



From Risk to Resilience: A Strategic Procurement Approach to Risk Mitigation in the Supply Chain

Leveraging Supplier Relationship Management and Multi-Criteria Decision-Making for Risk Mitigation

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Preface

In 2016, my journey towards becoming an engineer began with a focus on maritime engineering, culminating in a Bachelor's degree at TU Delft. Seeking to enhance my managerial skills, I pursued a Master's in Management of Technology, also at TU Delft. When presented with the chance to undertake my thesis at one of the world's leading maritime companies, the decision was easy, as my passion lies within the maritime industry.

This thesis marks the conclusion of months dedicated to exploring, researching, and reflecting on risk mitigation through supplier relationship management. The process of translating theoretical concepts into practical applications has been both challenging and rewarding, offering insights that have shaped my understanding of supply chain management and procurement. Reflecting the collaborative nature of knowledge creation, this work integrates diverse ideas, contributing to the dynamic landscape of supply chain management.

I extend my sincere gratitude to Allseas for granting me the opportunity to delve into such a fascinating and relevant topic. My appreciation knows no bounds for the invaluable insights, enriching experiences, and incredible colleagues in the procurement department, especially Rob, my external supervisor, who made this journey possible. A special thanks to my colleagues at Allseas who were willing to share insights that facilitated the case study aspect of this thesis.

A special acknowledgement and a massive thanks go to my supervisor, Jafar, whose guidance and technical insight have been indispensable throughout this research journey. His mentorship and encouragement inspired me to explore uncharted territories and strive for academic excellence. I am truly grateful for everything and hope our collaboration has been mutually enriching.

I express my gratitude to my second supervisor, Zenlin, for providing invaluable feedback during our sessions, significantly enhancing the depth and breadth of this thesis.

Heartfelt appreciation goes to my family, friends, and other loved ones who stood by me when I decided to dive back into the maritime sector with unwavering encouragement, and understanding of the sacrifices and commitments required for this academic pursuit. I could never have done this without you. Thank you for pushing me when I didn't want to be pushed.

Finally, I acknowledge the broader academic community, whose collective knowledge and discourse have been the driving force behind my academic endeavours. As I share this work with the scholarly community, I am humbled by the opportunity to contribute to the ongoing dialogue on risk mitigation in supply chain management.

I can't believe I'm finally done.

Celine Vaandrager
Delft, December 2023

Executive Summary

Modern supply chains, critical for seamless services, face escalating vulnerabilities and disruptions globally. The maritime industry, deeply embedded in these chains, encounters unique challenges due to interdependencies and heavy reliance on global suppliers. Procurement, which is responsible for managing a company's suppliers, is vital in mitigating supply chain risks.

Effectively managing procurement risks, especially in terms of supplier performance, is crucial for ensuring the resilience of supply chains. This research project focuses on mitigating supply risks and translating theoretical Supplier Relationship Management (SRM) strategies into practical applications within the maritime industry. By harnessing SRM strategies and employing the Best Worst Method (BWM), the study formulates robust risk mitigation approaches to fortify the resilience of maritime supply chains.

This study questions the conventional notion of lean management as the fundamental framework for supply chain management. While effective in certain aspects, the rigid and waste-reducing principles inherent in lean management may not inherently address the complexities and uncertainties associated with risk mitigation in the supply chain. As an alternative, this study advocates for agile supply chain management, emphasizing the importance of fostering collaborative relationships, building trust, and enhancing communication. Agile management, emerging in response to modern complexities, emphasizes flexibility and real-time adaptability. This transition challenges the long-standing principles of lean management, underscoring the need to balance efficiency with the imperative of risk mitigation in contemporary supply chain dynamics.

This study also questions the conventional power-based supplier segmentation matrix, known as the Purchasing Portfolio Matrix (PPM). To effectively implement SRM strategies, proper supplier segmentation must take place. While the PPM by Kraljic is valuable for segmenting suppliers based on economic value and supply risk, it primarily focuses on power dynamics. It lacks the interpersonal aspect of relationship-building with suppliers. The PPM is compared to the Supplier Potential Matrix (SPM) to address this, evaluating a supplier's willingness and capabilities. This research introduces the Integrated Supplier Matrix (ISM), enhancing the SPM and providing a more comprehensive framework for supplier segmentation for risk mitigation. The ISM integrates the criteria from both the PPM and the SPM, encompassing capabilities, willingness, profit impact, and supply risk.

Conducted as a case study at Allseas, a prominent maritime company, this research fills a knowledge gap by analyzing a real-world scenario; the case study offers a practical methodology to analyze and prioritize risks, determine relationships between risks and supplier segments, and provide practical SRM strategies. Employing interviews and surveys, the study identifies

and prioritizes procurement-related risks, shedding light on the interconnected nature of these challenges. The study employed data collection methods, including interviews with ten procurement experts, to determine and prioritize maritime-related supply chain risks. The BWM, which is a multi-criteria decision-making (MCDM) method, was used for risk ranking, revealing the uniqueness of the product as the most critical risk (49%), followed by rules and regulations (32%) and external factors (19%). This approach ensures an understanding of the common challenges faced by the procurement department at Allseas.

This research enhances the SPM by introducing distinct names for each quadrant in the 2x2 matrix, similar to the PPM. This modification aims to enhance the readability of the matrix and facilitate easier reference to specific quadrants throughout the thesis. The designated terms for each quadrant are not interchangeable. They are defined as follows: “inept” is used for the quadrant with low capabilities and low willingness, “reluctant” is assigned to the quadrant characterized by high capabilities and low willingness, “overeager” is chosen for the quadrant with high willingness and low capabilities, and “reliable” is assigned to the quadrant with high willingness and capabilities.

Furthermore, the graphical representation of the SPM illustrates a positive correlation between willingness and capabilities. Additionally, the plot reveals a connection between supplier approval ratings derived from the supplier evaluation form and the levels of willingness and capabilities exhibited by the suppliers.

Supplier segmentation using the ISM led to general conclusions regarding the relationship between supplier segments and identified risks. High-risk suppliers (>50% supply risk) exhibited lower average willingness and capability but had a fourfold larger profit impact than low-risk counterparts. Notable suppliers causing disruptions were identified through interviews and segmented separately on the ISM, providing insights into generalizable relationships between supplier segments and risks and aiding in navigating complexities in supplier dynamics. The uniqueness of the product poses a risk due to suppliers’ high bargaining power, making them challenging to work with and often displaying low willingness.

Additionally, the study explores SRM trade-offs, including considerations between keeping or relying on suppliers’ stock, long-term and short-term contracts, single and multiple sourcing, sole sourcing, and in-house manufacturing, and investing in or switching non-performing suppliers. Effective risk mitigation through communication and building trust is crucial in these trade-offs.

This study provides crucial insights for managers in the maritime industry, emphasizing the need for effective risk management strategies to address supply chain vulnerabilities. Integrating theoretical SRM approaches with MCDM methods, such as the BWM, is recommended for fortifying the resilience of maritime supply chains. Managers are encouraged to transition from conventional lean management to an agile supply chain approach, focusing on collaborative relationships and communication. The ISM proves instrumental in strategic supplier segmentation, offering a comprehensive framework for informed decision-making. During this report, an SRM framework has been developed, which can prove useful as a basis for SRM strategy formation and trade-off analysis. Implementing these insights can help managers optimize supplier relationships, navigate supply chain complexities, and establish adaptive procurement strategies to mitigate supply chain risks.

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List of Abbreviations

AFT	Aftermarket Part
BWM	Best Worst Method
CM	Contract Manufacturer
CPFR	Collaborative Planning, Forecasting, and Replenishment
ERP	Enterprise Resource Planning
IMO	International Maritime Organization
IoT	Internet of Things
ISM	Integrated Supplier Matrix
JIT	Just-In-Time
LP	Lean Production
LSCM	Lean Supply Chain Management
MCDM	Multi-Criteria Decision-Making
NDA	Non-Disclosure Agreement
OEM	Original Equipment Manufacturing
PO	Purchase Order
PPM	Purchasing Portfolio Matrix
QC	Quality Control
QHSE	Quality, Health, Safety, and Environment
R&D	Research and development
SC	Supply Chain
SCM	Supply Chain Management
SPM	Supplier Potential Matrix
SRM	Supplier Relationship Management
VG&S	Vessel consumables, general goods, and services
VM	Vendor Management
VMI	Vendor Managed Inventory

Chapter 1

Introduction

The success of companies has been closely linked to how well their suppliers perform (Jafarian et al., 2021). This is because suppliers play an important role in how competitive companies are, as they impact multiple aspects, such as the price, quality, and delivery of products or services, affecting the supply chain as a whole (Jafarian et al., 2021). Supply Chain Management (SCM) is a concept that every company has to deal with, affecting both suppliers and buyers when disruptions occur. The profitability of companies facing supply chain disruptions is estimated to be 33–40% lower than that of their competition in the same industry (Tang, 2006). This is why the disruptions in supply networks can also be defined as supply chain risks, as they can affect the production and delivery of goods and services and the performance, profit impact, and competitiveness of the supply chain (Chen & Xiao, 2015). Therefore, risk mitigation in supply chains is essential in engineering and business applications.

Supply chain disruptions can be classified as operational or disruption risks (Dominguez, Ponte, Cannella & Framinan, 2019). Operational risks tend to occur more frequently but are typically less severe. Internal processes often cause these types of risks. These can be caused, for example, by interactions between stakeholders and suppliers, increased price and lead times, quality issues, and safety risks (Dominguez et al., 2019). Alternatively, disruption risks are less probable but more severe. These risks are often caused by external factors that can be more difficult to predict and can often be out of a company’s control. These can include human-related incidents, technical failures, and other external factors, such as natural disasters and geopolitical conflicts (Dominguez et al., 2019).

One of the most recent and impactful examples of a disruption risk that has affected the global supply chain is the COVID-19 pandemic. The pandemic posed unprecedented challenges and uncertainties for the global supply chain, as many businesses have faced disruptions, delays, shortages, and losses due to lockdowns, travel restrictions, health risks, and demand shocks (Guan et al., 2020). The recent pandemic has exposed the supply chain’s vulnerabilities and emphasized the significance of resilience and risk mitigation.

One of the major challenges that the pandemic has caused for the supply chain is material scarcity (Brown, 2022). This has suddenly made once common products, now unique. The increased uniqueness of certain products increased competition and price volatility among buyers and suppliers, creating additional risks and uncertainties for the supply chain. Therefore, managing the supply and demand of materials is a critical issue for ensuring the sustainability

and resilience of the supply chain in the post-pandemic era.

As the process of acquiring the necessary resources for the supply chain, procurement is directly affected by material scarcity, shifting bargaining power between suppliers and buyers, and price volatility. Procurement is the process of acquiring materials, equipment, and personnel for the production and delivery of goods and services (Lysons & Farrington, 2020). Procurement is widely recognized as one of the most exciting parts and the backbone of the supply chain (Lysons & Farrington, 2020). Procurement decisions can establish and maintain supply chain relationships by improving supplier performance, fostering innovation, and building long-term partnerships (Novack & Simco, 1991). Strong supplier relationship management is essential to reduce and mitigate operational and disruption risks. Therefore, it can be argued that supply chain success and resilience can be achieved through procurement (Roberta Pereira, Christopher & Lago Da Silva, 2014). This is also because procurement oversees and is responsible for a company's suppliers and their management. How well their suppliers perform has been a key factor in the outcomes of companies in the past few years (Jafarian et al., 2021). Therefore, many of the risks in procurement are related to the suppliers. The likelihood of an event that affects the supply from a specific supplier or the entire supply market, which may result in the inability of the purchasing company to satisfy customer demand or endanger customers' health and safety, is called supply risk (Zsidisin, 2003). All supply chain risks can be categorized using Kraljic's Purchasing Portfolio Matrix (PPM) (Kraljic, 1983). This 2x2 matrix plots a supplier's or a supply's economic value against its supply risk, allowing for the segmentation of suppliers and the identification of potential SRM strategies. While many procurement professionals follow this approach, it has notable limitations, prompting the development of a more comprehensive model: the Integrated Supplier Matrix (ISM). The 'integration' of the ISM stems from its integration of criteria derived from both the PPM and the Supplier Potential Matrix (SPM). This incorporation includes capabilities, willingness, profit impact, and supply risk considerations. This thesis aims to redefine and apply the ISM for supplier segmentation, offering a solution addressing the PPM's inherent limitations.

The maritime industry is one of the most important and influential sectors in the global supply chain, accounting for around 80% of international trade (UNCTAD, 2022). However, the maritime industry is exposed to various challenges and uncertainties. Global supply chain disruptions can affect ports and shipping routes. These disruptions can result in essential goods like food, energy, and medicine failing to reach those who depend on them, causing supply shortages, price increases, and customer dissatisfaction. Therefore, the maritime industry must make strategic investments to bolster its resilience against forthcoming crises and reduce these risks.

One example of a leading maritime company that operates in the global maritime pipe-lay and sub-sea construction sector is Allseas. Allseas commands a fleet of six specialized vessels that are designed and optimized in-house for executing intricate and large-scale offshore projects (Allseas Group S.A., 2023). Their flagship vessel, the *Pioneering Spirit*, is the world's largest and most versatile offshore construction vessel (Allseas Group S.A., 2023). It is engineered for the single-lift installation and removal of offshore platforms, along with setting records for installing extraordinarily heavy pipelines (Allseas Group S.A., 2023). However, a maritime company like

Allseas also sees and feels detrimental effects when there is a kink in the maritime supply chain. Therefore, Allseas must adopt measures to enhance its supply chain resilience.

1.1 Problem Definition

Supply chains are complex systems that require precise coordination of goods and information to deliver uninterrupted services. However, this complexity also makes them vulnerable to various risks and disruptions, especially in the globalized context. The geographical distance between suppliers and buyers and the impact of disruptive events increase the uncertainty and challenges within the supply chain. Supply chain disruptions' consequences can include production delays, poor product quality, reduced efficiency, and revenue loss (Kanike, 2023). On top of this, the maritime industry is one of the most important and influential sectors in the global supply chain. However, the maritime industry also faces various challenges and uncertainties due to the interdependence among stakeholders and processes and the reliance on extensive global supply chains. These factors increase the susceptibility and complexity of maritime supply chains. Therefore, mitigating risks in supply chain management is a constant challenge for companies, and especially those in the maritime industry.

Since the performance of suppliers plays a crucial role in determining the outcomes of companies (Jafarian et al., 2021), segmenting suppliers and formulating SRM strategies based on these segments is essential. This is because it is important to tailor approaches to the unique characteristics of each supplier group. There are multiple different ways to segment suppliers. The PPM has become a standard among procurement departments and is used extensively to make procurement-related decisions (Rezaei & Lajimi, 2019). In recent years, the PPM has come under fire because of the narrow focus on supply and little to no focus on building relationships (Rezaei & Lajimi, 2019). Building supplier relationships is crucial as it fosters trust, communication, and collaboration (DeLemos et al., 2010).

The transformation in supply chain management, transitioning from the established principles of lean practices to the responsive nature of agile management, reflects a fundamental shift in priorities from efficiency-focused strategies to dynamic adaptability. As the conventional lean model encounters challenges in the face of modern complexities, the emergence of agile principles introduces a risk-mitigating alternative. This transformation disrupts the traditional supply chain management principle of lean practices, prompting an exploration of utilizing agile principles for risk mitigation and the creation of resilient supply chains.

Suppliers characterized by a high supply risk, indicating limited alternative options, tend to wield considerable bargaining power, creating challenges in communication and collaboration. On the other hand, suppliers with numerous alternatives may desire long-term commitments but often face challenges in securing them due to their replaceable nature. Addressing these dynamics involves navigating trade-offs within SRM strategies, including considerations for mitigating bargaining power, determining contract durations, and evaluating the feasibility of in-house manufacturing versus sole sourcing. Formulating supplier segment-specific recommendations within these complex choices poses a significant challenge and remains a prominent topic of discussion for many companies. Balancing these considerations is essential for establishing effective and mutually beneficial relationships with suppliers and creating solid SRM strategies.

However, while solid SRM strategies are essential for operational efficiency and competitive advantage, ineffective SRM strategies can lead to supply chains prone to vulnerabilities (O'Brien, 2014c). Unfortunately, ineffective SRM strategies for risk analysis and mitigation in SCM persist as a challenge, greatly due to the infancy of using these strategies for risk management and analysis. Supplier segmentation should be done to use SRM strategies effectively. Here, the challenge lies in various supplier segmentation methods, each relying on different variables while overlooking crucial aspects, creating an absence of a comprehensive framework (Rezaei & Ortt, 2011).

This research project tackles the challenge of managing and mitigating the supply risks that affect the performance and resilience of the supply chain. To address this problem, this research project implements and improves supplier relationship management strategies, which are the processes of developing and maintaining effective relationships with suppliers to achieve mutual benefits and goals. This research project also contributes to the literature by filling a knowledge gap on the practical implementation of supplier relationship management strategies, which are often overlooked or underdeveloped in many supply chain contexts. Moreover, this research project addresses the problem of finding a balance in reducing the dependency on suppliers, which is a common challenge for many companies and building partnerships to increase dependency. Having too few or too many suppliers can pose risks for the supply chain, such as supply disruptions, quality issues, price fluctuations, and coordination difficulties.

1.2 Knowledge Gap

While significant research has been conducted on SCM, procurement, and SRM, there remains a notable knowledge gap in practical methods and techniques for addressing potential supply chain challenges and implementing solutions through SRM. The literature reviewed in this report has provided a foundation of theoretical concepts and strategies, which is invaluable in understanding the principles of SCM and SRM. However, the transition from theory to real-world application often presents complex challenges not extensively explored in existing research.

There is limited practical guidance on overcoming potential disruptions and risks in supply chain operations effectively using SRM. While theoretical frameworks exist, their direct application to real-world scenarios, especially within the maritime industry, is not well-documented. This challenges companies like Allseas, which operate in a dynamic environment characterized by many suppliers and global supply chains.

This knowledge gap highlights the need for research that bridges the divide between theory and practice, focusing on implementing SRM strategies to address specific challenges encountered by companies operating in complex supply chain ecosystems.

A case study at Allseas will be conducted to address this gap in the thesis after a framework has been formulated during the literature review. This case study will explore Allseas' current procurement and SRM strategies, the risks they have encountered, and how they can be improved through the strategic application of SRM strategies. This approach enables collecting valuable data related to previous risks, supplier performance, supplier selection criteria, and more. Combining quantitative data analysis with qualitative insights gained through interviews and document analysis, the research aims to develop practical recommendations and guidelines

that Allseas and other organizations can directly apply in similar contexts.

1.3 Research Questions

This sub-chapter introduces the research questions guiding this thesis, which stem from the literature review highlighting knowledge gaps and challenges in maritime supply chain risk management. Consequently, the research questions focus on determining, prioritizing, mitigating risks, and identifying suppliers involved in these risks in the maritime supply chain context. By formulating questions based on these objectives and addressing them through a case study, the research aims to bridge the gap between theory and practice, generating practical SRM recommendations for real risks encountered by the procurement department. The ultimate goal is to address these gaps and challenges, thereby enhancing the resilience and sustainability of the supply chain.

Therefore, the research main research question is outlined as follows:

“How can supplier relationship management strategies contribute to mitigating supply chain risks?”

The subsequent three sub-questions were formulated to guide this research logically:

Sub-question 1: “How can procurement-related risks be identified and prioritized?”

Sub-question 1 addresses the latter aspect of the main sub-question concerning various types of supply chain risks. This sub-question aims to contribute to the overall research objective of understanding and prioritizing risks within the maritime supply chain by delving into the analysis of supply chain risks. Recognizing that procurement plays a crucial role in the broader supply chain process, the goal is to develop a method for identifying and prioritizing procurement-related risks. This is essential for effective risk mitigation, as a comprehensive understanding of these risks is a prerequisite for successful management.

Sub-question 2: “What is the relationship between supplier segments and the identified risks?”

Sub-question 2 explores the relationship between supplier segments and identified risks and is crucial in analyzing the main question. Understanding how different supplier segments correlate with specific risks within the supply chain can give insights into the areas where SRM strategies would be most effective. Analyzing these relationships provides valuable information on tailoring SRM strategies to address the unique challenges posed by various supplier segments.

Sub-question 3: “What supplier relationship management recommendations can be implemented to mitigate the identified risks effectively?”

Sub-question 3 looks at implementing SRM strategies and recommendations to mitigate identified risks effectively. This sub-question focuses on translating the insights gained from risk identification and their relationship with supplier segments (as explored in the previous sub-question) into actionable and practical SRM recommendations.

To conclude, addressing the mentioned risks the supply chain faces and providing solutions

through SRM can help improve the efficiency of Allseas' procurement and supply chain management and mitigate risks. The most important recommendations that can be formulated during the thesis include using supplier relationship management to ensure possible threats in the supply chain are mitigated and prevented instead of having to cure the problem at a later stage since this could lead to inefficiencies and uncertainties. It is essential to compare the risks to the supplier segment and, based on this, create or re-formulate SRM strategies.

1.4 Thesis Structure

The structure of this report is organized as follows. Chapter 2 comprises the literature review, which looks into the extensive information and challenges within the context of supply chain management, procurement, maritime supply chain risks, and supplier relationship management. This chapter establishes the groundwork for the revised supplier segmentation model, the Integrated Supplier Matrix (ISM), and outlines a framework for general SRM strategies. Using this as a foundation, the knowledge gap is identified, leading to the formulation of research questions aimed at bridging the gap concerning the practical application of SRM to mitigate risks in maritime supply chains.

To address and answer the research questions, Chapter 3 explains the methodology that will be used, which is designed to be applicable globally across various companies in the maritime industry.

Chapter 4 serves as a dedicated case study, employing the methodology in a company-specific context, namely as a case study at Allseas, to provide nuanced insights and responses to the first two sub-questions. Data is collected and analyzed within this chapter.

Subsequently, utilizing the data obtained from the risks and risk mitigation practices at Allseas, Chapter 5 formulates specific and general SRM strategies and recommendations. This chapter is a practical application of the theoretical concepts explored in the literature review and answers the last (third) sub-question.

Chapter 6 serves as a discussion chapter, discussing notable differences, uncertainties, or unexpected results that may have emerged during the analysis. This evaluation adds depth to the findings and enriches the overall understanding of the subject matter.

Finally, Chapter 7 is the conclusion, answering the research questions, offering recommendations for future research, specific guidance for Allseas, reflections on research limitations, and an academic reflection on the journey undertaken in this study.

Chapter 2

Literature Review

A careful selection of relevant sources was made to ensure the credibility and reliability of the literature gathered. Scopus, Google Scholar, and the online TU Delft library database were the main databases utilized to retrieve relevant literature on procurement in SCM, challenges in procurement, and supplier relationship management strategies. A systematic approach was followed for the inclusion and exclusion of papers, guided by pre-defined criteria. The full scope of source selection, including constraints used, and a table of the keyword search can be found in Appendix A.

2.1 Supply Chain Management

In 1982, a British logistician used the term ‘supply chain management’ for the first time during an interview (Ashcroft, 2021). They described that SCM includes planning, implementing, and monitoring products and services throughout the supply chain, aiming to meet customer needs most efficiently (Ashcroft, 2021). We have used this process for centuries when exchanging, selling, and transporting goods.

After this term was coined, multiple definitions for supply chain management came to light. According to the research conducted by La Londe and Masters in 1994, the supply chain is conceptualized as an interconnected group of firms that control the logistics of a product or material (La Londe & Masters, 1994). Similarly, Lambert, Stock, and Elram emphasize that the supply chain involves firms working together to bring goods or services to the market cooperatively (Lambert, Stock & Ellram, 1998). In ‘Defining Supply Chain Management’, Mentzer combines the previously mentioned definitions and defines a supply chain as three or more entities directly transferring goods, services, finance, and information (Mentzer et al., 2001).

Mentzer goes even further, declaring that SCM can be seen as a set of activities used to work towards this management philosophy (Mentzer et al., 2001). This is because being able to manage complex supply chains is a philosophy a firm works towards, not something that can be guaranteed. Companies, or firms, must implement seven distinct activities to align their actions with this underlying philosophy consistently. These activities, such as integrated behavior, mutual information sharing, risk and reward sharing, cooperation, customer-centric focus, process integration, and building long-term relationships with partners, collectively enhance the overall efficiency and effectiveness of the supply chain (Mentzer et al., 2001).

Since the term was coined, the supply chain industry experienced significant growth in the 1990s and 2000s due to technological advances and the expansion of global trade, especially with Industry 4.0 (Hickie & Hickie, 2021). Industry 4.0 revolutionized the supply chain process thanks to things like the Internet of Things (IoT), cloud computing, and machine learning. This period saw the emergence of new solutions, such as Enterprise Resource Planning (ERP). Moreover, the volume of international imports and exports has increased dramatically, continuing to grow and expand the supply chain.

2.1.1 Lean Supply Chain Management

Over the years, Lean Supply Chain Management (LSCM) practices and principles have been adopted in various industries (Rossini, Powell & Kundu, 2023). This growing interest can be attributed to the potential benefits associated with LSCM implementation, including cost savings, reduced downtime, and improved product quality (Rossini et al., 2023).

Incorporating external customers and suppliers into internal improvement processes serves as external support to enhance competitiveness and efficiency (Rossini et al., 2023). One effective approach for reducing waste and promoting sustainability in supply chains is Lean Production (LP) (Rossini et al., 2023). Waste reduction refers to the unnecessary consumption of resources and the reduction of defects in the process or product.

As previously defined, SCM involves coordinating various organizations to optimize upstream and downstream flows; this, along with lean management, results in enhanced value, cost reduction, and waste minimization. Even though this seems like a system with many benefits, the emphasis on reducing costs often overlooks the importance of flexibility in dealing with unexpected events (Waters, 2011). Modern SCM trends come with increased risks, which remove the buffer capable of absorbing small changes (Waters, 2011). There is an apparent contradiction between this trend and the notion that effective logistics management can lead to agile supply chains (Waters, 2011). When slack in the supply chain is fixed only for the sake of repair, overall supply chain performance deteriorates, disruptions in the supply chain become more frequent, and vulnerability increases (Waters, 2011). Therefore, it is important to look into balancing efficiency and risk mitigation in SCM.

Lean management has played a pivotal role in value creation for over seven decades and strives to identify and eliminate non-value-added activities, focusing on delivering what customers or end-users truly value (de Raedemaeker, Handscomb, Jautelat, Rodriguez & Wienke, 2020). In contrast, agile, a more recent development that emerged in software development during the 1990s, represents a departure from traditional, sequential, and time-consuming approaches to product or service development (de Raedemaeker et al., 2020). Agile methodologies prioritize speed and flexibility, advocating for iterative development that aims to swiftly deliver an early prototype of a new product or service to customers (de Raedemaeker et al., 2020).

The market demand for lean supply is typically characterized by predictability, whereas the demand for agile supply in the marketplace tends to be volatile (Bruce, Daly & Towers, 2004). Agile supply is responsive to real-time changes in demand, demonstrating market sensitivity (Bruce et al., 2004).

The agile supply chain strategy is characterized by its dynamic and continuous responsive-

ness to the evolving needs of customers and the competitive environment (Ahmed & Huma, 2021). This approach provides flexibility and adaptability, allowing organizations to navigate changes in the business landscape effectively. By implementing the agile supply chain strategy, organizations can respond promptly and enhance their adaptive capabilities in the face of supply chain disruptions (Ahmed & Huma, 2021). The reactive nature of the agile strategy aligns with the characteristics of a resilient supply chain, enabling quick recovery from disturbances (Ahmed & Huma, 2021). Challenging the long-standing principles of lean management that have served as the foundation for supply chain management for decades, agile management emerges as a risk-mitigating alternative.

2.2 Procurement

The shift from philosophy to practice in SCM using the mentioned activities emphasizes the importance of information sharing, risk and reward sharing, cooperation, and building partnerships to maintain long-term relationships among supply chain partners to achieve effective SCM. Even though the activities mentioned are not exclusively procurement activities, they all encompass an essential part of procurement, making procurement an essential step in working towards putting the philosophy of SCM into practice.

Procurement is defined as the business management function responsible for identifying, sourcing, accessing, and monitoring external resources needed by an organization now and in the future (Lysons & Farrington, 2020).

Procurement is essential to the overall performance of a company's core functions and contributes to its competitiveness (Novack & Simco, 1991). Procurement includes critical factors such as supplier requirements, product acquisition, and continuous supplier performance monitoring. Consequently, procurement plays an important role in developing strong relationships between stakeholders in the supply chain, which emphasizes its importance in the value chain (Novack & Simco, 1991). Understanding supplier interactions helps identify opportunities to improve supplier performance, foster innovation, and build long-term partnerships.

Unsurprisingly, procurement plays a vital role in cost and risk management in the supply chain. Effective procurement practices enable organizations to optimize costs by identifying cost-effective suppliers, negotiating favorable contracts, and implementing efficient procurement processes (Asif, 2022). However, if not done effectively or correctly, supply chain risks can increase, such as supplier problems, quality issues, and compliance challenges, impacting supply chain resilience overall (Asif, 2022).

2.2.1 Procurement Activities

Procurement activities are circular since they are treated and revised throughout the supply chain process, this can be seen in Figure 2.1 (Novack & Simco, 1991, p. 148). The first activity in procurement is to identify or reevaluate needs (Novack & Simco, 1991). This begins with acquiring a product or service for a specific need or job by evaluating user requirements (Stadtler, 2015). Initially, these products or services are delivered by the existing supply chain members and chosen based on core competencies.

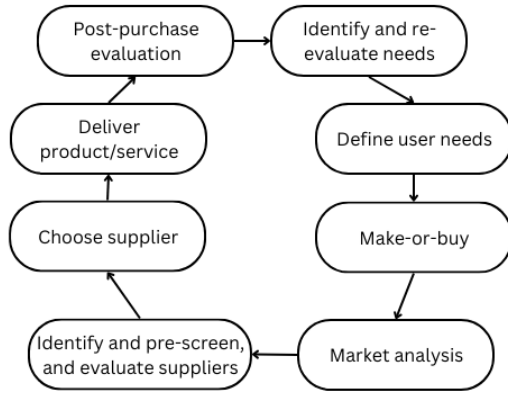


Figure 2.1: Procurement activities

Then, if there is a standard product and the variation of this product makes no difference from the end customer's perspective, the same products and services that are widely available in the market can be outsourced. After the make-or-buy decision, it is concluded that products will be bought from outside suppliers. Once a market analysis, identification of all possible suppliers, and screening of the suppliers lead to one or more suppliers. This supplier will become a part of the supply chain for all other potential future services (Stadtler, 2015).

When deciding on suppliers, not only costs should be looked at, but the partner's ability to support and contribute to long-term competitiveness in the supply chain is also key (Stadtler, 2015). After having selected a supplier, the product or service must be acquired and delivered. Subsequently, a post-purchase evaluation must be done to monitor and evaluate supplier performance (Lysons & Farrington, 2020).

Even though this is a very simple list of procurement activities, it clearly represents the main steps involved in procuring items and services for the supply chain.

Procurement has a series of functional attributes that assist in analyzing and visualizing the structure of the supply chain and affect the decision-making process (Stadtler, 2015). The first attribute considers the number and type of products to be procured, ranging from standard to highly specialized items (Stadtler, 2015). The second attribute is sourcing types, which include sole sourcing (one supplier but no choice in the supplier), single sourcing (one supplier of your choosing), dual sourcing (two suppliers sharing demand), and multiple sourcing (multiple suppliers) (Stadtler, 2015). The sourcing type is usually contractually bounded, and these contracts typically have medium-term validity. The next attribute is the flexibility of suppliers. Supplier flexibility in supplying amounts is crucial, with quantities being fixed, bounded, or freely available (Stadtler, 2015). After this, the attribute supplier lead time and reliability is mentioned, where the lead time is defined as the interval between ordering and arrival, which is directly linked to supplier reliability (Stadtler, 2015). For example, shorter lead times usually mean more reliable delivery dates. Finally, the materials' life cycle is the last mentioned attribute. The life cycle of components affects inventory obsolescence risk (Stadtler, 2015). Shorter life cycles require more frequent material substitutions.

2.3 Supplier Segmentation Matrices

The relationships between buyers and suppliers in the context of SCM is and has always been a topic of interest. Specifically to evaluate suppliers based on specific criteria and to use Multi-Criteria Decision-Making (MCDM) techniques to select the best suppliers available. The mentioned challenges, collaboration and communication, inventory management via timely deliveries, and technical expertise are all risks that can be mitigated when suppliers are willing and capable of working towards the goal of supply chain management with the buyer to create successful buyer-supplier relationships. Segmenting suppliers is crucial in creating successful

buyer-supplier relationships.

However, one of the fundamental issues is that there are different methods for supplier segmentation, all of which use various variables and overlook some important ones (Rezaei & Ortt, 2011). The lack of an overarching framework that includes all the significant variables poses a significant knowledge gap. This chapter will look into the two models, or matrices, that fit best given the topic of interest and an overarching integrated matrix that employs the criteria of both matrices.

2.3.1 The Purchasing Portfolio Matrix

The Purchasing Portfolio Matrix by Kraljic is a good starting point for understanding how risks can be posed by suppliers. Kraljic's Purchasing Portfolio Matrix is also known as the PPM and is a 2x2 matrix (Kraljic, 1983). It has been adapted slightly to outline preferred supplier relationships and directions as arrows depicted in Figure 2.2. The model categorizes supplies based on their level of complexity in the supply market compared to their importance of purchasing.

Even though there is much discussion on the definitions of the two dimensions of the matrix, the following definitions will be used throughout this thesis:

Supply risk is the probability of an event related to incoming supply from a particular supplier or the supply market as a whole, which may lead to the purchasing company's failure to meet customer demand or pose a danger to customers' well-being and safety (Zsidisin, 2003, p. 222).

Profit impact is the financial value of item(s) (Gelderman & Weele, 2003, p. 210).

