where more superficial integration enables strategic-level flexibility, while deeper integration is required to form network-level flexibility. Utilization breadth determines how widely these structural options extend across products, components, or regions. This allows firms to make deliberate decisions between depth and scope, depending on their resources, regulatory constraints, and strategic objectives. The results further show that broader utilization without sufficient integration primarily increases potential structural flexibility rather than realized structural flexibility, emphasizing the need to prioritize integration before scaling practices.

In addition, the thesis clarifies that firms must deliberately choose the state in which practices are adopted, whether as *ex-ante*, *ex-post*, or *ex-diem*, as this choice directly influences whether practices remain reactive or shift into long-term structural options. While practices may initially emerge in response to disruptions, they need to shift toward *ex-ante* planning or *ex-diem* routinization to contribute to structural flexibility. This highlights that enhancing structural flexibility is not only a matter of adopting practices but of stabilizing and maintaining them over time.

The findings further show that practices are only enabled when underlying requirements are systematically met. The identification of strategy-based, dependency-based, and practice-specific requirements provides managers with a structured way to assess feasibility before implementing practices. This sequence helps firms understand what needs to be addressed first and where critical requirements may occur, for example, whether a practice is strategically aligned, structurally supported by other practices, or operationally feasible.

6.3 Limitations and Future Research

This research has several limitations that open opportunities for future research. First, while the findings demonstrate that different design characteristics form different structural flexibility dimensions, the formation focuses on dual sourcing as a diversification practice. Although dual sourcing provides substantial variation in design characteristics, design characteristics of other practices, such as diversification practices, collaboration, and postponement, could be assessed to understand whether integration and utilization are not only design characteristics of dual sourcing but also apply to other practices enhancing structural flexibility.

Second, the findings reveal the requirements and their hierarchical sequence to enable practices to enhance structural flexibility. Thereby, certain practices, especially diversification practices such as dual sourcing and dual design, have been investigated. However, to validate and extend this framework, future research could include other

practices, particularly collaboration, as it is a practice that other practices rely on through dependencies.

Third, the empirical findings are based on a limited number of case studies within specific industries. While the cases provided detailed insights into how structural flexibility forms and how practices are enabled, the results may be influenced by the characteristics of the investigated firms and their supply chain contexts. Future research could therefore investigate additional industries and institutional contexts to validate and extend the proposed framework.

In addition, structural flexibility may generate performance outcomes and trade-offs that have not yet been systematically assessed but could have implications for design choices other than the formation of structural flexibility. Hence, future research could investigate whether certain formations of structural flexibility outperform others under specific environmental conditions or disruption types.

Finally, this research provides a snapshot of how practices shift between the states *ex-ante*, *ex-post*, and *ex-diem*. However, structural flexibility practices can shift the state and be improved or discontinued. Longitudinal research could therefore further examine how practices shift between these states and the transition and re-evaluation phases.

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