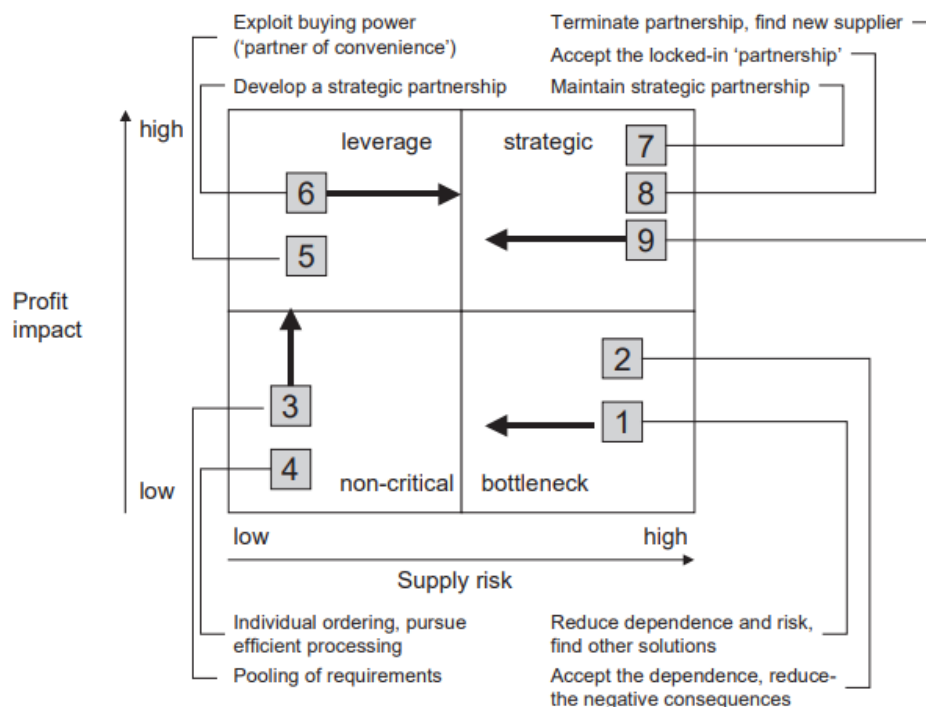


Figure 2.2: Purchasing Portfolio Matrix with directions (Gelderman & Weele, 2003, p. 212)

The profit impact of a specific supply item can be gauged by considering factors like the purchase volume, its contribution to the overall purchase cost, as well as its effect on product quality and business growth. When comparing this to the previously defined attributes, this directly concerns the number and type of products procured and the sourcing type. Supply risks are evaluated based on criteria such as availability, the influence of market competition, considerations of making or buying, storage risks, and the potential for substitutions. Using these criteria, in theory, all supplies fit in the matrix and can shift from position within the matrix depending on supply and demand. It can be seen that articles on the right-hand side of the model have a high supply risk, while articles on the left-hand side have a low supply risk.

Moving to the left of the portfolio is usually more favorable for buyers as it typically implies exerting more influence and control over the supply chain. This may involve strategies such as consolidating purchasing power, negotiating favorable terms, and seeking cost reductions. However, moving left on the PPM can affect supplier relationships, partnerships, and overall supply chain dynamics. Therefore, balancing exerting buyer power and maintaining healthy supplier relationships is important to achieve optimal outcomes since this is the least risky position.

There is a list of criteria measuring the dimensions of the matrix that have been formulated. On the basis of this, strategic choices can be made by the buyer. This list can be seen in Table 2.1 and has been adapted from Rezaei and Lamiji's table to include more maritime-related risks, such as the life-cycle location of the product, meaning in which stage of its life-cycle the product finds itself in (Rezaei & Lajimi, 2019, p. 422). It is interesting to note that most of the supply risk criteria can be linked to or affect the number of available suppliers.

Often, the movement of products within the PPM is not the buyer's strategic choice but the supplier's choice or happens due to unforeseen risks or challenges. For instance, based on the first criterion in the left column, the supply risk will increase with fewer providers. Similarly, the profit impact criterion in the right column will increase with the product's price. Combining the two allows an item that was possibly non-critical to become strategic when the number of suppliers decreases to a minimum (as was observed during a pandemic, for example) and when the item's price increases significantly (this could have also been an effect of the pandemic).

Often, movements within the PPM and purposely holding in the same position in the matrix are deliberate and known as strategic directions. The strategic directions can be seen in Figure 2.2 and are depicted by the numbers and arrows within the matrix (Gelderman & Weele, 2003).

Starting with the bottleneck items, there are two strategic directions. The first, which is the movement to the left-hand side of the model, is 'accept the dependence, reduce the negative consequences' (Gelderman & Weele, 2003, p. 212). Bottleneck items, characterized by low value and high risk, often mean a search for alternative solutions, especially from an economic perspective. Common alternatives involve modifications to the product (such as broadening specifications or simplification), seeking new suppliers, managing suppliers, and/or cross-sourcing suppliers (Gelderman & Weele, 2003). Cross-sourcing suppliers is a sourcing strategy where a company has a single supplier for a specific part or service while simultaneously engaging with another supplier possessing equivalent capabilities for a different part or service (Industries, 2020). This arrangement means that each supplier can serve as a backup for the other. These measures

Table 2.1: Adapted table of criteria measuring Purchasing Portfolio Matrix dimensions (Rezaei & Lajimi, 2019, p. 422)

Supply risk criteria	Profit impact criteria
Number of available suppliers	Total amount purchased
Product availability	Expected growth in company's demand
Delivery time	Perceived bargaining power of buyer
Substitution options	Product price
Product storage costs	
Legal requirements	
Ease of supplier substitution in case of failure	
Logistical proximity of supplier market	
Quality	
Importance of the product	
Perceived bargaining power of supplier	
Communication	
Coordination	
Life-cycle location of product	

aim to reduce supply risk and dependence on a single supplier, shifting to the left of the model. The other strategic direction is to stay in the bottleneck quadrant. When no other feasible options exist, no change happens. A typical response could be contingency planning, risk analysis, long-term contracting focusing on quality and supply assurance, and maintaining buffer stocks to mitigate risks in this unfavorable position.

Moving to the non-critical items, similarly to the bottleneck items, there are two options for strategic direction choices. 'Pooling requirements' is the shift in the model from the bottom left to the top left quadrant (Gelderman & Weele, 2003, p. 212). Preferably, non-critical items are consolidated in large quantities to enhance the firm's buying power. For example, the pooling/consolidating strategy can be implemented through a framework agreement with a preferred supplier, systems contracting, Vendor Managed Inventory (VMI) systems, or e-procurement solutions (Gelderman & Weele, 2003). If necessary, standardization processes are pursued. In all cases, the strategic direction reduces direct and indirect procurement costs. The other option, or strategic direction, is to stay in the non-critical quadrant. When pooling purchasing requirements is not feasible, the only option left is individualized ordering. The purchasing strategy focuses on reducing indirect procurement costs associated with administrative activities like ordering, invoicing, and procurement processes.

In the top left 'leverage' quadrant, moving to the right-hand side of the model would be done by 'developing a strategic partnership' (Gelderman & Weele, 2003, p. 212). This cooperative strategy is pursued only if the supplier is willing and capable of contributing significantly to the firm's competitive advantage. Such a shift is usually reserved for technologically advanced suppliers and is viewed as an exception rather than the norm (Gelderman & Weele, 2003). On the other hand, the other strategic direction would be to stay in the leverage quadrant. This is the typically preferred leverage position since it allows for more aggressive supplier management (Gelderman & Weele, 2003). Options like competitive bidding and short-term contracts can be used to maximize leverage (Gelderman & Weele, 2003). The dominant position enables a directive strategy.

Finally, and arguably the most complex quadrant, the strategic quadrant. Here three stra-

tegic directions can be chosen. The first is shifting back to the left side of the PPM. This is done by ‘terminating a partnership, seeking new suppliers’ (Gelderman & Weele, 2003, p. 212). Occasionally, a partnership may deteriorate, with the supplier’s performance becoming unacceptable and/or irreparable. The firm must reduce its dependence on the underperforming supplier in such cases. This process involves seeking, developing, and contracting with a new supplier while discontinuing the relationship with the non-performing one (Gelderman & Weele, 2003). The other two strategic directions are both to maintain their current position in the strategic quadrant. The first method to maintain position is by sustaining their strategic partnership (Gelderman & Weele, 2003). As emphasized earlier, long-term relationships with key suppliers should always enhance the firm’s competitive advantage. These relationships are characterized by mutual trust, commitment, and open information exchange, although they were found to be relatively rare in the case studies and should be highly valuable for both parties (Gelderman & Weele, 2003). The other option for strategic direction to maintain its position in the strategic quadrant is by accepting an involuntary locked-in partnership (Gelderman & Weele, 2003). Sometimes, a position in the strategic quadrant results from unfavorable conditions beyond the firm’s control; this could happen due to patent positions, monopolies, high switching costs, or customer mandates (Gelderman & Weele, 2003). Therefore leads to involuntary stay in the strategic quadrant.

2.3.2 The Supplier Potential Matrix

The Purchasing Portfolio Matrix has faced critique over the last decades (Gelderman & Weele, 2003). This is because, in essence, the PPM decisions are sensitive to dimensions, factors, and chosen weights (Gelderman & Weele, 2003). The terms ‘profit impact’ and ‘supply risk’ are critical, but their practical measurement remains a challenge (Gelderman & Weele, 2003). Consequently, there’s a chance the model won’t precisely capture the dimensions it’s meant to assess. This means that a critical phase that involves reaching a consensus among decision-makers is the subjective weighing of factors. Another issue is that the PPM focuses on exploiting power or avoiding supplier power risk, which both lacks the social aspect of building relationships with suppliers and is contradictory (Gelderman & Weele, 2003). Business decisions are too complex to be based on just two dimensions. The PPM focuses on supplies instead of suppliers, which may lead to misalignment between buyer and seller intentions, making partnerships difficult (Gelderman & Weele, 2003).

Gelderman and Weele are not the only researchers who feel buyer-supplier relationships or involvement is lacking in the PPM. In 1998, 15 years after the publication of the PPM, a model on supplier segmentation based purely on supplier involvement was published (Dyer & Singh, 1998). Since this publication, many authors have published novel ways to segment suppliers based on both the PPM as well as supplier involvement (Rezaei & Ortt, 2011).

In a novel approach to segmenting suppliers, Rezaei and Ortt determined three essential prerequisites (Rezaei & Ortt, 2011). Firstly, supplier segmentation should hinge on evaluating their long-term viability, which can be done by assessing supplier capabilities and willingness (Rezaei & Ortt, 2011). Secondly, it should encompass considerations beyond purchasing and must encompass other functional areas (Rezaei & Ortt, 2011). Thirdly, supplier segmentation

should be perceived as a phase within an ongoing, longitudinal process encompassing supplier selection, segmentation, relationship management, and proactive role development over time (Rezaei & Ortt, 2011). This definition and approach to supplier segmentation look like and feature many of the aspects of SRM strategies.

The second matrix that will be used to segment suppliers is the Supplier Potential Matrix (SPM), which can be seen in Figure 2.3 and plots suppliers' capabilities against their willingness (Rezaei & Ortt, 2011, p. 4603). Similarly to the Portfolio Matrix, this 2x2 matrix also has strategic directions of movement within the matrix. However, here, all directions lead to higher supplier willingness and capabilities.

A helpful way to improve the matrix is to give each quadrant a label similar to the PPM. These labels can be compared to the bottleneck, non-critical, leverage, and strategic labels of the PPM and are already implemented in Figure 2.3. This will improve the readability and make referring to every quadrant throughout the thesis less difficult. It is critical to consider that the terms selected for each quadrant can not be used interchangeably. "Reluctant" has been chosen for the quadrant with high capabilities and low willingness as it best represents the meaning of this quadrant. "Inept" has been chosen for the low capabilities and willingness quadrant. For the quadrant with high willingness and low capabilities, "overeager" has been chosen, and for the quadrant with high willingness and high capabilities, "reliable" has been chosen.

Rezaei and Ortt clearly defined the supplier's capabilities and willingness to avoid confusion on the terms used. The definitions of supplier capabilities and willingness that will be used are as follows:

Supplier's capabilities are 'complex bundles of skills and accumulated knowledge, exercised through organizational processes that enable firms to coordinate activities and make use of their assets in different business functions that are important for a buyer' (Rezaei & Ortt, 2011, p. 4598).

Supplier's willingness is 'confidence, commitment, and motivation to engage in a (long-term) relationship with a buyer' (Rezaei & Ortt, 2011, p. 4598).

Similarly to the PPM, the movement of suppliers within the SPM is not always the strategic choice of the buyer but is the choice of the supplier or happens due to unforeseen challenges. The movements are based on criteria measuring the SPM dimensions, capabilities, and willingness. This list can be seen in Table 2.1.

What is interesting to note is the similarities between some of the criteria from the SPM and the PPM. Price, delivery, reserve capacity (or product availability), geographical proximity, and quality are all capabilities and supply risk criteria. Communication is found in both willingness and supply risk criteria. This shows the interconnectedness of the criteria used in the PPM

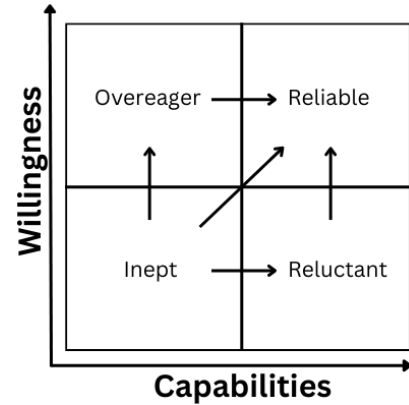


Figure 2.3: Redefined Supplier Potential Matrix with directions and labels

Table 2.2: Adapted table of criteria measuring Supplier Potential Matrix dimensions (Rezaei & Lajimi, 2019, p. 423)

Capabilities criteria	Willingness criteria
Price/cost	Commitment to quality
Delivery	Honest and frequent communications
Quality	Communication openness
Reserve capacity	Attitude
Industry knowledge	Relationship closeness
Supplier process capability	Open to site evaluation
Geographic location/ proximity	Commitment to continuous improvement
Design capability	Bidding procedural compliance
Technical capability	Dependency
Technology monitoring	Prior experience with supplier
Management and organization	Long term relationship
Production and manufacturing facilities and capacity	Willingness to integrate SCM relationship
Reputation and position in the industry	Willingness to co-design
Financial position	Willingness to develop new product
Performance history	Mutual respect and honesty
Cost control	Willingness to share information
Technology development	Willingness to share technology
Repair service	Willingness to share cost savings
After-sales support	Consistency and follow-through
Packaging ability	
Reliability of the product	
Operational controls	
Ease of maintenance design	
Communication system	
The desire for business	
Amount of past business	
Warranties and claims	
Market sensing	
Environmental health and safety	
Invoicing system including EDI	

and the SPM. It shows links between the two methods of segmenting suppliers. These links are beneficial to develop strategies for supplier management and risk mitigation in the supply chain.

Effective supplier segmentation must go beyond purchasing to link to the context of SCM. Supplier segmentation can, therefore, be redefined using Rezaei and Ortt's definition:

Supplier segmentation is 'the identification of the capabilities and willingness of suppliers by a particular buyer in order for the buyer to engage in a strategic and effective partnership with the suppliers with regard to a set of evolving business functions and activities in the supply chain management' (Rezaei & Ortt, 2011, p. 4603).

2.3.3 The Integrated Matrix

The integrated matrix seeks to address the demand for a comprehensive framework encompassing crucial variables from both the PPM and the SPM. While the PPM primarily concentrates on the aspect of supply, SPM significantly emphasizes the supplier relationship as it combines the social aspects found in the Supplier Potential Model. This is because, as was previously explained, it is essential to consider both the supplies and the relationships with those supplying

them, i.e., the suppliers themselves. An integrated matrix was formulated to harmonize these two approaches.

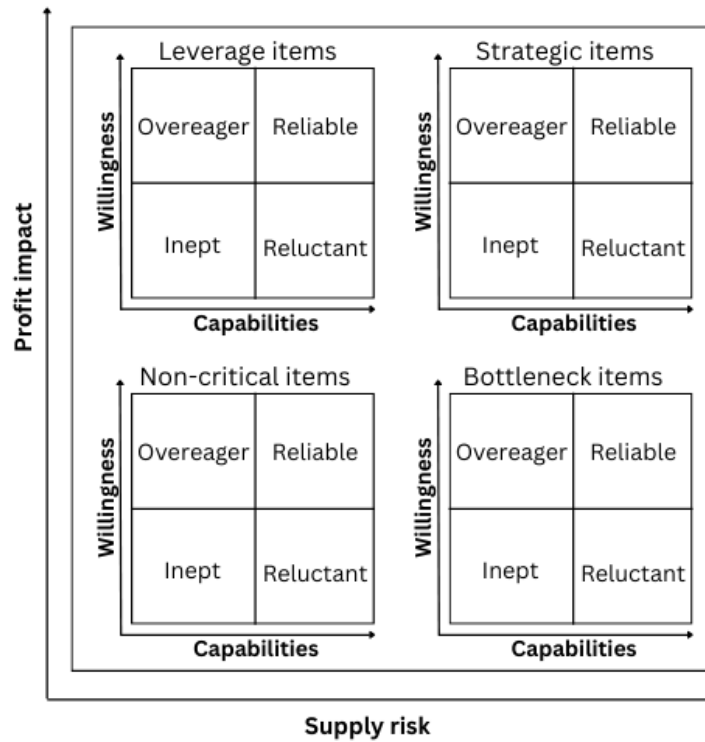


Figure 2.4: Adapted integrated matrix (Rezaei & Lajimi, 2019, p. 424)

Even though the SPM by Rezaei and Ortt encompasses a much more well-rounded matrix and criteria, it is important to look at the PPM and compare the two using this integrated matrix. This will be an extremely interesting and useful tool since the suppliers can be plotted on this integrated matrix to draw well-rounded conclusions.

The downfall with the integrated matrix is that the suppliers must first be segmented into one of the four quadrants of the PPM, then placed in the SPM. This means that the exact location of the suppliers in the SPM is taken into account, but the position of the suppliers on the PPM is very broad and only distinguished per quadrant, meaning the matrix makes no distinction within the PPM quadrant.

For example, a supplier in the ‘leverage’ top left quadrant may vary vastly in position within the quadrant, meaning the risk and profit impact may be relatively vastly different, but this isn’t considered. A visual representation of this example can be seen in 2.5, where the orange crosses mark the possible different locations of the supplier within the matrix. There is no way to place these crosses on the integrated matrix based on profit impact and supply risk like Figure 2.5 depicts.

To combat this, a new version of the integrated matrix can be developed to ensure profit impact and supply risk are considered by means of a bubble chart. The bubble chart can be seen in Figure 2.6. Here, the x- and y-axis follow that of the SPM, which are capabilities and

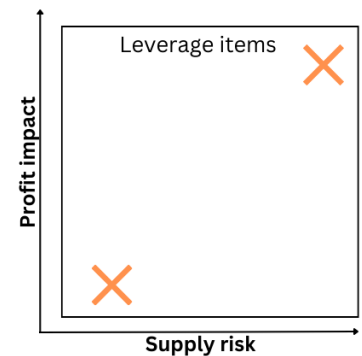


Figure 2.5: Downfall of the integrated matrix

willingness respectively. The bubbles each represent a supplier, and the supplier number is denoted as ‘s#’ as a data label, which is placed in the center of the bubble but may be moved to be placed above or next to the bubble when there are multiple overlapping suppliers to increase visibility. The bubble chart’s quadrants are named like the adapted SPM with reluctant, inept, overeager, and reliable. Compared to the SPM or the integrated matrix, the bubbles in the bubble chart represent risk and profit impact. The color indicates supply risk, where red is a high-risk supplier, yellow is medium risk, and green is low-risk. Everything in between can be given a color accordingly, as is depicted in the slider next to the graph. The size of the circle depicts the profit impact, where the larger the bubble, the larger the profit impact. Since the bubble chart is a 2x2 matrix and the SPM and PPM are referred to as matrices, the bubble chart will be defined as the Integrated Supplier Matrix (ISM).

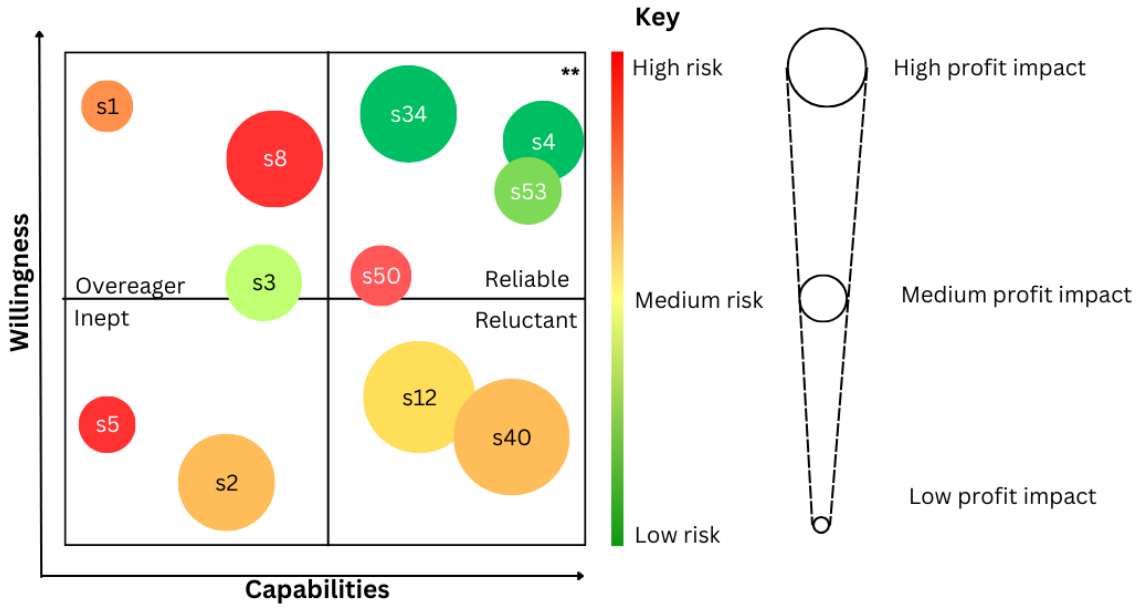


Figure 2.6: Integrated Supplier Matrix

2.4 Redefining Maritime Procurement-Related Risks

In its simplest form, risk can be determined by $Risk = P * S$, where P is the probability of occurrence, and S is the severity of the consequences (Dominguez et al., 2019). This combination effectively expresses many types of risks and is very similar to the definition of supply risk, where the severity affects the supply chain.

Considering the vast scale of the maritime industry and the harmful effects of supply chain disruptions in this sector, this study examines the risks in maritime supply chains. These risks can be broadly classified into two main categories: disruption and operational. The visualization of these risks can be seen in Figure 2.7.

Disruption risks encompass uncertainties and disturbances that disrupt regular supply chain flows; they are less frequent but more severe, and they are often caused by external factors that are harder to predict and control. These disruptions can arise from various sources, including human-related incidents (e.g., pandemics, labor strikes, low wages, poor working conditions),

technical failures (e.g., outdated facilities, slow digitization), or external factors (e.g., natural disasters, political instability, legal conflicts) (Sun, Wang & Cui, 2023). In contrast, operational risks that result from stakeholder interactions in routine business operations are more frequent but less severe, and internal processes usually cause them. They can include encompassing inadequate information exchange, insufficient coordination, and organizational inefficiencies (Sun et al., 2023).

Disruptive risks are often not caused by suppliers, but procurement can face challenges, or risks, with their suppliers when there are disruption risks. There may be supply interruptions due to natural disasters or labor strikes, which may lead to quality issues or increased lead times with the delivered product since the supplier may be situated in regions with political instability or may not be financially stable and, therefore, do not meet their obligations. Similarly, technical failures are challenges procurement often has to deal with, specifically the integration and use of ERP systems. In the 1980s, ERPs placed greater emphasis on electronic support and e-procurement for internal supply chains (Puschmann & Alt, 2005). One of the problems with the implementation of ERPs is that there is still a lack of research on how firms use these systems and the important factors involved in their successful implementation. Another problem is that the firm's team may not be capable of using complex e-procurement methods since the company may still be in a low maturity phase (Van Weele, Rozemeijer & Rietveld, 1998). This leads to a greater chance of technical failures, one of the previously mentioned maritime risks. All disruptive risks can cause a shift to the right-hand side of the Portfolio Matrix by changing an aspect of the supply risk criteria (found in Table 2.1).

Similarly, operational risks may not be directly caused by suppliers, but their effect on suppliers' activities does affect the supply chain as a whole. Collaboration and communication, specifically in procurement, can create the problem of conflicting objectives between different functional units within a company and can hinder efficiency in the supply chain (Stadtler, 2015). Decreased efficiency in the supply chain and increased risk of disruptions can similarly cause a shift to the right-hand side of the Portfolio Matrix. It is, therefore, essential to properly define and organize the interfaces between physical distribution systems to avoid cost overruns and customer service issues. This stresses the need for intra- and inter-organizational cooperation and coordination to optimize the supply chain's performance.

When not done properly, collaboration and communication, especially within procurement, can create conflicting goals inside and outside the company, potentially impacting supply chain efficiency (Stadtler, 2015). Consequently, it is important to clearly structure and communicate needs properly to prevent unwanted complications such as cost escalations and unsatisfied colleagues or suppliers. Effective collaboration and communication ensure everyone is aligned with the organization's procurement goals and objectives, enabling better supplier selection, negotiation, and contract management. This can happen when suppliers are willing and capable of collaborating and communicating efficiently. If cooperation and coordination get lost in translation, supply chain performance can feel the negative consequences of this. Therefore, even though it has been previously concluded, it is important to reiterate that a supplier's willingness and capabilities directly affect supply risk.

Changing rules and regulations is another operational risk that can not be forgotten when

looking at maritime supply chains. The changing rules and regulations in the maritime industry can create a shift to the right of the PPM. This is because the International Maritime Organization (IMO) can create and implement restrictions and rules regarding safety and security of the maritime industry, specifically focused on the environment.

The IMO has established increasingly stringent restrictions on nitrogen oxide (NOX) emissions from ships, which vary depending on the installation date of their engines, where the most strict tier is Tier III (Azzara, Rutherford & Wang, 2014). As a result, it is anticipated that there will be fewer issues in the future as Original Equipment Manufacturing (OEM) applications align with the IMO's Tier III requirements (Azzara et al., 2014).

OEM refers to the production of a product that has been entirely developed by a specific company (Digital, 2020). Authorized manufacturers can be granted licenses to produce these items, and legally, only those with licenses have the right to produce these products (Digital, 2020). The OEM bears the costs since this is the company's unique selling point, and they have to develop something distinctive from other models already present on the market (Digital, 2020). These items frequently feature unique designs that are not replicated or borrowed from existing products.

In situations where an original equipment manufacturer sources components from a Contract Manufacturer (CM), there exists the potential for the CM to manufacture and market its own-branded products, effectively becoming a competitor to the OEM (Dong, Ren & McIntosh, 2023). This dynamic creates a unique coopetitive relationship between these two entities (Dong et al., 2023). Coopetitive combines the words cooperation and competition, meaning competitive businesses that also cooperate when it is to their advantage (Lutkevich, 2021). In the model by Dong et al., the CM serves a dual role, acting not only as a competitor but also as the exclusive supplier of key components to the OEM and that, for the CM to leverage its monopoly power in the key component market and realize additional profits, the CM's final product must be a viable substitute for the OEM's product (Dong et al., 2023).

Aftermarket Part (AFT) refers to a manufactured component that is not sourced from the original manufacturer (Team, 2016). Numerous companies produce aftermarket components designed to function identically to OEM parts. Some AFT manufacturers go a step further by reverse-engineering the original part, where they may identify and rectify defects, potentially leading to an improved version (Team, 2016). The aftermarket has a higher number of manufacturers, driving competition that significantly reduces prices compared to OEM parts, where OEM parts can be priced up to 60% higher than AFT alternatives (Team, 2016). Another plus for buying AFT parts is that the availability is often greater for AFT parts than OEM parts (Team, 2016). The aftermarket sector is often a concealed supplier to the CM (Team, 2016).

The benefits of buying AFT products are evident: decreased costs, there is often increased availability of the products, and larger supplier diversity. This makes AFT products often non-strategic and can be found on the left side of the PPM. However, due to the strict IMO restrictions on the marine engine market, it is sometimes necessary to use IMO parts to ensure performance and safety. Because of this, the pool of possible suppliers is significantly reduced, as well as the competition between these suppliers, making a seemingly non-strategic item suddenly seemingly strategic and giving the supplier the idea of being in power this way.

In Sub-Chapter 2.2.1, procurement attributes and activities have been explained. These can also be the biggest procurement challenges. This is because both operational and disruption risks can easily influence these attributes and activities. The first example is that the more products that need to be bought, the more complex it becomes. This is especially true with specialized purchases. The Portfolio Matrix shows that the supply risk is higher when you need such items. This can also be seen as an operational risk since the concern is related to the complexity and management of procurement processes. In addition, the type of sourcing you choose is also related to the supply risk. With only a sole supplier, the risk of supply chain disruption increases. This is one of the toughest challenges in procurement since if the sole supplier faces either disruption or operational risks, the supply chain can be detrimentally disrupted. Another important attribute is the flexibility of suppliers. When suppliers are not flexible in supplying the required amounts, the risk of supply disruption also increases. If suppliers are not flexible and cannot meet the required amounts, it leads to operational challenges, such as difficulty in adapting to changing demand. Additionally, it poses a disruption risk because it can lead to supply disruptions when the suppliers fail to meet demand changes. Suppliers' lead time and reliability also impact the supply risk since they directly affect the supply chain's operational efficiency. Additionally, if suppliers are unreliable, it can lead to disruptions in the supply chain, especially if they fail to deliver as promised, causing disruption risks. Finally, the product's life cycle phase can also affect supply chain risk. Supply chain risks can increase if a product is nearing the end of its life and no replacements are available. The stage of a product's life cycle can affect the efficiency of the supply chain. When a product is approaching the end of its life, finding replacements for spare parts can become difficult. This lack of alternatives creates a unique product, which leads to the previously mentioned sourcing problem, which, again, is affected by both types of risk. These procurement attributes can lead to a shift to the right-hand side of Kraljic's PPM.

Kraljic defined how to shape a supply strategy based on the PPM, where, in one of the phases, the company evaluates the relative bargaining power of its suppliers in comparison to its own strength (Kraljic, 1983). This is done to determine supply risks further by looking at the possible supplier strengths and determining supplier weaknesses. The full list of purchasing portfolio evaluation criteria has been adapted and can be seen in Table 2.3. The disruption and operational maritime supply risks can be compared to Kraljic's supplier criteria. This is done to see how maritime supply chain risks can affect the supplier's position and performance. When comparing Kraljic's purchasing portfolio evaluation criteria, it is clear that some supplier weaknesses, as defined by Kraljic, have a direct effect on maritime risks. These include changes in the cost-price structure, capacity utilization issues, logistics issues, break-even stability, and uniqueness of the product.

The links can be found in Table D.1 in Appendix D.

Following closely in terms of risk probability is the supplier's break-even stability. This refers to the stability of a supplier's production processes, which directly impacts delivery time, cost, and quality of the delivered product. Such instability can cause products positioned on the left side of the PPM to shift to the right due to increased supply risk.

Similarly, capacity utilization is another factor with a similar probability of risk occurrence.

Table 2.3: Kraljic's purchasing portfolio evaluation criteria (Kraljic, 1983, p. 114)

	Supplier strength	Company strength
1	Market size vs. supplier capacity	Purchasing volume vs. capacity of main units
2	Market growth vs. capacity growth	Demand growth vs. capacity growth
3	Capacity utilization or bottleneck risk	Capacity utilization of main units
4	Competitive structure	Market share vis-a-vis main competition
5	ROI and/or ROC	Profitability of main end products
6	Cost and price structure	Cost and price structure
7	Break-even stability	Cost of non-delivery
8	Uniqueness of product and technological stability	Own production capability or integration depth
9	Entry barrier (capital and know-how requirements)	Entry cost for new sources vs. cost for own production
10	Logistics situation	Logistic

Here, organizational inefficiencies can lead to production bottlenecks, resulting in a shift to the right within the PPM due to heightened supply risks.

The cost-price structure also presents a noteworthy probability of risk occurrence. This includes potential costs stemming from non-delivery or inadequate quality due to organizational inefficiencies or increased costs due to external factors. The impact on the PPM is slightly different, as it shifts articles upwards, affecting profit margins. However, this can also be seen as a supply risk since little to no profit margins make for a higher-risk product.

Finally, logistic issues can create risks in the maritime supply chain. Logistic challenges often arise from poor communication and coordination, leading to disruptions in the supply chain and affecting the supplier's ability to meet demand. Logistic issues tend to increase supply risks, causing articles from affected suppliers to shift to the right within the PPM.

After looking at the PPM, the supplier weaknesses table by Kraljic, and the types of maritime risks, a mind map can be created to get a better visual understanding of what a risk is in its essence and the effects suppliers can have in determining the extent of the risk. The mind map can be seen in Figure 2.7. Here, it can be seen that the maritime risks procurement faces, in essence, are nothing more than shifts to the right side of the PPM.

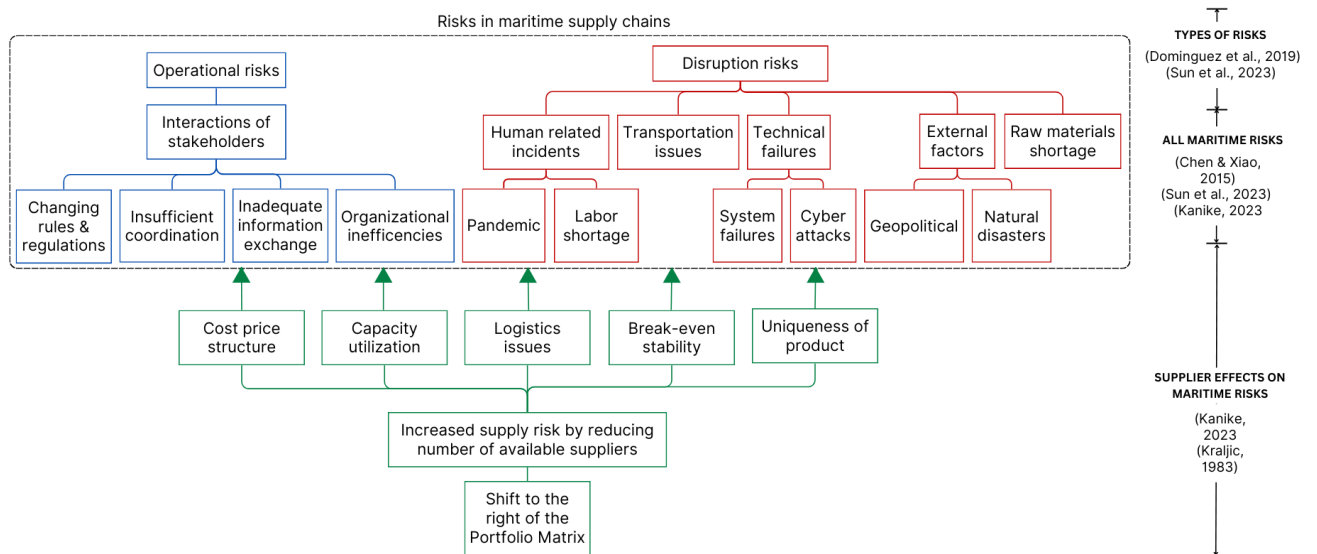


Figure 2.7: Redefined risks in the maritime supply chain

2.5 Supplier Relationship Management

Supplier relationship management is defined as a series of activities focused on establishing, nurturing, stabilizing, and terminating relationships with internal and external suppliers (Moeller, Fassnacht & PhD, 2006). The primary goal of SRM is to create and enhance value within these relationships through effective supplier engagement and monitoring (Moeller et al., 2006). This process aims to reduce costs, ensure consistent and repeatable purchasing, exchange buyer expertise, and optimize collaborations with suppliers (Tronnebati, El Yadari & Jawab, 2022). A thorough supplier selection process is indispensable for procurement. Moeller et al. divide SRM into three consecutive phases:

1. Out-supplier management: Monitoring and engaging with suppliers (out-suppliers) who are not yet connected to the purchasing firm. The goal is to maintain relationships with the top suppliers in the market, as existing relationships should not be viewed as permanent solutions. This involves evaluating and procuring out-suppliers (Moeller et al., 2006).
2. In-supplier management: When a former out-supplier begins their first transaction, they become an in-supplier. This aims to establish and maintain relationships with in-suppliers to maximize value creation (Moeller et al., 2006).
3. In-supplier dissolution management: When the chosen partnership ends, the purchasing firm can seek new potential suppliers (out-supplier management). In-supplier dissolution management terminates an unwanted relationship, regardless of the reason, meaning no resources are exchanged between the partners (Moeller et al., 2006).

The benefits can now be explored using the definition and the phases of SRM. The first is that there are 5 C's organizations need from their supply base; these include *confidence*, *contribution*, *closeness*, *collaboration*, and *clarity* and SRM can help realize this (O'Brien, 2014c). This is because accomplishing successful SRM provides many benefits, such as gaining a competitive edge, increasing brand growth, cost reduction, improving productivity, and better managing supply-side risks (O'Brien, 2014c). Other reasons to achieve one of the 5 C's - closeness with your supplier can be seen in Figure 2.11, also known as the VIPER model, which is explained in a later Sub-Chapter 2.5.3, compares the levels of supplier relationships to the benefits it could bring.

The bullwhip effect refers to the phenomenon where orders and inventory experience increased fluctuations and growth as you move further away from the final customer in a supply chain (Stadtler, 2015). Better managing procurement challenges by increasing *clarity* with the supplier can mitigate risks such as the bullwhip effect and better plan for them. The farther you go from the final customer in a supply chain, the more orders and inventory tend to fluctuate and grow. This is called the bullwhip effect. It happens even when the demand for the final product is relatively steady. Gaining a competitive edge and expanding brand influence can increase bargaining power, meaning *collaboration* through communication and coordination between the company and its suppliers and between the company teams internally can increase this way. Effective communication helps build stronger relationships with suppliers, enabling the company to negotiate better terms and prices. Better communication also ensures cooperation, improving efficiency and enabling faster response to market demands, providing competitive-

ness to the company. Integrating all these factors into SCM practices will enhance supply chain performance and reduce risks.

Multiple different strategies can be used to ensure the benefits SRM can have on SCM. These strategies can be developed, implemented, and tested through an integrative framework.

Various factors warrant attention for effective SRM. These include formulating purchasing strategies, supplier selection, supplier collaboration, supplier management, and implementing integrated approaches, among others (Tronnebati et al., 2022). Among these considerations, supplier selection and evaluation emerge as pivotal in the effective management of supplier relationships (Tronnebati et al., 2022).

A framework has been found that encompasses the previously mentioned SRM strategy factors. The framework that will be used as a basis can be seen in Figure 2.8. This framework is a guide that can be adapted to fit the needs of a company since industry, company size, and company objectives may vary and affect the preferred type and way of implementing SRM strategies. At the end of the literature review, a new proposed SRM framework has been developed to encompass the findings on SRM strategies during the literature review.

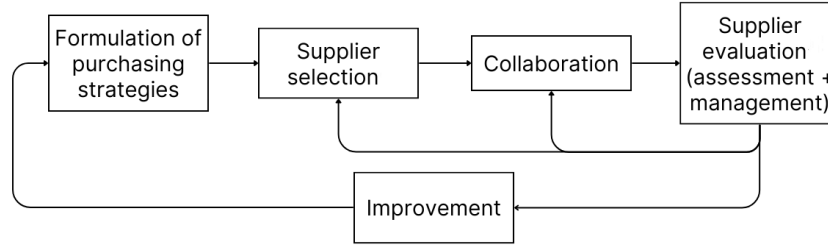


Figure 2.8: SRM framework (Park et al., 2010, p. 499)

2.5.1 Formulating Purchasing Strategies

This sub-chapter will look into shaping the purchasing strategies. Competition is a significant driving force for firms to enhance their purchasing strategies (Kraljic, 1983), aiming to augment the value proposition offered to their customers. To achieve this, firms often engage suppliers from regions with lower production costs, thereby reducing purchase expenses and increasing overall value. This strategy's effectiveness hinges on supply chain partners' ability to establish focused and value-adding buyer-supplier relationships (Trent & Monczka, 2003).

Purchasing strategies can be classified into competitive and cooperative approaches (Park et al., 2010). The competitive approach relies on supplier competition to obtain the lowest prices. In contrast, the cooperative approach requires establishing strategic relationships between suppliers and buyers, who work together to achieve shared goals over time (Park et al., 2010). Because there are two distinct categories, it is sometimes difficult to find the right fit for the buyer and the supplier, which is why purchasing managers are encouraged to adopt a 'fit-for-purpose' approach, meaning the purchasing strategy can differ per article and supplier. This can also be seen in an adaptation of the PPM, which can be seen in Figure 2.2, where articles are ranked by their difficulty managing the purchase situation against the strategic importance of the purchase and where there are desired streams and directions of suppliers within the matrix. This is also an example of adopting different approaches for different suppliers. Adopting a

purchasing strategy, or strategies, can reduce costs and increase contribution and collaboration between the buyer and supplier.

Taking it a step further, different purchasing strategies can be considered when the type of article has been determined in relation to the PPM (bottleneck, strategic, non-critical, or leverage). This can be seen in Figure 2.9, where the determination of the purchase strategy is based on risk, where low risk is defined as the left side and high risk is defined as the right side of the Portfolio Matrix. Table 2.5 lists and compares the different types of purchasing strategies that can be used based on the type of article against other indicators. It is a list based on Table 2.4 (Park et al., 2010, p. 501) and a table by Pieters et al comparing different purchasing strategies, (Pieters, Rooij & Glöckner, 2005, p. 4). Table 2.5 shows the importance of the supply risk and profit of the product on the type of purchasing strategy that should be used.

Table 2.4: Characteristics of competitive vs cooperative strategies (Park et al., 2010, p. 501)

	Competitive Strategy	Cooperative Strategy
Focus	Efficient processing, competitive bidding, systems contracting	Collaboration, supplier development and partnership
Purchasing Methods	Competitive bidding, short-term contracts	Form partnership, long-term contracts
Relationship	Buyer dominance	Supplier dominance or strategic partner
Key Performance Criteria	Cost/price, materials flow management, functional efficiency	Long-term availability, cost management, reliable short-term sourcing
Characteristics	Many suppliers are available	Few suppliers are available

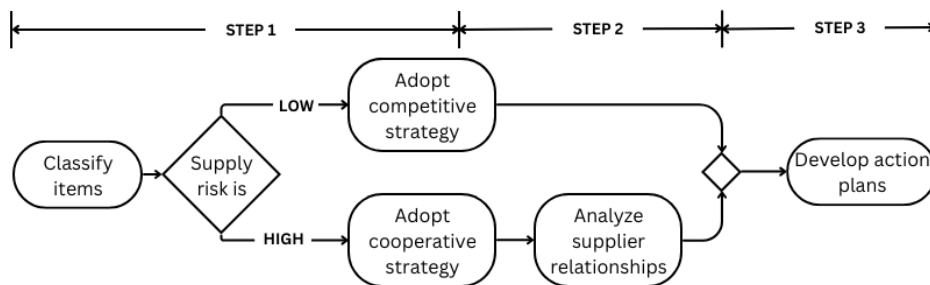


Figure 2.9: Adaptation of item type vs. purchasing strategy (Park et al., 2010, p. 500)

Table 2.5: Purchasing strategies based on the position in the Purchasing Portfolio Matrix

	Non-critical items	Leverage items	Bottleneck items	Strategic items
Strategy	Competitive	Competitive	Cooperative	Cooperative
Relationship	Buyer dominance	Buyer dominance	Supplier dominance or strategic partner	Supplier dominance or strategic partner
Procurement Focus	Purchasing Management	Materials Management	Sourcing Management	Supply Management

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Table 2.5 – *Continued from previous page*

	Non-critical items	Leverage items	Bottleneck items	Strategic items
Purchasing methods	Competitive bidding, short-term contracts (Limited, 12-24 months)	Competitive bidding, short-term contracts (Varied, 12-24 months)	Long-term contracts (Variable, availability vs. short-term flexibility)	Form partnership, long-term contracts (Up to 10 years, long-term strategic impact)
Key Performance Indicators	Functional Efficiency	Cost/Price, Material Flow Management	Cost Management, Reliable Short-term Sourcing	Long-term Availability
Typical sources	Established Local Suppliers	Many Local Suppliers	Global, New Suppliers	Established Global Suppliers
Supply	Abundant	Abundant	Production-Based Scarcity	Natural Scarcity
Decision Authority	Decentralized	Mainly Decentralized	Decentralized but Centrally Coordinated	Centralized

Overall, developing purchasing strategies is important in reducing risks in the supply chain because it allows firms to navigate competitive markets, reduce procurement costs, and develop strong and co-operative partnerships with suppliers, all of which contribute to supply chain resilience and success. The appropriate supplier relationship management strategy can be determined by referring to the different purchasing strategies in Table 2.5, where the level of strategic importance of the purchase/item is compared to other variables, such as the time horizon.

2.5.2 Supplier Selection

The following strategy in the framework is supplier selection. This process is needed for efficient purchasing and manufacturing (Park et al., 2010). Here, suppliers can be evaluated based on selected pre-qualification criteria. This can be difficult since every supplier has a different specialty and, therefore, different criteria to be evaluated. Four noteworthy supplier selection criteria were formulated by Dickson in 1966, Ellram and Cooper in 1990, and Weber et al. in 1991 (Stević, 2017). These criteria include financial aspects, organizational aspects, production facilities, and location. Even though the criteria may be outdated, they still lay the foundations for supplier selection criteria (which are quality, delivery, and price) and are, therefore, important to research and include in this literature study. Appendix B shows an overview of the supplier selection criteria.

However, instead of just focusing on operational metrics like price, quality, and delivery, supplier selection should be done by evaluating how well suppliers can build a long-term strategic partnership with the firm (Talluri & Narasimhan, 2004). This means assessing how suppliers can respond to the firm's evolving requirements in product development, design, manufacturing, and cost reduction (Talluri & Narasimhan, 2004). Suppliers who can do this will likely have the required infrastructure and organizational capabilities to satisfy the firm's needs.

One tool that can be used is the supplier capability questionnaire to evaluate suppliers for supplier selection. This measures the input capabilities of suppliers in six categories: quality management practices and systems, documentation and self-audit, process/manufacturing capability, management of the firm, design and development capabilities, and cost reduction capability (Talluri & Narasimhan, 2004).

2.5.3 Collaboration

Collaboration is the next strategy, which includes collaboration between the supplier and buyer. The extent of expected collaboration can vary based on the relationship type of the supplier. A partner, for example, needs to be close and collaborative to reach its full potential (O'Brien, 2014c). The full list of common types of suppliers and the nature of their relationship with buyers can be found in Table 2.6. Collaboration is one of the biggest challenges and one of the desirable 5 C's in the procurement supply chain, as was previously mentioned; therefore, finding and implementing collaboration strategies can enable efficiency and integration in the supply chain. Well-known collaborative approaches to SCM include Just-In-Time (JIT) purchasing, Vendor Management (VM), and Collaborative Planning, Forecasting, and Replenishment (CPFR) (Park et al., 2010).

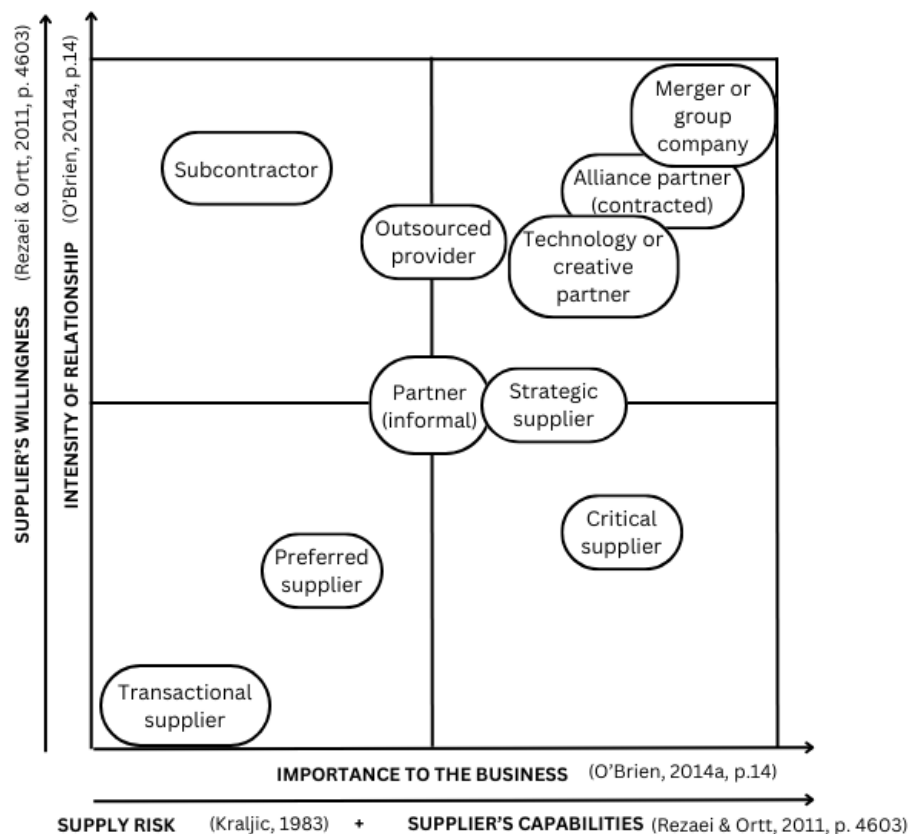


Figure 2.10: Intensity and importance for different types of supplier relationships

Table 2.6: Common types of suppliers, adaptation (O'Brien, 2014a, p. 12, 13)

Relationship type	Explanation	Typical nature of relationship
Arm's length supplier	A simple and commonly found buyer/seller transactional arrangement for named goods or services.	- Contractual fulfillment only, perhaps no or little interaction beyond communicating the requirement and fulfillment.

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Table 2.6 – *Continued from previous page*

Relationship type	Explanation	Typical nature of relationship
Subcontractor	A supplier, usually of services, engaged to complete a specific task or supply a package of work, perhaps as part of a bigger project or to deliver the entire project. Examples might include construction trades on a building site, software contractors	- Typically involves the communication of detailed requirements and interaction regarding technical or specification matters. - May be working alongside other people/subcontractors. - Can gain know-how of our needs that can afford them an advantage.
Preferred supplier	Supplier who has a formally or informally recognized status as one who is mandated or selected in preference of other suppliers	- Potentially defined within a framework or master agreement where the terms of engagement have perhaps been agreed on in advance. - Preferred status might be defined within a list or instruction to those with buying authority.
Outsourced provider	A supplier who has taken on the responsibility to fulfil a core activity and requirement or function of a company, perhaps one previously fulfilled in-house. Examples include outsourced call centre, cleaning, data management, and IT support.	- Close day-to-day interaction at an operational level. - Relationships and contracts built around performance and operational management.
Critical supplier	A supplier who fulfils a requirement that we cannot do without and where we cannot easily switch suppliers or source elsewhere.	- Should be one where we work to develop a good relationship with the supplier. However, many companies fail to identify critical suppliers and place themselves at risk.
Strategic supplier	A supplier who is of strategic importance and has something that can help enable our business to realize our goals and aspirations, e.g. innovation, complementary offerings, capacity, know-how, and coverage.	- Needs to be very close and collaborative in order to realize the potential, but this often falls short.
Partner	Perhaps called an Alliance Partner, Technology Partner, or Creative Partner. Parties have agreed to work together, perhaps with some sort of exclusive arrangement. The arrangement could be informal or a formal contract, and even incentives might exist	- Needs to be very close and collaborative in order to realize the potential, but this often falls short. - Close day-to-day interaction in the area concerned (e.g. at a technical level).

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Table 2.6 – *Continued from previous page*

Relationship type	Explanation	Typical nature of relationship
Group company	A supplier who we own or is owned within the group.	- Relationships should be as if one of us; however if the company is separated by distance, culture, or organizational structure or has recently been incorporated into the group, the relationship can be no different from that of a preferred supplier.

Figure 2.10 is an adaptation from O’Brien’s figure and provides an overview of the varying levels of intensity of the buyer-supplier relationship and the importance to the business linked to different types of supplier relationships (O’Brien, 2014a, p. 14). These criteria can be seen on the x- and y-axis of the figure. The importance to the business and the intensity of the relationship can be reevaluated and further developed by comparing it to the types of relationships in Table 2.6. By comparing this, it becomes evident that the importance to business is directly linked to supply risk and supplier’s capabilities. For example, a critical supplier finds itself on the right-hand side of the x-axis; using the description, it is given that this is a supplier that is needed to fulfill a requirement, and the buyer can not do without since it is not easy to switch suppliers. This makes a critical supplier capable, as well as a supply risk. Doing the same for the y-axis, the intensity of the relationship correlates almost directly to the supplier’s willingness. Taking a subcontractor as an example, they are extremely willing to participate, and this is usually reflected in their work since it is usually service-related. This new model, or matrix, can be used as a basis for supplier relationship management. It can also be used to understand better the significance of managing supplier relationships effectively and identify improvement areas within the supplier portfolio.

Similarly, Figure 2.11, also known as the VIPER model, compares the levels of supplier relationships to the benefits it could bring. Building a strong relationship with a strategic supplier can reduce risk and improve operational efficiency, enhance performance, and promote innovation from the supply base, leading to continuous supply chain improvement. To fully leverage that benefit, everyone in the organization must understand what SRM entails and how it works in practice (O’Brien, 2014c). This can be combined with Figure 2.10 to form strategies for risk mitigation.

Efficient supplier selection ensures that the right suppliers are chosen, minimizing potential disruptions caused by inadequate partners. Collaborative approaches such as JIT purchasing, vendor management, and CPFR enhance value and efficiency in the supply chain, addressing significant challenges. In summary, adopting effective supplier selection and collaboration strategies within the SRM framework can help a company mitigate supply chain risks, improve operational efficiency, and build strong relationships with suppliers, leading to overall supply chain resilience and success.

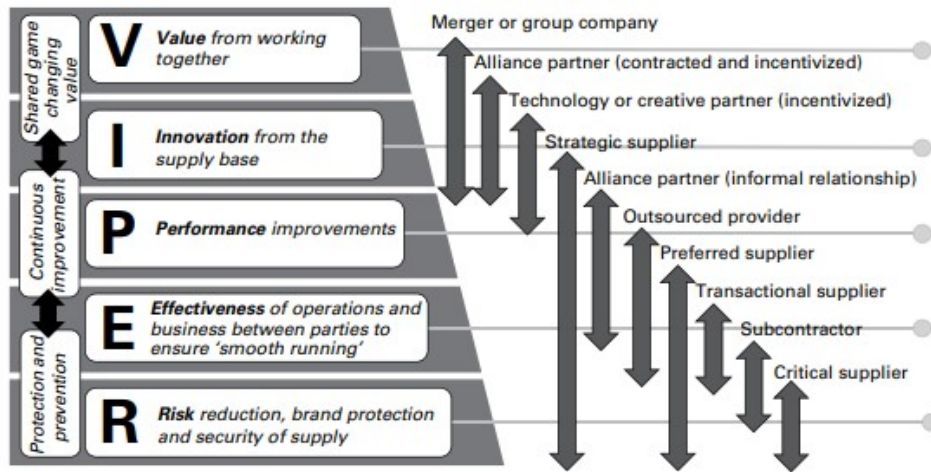


Figure 2.11: VIPER model (O'Brien, 2014b, p. 21)

2.5.4 Supplier Evaluation

Finally, the last strategy looked at is supplier evaluation. Supplier evaluation includes supplier involvement, assessment, and management in the proposed framework.

Supplier evaluation is the process of evaluating the value of a supplier based on their capabilities and performance (Ho, Xu & Dey, 2010). When it comes to vendor rating, or supplier assessment and evaluation, there are three key factors to consider: the extent of the operations and goals, the financial resources available, and the level of experience and development of the Logistics and Purchasing departments (Hockers, 2022).

When considering goals for supplier assessment, it is important to determine the specific issues that need to be addressed (Hockers, 2022). A simple system can suffice if the goal is to improve timely deliveries. However, more time and resources may be required if broader ambitions exist. Additionally, the number of suppliers one works with plays a role, and it may be worthwhile to use software for vendor rating when dealing with more than 50 suppliers or more than €15 million in purchasing (Hockers, 2022). A vendor rating system can benefit both the buyer and supplier by improving negotiations and reducing process disruptions and error costs (Hockers, 2022). While it might seem evident, it's important to note that having a system, along with assessment criteria, is great unless the team lacks the capability to effectively utilize them. In such cases, time and money are wasted. Therefore, the maturity stages in procurement need to be analyzed, and the company's place on this plot needs to be determined.

Another important feature of supplier evaluation is evaluating the supplier's involvement. Supplier involvement's importance has been briefly discussed in Sub-Chapter 2.5. Supplier involvement is essential for organizations to achieve the five C's from their supply base. However, achieving supplier involvement requires effective communication and coordination between the company and its suppliers and within the company's internal teams (O'Brien, 2014c).

Companies increasingly prioritize cooperative relationships with critical suppliers, so executives use supplier evaluations to meet performance objectives (Prahinski, 2004). There are four main communication strategies: indirect influence, formality, feedback, and collaborative, and they all have varying influences on supplier perception and performance improvement within

supplier development programs based on what type of evaluation is required (Prahinski, 2004). Next to the influence of perception of evaluation of suppliers, some factors are used to evaluate suppliers. These factors are often split into the following categories (Park et al., 2010):

- Performance factors
- Capability evaluation factors
- Relationship evaluation factors

This is similar to the method of segmenting using the SPM, which is based on capability evaluation factors (or criteria) and willingness evaluation factors. Since supplier segmentation will be done using supplier willingness and capabilities, these factors will be used to evaluate suppliers.

Weber et al. made a list comparing the different types of criteria that are used according to literature and the number of times they were mentioned in different literature (Weber et al., 1991); this list can be seen in Table 2.7. The supplier evaluation factors are compared to supplier willingness and capabilities.

Table 2.7: Adaptation of supplier evaluation criteria (Weber et al., 1991, p. 4)

Rank	Factor	Category	Mean rating	Evaluation
1	Quality	Capability	3.508	Extreme importance
2	Delivery	Capability	3.417	
3	Performance history	Capability	2.998	
4	Warranties and claim policies	Capability	2.849	
5	Production facilities and capacity	Capability	2.775	
6	Price	Capability	2.758	Considerable importance
7	Technical capability	Capability	2.545	
8	Financial position	Capability	2.514	
9	Procedural compliance	Willingness	2.488	
10	Communication system	Capability	2.426	
11	Reputation and position in industry	Capability	2.412	Average importance
12	Desire for business	Capability	2.256	
13	Management and organization	Capability	2.216	
14	Operational controls	Capability	2.211	
15	Repair service	Capability	2.187	
16	Attitude	Willingness	2.120	
17	Impression	Capability and willingness	2.054	
18	Packing ability	Capability	2.009	
19	Labor relations record	Capability	2.003	
20	Geographical location	Capability	1.872	
21	Amount of past business	Capability	1.597	

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Table 2.7 – *Continued from previous page*

Rank	Factor	Category	Mean rating	Evaluation
22	Training aids	Capability and willingness	1.537	Slight importance
23	Reciprocal arrangements	Willingness	0.61	

The supplier performance assessment questionnaire is a tool to measure the output performance of suppliers into categories: quality, price, delivery, cost reduction performance, etc. Each category has a score between 0 and 1. These scores are used to compare the performance of different supplier groups.

Companies can adopt similar supplier assessment and evaluation criteria and tools to improve their risk mitigation in the supply chain. Companies can select suppliers with higher reliability, quality, and responsiveness levels by carefully considering the vendor selection criteria and supplier management in the given framework. This, in turn, reduces the likelihood of supply chain disruptions caused by unreliable or underperforming suppliers.

Implementing SRM strategies is critical to mitigating the procurement supply chain's challenges and risks. An integrated SRM strategy provides a structured approach to addressing the supply chain's challenges and enhancing buyer-supplier relationships. Shaping purchasing strategies is not one size fits all, meaning a balance must be found between different approaches to best suit the company and its suppliers. Supplier selection is essential for procurement and product development. Evaluating suppliers based on criteria such as financial aspects and organizational features can help make informed decisions and trusted partnerships. Collaboration and supplier management allows companies to identify improvement areas and apply measures to ensure suppliers exceed performance expectations.

By implementing SRM strategies, organizations can enhance collaboration, improve supplier selection, and improve supplier performance, resulting in supply chain performance quality and consistent competitive advantage results, meaning that supplier relationship management strategies can mitigate challenges in procurement supply chain performance.

2.5.5 Trade-Offs in Supplier Relationship Management

The first trade-off must be made when an incumbent supplier no longer meets the buyer's expectations. When a supplier fails to meet the expectations or requirements under risk, there are three different ways to handle the situation. One way is to help the supplier improve its performance by investing resources such as time, effort, expertise, and capital (Jafarian et al., 2021). This is known as supplier development, which was first practiced in the Japanese automotive industry and is based on continuous improvement (kaizen) principles (Jafarian et al., 2021). Some of the methods for supplier development are offering training, consulting on-site, giving rewards, sharing resources, increasing capacity, upgrading machinery, and/or coordinating (Jafarian et al., 2021). Suppliers can benefit from this in the long run. However, putting time, money, and/or resources into the suppliers can expose buyers to potential problems, such as insufficient return on investment, lack of communication, loss of business and market, and violation of trust (Jafarian et al., 2021). To avoid these problems, specific suppliers should be selected for the development process, and the benefits and risks of investing in these given suppliers should be compared to the investment and allocation of resources needed.

This is effective because a buyer can greatly influence the supplier's performance. A buyer's leadership style affects the resilience of its suppliers in the face of supply chain disruptions (Verghese, Koufteros, Polyviou & Jia, 2022). This means that by implementing the right SRM strategies as a buyer, supply chain resilience can be achieved by increasing supplier resilience. There is a direct link between customer leadership styles and supplier resilience through trust and extra-role behaviors (relational flexibility and relationship-specific investments) (Verghese et al., 2022). The two leadership styles that can have these effects are:

Transactional leadership is ‘based on an exchange process in which the leader provides rewards in return for the subordinate’s effort and performance’ (Verghese et al., 2022, p. 4).

Transformational leadership is ‘behavior that inspire employees, or exchange partners, to focus on their firm’s or supply chain’s norms, values, and goals and seek to perform beyond expectations; that is, to demonstrate extra-role behaviors’ (Verghese et al., 2022, p. 2).

While relational flexibility enhances supplier resilience, relationship-specific investments may limit the supplier’s options and hinder its resilience (Verghese et al., 2022). A buyer can use its leadership style to foster supplier resilience, but also this effect can be positive or negative depending on the mechanism involved. Specifically, transformational leadership positively affects supplier resilience, while transactional leadership has a negative effect (Verghese et al., 2022).

Another way to handle a situation where the supplier no longer fulfils the buyer’s expectations is to search for and switch to a more suitable supplier. This can happen when the investment in the supplier is too risky or the supplier is unwilling to improve. Out-supplier management can be done if other suppliers are available, where alternative suppliers are actively considered and engaged. If these alternative suppliers offer better capabilities or willingness than the original supplier, such as lower costs or quality improvements, the alternative supplier can be switched. However, the drawback with this is that higher performance with an alternative supplier is not guaranteed so it can be seen as a gamble.

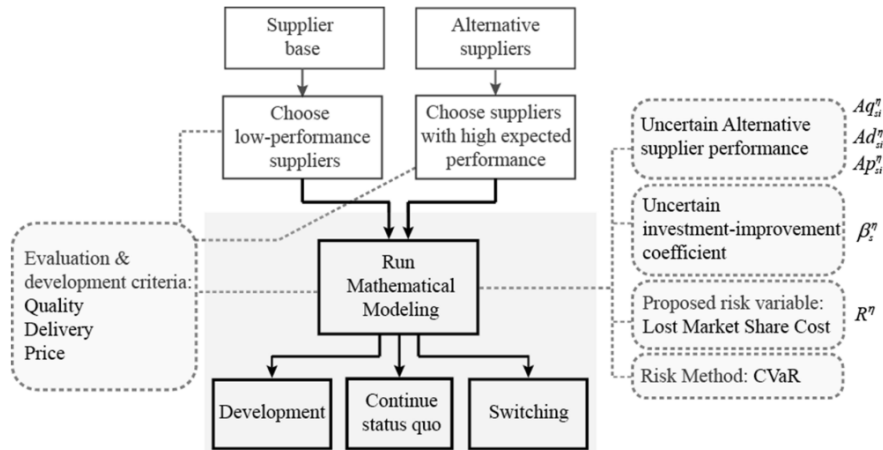


Figure 2.12: The problem diagram (Jafarian et al., 2021, p. 5)

The last way is to continue working with the same supplier without any changes, which is called status quo. This can happen when there are no other attractive alternative options or the product is so unique that there is only a sole supplier. The company often has no choice but to stick with the same supplier without any changes.

When looking at supplier development, it is important to know which suppliers to develop, switch, or continue working with. Figure 2.12 shows the process of determining this. This can be done through supplier categorization, where low-performing suppliers can be compared to alternative suppliers with a high expected performance. By comparing evaluation and development criteria and using mathematical modelling, a decision can be made regarding the future of the incumbent supplier.

There is a relationship between investment and improvement (Jafarian et al., 2021). The relationship follows a logarithmic function, which can be seen in Equation 2.1 and Figure 2.13.

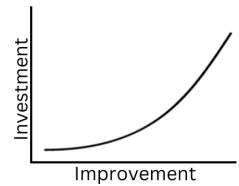


Figure 2.13:
Investment vs.
improvement

In Equation 2.1, I is the capital investment, ρ^* is the current out-of-control probability, ρ is the desired out-of-control probability, and ε is a coefficient that represents the percentage decrease in ρ per unit increase in $I(\rho)$ (Jafarian et al., 2021, p. 5).

$$I(\rho) = \varepsilon * \ln\left(\frac{\rho^*}{\rho}\right), \left(\frac{\rho^*}{\rho}\right) \in [1, \infty) \quad (2.1)$$

Considering the price (p), quality (q), and delivery (d) as the most important factors, equations for demand (D) can be seen in Equation 2.2 (Jafarian et al., 2021). In Equation 2.2, the demand (D) is the total market share of a given product (m), which is made up of price (p), quality (q), and delivery (d), but with corresponding weights (a, b, c) (Jafarian et al., 2021).

$$D = m(aq + bd + cp) \quad (2.2)$$

Using the previous two equations, the market share lost to the poor performance of the corresponding incumbent supplier, or the change in demand for specific items can be determined and can be seen in Equation 2.3 (Jafarian et al., 2021). Here, q^* , d^* , and p^* are the desired quality, delivery, and price, respectively.

$$\Delta D = m(a(q^* - q) + b(d^* - d) + c(p^* - p)) \quad (2.3)$$

To make an optimal decision using the given equations, one must compare the cost of investing in a supplier to the difference in market share between the supplier with no investment and the predicted market share if the supplier was invested in. The difference in this can be a deciding factor in whether it is worth it to stay and invest in a supplier if the market share gained is more than the investment or switching when the market share lost is too large that an investment in a supplier can not improve the supplier enough to make this viable.

The objective is to minimize the total costs, which consist of three factors: the costs of modifying the product design, the costs of developing new capabilities, and the income loss from losing market share (Jafarian et al., 2021).

Another trade-off that needs consideration is the duration of time that a contract with a supplier remains in effect. Buyers must choose the best supply contracts from different options, such as long-term, medium-term, and short-term contracts (Talluri & Lee, 2010). These contracts significantly impact the firm's performance and risks (Talluri & Lee, 2010). However, there is a lack of methods to help firms select the optimal contracts under various situations. Factors such as market price uncertainty, supplier discounts, investment costs, and supplier capacity restrictions should be considered to pick the right contracts.

In dynamic markets with rapidly changing component costs, buyers often utilize auctions for short-term contracts to capitalize on supplier competition and secure the lowest costs continuously (Merckx & Chaturvedi, 2020). However, excess competition through short-term contracts may fail to incentivize the incumbent supplier to invest in relation-specific measures for cost reduction due to the absence of assured future business (Merckx & Chaturvedi, 2020). A substantial quantity of short-term contracts frequently implies a considerable number of suppliers. This situation makes it challenging for companies to establish strong relationships with suppliers, posing a risk when a product becomes unique due to various risk factors.

One way to reduce the number of suppliers and rely on single sourcing is to use long-term contracts based on multiple criteria for choosing the best supplier (Talluri & Lee, 2010). Long-term contracts can lead to strategic partnerships, which offer many benefits. Providing a supplier with a guarantee of long-term business allows a buyer to realize cost savings resulting from the supplier's relation-specific investments, which involve unique commitments of time, effort, and resources tailored to the specific needs

of the buyer (Merckx & Chaturvedi, 2020). These investments are dedicated to serving a particular buyer. They can only be made after securing business from the buyer since they require knowledge about the buyer's specific needs or access to their specialized programs. Both of these can only be acquired through collaboration with the buyer (Merckx & Chaturvedi, 2020). One example of this is the reduction in production costs specific to the buyer because of the supplier's learning curve in production. This is unlikely to happen with short-term contracts since the investment could be too risky for a short period of time.

However, researchers have argued that long-term relationships with suppliers may not be beneficial in light of new and emerging trends in the business environment (Talluri & Lee, 2010). Two main reasons are given for this. First, the internet has lowered the search cost for finding suitable suppliers. For example, firms can use business-to-business (B2B) exchanges to access a wider range of suppliers and compare their capabilities and capacities (Talluri & Lee, 2010). This also gives them more bargaining power as they can invite competitive bids from the suppliers (Talluri & Lee, 2010). Therefore, sourcing from the spot market based on short-term relationships may be more cost-effective. Second, the increasing focus on supply chain risk challenges the idea of reducing the number of suppliers and pursuing long-term relationships (Talluri & Lee, 2010).

A strategic supplier is a major source of both operational and disruption risks for a buyer (Talluri & Lee, 2010). For example, if a natural disaster causes the strategic supplier's plant to stop production, the buyer can face a shortage of components and parts. Also, as the number of available suppliers decreases, the supply risk will increase (Talluri & Lee, 2010). Moreover, a short-term contract may allow the manufacturing firm to be more flexible and adapt quickly to changing market conditions by switching to other suppliers when needed (Talluri & Lee, 2010). Therefore, there must be a trade-off made between long-term and short-term contracts. The trade-off can be made based on the following factors: market price uncertainty, supplier discounts, investment costs, and supplier capacity constraints.

Generally, short-term and long-term contracts have advantages and drawbacks concerning performance criteria such as price and risk. It can be determined that a buyer tends to prefer long-term contracts when the supply base is small, meaning when a supplier has few alternatives and can find itself on the right-hand side of the PPM because of this. This preference is driven by higher savings derived from supplier investments compared to the savings achieved through competition (Merckx & Chaturvedi, 2020). However, for larger supply base sizes, the buyer is more advantageous in harnessing intense competition, seeking a lower-cost supplier in each period, and consequently leans towards short-term contracts (Merckx & Chaturvedi, 2020).

Another trade-off for buyers is whether to invest in research and development (R&D) to manufacture in-house or to rely on sole suppliers. Several elements contribute to shaping the profitability and commitment of firms to R&D. One pivotal factor is the size of the firm, with larger enterprises enjoying a distinct advantage in innovative pursuits due to their capacity to mobilize resources and exploit scale economies inherent in research (Kumar & Saqib, 1996). The positive influence of firm size on R&D intensity is evident, and there is also statistical significance in terms of the likelihood of firms engaging in R&D activities. Moreover, the presence of competitive pressures is a critical determinant, with the absence of such pressures anticipated to negatively impact the probability and intensity of R&D investments by firms (Kumar & Saqib, 1996). Another contributing factor is the incorporation of technology through imports. Firms engaging in technology imports often must complement these acquisitions by actively undertaking technological efforts (Kumar & Saqib, 1996). This is essential for absorbing, assimilating, and adapting knowledge to local conditions, ensuring the seamless integration of imported technologies. To conclude, this means that firms that are larger in size, with higher levels of competition and higher levels of integrated technology, can become profitable using research and development. However, it must be noted that in these kinds of situations, many options are often available. The trade-off between manufacturing in-house or relying on sole suppliers is more complex, and more factors must be considered.

2.5.6 Challenges and Downfalls with Current Supplier Relationship Management Strategies

Establishing strong supplier relationships is crucial for businesses to avoid disruptions and gain a competitive advantage. SRM is essential but comes with its challenges, including competency gaps and alignment issues, which recent disruptions like the pandemic have exacerbated (Earls, 2021). Addressing these challenges is essential.

Firstly, organizations must develop a clear SRM strategy instead of reacting ad hoc. This strategy should align with critical business goals and priorities and categorize suppliers based on their strategic importance since one of the challenges in using SRM is around strategic suppliers and the acceptable risk (Earls, 2021).

As was previously mentioned in Sub-Chapter 2.5.4, communication is essential. Transparency and collaboration with suppliers can rebuild trust between parties, fostering better relationships and, in this way, enhancing risk reduction (O'Brien, 2014c). However, communication needs to be actively participated in by both parties, making this one of the challenges and downfalls of implementing SRM. Porter's Five Forces is a framework used to analyze the competitive forces within an industry and can be used to explain how these forces can have an effect on communication between suppliers and buyers (Porter, 1985). These forces include the bargaining power of suppliers, the bargaining power of buyers, the threat of new entrants, the threat of substitutes, and competitive rivalry (Porter, 1985). The most important of the five forces to look at are the power of suppliers and the power of buyers. The difference in the bargaining powers of suppliers vs. buyers can also be seen in the PPM.

Suppliers with significant power in the industry may be less inclined to engage in open communication or negotiations. They could dictate terms and conditions, making it difficult for buyers to establish effective communication. If buyers have strong bargaining power, they may push suppliers to meet their demands without much need for communication or cooperation. This is why power is regarded as a fundamental element of supplier relationship management (Nurhayati, Rezaei & Tavasszy, 2021). Nurhayati characterized inter-organizational power as the possession and control of essential assets that enable an entity to acquire and increase wealth through ongoing influence over customers, competitors, and suppliers (Nurhayati et al., 2021).

The concept of power relations arises from inequalities in power positions between a buyer and suppliers (Nurhayati et al., 2021). Power relations lead to unequal relationships, posing potential adversarial outcomes for the less powerful party and the risk of exploitation by the more powerful counterpart (Nurhayati et al., 2021). By being able to recognize and acknowledging this inequality, it can serve as the initial phase in proactively addressing collaboration risks for both parties in the future.

In the context of supplier-buyer relationships, the bargaining power of each party is a critical factor that influences the dynamics of the negotiation process; therefore, understanding the principles of game theory can help businesses navigate negotiations (Chatterjee & Samuelson, 2001). In game theory, players follow the game's rules by taking actions that determine the final outcomes and payoffs, also known as strategic decision-making (Chatterjee & Samuelson, 2001). The best outcome is hard to reach when players can not or do not cooperate. For example, supplier A reduces its prices to gain some of supplier B's customers since they offer the same product. Supplier B sees this happening, so it reduces its prices; this vicious circle leads to low profit for both due to lack of cooperation. This is why game theorists have harbored a longstanding interest in the realms of bargaining and negotiation (Chatterjee & Samuelson, 2001).

In the context of negotiation, several factors can influence the balance of power between parties. These include competition, risk-taking behavior, legitimacy, recognized authority, the power of commitment, expertise in the subject area of the negotiation, and knowledge of the other party's needs (Chatterjee & Samuelson, 2001). A supplier with fewer competitors may have more power than one with many

competitors. Similarly, a supplier that is willing to take risks may have more power than one that is risk-averse, and a supplier that has a better understanding of the buyer's needs may have more power than one that does not.

Numerous aspects in the real world are open to negotiation (Chatterjee & Samuelson, 2001). If someone negotiating has multiple good options, the consequences are less detrimental if the current negotiation doesn't work out. This might make them more likely to stop negotiating (Chatterjee & Samuelson, 2001). This is often the case with suppliers on the left-hand side of the PPM, where buyers can easily switch, then there is an abundance of low-risk suppliers that offer the same product or services. In this case, the negotiator can use their competitive power to strike more attractive deals if there are multiple options.

Mitigating supply chain risks is critical. Suppliers should be categorized based on quantified risk factors such as cyber, credit, financial, and production risks; this can be done during the supplier selection or supplier evaluation phase of SRM (Earls, 2021). The problem is that most of these risks are inherently unpredictable, and the simple nature of most SRM strategies does not accommodate risks.

Another challenge is the over-reliance on JIT supply chain approaches, while efficient, can be risky. This is because, since it is a lean management process, it does not cater to risks (Park et al., 2010). Firms must, therefore, evaluate the rewards against the inherent risks. The concept of optimal SCM involves effectively integrating processes in SCM to maximize customer satisfaction and reduce cost savings (Rossini et al., 2023). However, it must be questioned whether it is possible in the real world to achieve true optimization in supply chain practices. This is because pursuing optimization often assumes an idealized scenario that may not match the complexities and uncertainties of the business environment; this is especially true for a company like Allseas, which has a plethora of suppliers and supply chains to manage. Although lean management has proven to be effective in increasing efficiency and reducing costs through its focus on reducing waste, it undermines the importance of risk mitigation (Waters, 2011). Lean management practices prioritize speed and efficiency and overlook potential risks that could disrupt supply chain operations (Waters, 2011). The prevalence of lean management in SCM and SRM strategies raises concerns as it prioritizes efficiency over risk reduction.

Another topic mentioned previously in this literature study is the use of ERPs. Effective tech integration, especially integrating SRM with ERP systems, is vital for streamlined processes. Continual optimization is necessary due to the ever-evolving nature of supply chains and technology, and when this is not done, this can pose a challenge for the implementation and upkeep of SRM.

Finally, organizations must link SRM activities with inventory management to prevent overbuying or underbuying and ensure efficient production-to-SCM alignment (Earls, 2021). While something such as the bullwhip effect can not be exactly predicted, it is a well-known risk in SCM that can be mitigated by better communication with suppliers through SRM for example (Stadtler, 2015).

In conclusion, addressing these challenges in supplier relationship management is crucial for businesses to enhance resilience and mitigate risks in today's dynamic environment.

To address these challenges, the proposed framework on SRM will be redefined to make for a more well-rounded framework and will combine elements from the previously mentioned supplier segmentation strategies. Using a combination of frameworks and information uncovered during the literature review, a more informative and integrated framework can be developed and can be seen in Figure 2.14.

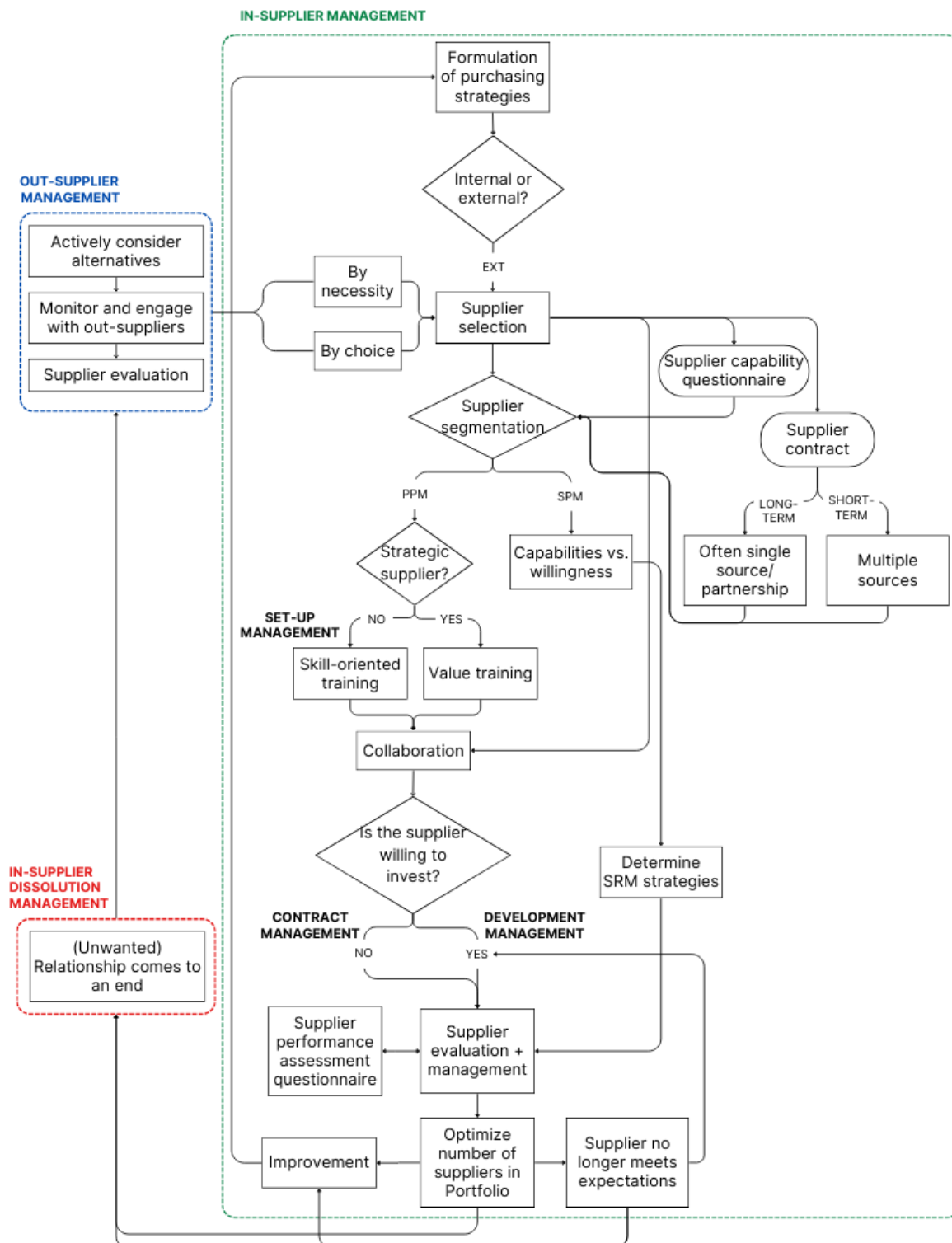


Figure 2.14: Proposed integrated SRM framework

Chapter 3

Methodology

This chapter presents the methodology used in this thesis, outlining the research approach and research methods. While the outlined methodology is not confined to a specific company, it is useful to use a company as a case study. This approach facilitates the practical application of the research findings, aligning with the applied nature of SRM strategies. As SRM strategies are inherently buyer-supplier-specific, a case study will be conducted within a company's procurement department. Aiming to gather and analyze data, draw robust conclusions, and formulate actual recommendations.

Initially, qualitative data collection and analysis in the form of semi-structured interviews and a literature study will be done. These interviews and literature will determine general risks in the maritime supply chain and risks experts encounter at the procurement department. This qualitative insight is vital in identifying the key risk areas and will help guide the quantitative data collection. After this, collecting numerical data on these identified risks, such as historical records and performance metrics, will create a quantitative perspective on the frequency and severity of these risks. This quantitative data, in turn, will aid the subsequent round of semi-structured interviews if necessary. During these interviews, the previously identified risks will be analyzed more thoroughly and ranked. This iterative approach to triangulation will be explained in more detail later in the chapter. Using MCDM methods, specifically the Best Worst Method (BWM), risks will be ranked during the second round of interviews.

Supplier segmentation can take place alongside the data analysis on risks. Supplier segmentation can be done alongside the risk analysis since all the risks and all the suppliers will be segmented and analyzed. Therefore, they do not have to be done after another but can be done alongside each other. Supplier segmentation will use quantitative data such as company data sheets on supplier's profit impact and qualitative data such as interviews with experts on supplier behaviour and influence, and, if applicable, the existing PPM can be used. The proposed supplier segmentation uses and compares the PPM (Kraljic, 1983) and SPM (Rezaei, 2015) to create a 2x2 ISM, which can be seen in Figure 2.6.

Comparison is the next step, where the objective is to explore the relationships between supplier segments on the ISM and specific risk categories. This phase aims to reveal valuable insights into how different supplier segments are associated with other risks. Understanding why specific supplier segments demonstrate low-risk levels can provide invaluable insights into effective supplier selection and relationship management strategies.

Building on the findings from the relationship analysis, the next step involves the formulation of tailored SRM strategies. These strategies are based on an integrated framework consisting of developing purchasing strategies, supplier selection criteria, collaboration frameworks, and supplier evaluation and management processes. The proposed integrated SRM framework can be seen in Figure 2.14. At each stage of the framework, adjustments can be made to current SRM strategies or new strategies can be developed, depending on supplier segments and encountered risks, to ensure future risk mitigation. The proposed research methodology is visually represented in Figure 3.1 and is split into sub-questions.

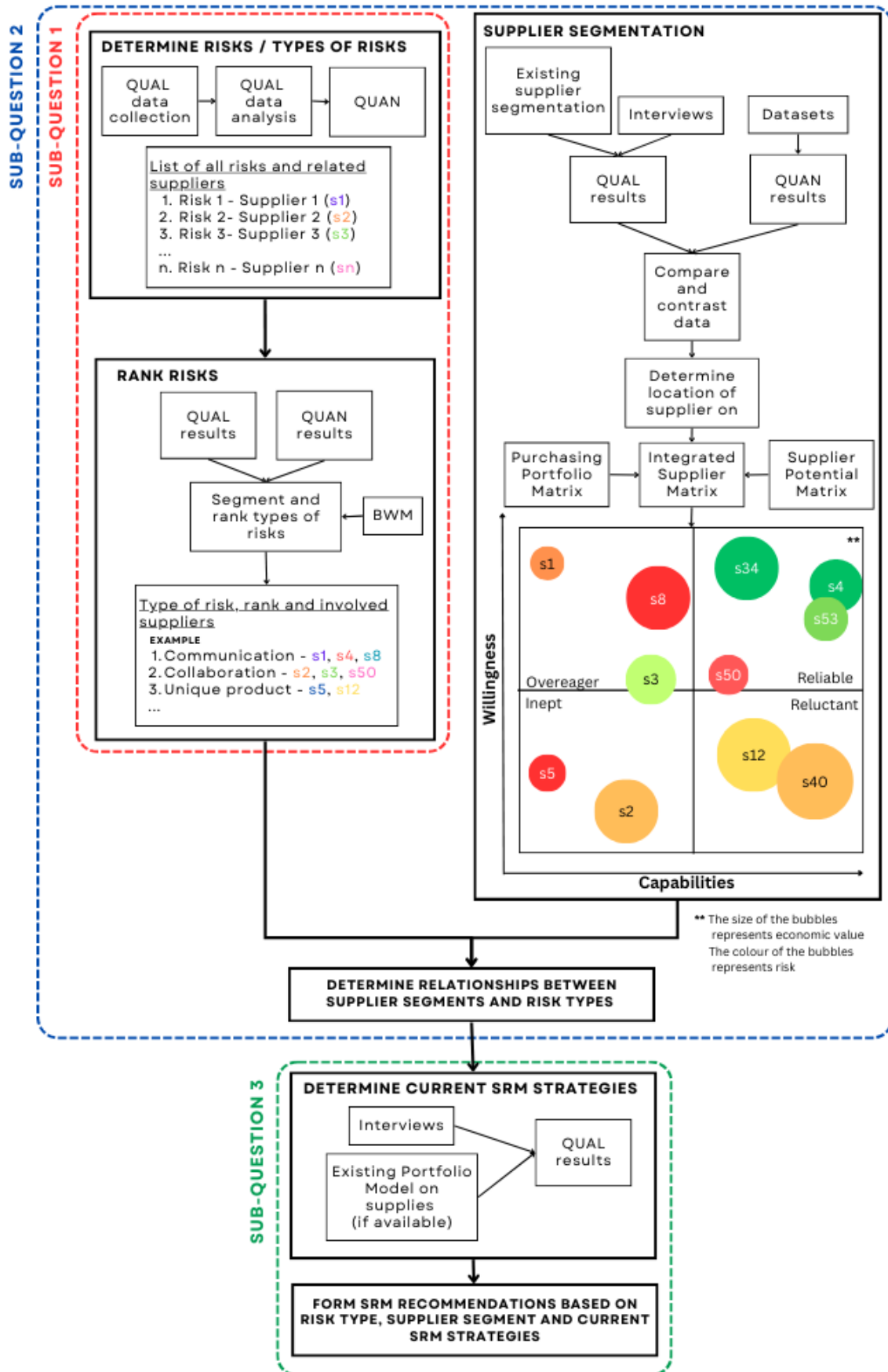


Figure 3.1: Proposed methodology

3.1 Qualitative Analysis

The qualitative research will include a literature review, semi-structured interviews, and other interpretations of non-numerical data. In the literature review phase of this thesis, an extensive exploration of relevant literature will be undertaken. This process involves accessing and collecting literature on supplier relationships and SCM. Subsequently, this gathered literature will be a foundational resource for developing an initial conceptual framework for semi-structured interviews with employees at Allseas. The selection of interviewees will be based on their relevant function within Allseas. Interviews will be recorded and/or transcribed for further analysis. Then, thoroughly examining and coding these interviews aims to identify recurring themes and insights.

Ethical considerations must be considered when working with experts or other people. It is essential to consider ethics in research when working with others. Even though the likelihood of ethical risks materializing may seem remote, especially for a thesis on risk mitigation, research ethics must be put into practice. Research ethics, as a holistic concept, revolves around the meticulous planning and execution of research endeavours (Delft, 2023).

3.2 Quantitative Analysis

Moving onto the quantitative analysis, one aspect that needs to be examined and analyzed is identifying and acquiring secondary supplier data, including metrics, performance indicators, and historical records. Next, this numerical data set will be analyzed through statistics, such as correlations, to try and determine relationships and patterns within the data. By determining relationships among various data sets, light may be shed on the factors influencing supplier relationships, SRM strategies, and their associated risks. The previously mentioned qualitative findings will be subjected to statistical analysis when coded and transformed into numerical representations.

3.3 Data Triangulation

The research approach will consist of quantitative and qualitative data analysis and collection. This approach makes sense when determining risks in the supply chain and looking at SRM strategies because of the following advantage: it allows for the use of numerical data sets and statistical metrics while also creating an understanding of and an analysis of qualitative insights through employee interviews or other written data. Supplier relationships and the associated risks often have aspects that can be quantified and require qualitative examination. A process of triangulation will be used by integrating both quantitative and qualitative research methods. This triangulation serves the purpose of identifying correlations and coherence between the two types of data collection. Specifically, this research will adopt a combined approach involving convergent triangulation to identify correlations and coherence (Creswell & Plano Clark, 2007) and an explanatory design to transition from qualitative findings from preliminary interviews to quantitative results to guide further qualitative analysis.

Initially, qualitative data collection and analysis in the form of semi-structured interviews will be done. These interviews will determine the risks employees perceive as important. This qualitative insight is vital in identifying the key risk areas from an insider perspective and will help guide the quantitative data collection. The recorded interviews can be transcribed and coded using Delve. Delve is a software designed to analyze qualitative data, making it easy to code data from interviews and focus groups (Delve, 2022). This can lead to key insights and data that are easier to analyze and compare since the codes are quantitative data.

This method allows a comparison of the frequency of mentions of perceived risks and the frequency

of mentions of specific examples of those risks. This comparison assists in determining if there is a link between the observed risks and the actual risks encountered. Such an analysis provides valuable insights into the awareness level within the procurement department regarding the risks they genuinely face.

Another important insight is the significance and ranking of risks within the department. This aspect provides a clear understanding of how suppliers can be positioned on the PPM, which is determined by the department's definition of supply risk.

After this, the collection of numerical data on these identified high-risk suppliers that were mentioned in the interviews, such as historical records and performance metrics, will gain a quantitative perspective on these suppliers' prevalence and potential impact on supply risk and profit impact, which will be of value for the PPM. If necessary, the quantitative data, in turn, will aid the subsequent round of semi-structured interviews. This iterative approach to triangulation ensures comprehensive data coverage and strengthens the validity and reliability of our research findings by cross-verifying qualitative and quantitative insights. Figure 3.2 shows a visual representation of a combination of the two chosen types of triangulation. Risks can be prioritized and ranked using MCDM, specifically using the BWM.

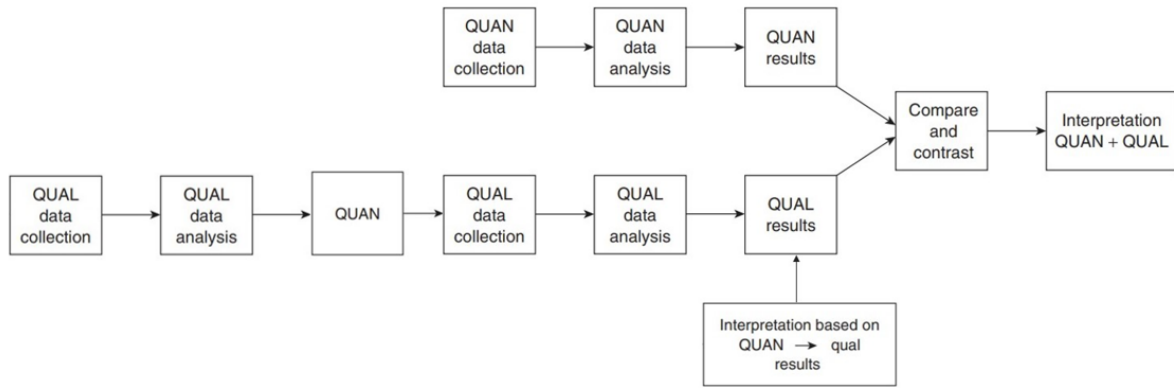


Figure 3.2: Combination of the different types of triangulation

3.4 The Integrated Matrix

Upon reviewing the criteria in the literature study using the matrices (PPM and SPM), a redefinition of procurement-related risks has become evident, influenced by the impact of buyer-supplier relationships. Kraljic's model, introduced in 1983, outlines a strategy for shaping a supply strategy based on the PPM. The initial phase involves categorizing items within the PPM and subsequently selecting an appropriate SRM approach based on their category. As the portfolio can shift with changes in the given criteria, it's crucial to update procurement strategies accordingly. This is because most changes in criteria lead to a shift into the right-hand side of the PPM, meaning higher supply risk. This understanding emphasizes the importance of addressing supplier weaknesses or other procurement-related risks to mitigate supply chain risks effectively.

However, it became evident in the literature study that the PPM has faced criticism for its undefined dimensions and weights. Measuring profit impact and supply risk remains a challenge and can vary depending on the evaluator's perspective, therefore, raising concerns about the matrix's accuracy. Additionally, the PPM focuses on supply over suppliers, potentially leading to misaligned intentions and difficulties in forming partnerships with suppliers. Researchers have highlighted the need to incorporate buyer-supplier relationships into supplier segmentation models.

Rezaei and Ortt introduced an alternative approach to supplier segmentation, which includes a more well-rounded matrix, the Supplier Potential Matrix (Rezaei & Ortt, 2011). The SPM segments suppliers

based on capabilities and willingness and, similarly to Kraljic's matrix, provides strategic directions. To integrate supplier segmentation effectively into supply chain management, it should extend beyond traditional purchasing (which focuses on cost savings and power dynamics), aligning with supplier relationship management strategies and early engagement with suppliers. This combination offers a comprehensive approach to managing supplier relationships while addressing the limitations of the PPM. The developed ISM will be used (Figure 2.6) since this matrix gives a visual representation of all the mentioned aspects.

3.5 The Best Worst Method

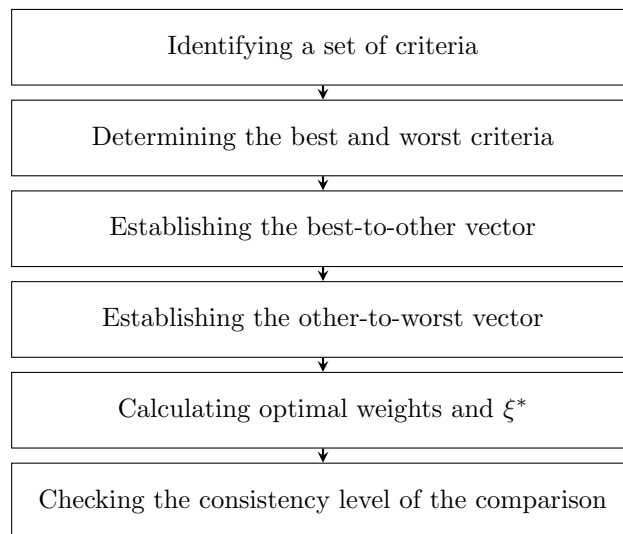
After collecting, triangulating, and thoroughly analyzing the possible risks, this research will employ the BWM as a tool for MCDM analysis. This is chosen strategically to address the main question of this thesis: 'How can supplier relationship management strategies contribute to mitigating supply chain risks?' specifically for ranking risks and determining the importance of willingness and capabilities criteria.

The BWM, characterized as a comparison-based approach, systematically conducts comparisons in a structured manner (Rezaei, 2016a). This unique structure reduces the amount of necessary information and enhances the consistency of the comparisons (Rezaei, 2016a). The BWM offers distinct advantages in the context of solving MCDM problems (Rezaei, 2015). This can be applied as a systematical identification of the most effective strategies for supplier relationship management concerning risk mitigation since it is a discrete problem. Specifically, it could be used during risk ranking and determining the most important supplier selection and evaluation criteria.

The BWM enhances risk prioritization by considering their relative importance, aligning well with the thesis's goal of assessing critical risks within the procurement supply chain. Second, it ensures objective decision-making in supplier relationship management, reducing subjective bias. Another benefit is that it quantifies qualitative data, harmonizing the research's qualitative and quantitative aspects. By being an objective decision-making tool, it ensures consistency in risk assessment and aids in developing a consistent risk mitigation strategy. This increases the reproducibility of this study by ensuring consistency.

3.5.1 Applying the Best Worst Method

A summary of the stages of the BWM can be seen in the flowchart below. The flowchart is an adaptation of Rezaei's stages of implementing the BWM (Rezaei, 2015, p. 51).



An Excel solver can be found online, which can be used to simplify and accelerate the process of implementing the BWM (Rezaei, 2016b). The solver uses a linear model of the BWM (Rezaei, 2016b).

The first step in the process of the BWM, and in using the solver, is defining the criteria, $\{c_1, \dots, c_n\}$. The solver template can be used for three to nine criteria. An example of implementing the BWM is to rank five supplier evaluation criteria: quality, delivery, performance, warranties, and price.

Once the criteria are known, the best and the worst criteria must be determined. This is based on the decision-maker's preferences. Using Weber et al.'s ranking of supplier evaluation criteria, quality is the best, and the price is the worst (least favoured) (Weber et al., 1991). The decision-maker compares the best criteria to the other criteria on a scale of one to nine. One means the criteria has equal importance to the best criteria, and a score of nine shows the criteria is absolutely more important or different than the best criteria (Rezaei, 2016b). The same is done for the worst criteria. The preference of the criteria compared to the best criteria result in the best-to-others vector $A_b = \{a_{b1}, \dots, a_{bn}\}$, and the preference of the criteria compared to the worst criteria result in the worst-to-others vector $A_w = \{a_{w1}, \dots, a_{wn}\}^T$. These vectors are pairwise comparison vectors.

The solver calculates optimal weights for each criterion by seeking solutions that minimize the maximum differences in $|w_B - a_{Bj}w_j|$ and $|w_j - a_{jw}w_w|$. This can be seen mathematically in Model 3.1.

$$\begin{aligned} \min \max_j \{ & |w_B - a_{Bj}w_j|, |w_j - a_{jw}w_w| \} \\ & \sum_j w_j = 1 \\ & w_j \geq 0, \text{ for all } j \end{aligned} \quad (3.1)$$

Model 3.1 can be equated to the minimum value of ξ to calculate optimal criteria weights, so that:

$$\begin{aligned} \min \{ & \xi \} \\ & |w_B - a_{Bj}w_j| \leq \xi^L, \text{ for all } j \\ & |w_j - a_{jw}w_w| \leq \xi^L, \text{ for all } j \\ & \sum_j w_j = 1 \\ & w_j \geq 0, \text{ for all } j \end{aligned} \quad (3.2)$$

By solving models 3.1 and 3.2, the optimal weights, $(w_1^*, w_2^* \dots, w_n^*)$ and the consistency index ξ^{L*} are calculated by the solver. The consistency index gauges the consistency of a comparison, which is valuable for the non-linear model. However, only the consistency ratio is relevant for the linear model employed in this thesis. The consistency ratio is crucial for verifying the logical consistency of pairwise comparisons, ensuring reliable results. The consistency ratio can be calculated using the following equations:

$$\begin{aligned} CR &= \max_j CR_j \\ CR_j &= \left\{ \frac{|a_{Bj} * a_{jw} - a_{Bw}|}{a_{Bw} * a_{Bw} - a_{Bw}}, a_{Bw} > 1 \right. \\ CR_j &= \{0, \quad \quad \quad a_{Bw} = 1 \end{aligned} \quad (3.3)$$

Table 3.1 shows the thresholds for different combinations using input-based consistency measurement. These threshold values for the consistency ratio allow the solver to make recommendations on whether the pairwise comparison consistency level is acceptable or not by comparing the input-based consistency ratio to the associated threshold. The pairwise comparison consistency level is acceptable if the threshold is larger than the input-based consistency ratio.

An example of using the BWM Excel solver to define new weights and calculate the consistency ratio can be seen in Appendix C. This example uses supplier evaluation criteria that can be found in Table 2.7.

Table 3.1: Thresholds using input-based consistency measurement (Liang et al., 2020, p. 9)

	Criteria						
Scales	3	4	5	6	7	8	9
3	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667
4	0.1121	0.1529	0.1989	0.2206	0.2527	0.2577	0.2683
5	0.1354	0.1994	0.2306	0.2546	0.2716	0.2844	0.2960
6	0.1330	0.1990	0.2643	0.3044	0.3144	0.3221	0.3262
7	0.1294	0.2457	0.2819	0.3029	0.3144	0.3251	0.3403
8	0.1309	0.2521	0.2958	0.3154	0.3408	0.3620	0.3657
9	0.1359	0.2681	0.3062	0.3337	0.3517	0.3620	0.3662

Chapter 4

Case Study Results

This chapter will implement the methodology on Allseas, serving as a case study. Focused on data collection and analysis, this chapter aims to gather information for the Purchasing Portfolio Matrix (PPM), Supplier Potential Matrix (SPM), and Integrated Supplier Matrix (ISM). The collected data will be analyzed and plotted to address the first two sub-questions posed in this thesis. These sub-questions identify and prioritize procurement-related risks and examine the relationship between supplier segments and the identified risks.

4.1 Procurement at Allseas

Starting with insights into the procurement procedures at Allseas, the company's procurement activities encompass the entirety of the purchasing process explained in Chapter 2. This process involves key stages such as supplier selection, contracting, ordering, and expediting. Additionally, procurement practices at Allseas incorporate various essential elements, including analyses, reporting, audits, process automation, vendor rating, contract management, SRM, market research, procurement innovation, process integration, and alignment. Collectively, these components contribute to the comprehensive and strategic approach undertaken in procurement at Allseas.

The procurement department is divided into two main sections: the procurement of commercial project goods and services and the procurement of vessel consumables, general goods, and services (VG&S).

In both project goods and services as well as VG&S, there are both buyers and subcontractors involved. Suppliers or subcontractors can be chosen once a requisition is initiated on either side. The selection of new subcontractors involves an evaluation process utilizing a pre-qualification questionnaire, and they are often required to sign a Non-Disclosure Agreement (NDA).

The determination of whether a specific scope necessitates a contract or a Purchase Order (PO) is based on various criteria, including complexity, risk profile (considering its impact on the project and criticality to other projects), lead time, supplier availability, client interface, scheduling, and cost or budget implications (Allseas, 2021). For routine products, frame agreements are established, outlining general terms such as pricing, delivery schedules, and quality standards for specific purchases over a defined period. Subsequently, a criticality analysis is conducted to identify and prioritize items or suppliers based on their criticality to the business, followed by material management. The process concludes with an evaluation, whereby incumbent subcontractors undergo assessment using an evaluation form. A flowchart describing the process from a request to evaluation can be seen in Figure 4.1.

At Allseas, the procurement manager deliberately uses the strategic PPM, explicitly utilizing the adapted version with directional streams, as illustrated in Figure 2.2. This is done mostly for the VG&S side of the procurement department. This model serves as a method for segmenting supplies the procurement department buys. Something important to note is that supplies are plotted and grouped based on

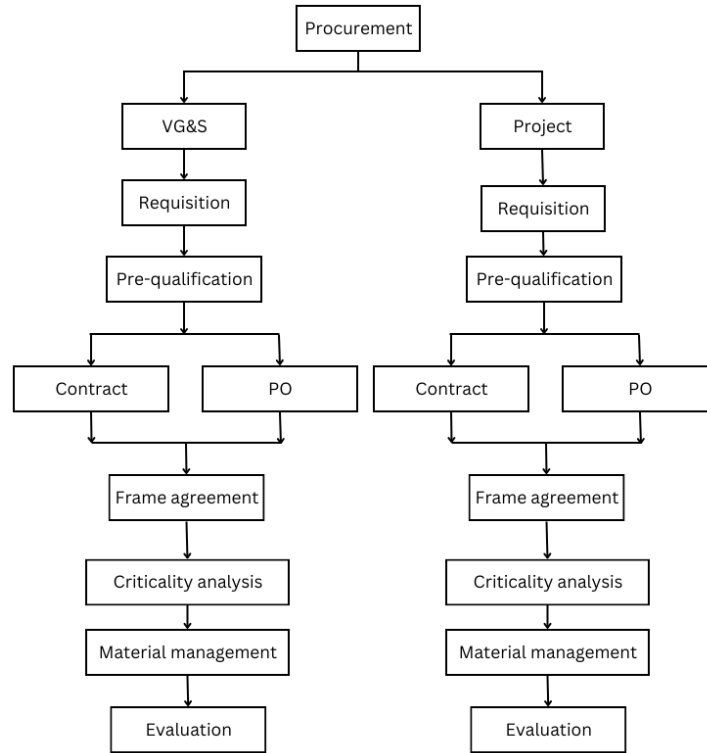


Figure 4.1: Supply chain management flowchart at Allseas

commodity type on the Portfolio Matrix at Allseas, not the suppliers.

The primary objective of plotting groups of supplies by the procurement manager is to follow the strategic directions and movements in the matrix, as was described and visualized in the literature review (Figure 2.2). This means transitioning from the lower-right quadrant, ‘bottleneck,’ to the left side, ‘non-critical’. This transition is achieved by reducing dependence and associated risks through diversification. For Allseas, this may involve increasing the number of sources for a particular item from single to dual suppliers. Non-critical items are typically grouped, allowing for the consolidation of requirements—consequently, this cluster of items shifts from the bottom-left quadrant to the upper portion of the model. Moreover, strategic partnerships are often established for leverage items, causing them to move from the upper-left quadrant to the upper-right quadrant. This strategy aligns with Allseas’ complexity as a company. Given these items’ large volumes or significant monetary value, streamlining the supply chain through partnerships is a logical choice. On the left side of the model, where the buyer typically has more negotiating power, Allseas envisions full automation through framework agreements. These agreements entail predefined terms per item, including the designated supplier and price per item. Allseas’ ERP system plays a pivotal role in this process, automatically selecting suppliers, determining costs, and generating draft PO. This automation minimizes time spent on routine procurement tasks and administration and increases overall supply chain efficiency.

Allseas applies some elements of SRM besides determining purchasing strategies and defining supplier segments using the Portfolio Matrix. One of these elements is new supplier selection, which is a form of SRM strategy that Allseas uses. In this process, new suppliers must complete pre-qualification questionnaires and sign an NDA. Another element is supplier management and evaluation, which is done through supplier evaluation forms. Next to this, Allseas uses a tendering process, which is a process of selecting suppliers for a given product group when there are many suppliers available. In this process, a group of around ten pre-filtered suppliers, both existing and new, can bid to become either a single or dual source for the product group. In theory, these SRM strategies and steps always have to take place. The SRM

The supplier evaluation form is filled out by an expert at Allseas, either from the procurement or the technical department. There are three different versions of the form, dependent on when the evaluation has taken place since the template has changed throughout the years. Here, the supplier evaluation criteria and the criteria weights change per template. Only the most recent supplier evaluation form will be analyzed; this is done to ensure relevance since they may otherwise be too outdated, as well as to ensure reliable results since the criteria are the same for the suppliers. This form has been used for the last five years and is still used today.

The evaluation forms from the latest version were available for 55 suppliers. This is much lower than the expected number of suppliers to be analyzed, but it ensures consistency and accuracy in segmenting and comparing the suppliers. Supplier names have been removed in this thesis to protect the privacy and confidentiality of the suppliers and entities involved. They will each be given random numbers between 1 and 55 to increase randomness and privacy further.

Using literature, the criteria from the evaluation forms will be determined to be either supplier willingness or supplier capabilities. There is a distinct preference per criteria on whether they fit as willingness or capabilities. Once this is done, it is determined that from the twelve criteria, eight are capabilities, and four are willingness. Table 4.1 shows the division of supplier criteria based on literature.

Table 4.1: Supplier evaluation criteria as willingness or capability

Criteria	Willingness or Capability
Safety performance	Capability
Environmental performance	Capability
Completion of work/services	Capability
Performance of work/services	Capability
Subcontractor's subcontractors	Capability
Project team	Capability
Final (as-built) documentation	Capability
Administrative management/ invoicing	Capability
Business ethics	Willingness
Corporate social responsibility	Willingness
Variations to work/services (attitude)	Willingness
Information/communication	Willingness

4.2.2 Supply Risk

Experts from Allseas' procurement department participated in one round of semi-structured interviews. These interviews aimed to identify the various types of risks, gather specific examples of risks, including which supplier was involved, and prioritize these risks to answer the first two sub-questions of this thesis. The interview transcript can be found in Appendix E.

Initially, a deliberate selection of ten employees with different roles, sub-departments (VG & S, project, contract, and group-wide procurement), and experience was chosen. The difference in the scope of work of the selected experts at Allseas can be seen in Figure 4.4b. By including a range of perspectives and expertise, the data collected is well-rounded and reflective of the procurement department at Allseas.

Furthermore, the varying levels of professional experience among the chosen employees contribute to the richness of the data. Figure 4.3 depicts the role the selected experts have within the company, and Figure 4.4a shows the experts' years of experience in their current role. It allows for the exploration of how different experience levels may influence their perceptions and responses regarding the subject matter, providing a more nuanced understanding of the research topic.

After seven interviews, it was clear that the interviews had reached a point where the perceived risks and examples of supply chain disruptions had become saturated, meaning that no extra information

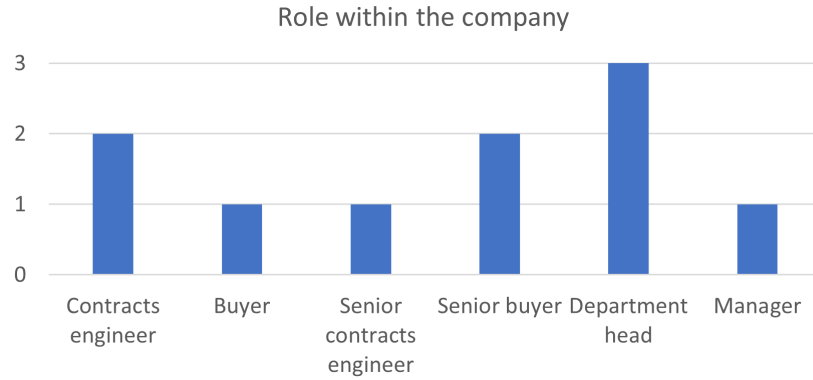


Figure 4.3: Role of experts within Allseas

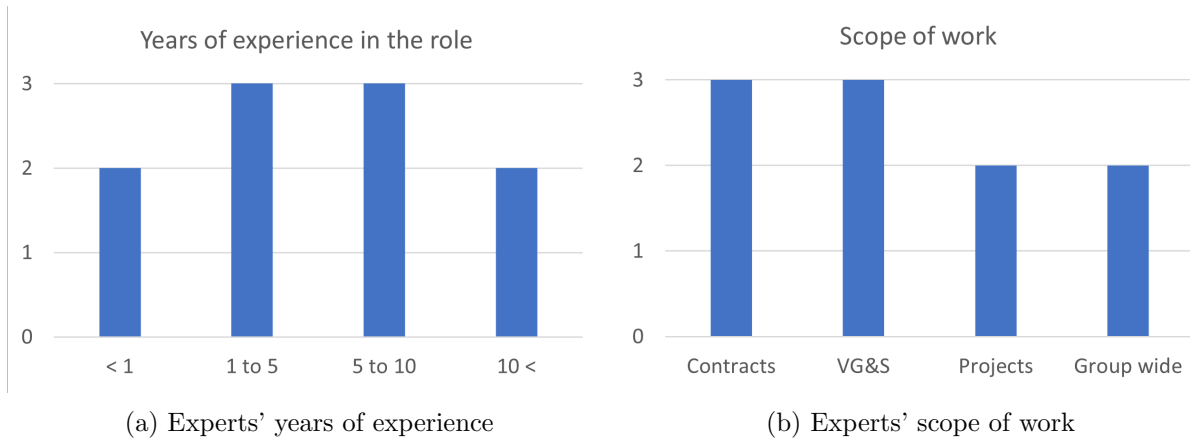


Figure 4.4: Experts' years of experience and scope of work at Allseas

was learned. This saturation was a positive sign, indicating that a comprehensive understanding of the subject matter had been gained. The recorded interviews were then transcribed and coded using Delve.

4.3 Quantitative Analysis

In this sub-chapter, the quantitative analysis will be explained. This includes the data gathered on supply risk, profit impact, willingness, and capabilities and an overview of the findings derived from the case study.

4.3.1 Supply Risk

To answer the first two sub-questions as part of the quantitative analysis, the information from the interviews was divided into these categories: perceived risks, types of supply chain disruptions and their examples (risks experienced), consequences of supply chain disruptions and their examples, suppliers involved in the disruption, risk prioritization and criteria, risk mitigation strategies, and improvements. After coding the data using Delve, the data was exported to Excel (and Matlab where needed) to be analyzed further.

The experts in the procurement department identified various risks they perceived as supply chain disruptions. These risks were grouped into the first category of codes. The perceived risks can be seen in the bar chart in Figure 4.5. The risks were also subdivided and compared to maritime risks (Figure

2.7). The legend of Figure 4.5 displays the different types of maritime risks and their relationship with the risks perceived at Allseas.

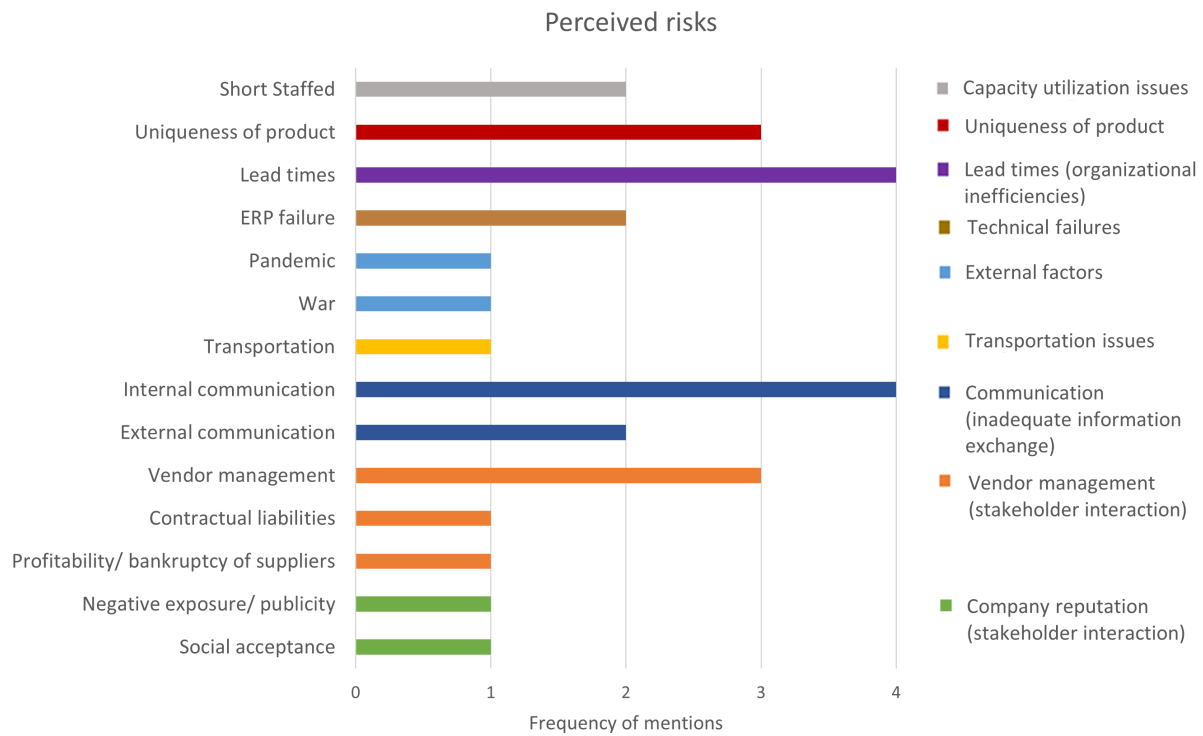


Figure 4.5: Bar chart of perceived risks

Since the difference between rules and regulations and external factors may be unclear to the reader, to avoid confusion, the following definitions will be used to ensure risks are defined clearly throughout this report. The difference in definition comes down to the difference in the nature and the origin of these risks. These definitions are based on literature and definitions mentioned or used in the interviews.

Rules and regulations are the standards or requirements that relevant authorities have established to ensure companies adhere to international conventions or industry-specific standards. They are predefined. If certain rules and regulations are not met or adhered to, penalties or limitations on activities can be implemented. Rules and regulations are not influenced by the physical features of a country or area but by agreements between governing bodies and authorities.

External factors are the events that affect the maritime supply chain from outside the industry. They can include natural disasters, economic fluctuations, geopolitical developments like wars, and global health crises like the COVID-19 pandemic. These factors are often unpredictable and influenced by global, national, or regional events and conditions. The maritime industry cannot control or prevent these factors, often going beyond the direct control of governing bodies.

The analysis revealed that the procurement department perceives both disruption and operational risks as threats. The experts noted long lead times and poor communication as the most frequently perceived risks. Internal and external communication was the most frequently mentioned perceived risk, accounting for 22% of the cases. However, deeper analysis showed that communication issues often resulted from other risks. For instance, the limited number of suppliers for unique products gave them high bargaining power, which made it hard to communicate and coordinate with them. Likewise, poor vendor management, such as choosing unsuitable suppliers, resulted in suppliers who were unwilling or unable to communicate and coordinate effectively. Similarly, long lead times were also influenced by other

risks, such as raw material shortages or a supplier's operational inefficiencies, which increased their lead times and reduced their flexibility.

The risks that the experts experienced in the supply chain can also be coded and grouped into categories. By doing this, it becomes evident that the risks that were encountered are not entirely consistent with the risks that were perceived as threats.

Figure 4.6 shows the similarities and differences between the risks that experts perceived and the risks they actually encountered. Communication issues were found to be high in both perceived and encountered risks. Similarly, vendor management, transportation issues, technical failures, and capacity utilization issues were mentioned a lower but similar number of times. However, the more interesting findings from the graph were the differences in perceived and encountered risks. It was notable that experts did not mention company reputation and contractual liabilities as having an effect on supply chain disruptions or as risks experienced, whereas rules and regulations and product life cycle had a relatively high number of mentions when it came to actual experiences. The reasons for this possible difference in perception will be analyzed in Chapter 6.

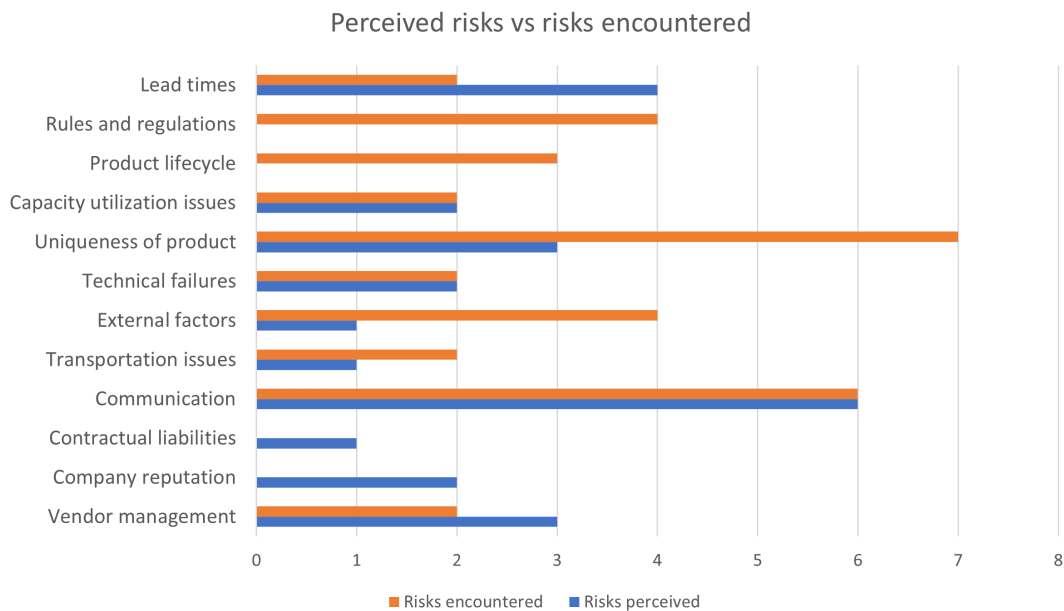


Figure 4.6: Bar chart of risks encountered vs. risks perceived

Table 4.2: Number of interviewees that mentioned the risks

Encountered risks	1	2	3	4	5	6	7	Number of interviewees
Vendor management			1				1	2
Company reputation								0
Contractual liabilities								0
Communication		3	1	1	1			4
Transportation issues	1	1						2
External factors	1		3					2
Technical failures	1		1					2
Uniqueness of product	3	1	1		1	1		5
Capacity utilization issues	1	1						2
Product lifecycle	3							1
Rules and regulations	2	1	1					3
Lead times		1			1			2

The analysis of the frequency of mentions of experienced risks shows that the uniqueness of the product, rules and regulations, external factors, product lifecycle, and communication and coordination are the most frequent. However, when looking at Table 4.2, it can be seen that product lifecycle was only mentioned by one expert in different examples, which casts doubt on its importance at Allseas. It is important to note that a product's lifecycle is essential when procuring goods so should not be ignored. The other risks that ranked highly seemed to have directly affected the majority of the interviewees. Therefore, even though product lifecycle is an important risk, it will not be evaluated or taken into account as one of the most important risks. Also, as discussed earlier, communication is affected by many other factors. This can be seen in Figure 4.7, which shows that lack of communication resulted from other given risks. This causes communication to be excluded from the ranking of important risks as it seems to be caused by other risk factors. Therefore, it can be concluded that the most important risks are the uniqueness of the product, rules and regulations, and external factors.

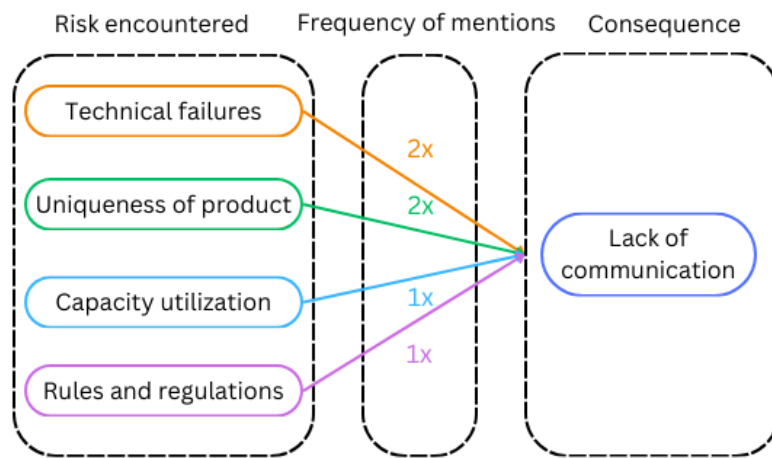


Figure 4.7: Communication as a consequence of other factors experienced

The BWM was used to determine the importance, or weights, of the three risks. Since interview saturation was reached after seven interviews with experts, the remaining experts were asked to fill in the BWM Excel Solver. Table 4.3 shows the results from the solver. Here, it shows that the uniqueness of the product is seen as the most important risk at 49%, rules and regulations come second with 39%, and external factors come third with 19%. The consistency ratios (CR) are also shown. They are all relatively close to zero, showing high levels of consistency.

Table 4.3: Weighted risk importance

	Uniqueness of product	Rules and regulations	External factors	CR
Expert 1	0.58	0.11	0.32	0.05
Expert 2	0.44	0.39	0.17	0.16
Expert 3	0.45	0.45	0.1	0.12
Average	0.49	0.31	0.19	
Rounded Average	49 %	32 %	19 %	

Following the same procedure as with the risks perceived as a threat and the risks encountered by experts, the consequences of the encountered risks could be coded and analyzed. The results of comparing the consequences of encountered risk with the type of encountered risk can be seen in Figure 4.8. The links in this figure are interview-specific. Whether or not they can be seen as generalizable will be discussed further in Chapter 6.

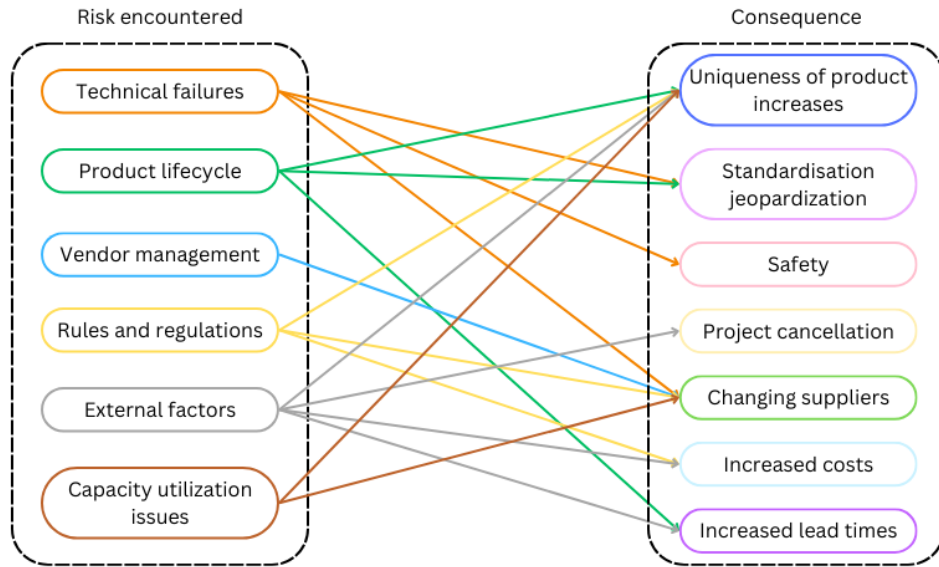


Figure 4.8: Encountered risks compared to the consequences of these risks

As depicted in Appendix E, an interview answer sheet was utilized to gather information from experts. To facilitate the qualitative data analysis, the question addressing the risks experienced by the experts was systematically divided into components. This structured approach guided the experts to articulate the risks they encountered by first explaining the risk, specifying its type (as depicted on the left side of Figure 4.8), and subsequently detailing the associated consequences, as well as the supplier responsible. The consequences for each identified risk are presented on the right side of the same figure. It is crucial to note that the connections between risks and consequences were established based on the frequency with which the consequences were mentioned during the interviews. A higher number of consequences does not necessarily indicate a greater severity of the risk but rather signifies that the interviewer discussed more aspects of that risk.

The interviews revealed seven suppliers that were frequently involved in supply chain disruptions. These suppliers labelled 56, 57, 58, 59, 60, 61, and 62, reached saturation when the interviewees mentioned no new names. They will be assessed and categorized along with the 55 suppliers with the completed supplier evaluation forms. The reason is that these suppliers pose a high risk to the supply chain and will serve as case studies to explore the threats they entail. Notably, increased costs and project cancellation were common consequences that did not depend on specific suppliers; hence, there is no link between them and any supplier. It is also important to note that switching suppliers resulted from supply chain disruptions in four out of the seven cases.

The weighted risks from the BWM have prioritized the procurement-related risks Allseas has faced, with communication being an underlying factor partaking in all risks. In theory, using these weighted risks, the suppliers can be given weighted scores and, based on this, receive a score for their overall supply risk, but this was not easy to do in practice. Two experts tried to determine the supply risk for the 62 suppliers (55 suppliers from the supplier evaluation forms plus the seven suppliers from the risk interviews) but found that the product uniqueness, or the number of available suppliers, was the simplest indicator of supply risk. This was because other factors, such as rules and regulations and external factors, affected the number of available suppliers, so they were already considered. The supply risk was then measured on a scale from 0 to 100 based on the number of available suppliers and filled in per supplier by experts.

4.3.2 Profit Impact

To determine where in the PPM, as well as the ISM, the supplier will be plotted, profit impact needed to be determined. This has been determined by summing the total monetary value of purchase orders over the last five years per each given supplier. Five years was chosen since this is the length of time that the supplier evaluation template has been used and, therefore, can act as a guideline for this. The profit impact is shown on the PPM using a random logarithmic scale that helps to conceal the supplier identity.

4.3.3 The Purchasing Portfolio Matrix

Using the values per supplier for profit impact and supply risk, the PPM can be plotted. This can be seen in Figure 4.9. Profit impact refers to the economic value that a specific supplier holds concerning the buyer. In other words, it quantifies the financial importance of a particular supplier to the buyer's overall business. The PPM is a bubble chart to better visualize the effect of profit impact on supplier position, as each bubble's diameter corresponds to the percentage of the total profit impact contributed by the segmented suppliers. Another reason is that the PPM developed by the procurement manager at Allseas is also a bubble chart, and therefore, it will be interesting to share and compare results this way. The orange bubbles are the seven seemingly high-risk suppliers mentioned in the interviews.

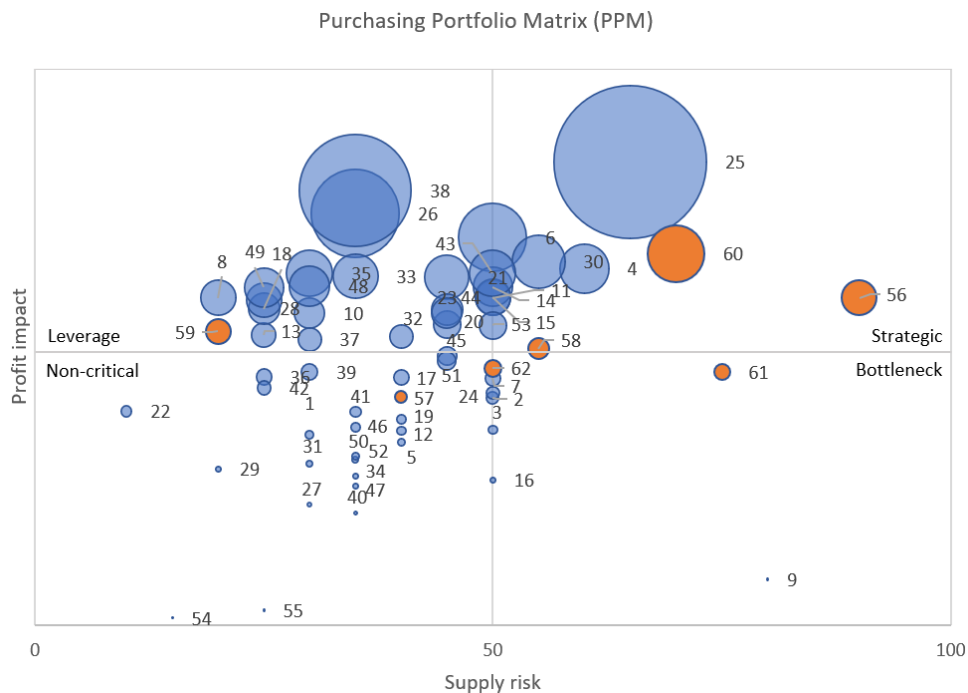


Figure 4.9: Purchasing Portfolio Matrix

Suppliers can be found in all segments of the PPM; this means that choosing these suppliers can lead to varied outcomes that will be interesting to compare when plotted on the SPM and the ISM. This also shows that subcontractors at Allseas really come in all types of economic value and supply risk.

For the PPM, the SPM, and the ISM, high-risk suppliers will be defined as those with a supply risk of above 50%. Eight suppliers meet this criterion, which is about 13% of all the suppliers. This is a relatively low percentage for a highly specialized company like Allseas. However, these high-risk suppliers account for about 39% of the total profit impact and have a higher average profit impact compared to low-risk suppliers. This shows that there is a positive relationship between supply risk and profit impact.

The PPM does not show this relationship clearly, probably because of the random logarithmic scale used for the y-axis.

More interesting to note is the location of the suppliers mentioned in the interviews on risk analysis. These suppliers can be seen plotted separately in Figure 4.10. It shows that only three are found in the strategic quadrant, one in the bottleneck quadrant, two in the non-critical quadrant, and one in the leverage quadrant. It is interesting to look into why suppliers that were mentioned in the interviews with repeated risk occurrences do not automatically make a supplier high risk.

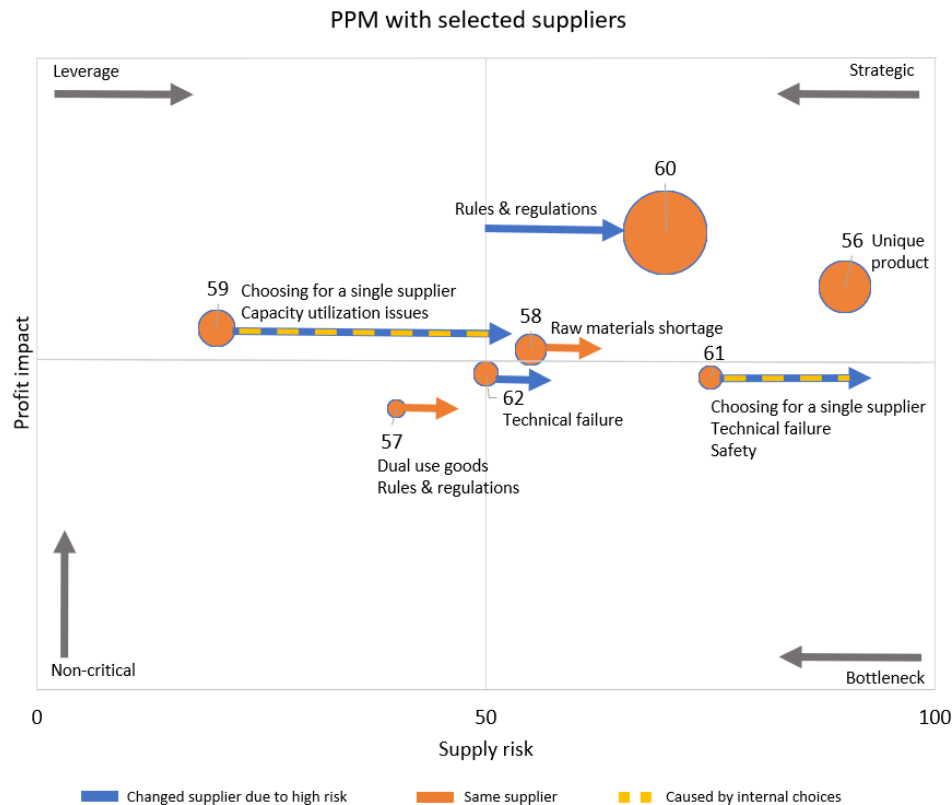


Figure 4.10: Purchasing Portfolio Matrix for selected suppliers

The supply risk of each supplier is not determined by the number of available suppliers alone but by various factors that were identified in the interviews and the literature study. However, the number of available suppliers was the only criterion used to assign supply risk to each supplier, which explains why there are repeated risk occurrences with suppliers that do not automatically have a high supply risk.

Figure 4.10 illustrates how the suppliers' positions in the PPM have changed based on the risk interviews and the actual supply risk they face. The grey arrows on the outer corners of the figure indicate the strategic choices buyers can make to move suppliers from one quadrant to another, as explained in Chapter 2, Figure 2.2. The blue arrows show that Allseas has switched suppliers due to the high risk, while the orange arrows show that Allseas has stayed with the same supplier. The arrows also show the direction and the reason for the suppliers' movement in the PPM. The yellow dotted line separates the suppliers whose movement was caused by internal choices within Allseas, such as choosing single sourcing and increasing risk intentionally.

Only supplier 56 adheres perfectly to the narrow definition of supply risk, which is based on the number of available suppliers. There are no other risk factors that affect this supplier other than the uniqueness of the product they offer, so there is no change in the PPM for this supplier.

Supplier 57 supplies a dual-use product that is subject to strict regulations, making it difficult to ship and import to project locations. This increases the supply risk, but it is not feasible to change suppliers.

Supplier 58 faces a shortage of raw materials due to geopolitical issues, resulting in longer lead times. This is unavoidable and affects all suppliers of this product, so Allseas also continues to work with them.

Supplier 59 was chosen as a single supplier to increase dependency and reduce costs, but they failed to deliver due to inaccurate forecasts and capacity utilization issues. This increased the supply risk, so Allseas decided to reduce dependency by switching to dual sourcing and involving another supplier.

Supplier 60's products became unique due to new rules and regulations enforced by the IMO, reducing the number of eligible suppliers. Allseas had to switch to this supplier because of the mandatory regulations.

Supplier 61 has a product that many suppliers can offer, but Allseas decided to standardize it to avoid safety issues. However, a technical failure on the supplier's side caused a sudden increase in lead time, putting standardization at risk and increasing supply risk. Allseas considered other options due to the long lead times and supply chain disruptions.

Finally, supplier 62 has a technical solution that is prone to technical issues, and communication with the supplier is difficult, jeopardizing the technical system at Allseas. Allseas switched suppliers due to this shift in PPM.

The new supplier should have the same supply risk as the original supplier before any risks affect it. This supply risk can be estimated by the number of available suppliers, which is shown by the PPM position of the original orange dot. However, if the supply risk is caused by specific suppliers and not market-wide factors, then the new supplier should have a different PPM position, and switching to it could be beneficial. This was the case for suppliers 59, 62 and 61.

All in all, how these suppliers have caused these high risks alongside possible risk mitigation will be looked into more elaborately using these suppliers as case studies in the following chapter, Chapter 5.

4.3.4 Supplier Willingness and Capabilities

Experts at Allseas give criteria from the evaluation form a score between 0 and 3, where 0 is poor/ no information, 1 is adequate, 2 is good, and 3 is excellent. Allseas has assigned its own weights to the phases. However, due to the lack of consistency between the criteria weights in the different versions of the supplier evaluation form, new criteria weights will be determined using the BWM.

The difficulty with this evaluation form is that it can vary from person to person since most criteria are subjective. To ensure consistency, interviews with reviewers can be beneficial to get a better understanding of the way the individual scored; this way, it is possible to calibrate their scores. In the future, more clear guidelines for the reviewer instead of a 0-3 scale might be beneficial to remove inconsistencies. The willingness and capabilities of a supplier are also subjective criteria. This makes the reproducibility of this research more difficult and is therefore going to be determined based on the existing criteria.

The suppliers are also given one of the four approval ratings: approved and preferred, approved with controls, not preferred, and not approved and blacklisted. It is interesting to compare the approval rating Allseas has given suppliers to the placement of the supplier in the SPM.

The BWM was explained to two experts who evaluated the supplier evaluation criteria using the BWM Excel Solver. They did this twice, once for the willingness criteria and once for the capabilities criteria. Table 4.4 shows the results.

The original weights from the form that were assigned to willingness criteria will be adjusted to ensure they total 100%, necessitating the normalization of the current weights. Similarly, the weights for capability criteria will also be normalized to ensure they collectively sum to 100%. The weights from the BWM solver will be averaged and normalized to ensure the weights equal 100% for willingness and 100% for capabilities. This way, the results can be compared and seen in Table 4.5. It is interesting to note that the consistency ratio for supplier capability of both experts was the same, and the consistency ratio for supplier willingness was the same. This observation indicates a high level of agreement and consistency

in the assessments provided by both experts regarding the capabilities and willingness of the suppliers, improving the reliability and validity of the obtained results.

Table 4.4: Weighted supplier evaluation criteria using the BWM

Criteria		Expert 1	Expert 2	Average
Safety performance	Capability	11.52%	16.17%	13.84%
Environmental performance	Capability	3.03%	2.81%	2.92%
Completion of work/services	Capability	17.27%	16.17%	16.72%
Performance of work/services	Capability	27.88%	26.02%	26.95%
Subcontractor's subcontractors	Capability	8.64%	10.78%	9.71%
Project team	Capability	8.64%	10.78%	9.71%
Final (as-built) documentation	Capability	11.52%	6.47%	8.99%
Administrative management/ invoicing	Capability	11.52%	10.78%	11.15%
Business ethics	Willingness	8.51%	20.00%	14.26%
Corporate social responsibility	Willingness	6.38%	6.67%	6.52%
Variations to work/services (attitude)	Willingness	55.32%	46.67%	50.99%
Information/communication	Willingness	29.79%	26.67%	28.23%
Capability Consistency Ratio (CR)		0.26	0.26	
Willingness Consistency Ratio (CR)		0.07	0.07	

Table 4.5: BWM supplier criteria compared to previous weights

Criteria		Previous	Normalized	BWM	Difference
Safety performance	Capability	10%	12.50%	13.84%	1.34%
Environmental performance	Capability	5%	6.25%	2.92%	-3.33%
Completion of work/services	Capability	20%	25.00%	16.72%	-8.28%
Performance of work/services	Capability	20%	25.00%	26.95%	1.95%
Subcontractor's subcontractors	Capability	5%	6.25%	9.71%	3.46%
Project team	Capability	5%	6.25%	9.71%	3.46%
Final (as-built) documentation	Capability	5%	6.25%	8.99%	2.74%
Administrative management/ invoicing	Capability	5%	6.25%	11.15%	4.90%
Business ethics	Willingness	5%	20.00%	14.26%	-5.74%
Corporate social responsibility	Willingness	5%	20.00%	6.52%	-13.48%
Variations to work/services (attitude)	Willingness	10%	40.00%	50.99%	10.99%
Information/communication	Willingness	5%	20.00%	28.23%	8.23%

The main difference that can be inferred from Table 4.5 between the BWM and the original supplier evaluation criteria weights is that the performance of work and services has a much higher weight among the capabilities criteria. This could be because the supplier evaluation form was not designed by procurement and did not reflect their priorities. The weights of the willingness criteria are also higher than before since they are now compared only with three other criteria (the other willingness criteria) instead of 11 (the other willingness and capabilities criteria). Communication has a high weight, which is consistent with the interview results. A surprising finding is that variations to work/service, or attitude, has a weight of 51%, meaning that both experts find this a significant important supplier attribute.

This is done by multiplying the normalized weight per criterion by the score the supplier has received (between 0 and 3) for that criterion. The total supplier willingness can be calculated by adding the willingness criteria (Equation 4.1). The same can be done for the supplier's total capabilities (Equation 4.2).

$$\text{Supplier's total willingness} = \sum_{i=1}^n \text{Weight}_i \times \text{Score}_i \quad (4.1)$$

$$\text{Supplier's total capabilities} = \sum_{i=1}^m \text{Weight}_i \times \text{Score}_i \quad (4.2)$$

To segment the suppliers that already have evaluation forms, the existing 0 to 3 rating per criteria from the forms will be used. The suppliers that were mentioned in the risk examples did not have evaluation forms, but they were also of interest for segmentation. For these suppliers, the evaluation form was completed by two experts each, one from the technical department and one from the procurement department. These experts had close experience with the suppliers. The aim was to compare and evaluate the scores that the suppliers received from different perspectives since the evaluation forms are usually filled out by either the technical or the procurement department. The diamonds on the SPM represent the suppliers that were identified as high risk in the risk analysis interviews. The legend shows the approval ratings Allseas has given the segmented suppliers.

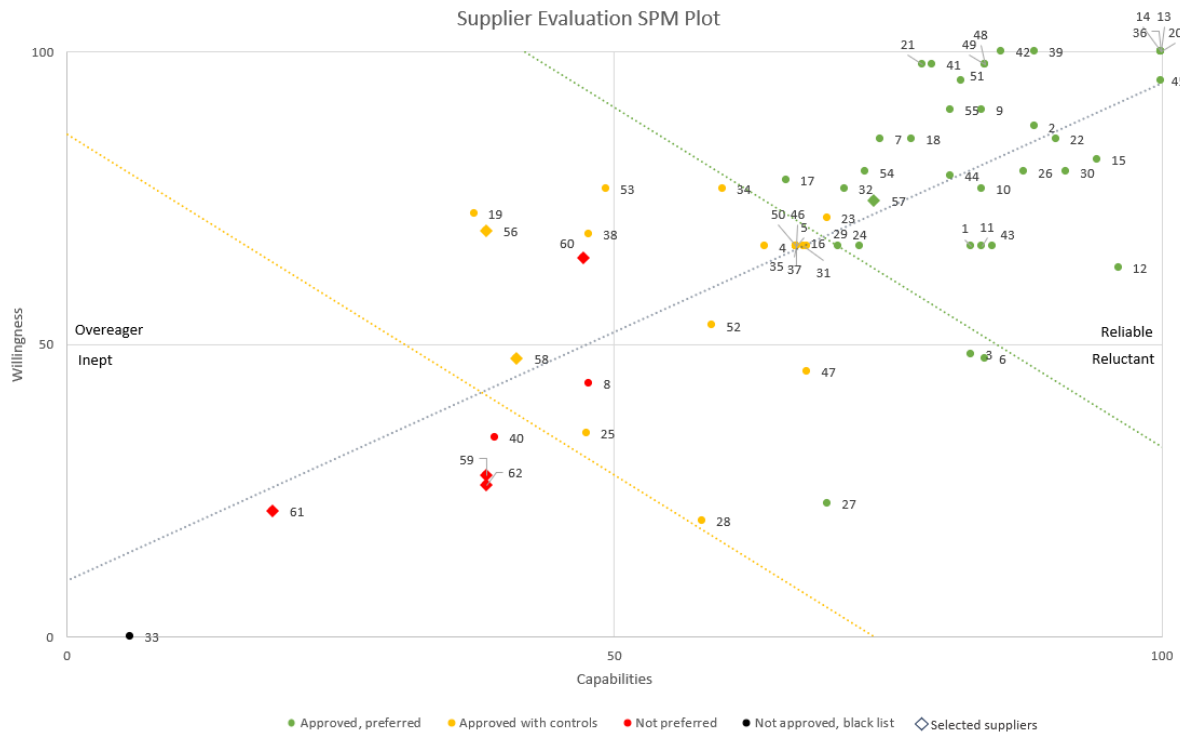


Figure 4.11: Supplier Potential Matrix

The SPM shows that there is a positive correlation between the willingness and capabilities of the suppliers. This means that the more willing a supplier is, the more capable they are, and vice versa. The SPM also uses the approval ratings from the procurement or the technical department based on the supplier evaluation form. As expected, the approved and preferred suppliers have the highest scores of willingness and capabilities. The approved with controls suppliers have relatively high scores but lower than the approved and preferred ones. The not preferred suppliers have low scores of both willingness and capabilities. The blacklisted supplier has the lowest scores, indicating that it is completely inept.

The approval ratings form three distinct clusters on the SPM. These clusters can be separated by finding the perpendicular trendline and changing the c value of the equation $y = mx + c$ to find the midpoint between two clusters. This method is applied to separate the approved and preferred cluster from the approved with controls cluster and the approved with controls cluster from the not preferred cluster. The not preferred cluster and the blacklisted supplier are not separated by this method because there is only one blacklisted supplier, and it is not enough to draw conclusions from.

Most of the selected suppliers that were mentioned during the interviews are in the inept quadrant, which means they have low willingness and low capabilities, or in the overeager quadrant, which means they have high willingness but low capabilities. These results match the perception of high risk for these suppliers. However, supplier 57 is an exception, as it is in the reliable quadrant, which means it has high willingness and high capabilities. It was also recently approved and preferred by the procurement and technical departments since the supplier evaluation forms for these selected suppliers were filled in during this thesis. This suggests that supplier 57 is not high-risk despite the interviews indicating otherwise.

4.3.5 Integrated Supplier Matrix

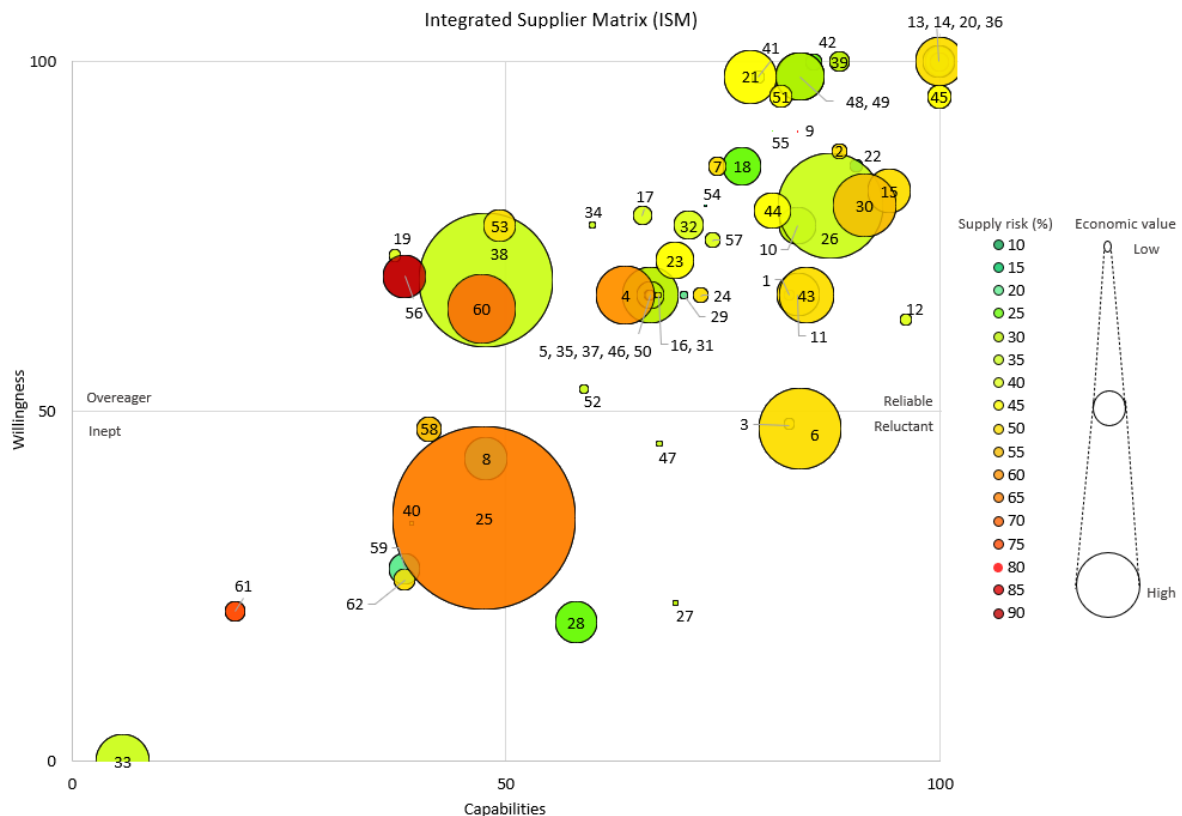


Figure 4.12: Integrated Supplier Matrix

The ISM can be plotted based on the data for profit impact, supply risk, supplier willingness, and capabilities. This can be seen in Figure 4.12. A larger copy of the ISM can be found in Appendix G, Figure G.1. The plot shows a correlation between supply risk and supplier attributes. In general, higher-risk suppliers can be found to have lower willingness and capabilities. This is also proven in Figure 4.14a and Figure 4.14b where the low-risk suppliers, with a supply risk of equal to or less than 50%, and high-risk suppliers, with a supply risk of more than 55%, are compared. The average results of these plots can be seen in Figure 4.13, where the average profit impact for both low and high-risk suppliers is compared to the average results of their willingness and capabilities. It shows, as could be inferred from the ISM, that high-risk suppliers have an average lower

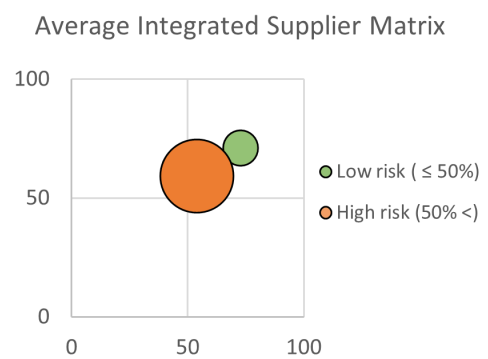


Figure 4.13: Average ISM results

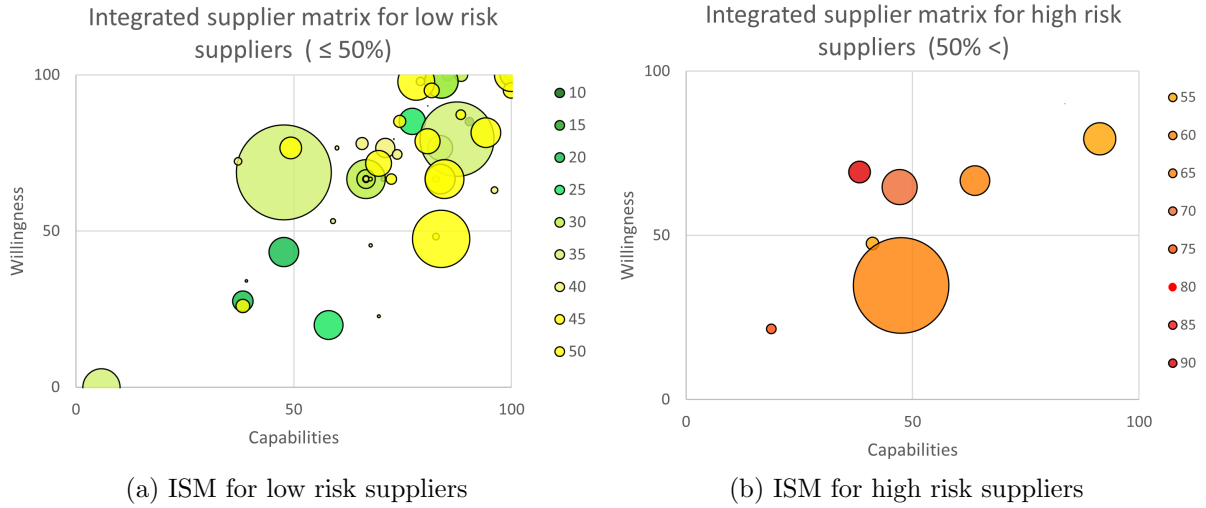


Figure 4.14: Integrated Supplier Matrix comparing both low and high risk suppliers

willingness and capabilities score. Interestingly, high-risk suppliers have a higher average profit impact than low-risk suppliers.

The average results and differences between low and high-risk suppliers are presented in Table 4.6. Out of the 62 suppliers evaluated for the ISM, most of them (42 or 68%) are low risk, while only a few (8 or 13%) are high risk. The table also confirms what the figures showed: that low-risk suppliers have higher scores on willingness and capabilities and lower scores on profit impact than high-risk suppliers.

Table 4.6: Average results for high and low-risk suppliers

Type	# of suppliers	% of total	Capabilities	Willingness	Profit impact
Low risk ($\leq 50\%$)	54	87.10%	72.80	71.04	1.14%
High risk ($50\% <$)	8	12.90%	53.94	59.24	4.83%

However, there are three outliers. Supplier 33 has low risk but also low willingness and capabilities, which makes it inept. This supplier has been blacklisted. One of the limitations of the supplier evaluation forms is that they may not reflect the true performance of the suppliers. For example, if a criterion is not applicable to a supplier, they will get a zero weight for that criterion, which can lower their overall score. This seems that it could have been the case for supplier 33. However, the comments on the evaluation form disproved this theory, stating that the main problem with this supplier was the lack of communication, which made them difficult to work with. This supplier was not used for any project or PO after the evaluation, which shows that poor communication resulted in the loss of a potential supplier.

Supplier 9 and 4 have high risk but also high willingness and capabilities, making them reliable. These suppliers could be interesting case studies. The evaluator for supplier 4 has commented that they have especially good performance because of their know-how, which is a capability. However, they also have a high willingness score meaning the high overall evaluation score was not only thanks to their capabilities but also their willingness to cooperate. The supplier relationship management strategies used for these suppliers will be interesting to analyze in the next chapter since these suppliers seem to be reliable, high-risk suppliers.

The aim is to see if the type of risk is linked to the supplier segment. Although the data on types of risks and involved suppliers is limited, some patterns can be observed. The ISM in Figure 4.15 shows the risks related to the supplier segment based on the interviews with suppliers 56 to 62. The suppliers that faced or still face risks due to rules and regulations are found in the overeager and the reliable quadrant, both showing high willingness. The suppliers with risks due to technical failures are in the inept segment,

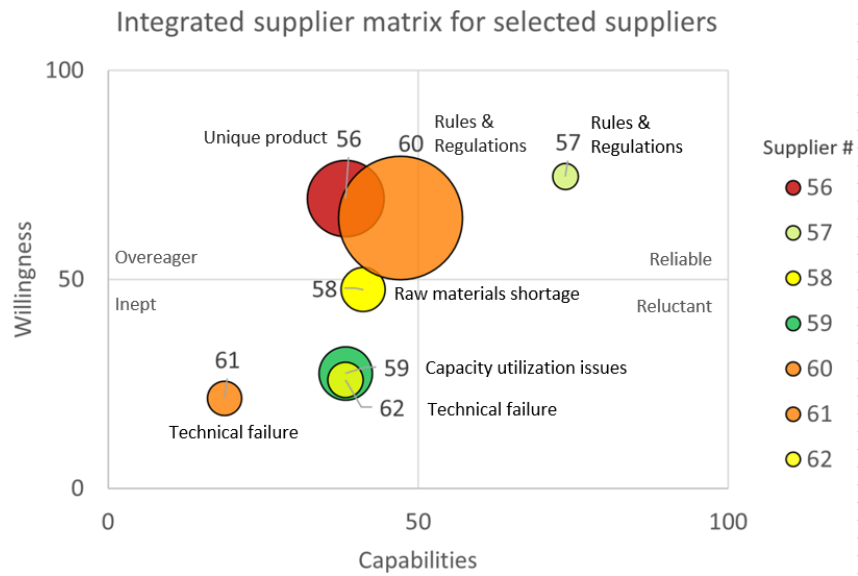


Figure 4.15: Integrated Supplier Matrix for selected suppliers

with both suppliers showing low willingness and capabilities. Similarly, the supplier with threats due to capacity utilization issues is found in the inept quadrant, showing low willingness and capabilities. The supplier with raw material issues is also found in the inept segment with low capabilities and willingness. Finally, the supplier with a risk due to the uniqueness of the product is in the overeager segment, which shows that they have high willingness but low capabilities.

Chapter 5

Supplier Relationship Management

This chapter will look into answering the third sub-question, which focuses on how supplier relationship management strategies can be used to mitigate risks. Allseas is used as a case study, and the high-risk suppliers that came forth during the interviews are used as examples. Using the Integrated Supplier Matrix (ISM), this chapter will suggest specific and general ways to manage the relationships with suppliers using supplier relationship management strategies, reduce or prevent supply chain disruptions, and mitigate risks this way.

5.1 Using Supplier Relationship Management Strategies for Power Imbalance Mitigation

Power is regarded as a fundamental element of supplier relationship management (Nurhayati et al., 2021). Nurhayati characterized inter-organizational power as the possession and control of essential assets that enable an entity to acquire and increase wealth through ongoing influence over customers, competitors, and suppliers (Nurhayati et al., 2021).

Resource dependence theory explains why those with resources can get more value from deals (Nurhayati et al., 2021). This theory suggests that companies should examine all the resources they can use as power over others in their supply chains (Nurhayati et al., 2021). The goal is to control how power dynamics evolve in relationships, leading to better business results.

The concept of power relations arises from inequalities in power positions between a buyer and suppliers (Nurhayati et al., 2021). Power relations lead to unequal relationships, posing potential adversarial outcomes for the less powerful party and the risk of exploitation by the more powerful counterpart (Nurhayati et al., 2021). By being able to recognize and acknowledging this inequality can serve as the initial phase in proactively addressing collaboration risks for both parties in the future.

The PPM at Allseas guides procurement decisions and supplier relationship management decisions based on exploiting or avoiding supplier power risk, which often ignores the social aspect of building relationships with suppliers. This can be useful when power relations and power imbalance can be used to the company's advantage by working with low-risk suppliers on the left side of the PPM, but this does not always work in the company's favour since approximately 13% of suppliers are high-risk suppliers, which means the suppliers have more bargaining power here.

This inequality is why working with non-performing incumbent low-risk suppliers is not recommended, especially with suppliers that find themselves in this situation and still show low willingness and capabilities. In this situation, the buyer has more power since there is usually an abundance of low-risk alternatives to the incumbent supplier. The buyer will likely find suppliers more willing to work with them and excel in different capabilities criteria, such as price or quality.

In the supply chain, quality is identified as a potential source of power, and enhancing various aspects of quality is seen as a means to strengthen one's bargaining position (Nurhayati et al., 2021). Quality can take various forms, such as traceability, safety, and adherence to specific quality standards (Nurhayati et al., 2021). When a company chooses a supplier as a standard, it becomes dependent on the quality and products it delivers. By choosing to standardize a product, the supplier has a new potential source of power and bargaining position since the reliance on the product increases. The dependency on suppliers that have become a standard creates a stronger connection or relationship between the supplier and buyer. This is very similar to long-term contracts since standardization of supplies means long-term dependence on a supplier. However, standardization is often more difficult to reverse than a long-term contract. The reason behind this lies in the nature of standardization, which typically involves establishing uniform products or processes across various aspects of operations. Once these standardized practices are implemented, they may become ingrained in the organizational structure, making them more challenging to remove or break than a long-term contract, which can often be terminated or renegotiated under certain conditions.

Supplier 61 is an example of a supplier where Allseas became dependent on a single supplier by implementing a standard range of products. Choosing a standard was to increase the quality of work and safety. However, the products supplied could be hazardous, so training was needed to work with and operate them. The presence of diverse products from various suppliers on board may pose a safety risk. The crew may not be adequately trained to use various products, leading to potential safety hazards. Also, confusion may arise regarding which product is intended for specific training purposes, compromising safety.

Unfortunately, due to unpredictable and unforeseen technical failures, the supplier's supplier could not deliver the products, jeopardizing standardization. As a result, other products and suppliers had to be called to action to ensure the supply chain disruption was minimal and the crew could continue working. In this case, there was no other option except temporarily using a different supplier. Managing the stress of the situation could have been addressed through timely communication about the issue, although it wouldn't have resolved the problem. Taking swift action through the implementation of dual sourcing could have proven beneficial. For instance, the primary supplier, responsible for the majority of supplies, could have products in their original color. Meanwhile, the secondary supplier, reserved for emergency situations, could have its products marked with a distinctive color, such as red. This color coding would serve as a visual cue for crew members, prompting them to consult the handbooks of the secondary supplier when working with the product during these specific scenarios. Another potential solution, given that the product is dual-sourced, involves designating one or two crew members with specialized training to handle hazardous products. This approach aims to eliminate confusion and guarantee the safe usage of these items. Given that most crew members on the *Pioneering Spirit* (Allseas' largest vessel) have multiple responsibilities, like cleaning and cooking, it would be beneficial to assign a small group of individuals whose sole responsibility revolves around the secondary product. They can be ready to step in when needed, ensuring dedicated attention and expertise for the safe handling of the specified products.

5.2 Trade-Offs in Supplier Relationship Management Strategies

Comparing the literature review to the risks encountered at Allseas, it is clear that trade-offs must be made. These trade-offs include choosing between short and long-term supplier contracts, investing in or switching non-performing suppliers, choosing between single or multiple sourcing, and finally, choosing sole sourcing or manufacturing in-house.

5.2.1 Trade-Off between Keeping Stock or Relying on Suppliers Stock

When looking at supplier 61, Allseas could have also considered preemptive inventory management to reduce risks. Since Allseas has a large warehouse, maintaining strategic stockpiles of these critical products could act as a buffer during supplier interruptions and temporarily reduce supply chain disruptions this way. This can be done by reviewing inventory levels and replenishing them proactively to mitigate potential risks. However, there are many risks associated with having high levels of inventory. Firstly, products continuously improve, so the risk of changing demand can be significant. This also increases the risk of obsolescence if the product is not used quickly since either the product has a shelf life or the product is already so far in the product life cycle that it will soon become obsolete or replaced. Lean inventory management and adhering to the JIT principles, which are stepping stones of supply chain management, prioritize efficiency and small inventories, which this is the opposite of.

Therefore, by ensuring good relationships, long-term contracts, and better rules about where the product is in its lifecycle or the possibility of limited supplier stock due to supply chain disruptions, companies can strike a balance between meeting demand and avoiding the drawbacks of maintaining excessively large inventories. This approach allows them to remain agile, cost-efficient, and responsive to dynamic market conditions, mitigating risks associated with excess inventory while maintaining the flexibility to adapt to changing circumstances.

5.2.2 Trade-Offs Between Long-Term and Short-Term Contracts

The literature review explored the trade-off associated with the duration of supplier contracts. While some may argue that extended relationships with suppliers may not be advantageous given evolving business trends, factors such as the Internet reducing search costs for identifying suitable suppliers and the growing emphasis on addressing supply chain risks challenge the notion of minimizing supplier numbers and favoring long-term commitments (Talluri & Lee, 2010).

Generally, short-term and long-term contracts exhibit advantages and drawbacks regarding performance criteria, including price and risk. An analysis reveals that a buyer tends to favor long-term contracts when dealing with a small supply base, indicating a situation where a supplier has limited alternatives and may position itself on the right-hand side of the PPM. This inclination is motivated by higher savings from supplier investments compared to the savings obtained through competition (Merckx & Chaturvedi, 2020). However, with larger supply base sizes, the buyer finds a greater advantage in leveraging intense competition, actively seeking a lower-cost supplier in each period, and thus tends to prefer short-term contracts (Merckx & Chaturvedi, 2020). Therefore, the trade-off can be made based on the following factors: market price uncertainty, supplier discounts, investment costs, and supplier capacity constraints.

Long-term contracts can lead to developing strategic partnerships, offering numerous benefits such as a reduced total cost of ownership. This cost reduction encompasses life cycle management costs, maintenance costs, and the expenses associated with energy usage and returns. Additionally, long-term contracts provide greater certainty for suppliers, making them particularly attractive for suppliers on the left-hand side of the PPM. Suppliers in this position face significant competition and often offer lower costs to secure long-term contracts with buyers; this is also because they have less bargaining power than the buyer due to their location on the PPM. Furthermore, the ISM revealed that low-risk suppliers are more capable and willing as they strive to prove themselves and alleviate risk by securing long-term contracts. While long-term contracts may not be necessary for suppliers on the right-hand side of the PPM, entering into such agreements helps mitigate risks for buyers of high-risk suppliers.

Due to the advantages discussed, Allseas consistently prefers long-term contracts whenever feasible. Their unique approach allows them to terminate contracts when needed, especially if an incumbent supplier fails to meet expectations. This distinctive feature sets them apart, as it combines the stability of long-term contracts with the flexibility to terminate them at any time. This approach proves profitable

in all scenarios, making long-term contracts with suppliers favorable for Allseas.

5.2.3 Trade-Off Between Single and Multiple Sourcing

As was previously mentioned, the procurement manager purposefully chooses suppliers to move from the leverage to the strategic quadrant in Kraljic's matrix by developing long-term relationships through contractual agreements and increasing supply risk this way. A partnership with a supplier can build trust and reliability, but it can also create dependency and vulnerability in case of supply chain disruptions. Therefore, it may be better to diversify the sources and have two or more suppliers for the same product. However, this is not always feasible, as some products are unique or scarce, and some situations are urgent or complex.

Supplier 59 and supplier 61 have purposefully been chosen to be single-sourced, even though the supply risk was not high and there were multiple supplier options available; by choosing these suppliers as single suppliers and making them a standard at Allseas, supply risk increases by increasing dependency on these suppliers. Even though suppliers 59 and 61 had long-term contracts that could be terminated at any time, because of opting for single sourcing due to the long-term nature of the contracts, the company ran into problems.

In the case of supplier 61, the reason for choosing a single supplier was safety issues. Due to the products being supplied being classified as high-risk to work with, the buyer's staff need to be trained to use the product, making it more cost and time-effective, but most importantly, safe to work with products they are used to. This makes the choice for single sourcing a very logical one. However, when a problem such as a technical failure is encountered, it is crucial to maintain this safety aspect as well as find a quick solution.

The rise of global contract manufacturers (CM) has disrupted the subcontracting landscape, challenging the traditional dominance of original equipment manufacturers (OEM) (Heese, 2015). When deciding whether to opt for single or multiple sourcing, buyers consider the power dynamics within the supply base (Heese, 2015). Single sourcing can promote learning effects and cost reduction, but it can also elevate the supplier's bargaining position (Heese, 2015). Therefore, the optimal sourcing strategy depends on the buyer's bargaining capabilities and power position. While a powerful buyer may prefer single sourcing, weaker buyers often find value in distributing volume among various suppliers, even though this approach introduces inefficiencies compared to the more streamlined single sourcing method.

Another way to use multiple sourcing is that buyers can reduce costs by turning down some demand that could be delayed in a dual-sourcing inventory system (Xu, Serel, Bisi & Dada, 2022). Dual sourcing means that the buyer can order from two suppliers, one fast and expensive and one slow and cheap (Xu et al., 2022). The buyer has to decide how much to order from each supplier and how much demand to back-order or reject. This is called the endogenous partial back-ordering strategy (Xu et al., 2022). Dual sourcing and partial back-ordering can help the retailer cope with demand uncertainty (Xu et al., 2022).

This means there should be a trade-off between lead time and price, where there should only be back-ordered this way. When comparing the price of the two different types of suppliers and the cost per period of the unit backorder, the procurement plan can be made accordingly, meaning timely procuring of goods with longer lead times needs to be considered. However, the difference in lead times and price for competitive suppliers usually does not vary greatly, making it easier to spread risk by dual sourcing.

5.2.4 Trade-Off Between Sole Sourcing and In-House Manufacturing

In Chapter 2, the factors influencing the profitability and intensity of investment in research and development (R&D) by firms were examined. The conclusion was that firms that are larger in size, with higher levels of competition and higher levels of integrated technology, can become profitable using research and development. Allseas participates in many in-house R&D projects relating to the maritime industry,

specifically pipe-laying and heavy lifting. Therefore, they have the capability to develop and manufacture in-house. However, when looking at the criteria, it is usually most profitable with higher levels of competition because, due to this heightened competition, companies can allocate resources to R&D activities quicker to try and expand market share. Furthermore, the pressure of competition compels companies to enhance operational efficiency and reduce costs through R&D-driven improvements in processes and technologies.

Products or services facing high levels of competition typically reside on the left-hand side of the PPM. In such cases, there may be little need for Allseas to internally produce or invest in R&D in these products as their existing bargaining power suggests low-cost effectiveness in these well-established markets. The more intriguing consideration lies in the potential internal production of unique products, such as remotely operated vehicles (ROVs) or specialized pipeline components. While Allseas is renowned for its distinctive offerings and maintains an innovation department dedicated to R&D, venturing into areas like ROVs, which are not core to their business, poses challenges. Staying three steps ahead of the competition is a strategic goal; therefore, investing money and research in highly specialized products not within the company's core competencies may not be the most effective approach. Instead of looking back and investing in existing market offerings, Allseas should focus on enhancing its core competencies and offering unique products aligned with its expertise. They achieved this when they created the cutting-edge automated Phoenix welding system. In the maritime supply chain, disruptions usually affect the whole industry, specifically for highly specialized or unique products or services. Thus, maintaining robust supplier relationships through effective communication and trust becomes paramount. In the event of supply chain disruptions, a strong relationship ensures timely information, potentially positioning Allseas as a preferred buyer for the supplier, thereby mitigating the impact of logistical challenges on their operations.

Unless there are clear economic or lead-time benefits to start manufacturing in-house, the recommendation is to continue moving forward in their niche industry and continue being pioneers in the field of offshore engineering while still improving communication and trust with suppliers on the right-hand side of the PPM.

Supplier 56 is unique because their products are distinctive and unlikely to be replicated easily. Despite the option to produce these unique products in-house, the associated challenges, including the need for specialized expertise, significant financial investment, and time commitment, make this a less viable option. Moreover, during a risk interview, an expert identified supplier 56 as a reliable and preferred supplier, even though they pose a supply risk due to the uniqueness of their product. This seemingly paradoxical situation raises questions about how a supplier with the potential to pose high risks and contribute to supply chain disruptions can still be regarded as an ideal supplier. The decision to continue working closely with such a supplier involves carefully balancing the perceived benefits of being reliant and not having to manufacture their products in-house and the potential risks they can cause, emphasizing the complexity of supplier relationship management in a dynamic business environment.

5.2.5 Trade-Off Between Investing in and Switching Non-Performing Suppliers

As was learned in the literature review, Chapter 2, there is a relationship between investment and improvement, and it follows a logarithmic function. This means as the investment into suppliers increases, the improvement process may start slowly, but the improvement will increase rapidly with increased investment.

Deng and Xu back up the theory that investing in suppliers may be worthwhile; they show that the profits of both OEMs and CMs tend to decline with higher discount rates and market potential while experiencing an increase in elevated fixed investment costs (Deng & Xu, 2023). This is because

investment costs can indicate a higher investment in resources, technology, or infrastructure, which may improve production efficiency, lower unit costs, and ultimately result in increased profits over time. Further proving the correlation between investment and improvement.

Next, the literature review considered only three evaluation and development criteria for suppliers when determining whether to invest in, stay with or switch suppliers. Since Allseas has 12 evaluation form criteria, these can be used and considered when determining the demand function, found in Equation 2.2 in the literature review in Chapter 2. Table 5.1 shows the supplier evaluation criteria used in the equations, the criteria weights which were calculated using the BWM in Chapter 4, and the criteria from the supplier evaluation form.

Table 5.1: Criteria references

Criteria reference	Criteria weight	Criteria
a	13.84%	Safety performance
b	2.92%	Environmental performance
c	16.72%	Completion of work/services
d	26.95%	Performance of work/services
e	9.71%	Subcontractor's subcontractors
f	9.71%	Project team
g	8.99%	Final (as-built) documentation
h	11.15%	Administrative management/ invoicing
i	14.26%	Business ethics
j	6.52%	Corporate social responsibility
k	50.99%	Variations to work/services (attitude)
l	28.23%	Information/communication

Considering all the supplier evaluation form criteria as the most important factors, equations for demand (D) can be seen below in Equations 5.1 and 5.2. In Equation 5.1, demand (D) is a function of the supplier evaluation form criteria, while in Equation 5.2, the demand (D) is the total market share of a given product (m), which is made up of the criteria, but with corresponding BWM weights.

$$D = f(a, b, c, d, e, f, g, h, i, j, k, l) \quad (5.1)$$

$$D = m * (13.84\% * a + 2.92\% * b + 16.72\% * c + 26.95\% * d + 9.71\% * e + 9.71\% * f + 8.99\% * g + 11.15\% * h + 14.26\% * i + 6.52\% * j + 50.99\% * k + 28.23\% * l) \quad (5.2)$$

Using the previous two equations, an equation for the market share lost to the poor performance of the corresponding incumbent supplier for specific items can be determined and can be seen in Equation 5.3. Here, x^* is the desired criteria, where x is a variable and dependent on the criteria.

$$\begin{aligned} \Delta D = m * (13.84\% * (a^* - a) + 2.92\% * (b^* - b) + 16.72\% * (c^* - c) + 26.95\% * (d^* - d) + 9.71\% * (e^* - e) + 9.71\% * (f^* - f) + 8.99\% * (g^* - g) + 11.15\% * (h^* - h) + 14.26\% * (i^* - i) + 6.52\% * (j^* - j) + 50.99\% * (k^* - k) + 28.23\% * (l^* - l)) \end{aligned} \quad (5.3)$$

The market share loss, ΔD , due to the low performance of the current supplier is related to the product's total market share, m, which depends on the product's demand and the availability of alternatives since the supplier evaluation criteria and the respective weights are the same. A supplier with a unique product in high demand will have a higher m and a higher market share loss if they perform poorly. This also implies a higher supply risk, which is the product of the probability and the impact of the loss. Therefore, investing in these suppliers to improve their performance is worthwhile, which follows a positive and logarithmic learning curve. For suppliers with a non-unique product that still has a high m

because of their quality, for example, the trade-off between the costs and benefits of switching or investing should be carefully evaluated. Switching may be more profitable if the costs are more than the benefits and the potential for improvement is low. When a supplier has a low m , the supplier's product is not very popular among the buyers, or many other suppliers can offer the same or better product, then they have a low market share loss if they perform poorly and a low benefit if they perform well. Therefore, switching to another supplier may be cheaper and result in a better product, as many competitors and alternatives are available. In this case, the optimal decision may be to switch rather than invest in this supplier.

In some cases, there is no option of switching. This can be seen in the case of most high-risk suppliers, where limited options are available. The supplier is aware of the buyers' dependency on them, and as a result of this, a high-risk supplier often has higher bargaining power. This is a common result of suppliers on the right-hand side of the PPM.

As a result, it is important to manage relationships with these high-risk suppliers and, where necessary, try to improve their performance when they are underperforming since there is little other option a buyer has to reduce this risk. One way to reduce this risk is to invest and increase the supplier's capabilities, such as providing training or investing in new R&D for the supplier. This can help the supplier enhance their capabilities, which can also benefit the buyer. In Chapter 4, it could be seen that higher-risk suppliers have lower capabilities; therefore, investing in increasing these capabilities could be very beneficial. However, a direct positive correlation exists between a supplier's willingness and capabilities, meaning that investing in the supplier's capabilities is not enough. The supplier must, therefore, also be willing to improve its capabilities and share the benefits of the investment with the buyer. Otherwise, the supplier may take advantage of the buyer's investment and use it to increase their own profits.

Therefore, the buyer should assess the supplier's willingness before investing in improving their capabilities. This can be done by looking at places to improve the supplier evaluation form and holding honest and open conversations with the supplier about improvement areas. Since the pillars of good collaboration start with clear and transparent communication, this will be very beneficial to determine the potential improvement in a supplier's willingness. By providing long-term contracts to prove their commitment, the willingness to collaborate may improve this way on the supplier's side. The goal is to create a profitable situation where the buyer and the supplier can achieve their joint objectives and reduce risks by working together.

For supplier 56, which is the sole supplier of a unique product, it could be worth the investment since the supplier finds itself in the overeager quadrant of the ISM in Figure 4.15. Assuming that the results of the ISM are generalizable, and most suppliers that are high risk due to the uniqueness of their product can be found in the overeager quadrant with supplier 56, then it can be assumed that they have high willingness and lower capabilities, making them more likely to be willing to enhance their capabilities with investment.

Facing raw material shortages, supplier 58 has low willingness and capabilities. The cause of this will be further discussed in Chapter 6, but other suppliers in the same market and sector likely have similar issues. Therefore, supplier 58 may have limited alternatives to switch, and none of them may be better than us regarding willingness and capabilities. In this case, investing in improving their willingness and morale may be worthwhile until the raw material shortages are resolved. However, consider factors such as their willingness and capabilities before the materials shortage.

On the other hand, suppliers 61 and 62 have low capabilities and willingness and face risks due to technical failures, and supplier 59 suffers from the same problem and is at risk due to their capacity utilization issues. These issues are likely specific to each company, not the whole market. Although the risks are assumed to be common for each supplier segment, they are not faced by all suppliers in the same market. In this scenario, there is little incentive to persist with these suppliers. The buyer holds considerable bargaining power, and it is advisable to seek better deals or explore alternative suppliers who

may offer more favorable terms, enhancing the overall efficiency and effectiveness of the supply chain. Continuing to work with these suppliers may not align with the buyer's interests in optimizing their sourcing strategy and ensuring quality and reliability in the supply network.

The game theory further supports the idea of switching or renegotiating with non-performing incumbent suppliers when the buyer has a power advantage (Chatterjee & Samuelson, 2001). If there are multiple other options available, the party with the highest bargaining power, which in the case of suppliers on the left side of the PPM are the buyers, should consider or switch to the most attractive party, or they can negotiate a better deal with the incumbent supplier. The limitation is that there is always a risk that the incumbent supplier is the more attractive supplier and a new supplier's predicted capabilities and willingness fall short. Switching is not always the better option if negotiation is a feasible option.

5.3 Risk Mitigation through Communication and Building Trust

Arguably, lack of communication is one of the most pivotal consequences of supply chain risks. This was also seen in Chapter 4, where communication seemed to be one of the most frequently perceived risk factors and consequences of the given risks. Timely communication about supply chain disruptions, especially at the supplier's supplier level, can empower the buyer to address risks proactively.

Establishing and sustaining effective communication is crucial for building and nurturing trust within buyer-supplier relationships (DeLemos et al., 2010). This is significant in the many benefits associated with trust in buyer and supplier dynamics. Foremost, trust exerts a powerful influence on performance and serves to lower supplier costs significantly (Paparoidamis, Katsikeas & Chumpitaz, 2019). Furthermore, trust contributes to heightened satisfaction and fosters a long-term orientation, thereby amplifying the overall value within the relationship (Paparoidamis et al., 2019). The interconnected nature of trust, communication, and the resulting benefits underscores the pivotal role of effective communication strategies in cultivating and maintaining robust buyer-supplier collaborations.

Two overarching themes emerge when examining the trade-offs inherent in SRM strategies: the imperative to improve communication and foster trust. The synergy of these two elements renders trade-offs, such as maintaining stock or relying on supplier stock, irrelevant. In a scenario where communication and trust prevail, the buyer and supplier can collaboratively navigate challenges related to stock issues, negating the need for the buyer to maintain excess inventory unless absolutely necessary. Long-term contracts gain preference due to the elevated levels of trust and collaboration they foster. The mutual dependence inherent in such contracts naturally encourages robust communication, as both parties share a vested interest in the success of their enduring partnership.

The trade-off between single and multiple sourcing also becomes intriguing within the context of communication and trust. When communication channels are open and trust is established, buyers in close contact with their suppliers will likely be informed promptly about any issues arising in the suppliers' supply chain. This early awareness allows buyers to mitigate risks proactively. The need for multiple sourcing diminishes when communication and trust are high, and dual sourcing may suffice. Suppliers demonstrating a willingness to communicate and collaborate are deemed valuable investments, even if they may appear to lack certain capabilities—willingness, in this context, outweighs perceived capability.

The critical question arises: How can communication and trust be cultivated and strengthened? Establishing regular and transparent communication channels, fostering an environment of open dialogue, and investing in relationship-building initiatives are key strategies. Additionally, providing incentives for collaboration, such as mutual performance goals, can reinforce the foundation of trust. Continuous feedback mechanisms, regular joint planning sessions, and a shared commitment to problem-solving contribute to developing robust communication and trust, forming the cornerstone of effective SRM strategies.

Purchasing organizations have the capacity to impact a supplier's dedication by intensifying cooperative efforts and commitment (Prahinski, 2004). The findings further suggest that a purchasing firm's employment of collaborative communication correlates with a positive perception of its influence on the buyer-supplier relationship from the supplier's perspective (Prahinski, 2004). Specifically, when a buying firm employs an indirect influence strategy involving formality and feedback in tandem for their supplier development program, suppliers perceive an enhancement in the buyer-supplier relationship (Prahinski, 2004). The indirect influence strategy aims to alter the recipient's beliefs and attitudes, achieved through means such as education and communication of evaluations (Prahinski, 2004). This process ensures that recipients acquire more comprehensive knowledge to inform their decision-making.

Buyers that aim to foster enhanced relationships through indirect influence strategy with their suppliers should explore initiatives such as site visits and education and training programs tailored to the supplier's personnel (Prahinski, 2004). These programs should prioritize aspects of production and process techniques that directly influence the supplier's output and future capabilities (Prahinski, 2004).

Even though these standardized procedures and formal communication channels are important, they cannot guarantee an enhancement in the supplier's performance and capabilities alone. Achieving improved supplier performance necessitates the coordination of factors beyond the buying firm's immediate control. However, to foster an environment conducive to enhancing controllable factors, such as the buyer-supplier relationship, the buying firm must play a proactive role (Prahinski, 2004).

To cultivate a more robust buyer-supplier relationship, it is imperative that executives within the buying firm attentively consider suggestions for performance enhancement put forth by their suppliers (Prahinski, 2004). Moreover, there is a need to provide clear explanations regarding the buying firm's objectives, evaluation procedures, and the outcomes of evaluations (Prahinski, 2004). This two-way feedback process serves not only to enrich the supplier's comprehension but also plays a crucial role in bolstering their perceptions of the buying firm's commitment and cooperation.

Once business partners clarify their motivations for wanting to establish trust, identify the potential benefits, assess what is at stake, examine their own trust attitudes (intention and willingness to collaborate), and receive feedback on their trustworthiness, the process of building trust in a mutual climate of open, honest, and direct communication is cultivated (Hacker, Israel & Couturier, 1999).

The supplier evaluation forms can be utilized to evaluate trustworthiness or trust readiness at Allseas, as they already gauge a supplier's capabilities and, more importantly, their willingness. Utilizing the information from these forms, the trust-building process unfolds as follows: the initiator evaluates and takes steps to enhance organizational trust readiness, initiates discussions with the business partner, the partner evaluates and takes actions to enhance its organizational trust readiness, and finally, both partners exchange feedback (Hacker et al., 1999).

Improving trust and communication through collaborative strategies is particularly valuable when dealing with critical or strategic suppliers within the supply chain. These suppliers, often providing crucial components or services, play a pivotal role in a company's success, and disruptions in their performance can have cascading effects on the entire supply chain. Strategic partners and suppliers engaged in long-term contracts especially deserve focused communication and trust-building efforts due to the complexity of these relationships. Similarly, suppliers of innovative or unique products, including those involved in R&D, may require specialized approaches to align goals effectively. These suppliers are also the suppliers where investing is better than switching suppliers. Building trust and communication is a form of investment.

This targeted approach to trust and communication becomes a risk mitigation strategy when applied to suppliers that are sole suppliers. A company can enhance its supply chain resilience by fostering stronger relationships with these suppliers. The early warning system established through improved communication also ensures that potential issues are communicated promptly, enabling proactive risk mitigation.

Collaborative problem-solving is facilitated by a high level of trust, allowing the buying firm and suppliers to work together to find innovative solutions to unexpected challenges. Furthermore, the adaptability and flexibility that arise from a trusting relationship are crucial for navigating uncertainties and changes in the business environment. Continuous communication and feedback contribute to ongoing performance improvement, reducing the likelihood of performance-related risks. Building trust and communication with key suppliers creates a proactive framework for addressing and mitigating potential risks.

5.4 Revising Allseas' Current SRM Strategies

As was previously mentioned, the strategic directions in the PPM act as a basis for procurement decisions and SRM strategies. Allseas often chooses to 'pool requirements' for non-critical items in the PPM. This means buying large quantities to increase the firm's bargaining power and automate purchasing. This strategy moves the items from the bottom left to the top left quadrant of the PPM, where they are classified as 'leverage' items. To further optimize the procurement of these items, Allseas then chooses whether they want to adopt long-term contracts and sole sourcing, which are forms of 'strategic partnership'. However, partnership may not be the best term to describe these relationships, as they are more based on convenience and cost reduction. These strategic directions are often reevaluated when necessary since the PPM constantly changes, and suppliers often move around within the matrix.

To make sure historical decisions can be explained and to transfer valuable knowledge from the procurement manager at Allseas, who uses the PPM as a key element for SRM strategies, the procurement manager should carefully record past decisions, extracting important insights and experiences related to the PPM and its use in SRM. Organized knowledge-sharing sessions, such as workshops and presentations, can be used to share these learnings among relevant teams. Supporting training materials, such as manuals and guidelines, should summarize the concepts of the portfolio matrix for future reference. Using technology for knowledge management and regular reviews of SRM strategies will promote a culture of continuous improvement, ensuring the lasting relevance and effectiveness of the PPM in procurement practices at Allseas.

5.4.1 Relying on the PPM for Procurement Decisions

The PPM is dynamic and changes over time as suppliers move along the profit impact and supply risk dimensions. The PPM created by the procurement manager is confidential, but it can be compared to the one in this report. There are some noticeable differences between them. First, the procurement manager's PPM segments supplies, not suppliers, which is a significant deviation from this report's model. Second, the procurement manager's PPM has a balanced distribution of supplies across the high-risk and low-risk sides, while this report's PPM has more suppliers on the low-risk side. Third, the procurement manager's PPM has a lower average profit impact for the high-risk supplies than low-risk supplies, which is also different from this report's findings. These discrepancies may be due to the difference in suppliers and supplies used and the fact that the procurement manager's PPM was made before COVID-19, which may have affected the availability and performance of suppliers. Moreover, the IMO has imposed stricter rules and regulations on the use of OEM products since the pandemic, which may have also influenced the PPM.

Despite the past success and implementation of the PPM at Allseas, this report, specifically Chapters 2 and 4, has demonstrated that relying solely on the PPM to segment suppliers and determine SRM strategies is insufficient. This is due to several limitations and issues associated with the PPM. One issue is that the PPM focuses on exploiting or avoiding supplier power risk, which neglects the social aspect of building supplier relationships and creates a contradiction. Another issue is that the definition

of supply risk varies across contexts and situations. At Allseas, supply risk is seen only based on the number of available suppliers, which is too narrow of a definition. As shown in Figure 4.10, the supply risk of selected suppliers increases dramatically due to internal choices and external factors that are not captured by the PPM. Furthermore, the ISM reveals the relationships between the low willingness and low capabilities of high-risk suppliers, which are crucial factors for SRM strategies. Ultimately, looking at the different trade-offs and types of SRM strategies, willingness and capabilities seem as important as the number of available suppliers in most instances. Therefore, the ISM provides a more comprehensive and well-rounded overview on which to base SRM recommendations. Looking only at the number of available suppliers as supply risk and comparing it to profit impact is not risk-mitigating. However, comparing it to the willingness and capabilities of suppliers, as well as the possible risks posed in each segment (Figure 4.15), enables more effective SRM recommendations for risk mitigation.

5.4.2 Supplier Pre-Qualification

Additionally, there is a pre-qualification questionnaire to pre-qualify suppliers, especially for subcontractors with a larger scope and more collaboration than regular suppliers. At the start of a tender, potential incumbent suppliers are selected based on the data from the pre-qualification questionnaire. When the number of suppliers is reduced to a small group, they are invited to participate in the tender process. New suppliers are also invited if the existing suppliers are not sufficient.

A pre-qualification questionnaire is often used in SRM because a buyer's performance is heavily influenced by its choice of suppliers and supply chain partners (Duarte & Sousa, 2020). This is a crucial step for buyers, as their performance depends largely on the quality and suitability of their suppliers. A typical supplier pre-qualification form can be split into SPM criteria: willingness and capability. It also requires a lot of background information from the supplier, such as their previous experience and financial situation. Table 5.2 shows a list of common supplier pre-qualification criteria based on literature and adapted to include the most relevant and important ones (Olanrewaju et al., 2022) (Duarte & Sousa, 2020). The criteria are divided into sections and categories of willingness and capability. It is noticeable that there are more capability criteria than willingness criteria and that the background information is extensive. This indicates that buyers are interested in what the supplier can do, what the supplier has done, and how they operate.

Table 5.2: Pre-qualification criteria (Olanrewaju et al., 2022), (Duarte & Sousa, 2020)

Criteria	Section	
Previous experience	Previous experience	Capability
Experience of supervisors	Previous experience	Capability
Types of specialised work	Previous experience	Capability
Quality	QHSE	Capability
Health and safety records	QHSE	Capability
Occupational accident rate	QHSE	Capability
Knowledge and compliance to government regulations	QHSE	Capability
Commitment to sustainability requirements	QHSE	Capability
Cash flows	Financial capacity	Capability
Profit growth	Financial capacity	Capability
Expected completion date	Progress	Capability
Planning	Progress	Capability
Amount of resources	Progress	Capability
Relationship with client or other subcontractors	Communication	Capability
Contractual relationships	Contractual agreements	Capability
Appropriate insurance coverage	Contractual agreements	Capability
Participation in the proposal phase	Willingness to tender	Willingness
Attitude	Willingness to tender	Willingness

The current pre-qualification questionnaire at Allseas is similar to the supplier evaluation form, as the supplier receives a score at the end of the form. The true supplier scores do not always reflect the actual score when a field is not applicable, much like the evaluation form. In such cases, the supplier receives a score of zero, which reduces their overall score. This is why some experts at Allseas will use the pre-qualification questionnaire without scoring them and as a source of information for the tenders, for example. Here, there is a discrepancy in how the form is used, so it may be beneficial for Allseas to create a common guideline on using the form.

The pre-qualification questionnaire at Allseas consists of several categories, such as general information, previous experience, financial status, organization, Quality, Health, Safety, and Environment (QHSE), Quality Control (QC), and additional scope-specific questions. The main differences and similarities between the pre-qualification criteria found in literature and those found on the Allseas pre-qualification questionnaire can be seen in Table 5.3. The main difference from the literature is that planning-related criteria, such as the expected completion date and the planning itself, are not included in Allseas's questionnaire. This document aims to gather more information on suppliers rather than inviting them for a project immediately. Therefore, it makes sense to omit planning from the form since it is not relevant for this purpose. The three criteria that stand out from the literature that are missing in Allseas' document are the appropriate insurance coverage, attitude, knowledge and compliance with government regulations. Considering that the second highest ranked risk experienced by experts at the procurement department at Allseas was rules and regulations, this may be a very beneficial criterion to add to their evaluation form. Other than this, Allseas has more specific criteria that are added to their pre-qualification criteria and were not found in literature, which could be due to the specific and niche nature of Allseas' projects and products.

Table 5.3: Pre-qualification compared to Allseas' pre-qualification questionnaire

Criteria	Comparison
Previous experience	Pre-qualification criteria found in both
Experience of supervisors	Pre-qualification criteria found in both
Types of specialised work	Pre-qualification criteria found in both
Quality	Pre-qualification criteria found in both
Health and safety records	Pre-qualification criteria found in both
Occupational accident rate	Pre-qualification criteria found in both
Commitment to sustainability requirements	Pre-qualification criteria found in both
Cash flows	Pre-qualification criteria found in both
Profit growth	Pre-qualification criteria found in both
Relationship with client or other subcontractors	Pre-qualification criteria found in both
Amount of resources	Pre-qualification criteria found in both
Knowledge and compliance to government regulations	Pre-qualification criteria found in literature
Expected completion date	Pre-qualification criteria found in literature
Planning	Pre-qualification criteria found in literature
Contractual relationships	Pre-qualification criteria found in literature
Appropriate insurance coverage	Pre-qualification criteria found in literature
Participation in the proposal phase	Pre-qualification criteria found in literature
Attitude	Pre-qualification criteria found in literature
Project control procedures	Allseas pre-qualification criteria
Engineering control procedures	Allseas pre-qualification criteria
Risk management procedures	Allseas pre-qualification criteria

Another comparison that can be made is between Allseas's pre-qualification criteria and the supplier evaluation criteria. This examination assesses the alignment between the initial selection criteria and the ongoing evaluation standards. The degree of consistency observed reflects the coherence and integration of Allseas's supplier management system. Moreover, the comparison facilitates an evaluation of the

efficacy of pre-qualification criteria in predicting and ensuring supplier performance over time. Identifying similarities and differences between these sets of criteria offers insights into areas for continuous improvement, allowing for adjustments to enhance their relevance and effectiveness.

The supplier evaluation and pre-qualification forms differ in the willingness and capability criteria proportions. The evaluation form has more willingness criteria, while the pre-qualification form has more capability criteria. This is a discrepancy, as the suppliers should be assessed and accepted based on their willingness and capability before starting a collaboration rather than being evaluated afterward. A notable example is the attitude criterion, which is present in the pre-qualification criteria from the literature review and the criteria from the evaluation form but not in the pre-qualification form. Therefore, it is suggested that the pre-qualification form should include the willingness criteria, especially attitude, which is most important in the evaluation form according to the new weighted results from the BWM. The criteria that are present in the pre-qualification form but not in the evaluation form are reasonable, as they provide background information on the supplier and their capabilities.

Table 5.4: Pre-qualification compared to Allseas' supplier evaluation

Criteria	Comparison	
Quality	Found on both pre-qualification and evaluation	Capability
Health and safety records	Found on both pre-qualification and evaluation	Capability
Commitment to sustainability requirements	Found on both pre-qualification and evaluation	Capability
Relationship with client or other subcontractors	Found on both pre-qualification and evaluation	Capability
Previous experience	Found only on pre-qualification	Capability
Types of specialised work	Found only on pre-qualification	Capability
Occupational accident rate	Found only on pre-qualification	Capability
Project control procedures	Found only on pre-qualification	Capability
Engineering control procedures	Found only on pre-qualification	Capability
Risk management procedures	Found only on pre-qualification	Capability
Financial capacity	Found only on pre-qualification	Capability
Final documentation	Found only on evaluation	Capability
Business ethics	Found only on evaluation	Willingness
Social responsibility	Found only on evaluation	Willingness
Attitude	Found only on evaluation	Willingness

5.4.3 Supplier Evaluation

The supplier evaluation form has been extensively reviewed in Chapter 4, revealing the difference in the importance of criteria between the original document and the new weights formulated by experts at the procurement department using the BWM. It is therefore recommended to revise the criteria weights since there are large inconsistencies in the importance of criteria.

However, the criteria have been weighted according to experts in the procurement department. In reality, both the procurement department and the technical department should be involved in weighing criteria since both departments use the evaluation form.

5.4.4 Implementing SRM Strategies

A risk scoring system based on the newly discovered information on the risks Allseas faces and the knowledge that the PPM is a dynamic model with movements within the model due to more than changes in supplier availability is essential. The ranking of these risks based on the analysis in Chapter 4 can help evaluate suppliers. Although it was difficult for experts to rank risks accordingly per supplier for this project for the suppliers that were analyzed, a third-party supplier management platform or a new feature of the ERP might be able to monitor changes in risk and prioritize risks. According to

experts, the uniqueness of the product was the most important and impactful type of risk. This means that suppliers with a unique product get a high rating here, which the number of available suppliers can determine.

The following can be done to determine the number of available suppliers for a specific product. Firstly, it is important to establish the product specifications and requirements clearly. Next, list key suppliers by using various sources such as online platforms, industry directories, and tailored market-places. This will probably already be known within Allseas by specialists in the procurement department. Attending trade shows and conventions like Europort to connect with potential suppliers is also useful. Then, research online to find manufacturers, distributors, and wholesalers who specialize in your desired product. You may also conduct supplier audits, including visiting and interviewing their facilities. Furthermore, consider the location of the suppliers and how it affects the distribution needs. Create and maintain a central database of suppliers with their contact details, product offerings, and other relevant information. Finally, regularly monitor the changes in the supplier market, industry conditions, and trends, and update your list accordingly. A systematic approach for new products and situations with external risk factors, such as the pandemic, will help you find a wide range of potential suppliers for your product and prioritize factors such as product quality and reliability during the evaluation process.

The uniqueness of the product, rules and regulations, and external factors ranked first, second and third, respectively, as the most important risks; however, all maritime risks explored throughout this literature study can affect the maritime supply chain. To enhance supply chain resilience, an integrated sophisticated monitoring system into the ERP or another software platform can be useful. For example, the system can employ AI detection by analyzing daily global news, specifically focusing on maritime risks. This triggers the system to send a message to the ERP system whenever it identifies pertinent information related to these risks. This immediate alerting mechanism notifies the procurement department through automated notifications in the event of significant occurrences, such as the emergence of pandemics like COVID-19 or geopolitical disasters. By staying informed about these external factors, the company can proactively address potential disruptions in the supply chain. Additionally, the system should extend its analysis to maritime forums/ news pages, where changes in maritime rules and regulations are often discussed. By tracking these forums, the company can stay on top of regulatory modifications and promptly adapt its operations to comply with new requirements. This proactive approach ensures that the company can swiftly respond to regulatory changes, minimizing the risk of supply chain interruptions related to maritime logistics. Integrating such a comprehensive monitoring and alert system allows for a more agile and adaptive supply chain management strategy, ultimately contributing to greater overall resilience. This way, when the procurement department receives notice about possible risks, affected suppliers can be re-evaluated for risk accordingly. An example of the implementation of risk notifications on Allseas' homepage for employees of the procurement department can be seen in Figure 5.1. An example of the supplier page with supply risk incorporated per supplier can be seen in Figure 5.2.

Risk management factors should be a part of the pre-qualification and supplier evaluation criteria. Since these forms are filled out regularly for suppliers, adding risk management and mitigation criteria would not be extra effort but can indicate a supplier's supply risk. This can be implemented in the ERP or SharePoint system when comparing or selecting suppliers.

To fortify the supplier evaluation and pre-qualification processes, it is recommended to seamlessly integrate risk management factors into the existing pre-qualification criteria. By carefully reviewing and identifying relevant risk factors such as financial stability, geopolitical considerations, and regulatory compliance, companies such as Allseas can tailor specific questions and indicators within the pre-qualification and evaluation forms. The key is to ensure that these risk management criteria align cohesively with established assessment factors and are easy to understand and answer.

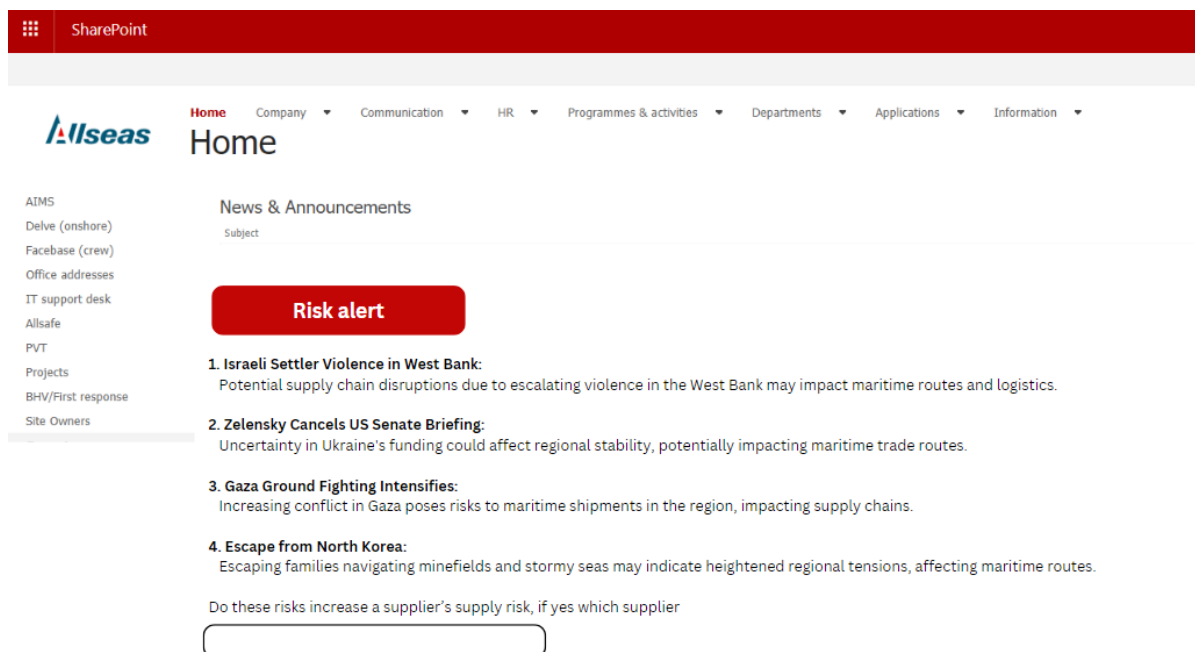


Figure 5.1: Example of the implementation of risk notifications on Allseas' homepage

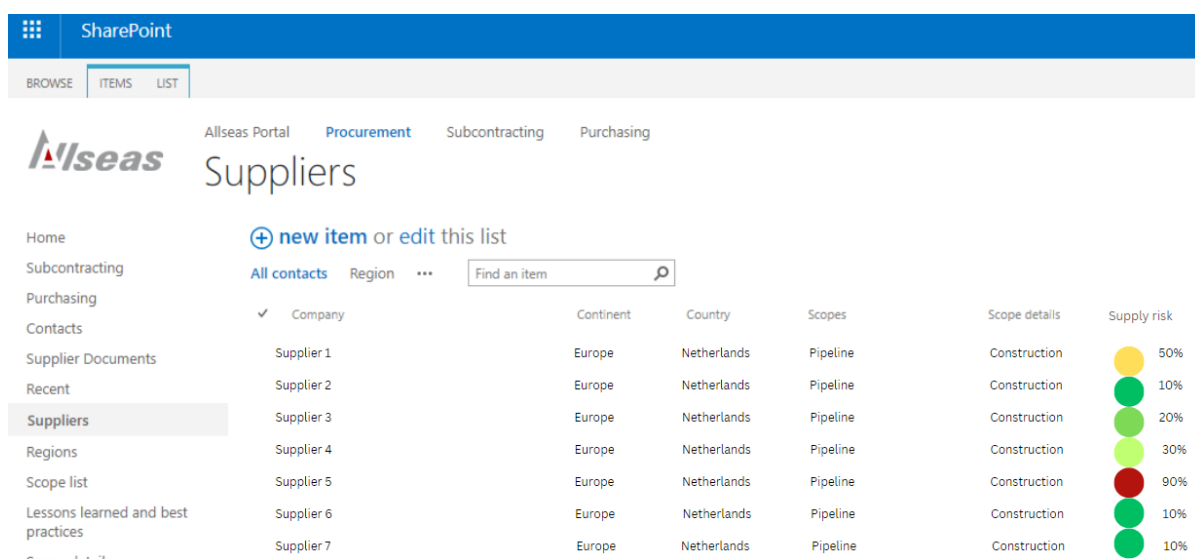


Figure 5.2: Example of the implementation of supply risk on Allseas' supplier page

Examples of questions that can be incorporated into the pre-qualification questionnaire can be:

1. Operational Resilience:
 - Describe your business continuity and disaster recovery plans.
 - What measures are in place to ensure continuous operations during unforeseen disruptions?
2. Regulatory Compliance:
 - How do you stay informed about changes in relevant rules and regulations impacting your industry?
 - Provide documentation of your compliance with industry standards and regulations.
3. Geopolitical Considerations:
 - How do you assess and manage geopolitical risks in your supply chain?
 - Provide information on your suppliers' geographic diversity and potential geopolitical challenges.

4. Supply Chain Visibility:

- Describe your visibility level in your own supply chain.
- How do you address and mitigate risks related to tier-2 or tier-3 suppliers?

5. Innovation and Adaptability:

- How do you foster innovation within your organization to adapt to changing market conditions?
- Describe instances where your company successfully adapted to unforeseen challenges.

Examples of criteria that can be incorporated into the supplier evaluation form can be:

1. Performance Timeliness (Score 0-3)
2. Communication and Responsiveness (Score 0-3)
3. Issue Resolution Effectiveness (Score 0-3)
4. Collaboration and Innovation Contribution (Score 0-3)
5. Supply Chain Transparency Level (Score 0-3)
6. Continuity Planning Adequacy (Score 0-3)

It is important to note that communication was mentioned by an expert as a criterion they missed on the supplier evaluation form, therefore making it very important to incorporate in the future. Offering training to evaluators on the nuanced assessment of these risk factors and establishing a systematic approach for regular reviews and updates will further enhance the efficacy of the process and help better understand rating the new questions and criteria of the supplier pre-qualification and evaluation forms. By incorporating risk management into routine supplier evaluations, organizations can seamlessly gauge the supply risk associated with each supplier, making informed decisions that contribute to the overall resilience of the supply chain.

While implementing intelligent software capable of monitoring news and maritime forums for rule and regulation updates is intriguing, the practical execution of such a system may pose difficulties. Therefore, emphasizing improving relationships with suppliers and fostering open communication becomes paramount. Establishing strong ties with suppliers is a strategic move, as it enhances the flow of information and relies on a foundation of trust. Clear and consistent communication between buyers and suppliers is instrumental in managing supply chain disruptions effectively. By promptly sharing information about potential risks, disruptions can be mitigated in a timely manner, and contingency plans can be activated. In essence, the success of supply chain resilience hinges on the pillars of trust and communication, where transparent exchanges between stakeholders can significantly diminish the overall impact of disruptions.

5.5 Frequency of Supplier Segmentation

To optimize the frequency of supplier segmentation using the ISM, a strategic approach aligning with the industry's dynamic nature is essential. As was previously mentioned in this chapter, considering the potential integration of AI technology, particularly in response to news alerts, presents an innovative solution. By implementing an AI add-on to the procurement department's homepage, tailored alerts based on world and maritime news could efficiently prompt targeted messages. This approach ensures that supplier segmentation is promptly adjusted in response to emerging risks, maintaining accuracy while significantly reducing the time and effort required for manual reassessment.

The proposed AI-driven system could revolutionize the process, offering real-time insights into potential risks and enabling swift adjustments to supply risk evaluations. A potential downfall would be the feasibility of implementing such a system and determining the time investment required from the procurement department. However, it is important to note that Allseas is implementing a new ERP system, so implementing such a tool may be possible soon. This automated solution, driven by AI,

holds the promise of streamlining the segmentation process and enhancing its responsiveness to dynamic external factors. If implementing AI is not feasible, closely monitoring supplier performance and risk factors through regular communication can be a valuable and efficient method to update supply risk consistently. This underscores the significance of building trust and enhancing communication.

While AI-driven updates provide quick and daily updates on changes in supply risks, aspects such as willingness, capabilities, and profit impact could be addressed through bi-annual supplier evaluation forms. These evaluations, being less prone to volatile changes than supply risk, offer a balanced approach. By utilizing supplier evaluation forms bi-annually, the procurement department can effectively measure essential criteria, ensuring a comprehensive understanding of supplier dynamics over a more stable time frame.

5.6 Main SRM Take-Aways for Risk Mitigation

Managers can utilize the insights derived from this study to improve supplier selection, evaluation, communication, and risk management processes. They can initiate the supplier selection process by prioritizing suppliers with a higher willingness to collaborate, adding willingness criteria to the supplier pre-qualification questionnaire. The study revealed a positive correlation between willingness and capabilities, suggesting that suppliers with greater willingness are likely to possess higher capabilities, thereby reducing overall risk. Regularly updating the supplier pre-qualification questionnaire and incorporating willingness assessments ensures a dynamic and responsive supplier selection process.

Strategic investment in suppliers deemed willing but lacking capability is recommended to enhance their overall performance. For non-performing incumbent suppliers with low willingness, managers should consider alternative suppliers unless other suppliers' critical evaluation criteria are substantially worse. In the PPM context, buyers dealing with suppliers with readily available goods and many alternatives (on the left side of the matrix) should adopt dual-sourcing strategies to mitigate risks, even if at a 10% and 90% ratio.

Maintaining a balanced supplier dependency is crucial to prevent capacity utilization issues and power imbalances. Managers should select suppliers based on their capacity to meet requirements and implement dual-sourcing strategies strategically. High-risk suppliers, particularly those dealing with unique products, warrant special attention. Given their smaller percentage in the total supplier pool (around 13%), investing in and building trust and communication with these suppliers is essential for effective risk mitigation.

The integration of AI technology for real-time risk alerts, coupled with bi-annual supplier evaluation forms, presents a harmonized, data-driven, efficient approach. This strategy allows the procurement department at Allseas to adapt swiftly to evolving risks without compromising the integrity of supplier segmentation. The suggested frequency of regular reviews, potentially on a quarterly or bi-annual basis, ensures a balanced and proactive stance in addressing shifts in the risk landscape while optimizing time and resources.

When implementing risk mitigation strategies, managers should favour agile and collaborative approaches over traditional lean management and vertical power dynamics. Trust and communication play a crucial role in inventory management, rendering it unnecessary for buyers to hold excessive stock if a reliable supplier relationship is established. The study emphasizes that effective supplier communication and trust-building can mitigate stock-holding risks, such as item obsolescence and increased storage costs.

In-house manufacturing is particularly beneficial for companies like Allseas when aligned with innovation goals or cost-effectiveness. However, managers should carefully assess ventures into sectors that may not align with the core relevance of Allseas or other companies, as this could divert crucial resources from areas contributing to progress. Establishing trust and communication with suppliers remains vital for obtaining favourable prices, high-quality products, and proactive risk mitigation.

The adapted SRM framework, as depicted in Figure 5.3, provides a visual guide for managers, highlighting the interconnected nature of risk mitigation and SRM practices.

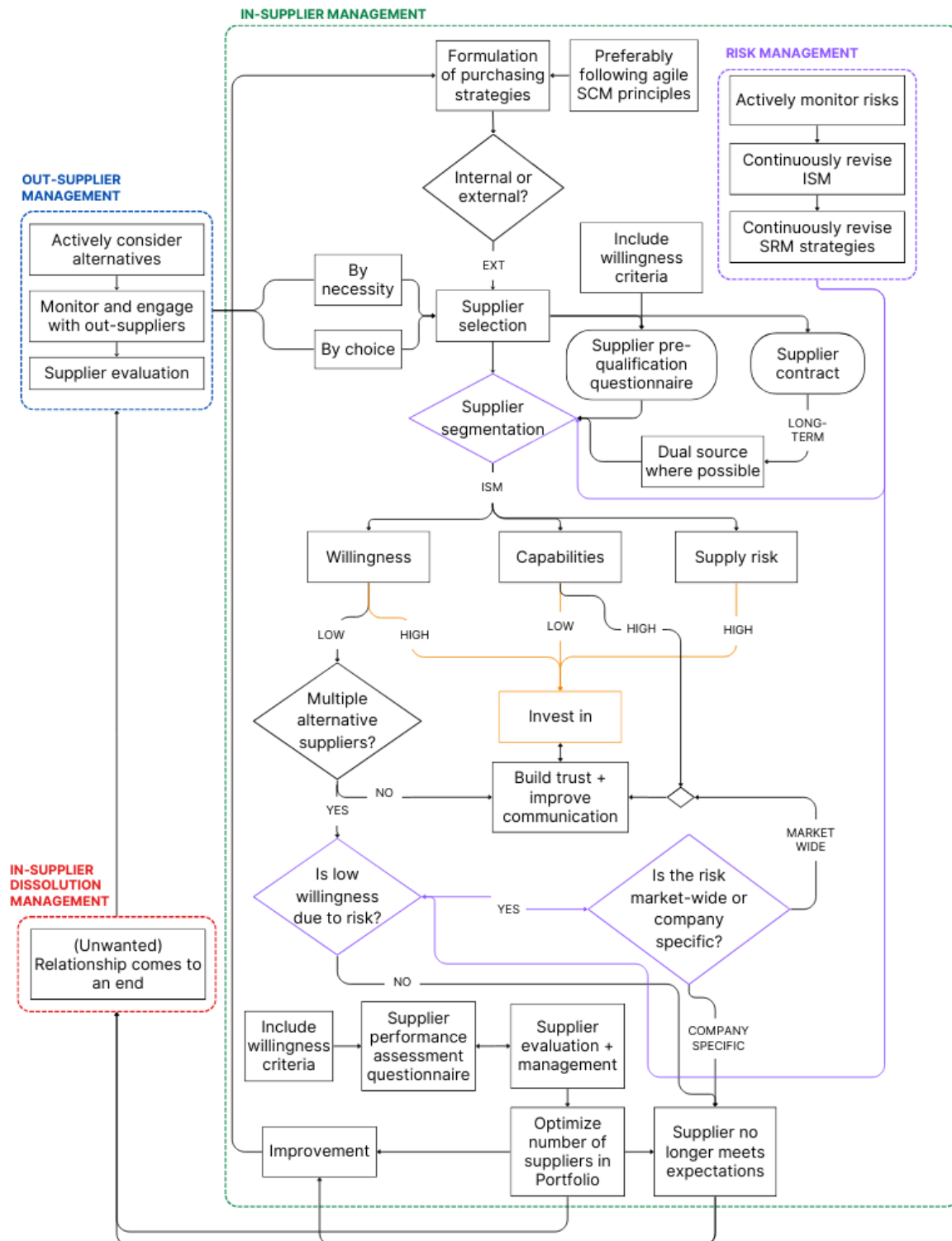


Figure 5.3: SRM framework for risk mitigation

Chapter 6

Discussion

In this chapter, a discussion of potential thesis topics that remain unanswered or provoke intriguing considerations will be analyzed. The discussion will encompass areas of research that warrant further exploration, identifying gaps in existing knowledge, and suggesting avenues for future investigations. A critical analysis of the current literature, and using logical reasoning, aims to highlight the unresolved aspects and the possible reasons why they remain unclear or unresolved.

6.1 The Role of Subcontractors at Allseas

This research is based solely on subcontractors since the evaluation forms were a good starting point for determining the willingness and capabilities of suppliers, as was explained in Chapter 4.

In literature, the definition of a subcontractor varies vastly from that of the procurement department at Allseas. In literature, the following definition can be found:

A subcontractor is ‘a supplier, usually of services, engaged to complete a specific task or supply a package of work, perhaps as part of a bigger project or to deliver the entire project’. (O’Brien, 2014a, p. 12)

At Allseas, subcontractors are not seen as a homogeneous group of suppliers. Figure 2.10, which is part of the literature review, suggests that subcontractors have low importance to business, which means low supply risk and low capabilities. However, this does not reflect the reality of subcontractors at Allseas’ procurement department. The relationship with subcontractors can range from distant to close and collaborative, depending on the type and uniqueness of the product or service they provide. The PPM (Figure 4.9) includes only subcontractors and shows a wide variation in supply risk and profit impact, indicating that they have different levels of importance to the business. This contradicts the literature’s definition and placement of subcontractors in Figure 2.10. The PPM also demonstrates that the intensity of the relationship between a buyer and a subcontractor can vary significantly. When asked to define what a subcontractor means to them or to choose a definition from the common types of suppliers (Table 2.6), the experts at Allseas could not agree on a single definition. They said that any of the definitions from arm’s length supplier to strategic supplier could apply to a subcontractor at a certain point in time.

The reason why price is not a criterion on the supplier evaluation form is related to the previous point about the diversity of subcontractors. The literature on supplier evaluation usually considers price, quality, and delivery to be the most important criteria; however, this does not apply to Allseas’s situation. A subcontractor’s price depends entirely on the nature and scope of the product or service they offer. Just like the definition of a subcontractor at Allseas, the price of a subcontractor also varies greatly. Therefore, it is not feasible to assign a rating to a subcontractor based on the price of their product or service. The

rating would be subjective and inconsistent among the experts in the procurement department who fill out the evaluation form. However, this does not mean that price is irrelevant to Allseas. Price is still crucial in pre-qualification, tenders, and supplier selection in general. If two suppliers had the same score on the evaluation form, but one had a lower price than the other, the lower-priced one would be the preferred choice.

6.1.1 Generalizability of Subcontractors as Standard Suppliers

The findings can be generalized to the overall population of suppliers, as the subcontractors are a representative sample. This can be seen by the difference in supply risk between subcontracted suppliers, ranging from 10 to 90% supply risk. There is also a very large range in profit impact between the subcontracted suppliers. To ensure this statement is true, a sample of 366 different and randomly selected suppliers are compared to the subcontractors to ensure the spread of profit impact is comparable. The sample taken to prove the generalizability revealed that the average profit impact was 11.74% higher for the chosen subcontractors than for the sample of 366 suppliers.

Even though 11% is a relatively small difference, this increased average profit impact could be due to a few things. Firstly, subcontractors specialize in certain areas that are not necessarily the core competencies of a standard supplier and provide more customized and high-value services to the customers (Hayes, 2020). Because of this, they can also charge more for customized solutions. Subcontractors can also reduce their overhead costs by avoiding the expenses of hiring and staffing, employee benefits, and office space that suppliers have to incur (Filion, 2016). Table 2.6 explains the difference between different supplier types. Here, the difference in definition between a subcontractor and a standard arms-length supplier could explain the technical skills a subcontractor has over a standard supplier and the higher profit impact. As was previously discussed, the Table also states that a subcontractor is usually hired for a specific task or project that requires specialized skills or expertise, and a supplier, on the other hand, is usually hired for something more general.

6.1.2 Accuracy of the Supplier Evaluation Forms

There are two issues with the supplier evaluation forms. The first issue is that the forms span from 2018 to 2023, meaning that suppliers who worked for Allseas in 2018 and again more recently may receive a different score now. To accurately compare subcontractors, the supplier evaluation forms should have all been done recently, preferably within the span of this research, as this could have made the results more accurate. However, the time the evaluation form took place should not affect the score a procurement expert has given the supplier since the form was the same throughout, with the same template, criteria, and weights. There's also a possibility that Allseas will not work with that specific subcontractor in the future. Assuming the same format and a limited time frame, it can be inferred that the outcomes are as accurate as possible within the specified time limit.

Additionally, the form presents a problem where if a criterion is irrelevant to a supplier, the supplier's score is marked as 0, which is factored in and lowers the supplier's total score. This is often unfair to the supplier's score. However, this was often noted on the supplier evaluation forms, so the criterion could be removed and not considered for the willingness and capabilities criteria, making the results more reliable.

6.2 Data Collection Results

Going further than just the conclusions drawn in Chapter 4, some discussion points must be looked into and discussed further.

6.2.1 The Difference Between Risks Encountered and Risks Perceived

There was a noticeable difference between the risks experts perceived and the risks, or supply chain disruptions, they had experienced. To visualize this difference, Figure 6.1 was created. The values on the x-axis show the difference in mentions. The risks perceived are subtracted from the risks encountered. Negative (red) values show that the risks were only perceived and not encountered. Positive (green) values show that the risks were only encountered and not perceived.

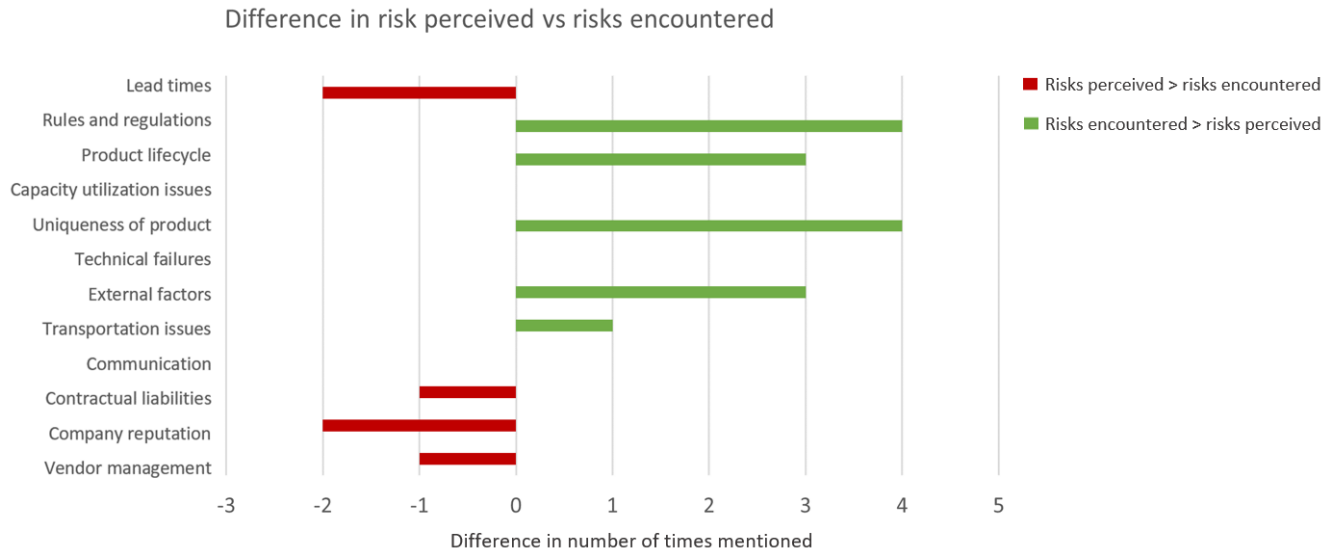


Figure 6.1: Difference in risks encountered vs. risks perceived

It is difficult to pinpoint the reason for this difference in perception, but it could be due to different types of biases. One possible explanation is the recency bias, where the interviewee has recently experienced disruptions in the supply chain and mentioned these but kept the perceived risks quite global and more long-term (Azzopardi, 2021). Another bias that could explain these differences is the priming effect, where an individual's prior exposure to a stimulus subliminally shapes their reaction to subsequent stimuli (Azzopardi, 2021). This may have happened because the report's introduction was sent to the interviewees before the actual interviews took place, which meant that they already knew what kind of categories were expected as risks and may not have matched the risks they actually experienced.

Some biases may have affected the experts' perceptions of supply risk, this is why the conclusions drawn from the interview analysis are mainly based on the risks they actually faced. Next to this, the expert group was diverse, which may have reduced the impact of biases on the risks they encountered, as they experienced different risks.

6.2.2 The Perception of High-Risk Suppliers

The significance of supplier criticality (how high-risk a supplier is) and the definition of risk in the context of supplier segmentation requires careful consideration. While this thesis primarily focuses on suppliers, it's essential to acknowledge that internal communication gaps and uncoordinated behaviours within Allseas can influence the perception of risk. This aspect was not extensively explored in the thesis, but it is crucial.

Figure 6.1 illustrates an interesting phenomenon. For instance, lead times are perceived as a significant risk, but internal factors may influence this perception. In reality, lead times, if well-known and planned for, shouldn't inherently pose a risk. However, if there are deficiencies in the planning processes within a department, lead times may be mistakenly labelled as a risk. This dynamic highlights how suppliers' criticality is subject to buyers' perceptions and internal communication and coordination effectiveness.

Consider the example of Supplier 59, which was chosen as a single-sourced supplier despite Allseas having alternative options. Issues arose due to forecasting challenges, leading to capacity problems and delivery issues. Allseas, having consciously selected this supplier, now categorizes them as high-risk. This raises questions about the fairness of such a label—is it a genuine reflection of the supplier’s risk profile, or does it stem from internal choices and mistakes within Allseas? The situation could have been different if dual or multiple sourcing strategies were employed, providing alternative suppliers.

It’s crucial to recognize that buyers assign suppliers to segments; suppliers themselves don’t determine their segmentation. Therefore, understanding the perception of supplier location on matrices like PPM, SPM, and ISM becomes intriguing, as it’s influenced by internal dynamics and choices within the buying organization. To address this, Allseas needs to manage the expectations of internal stakeholders better, ensuring that communication and coordination gaps are minimized, and stakeholders are well-informed about the intricacies of supplier criticality and risk perception.

Biases also play a large part in the perception of high-risk suppliers. Biases in decision-making within procurement often show in scenarios like supplier selection, particularly when assessing risks associated with geopolitical events. A common bias is the recency bias, where decision-makers might disproportionately focus on recent events, such as the ongoing conflict in Ukraine, potentially influencing their perceptions of suppliers from that region (Azzopardi, 2021). This bias could lead to heightened concerns and a reluctance to re-engage with suppliers previously deemed high risk, even if circumstances have evolved.

Additionally, confirmation bias may play a role, as decision-makers may be inclined to interpret new information in a way that aligns with their pre-existing beliefs or biases (Azzopardi, 2021). In the case of a supplier once labelled as high risk, there could be a tendency to maintain that perception, even when conditions change. To change or erase these biases, it is crucial to implement practices such as regular supplier evaluation forms, improved communication, and data-driven decision-making. By working towards a more forward-thinking approach, buyers can make informed decisions on supplier engagements based on current, relevant information rather than historical biases.

6.2.3 The Perception of Communication as a Risk Instead of an Underlying Consequence

Communication has an interconnected relationship with risks experienced and perceived. This was seen due to the frequency of mentions of communication as a risk, and upon further examination, that communication was a consequence of a risk each time.

Within the context of interviews, communication is often regarded as a risk rather than a consequence due to its pivotal role in shaping the success of a project or business operation. The perception of communication as a risk can stem from various factors. Firstly, communication is essential for any project, and any gaps or delays in information can cause confusion, errors, and poor choices that can jeopardize the project’s smooth execution. This makes it seem like communication is a supply chain disruption. Communication also helps coordinate the actions of team members, departments, or external partners, ensuring they are aligned and working towards the same goals. Poor communication may result in coordination challenges, disrupting workflows and creating potential bottlenecks. Additionally, intra- or inter-company conflicts can arise from miscommunication, and the failure to address these conflicts promptly poses a risk to the overall working environment. The potential for miscommunication, misunderstandings, and breakdowns in information flow due to other risk factors can lead to frustration and irritation among both buyers and suppliers, making it seem like communication is the disruption; however, in reality, the disruption is caused by other risks that in turn decrease effective communication.

6.2.4 The Blacklisted Supplier

As was mentioned previously, supplier evaluation forms may not always give accurate results regarding the scoring of the suppliers since if a criterion does not apply to a supplier, the weight the supplier will receive is zero. This can lower the supplier score this way. Therefore, supplier 33, the blacklisted supplier with near to zero scores for both willingness and capabilities, still had a relatively high-profit impact and low risk, was interesting to look at. It could immediately be deduced from the comments on the evaluation form that the supplier was very inadequate and was underperforming. The key reason was that communication was difficult and made them difficult to work with. The project where the supplier evaluation form was filled in was also the last project and PO that the supplier has been used for, meaning that this lack of communication resulted in the loss of a supplier in this case.

6.2.5 Why High-Risk Suppliers have Lower Willingness and Capabilities but Higher Profit Impact

In the literature, it can be determined that a powerful firm might experience declining performance within its supply chain (Nurhayati et al., 2021). Despite being able to influence prices and being in a dominant position, the decline in quantity demanded may offset the gains from higher prices, leading to reduced overall performance.

As power is flexible and can be influenced through intervention, it has the potential to transfer between buyers and suppliers. The common assumption is that a more powerful firm will generate higher marginal profits than its counterpart (Nurhayati et al., 2021).

This is why, on the left-hand side of the Kraljic's PPM, both buyers and suppliers are more willing to either pay for the product that can be found on the right-hand side of the matrix or to work with a buyer on the right-hand side of the matrix. The PPM is relative, and Allseas is a unique company with large market dominance, meaning that many companies would like to work with Allseas, specifically those on the left-hand side, that have little market dominance and a lot of competition. The procurement manager at Allseas uses the strategic directions of Kraljic's PPM to determine SRM strategies. Products usually found in the non-critical quadrant of the PPM are often bundled, and the procurement process of these goods is automated. A long-term contract is usually given to secure prices for products. Due to the high levels of competition, a long-term contract from a company like Allseas means the supplier gains assurance and stability of cash inflow, making it mutually beneficial for both parties to work together. However, an incumbent low-risk supplier also knows that due to these high levels of competition, they are easily replaceable and are, therefore, usually more willing and show higher capabilities to ensure their contract is maintained and ensure Allseas continues working with them. Table 4.6 and Figure 4.13 show that low-risk suppliers have higher capabilities and willingness than high-risk suppliers. The average profit impact is lower with low-risk suppliers. This can be explained by low-risk suppliers wanting long-term contracts or security. Low-risk suppliers with a lot of competition are more likely to give Allseas a good deal and reduce profit impact this way to ensure collaboration.

The concept of economies of scale is vital for organizations across industries, as it signifies the cost efficiencies and competitive benefits that larger businesses or industries enjoy in comparison to smaller counterparts (Mathur, 2022). This means larger markets can benefit from economies of scale that smaller, niche markets cannot. Due to economies of scale, the products that are being produced and sold by suppliers on the left side of Kraljic's PPM are also more likely to be cheaper to manufacture compared to the right-hand side since multiple companies are investing in and developing these products (Mathur, 2022). Therefore, the low-risk suppliers can have a smaller profit impact on average because the price it costs to manufacture their goods is lower.

Even though perfect competition is a theoretical market structure, it can explain why suppliers on the left-hand side of the PPM can offer products for lower prices. In a market with perfect competition,

such as most markets on the left-hand side of the PPM where there are vast amounts of similar suppliers and high levels of competition, prices are determined by the forces of supply and demand (Hayes, 2023). Companies generate enough profit to sustain their operations without exceeding this threshold. The possibility of earning excess profits encourages additional companies to enter the market, leading to a decrease in profits (Hayes, 2023).

Conversely, the power logic can explain why suppliers on the right-hand side of the PPM have lower willingness and capabilities on average. They know they are more difficult or unable to be replaced, either because Allseas has created a dependency on them through partnerships or standardization or because they are a sole product supplier. This means that they do not need to be willing or capable due to their high levels of power since they know buyers will continue working with them. Another important thing to note is that due to the uniqueness of the product many high-risk suppliers offer, they may have a limited scale, which means that they lack the economies of scale that larger firms with larger markets can benefit from, which can limit their capabilities (Mathur, 2022). Not having economies of scale could also account for the higher average profit impact since the suppliers may not be able to offer their products or services for lower prices. Allseas is a unique company, meaning that if there is a unique supplier for a company like Allseas, chances are that there is a very niche small market the supplier caters to, making them dependent on a few clients. However, due to their high levels of power, it is also possible that they can charge high prices since they know their buyers are dependent on them. Also, the type of companies interested in this product are likely companies similar to Allseas, which are large profit-making companies. This means that a company with a unique product can squeeze money out of the company.

6.2.6 The Number of Supplier Willingness Criteria on the Supplier Evaluation Form

The willingness criteria encompass four factors, reflecting a limited set. Consequently, each criterion holds substantial weight in determining the overall score. If a supplier receives a low score in any one of these four criteria, the impact on their overall score may be significant. However, because every criterion operates on a scale of 0 to 3, and if a supplier is underperforming, they would receive a low score. While this impacts their willingness score, the magnitude of the effect is not substantial.

Furthermore, the SPM exhibits distinct segments of approval, showcasing clear correlations. A well-defined correlation line between supplier capabilities and willingness emerges, with minimal outliers. This consistency suggests that the criteria employed in the evaluation process are reliable and contribute to a robust assessment of supplier potential.

6.2.7 The Percentage of High-Risk Suppliers

As was previously mentioned, Allseas is one of the market leaders in a niche market- offshore pipe-laying and heavy lifting. With only seven market leaders noted in 2020, navigating the global market for heavy lift vessels presents considerable challenges, which is why so few companies are active in this market (Macfarlane, 2020). Given the market's uniqueness, the question arises whether 13% high-risk suppliers are expected for a company like Allseas, based on the results from the ISM and Table 4.6. The table provides a quantitative overview of the average results and differences between low and high-risk suppliers, where only eight suppliers out of the 62 are high-risk, which is approximately 13%. It is important to note that the suppliers are subcontractors, which are generalizable as normal suppliers for Allseas, as previously discussed, and they should not impact the average value of supply risk or the number of high-risk suppliers. This sample is assumed to be generalizable, and the definition used to determine supply risk is based on the number of available suppliers.

The category of strategic suppliers constitutes a minor segment, comprising approximately 5% of the total (Giguere & Goldbach, 2012). Despite their limited numerical representation, their importance is

disproportionately significant since failure at this level would result in substantial disruptions (Giguere & Goldbach, 2012). Even though the reference is eleven years old, the foundational principles highlighted in the text are likely to remain relevant because, in essence, companies still categorize suppliers based on their importance for long-term goals versus day-to-day operations. Core suppliers, which make up about 15% of the total, are essential for daily business operations, and their loss would create operational stress (Giguere & Goldbach, 2012). Transactional suppliers, on the other hand, encompass the majority of suppliers providing commodity or interchangeable goods and services (Giguere & Goldbach, 2012).

While strategic suppliers fit the definition of high-risk suppliers and transactional suppliers fit the definition of low-risk suppliers, determining if core suppliers are high or low risk is crucial to determining if 13% high-risk suppliers uncovered during data collection is a representable or expected result. The definition of core suppliers is that they are typically considered essential for day-to-day operations, and their importance makes any disruption in their services potentially impactful. However, it seems to say nothing about the number of available suppliers (Giguere & Goldbach, 2012). Therefore, assuming half of the core suppliers are high-risk and the other half are low-risk, the expected total percentage of high-risk suppliers is the sum of the percentage of strategic suppliers plus half the sum of the core suppliers, giving a total of 11.5%, which is slightly lower than 13%. This slight percentage increase is due to the uniqueness of the market Allseas finds itself in, meaning that 13% is expected and can be assumed to be average to low for the given market.

6.2.8 The Generalizability of Relationships Between Risks and Consequences

In Figure 4.8, connections are drawn between the risks encountered at the procurement department at Allseas and the consequences.

The first point to consider is that technical failures within a supply chain can give rise to safety issues. This, in turn, threatens the standardization processes established within the system. When safety is compromised, adherence to standardized procedures may become challenging. The potential jeopardy to standardization, as a consequence of safety issues stemming from technical failures, may prompt a reconsideration of supplier relationships. In such cases, businesses might find themselves compelled to explore alternative suppliers to ensure the reliability and consistency of their procurement processes. Therefore, the logical sequence suggests that technical failures, by causing safety issues and challenging standardization, could ultimately lead to the decision to change suppliers. This is a logical flow of sequences assuming the supplier encountering the technical failure has become a standard at the company. This also assumes that the standard is implemented to increase overall safety. Then it can be assumed that this sequence of risk and consequences is generalizable.

The second risk is product lifecycle, which has three notable consequences from the interviews. Firstly, as the product lifecycle progresses, the uniqueness of the product increases. The uniqueness of a product tends to increase over its lifecycle due to various factors related to technological advancements. For example, manufacturers often introduce innovations and technological enhancements to stay competitive as a product matures. These improvements can lead to unique features, functionalities, or design elements that differentiate the product from earlier versions or competitors. This uniqueness, in turn, challenges standardization within the supply chain. The evolving nature of the product may deviate from standardized norms, making it harder to maintain consistency in processes. Additionally, the extended product lifecycle contributes to heightened lead times. The prolonged duration from product conception to market availability can impact the overall efficiency of the supply chain. Therefore, the logical flow of this risk involves an increase in product uniqueness, posing a threat to standardization and concurrently leading to extended lead times, making this generalizable.

The third identified risk is vendor management issues, a situation that may prompt the changing of suppliers. This risk arises when a supplier consistently falls short of meeting performance expectations,

leading to concerns about reliability and quality. In general, in response to these issues, companies may contemplate transitioning to an alternative supplier that offers better performance, alignment with strategic objectives, and greater overall stability, ensuring a more resilient and efficient supply chain. In Chapter 5, there is a more thorough analysis of when it is worth it to switch suppliers. In most cases, incumbent suppliers can be switched when there are many other alternatives, and the incumbent supplier is underperforming.

The following risk is related to rules and regulations. Usually adherence to strict rules and regulations often increases the uniqueness of the product. This is what was seen with supplier 60, where rules and regulations set by the IMO have made the product unique. This is driven by the necessity to comply with specific standards or legal requirements, making the product distinct from others in the market. This may lead to increased costs for the company since they are forced to work with suppliers that may ask for higher prices due to their sudden high bargaining power. Moreover, adherence to rules and regulations can prompt a reevaluation of suppliers, oftentimes enforced by the IMO. However, in some cases, suppliers may struggle to meet the evolving compliance landscape, leading to a decision to change suppliers.

Next, external factors can contribute to an increase in the uniqueness of the product. Geopolitical tensions or widespread health crises can disrupt the regular flow of materials and resources, prompting companies to modify or adapt their products to navigate the challenges posed by these external factors. Sometimes, these products can not even be shipped due to logistical issues, increasing the uniqueness of the product. Similarly, this extends to project cancellations, where projects can not be done because of external factors. The cancellation of projects can affect the company's overall operational continuity and financial stability. Alongside this, increased lead times become a notable and obvious consequence. Therefore, even though external factors such as raw material shortages or labor shortages may have more detrimental consequences, the consequences drawn from the risk can be seen as generalizable depending on the severity of the external factor.

Finally, the risk of capacity utilization issues has consequences such as an increase in the uniqueness of the product and switching suppliers. When a company faces issues with capacity utilization, it often implies that production capabilities are strained or constrained, leading to alterations in the nature of the product. This is because companies may need to adjust or modify their products to align with the available production capacity, resulting in variations or unique features that address the challenges posed by capacity-related issues. When capacity utilization problems persist, companies might explore alternative suppliers to overcome limitations and maintain a consistent supply chain, but this depends on factors such as increased lead times, lack of shipped products, or the inability to deliver for some time.

In conclusion, it is reasonable to infer that the connections between risks and their consequences possess a degree of generalizability, even though limited literature directly supports these assertions. The scarcity of available literature prompts reliance on logical reasoning to substantiate these relationships. It is important to acknowledge that the identified risks may have additional consequences beyond those explicitly outlined, and conversely, a single consequence may result from multiple risks.

6.2.9 The Generalizability of Risks per Supplier Segment

As was discussed in Chapter 4, the ISM in Figure 4.15 shows the risks related to the supplier segment based on the suppliers 56 to 62, which came forth as apparent high-risk suppliers during the interviews.

Ensuring that your suppliers follow the rules and policies that apply to them can be a difficult task for any business, but supplier compliance can improve both risk and supplier performance in procurement (oboloo, 2021). The suppliers that faced or still face risks due to rules and regulations are in the upper segments of the model; they have the highest willingness and capabilities on average of the suppliers that were mentioned in the interviews. This is because these suppliers may have a strong commitment to compliance and risk management, demonstrating their capability to navigate regulatory challenges

effectively (oboloo, 2021). Their willingness often stems from a proactive approach to addressing and mitigating regulatory risks.

Supplier 57 faces a high risk due to rules and regulations, as they supply a dual-use product. However, this is a common problem for any supplier of this product, as Allseas needs it for their projects. Therefore, the supplier tries hard to find solutions to reduce supply chain disruptions for Allseas. This should also apply to other suppliers since their goal is to sell their products even if there are rules and regulations. This will increase their willingness and capabilities to ensure that their product complies with the rules and regulations for this reason.

Additionally, these suppliers might view compliance with rules and regulations as a competitive advantage, showcasing their commitment to ethical business practices (oboloo, 2021). This is the case for supplier 60, where rules and regulations by the IMO have been put into place to ensure improvement of emissions in the maritime sector. They show they are willing and capable of adhering to regulations can enhance their reputation, attract more business opportunities, and foster long-term relationships with clients who prioritize compliance. Furthermore, this supplier invests in capabilities and resources specifically tailored to ensure regulatory adherence, demonstrating their commitment to meeting environmental industry standards. The reason why only a handful of suppliers can be used to deliver and manufacture this product is because of their environmental capabilities.

Suppliers that deal with rules and regulations tend to be more compliant and capable of handling complex regulatory environments. They demonstrate a proactive attitude toward reducing risks and promoting sustainable business practices in general. Therefore, the conclusion is that suppliers that face rules and regulations are more willing and capable, as otherwise they would lose business and market share to other suppliers that can prove their willingness and capability under the regulations.

The suppliers that had risks due to technical failures, 61 and 62, are both in the inept segment. This means they have low willingness and low capability. In both cases, the technical failure caused Allseas to switch to another supplier. This shows that their capabilities are poor, as they cannot handle such major supply chain disruptions. Suppliers facing technical failures have a double challenge that affects their willingness and capability. When ERP failures occur, it can have serious consequences for a supplier, such as longer lead times, lack of integration of purchasing, sales, and inventory, and higher costs (Xue, Liang, Boulton & Snyder, 2005). This was the case for suppliers 61 and 62.

In general, technical failures such as ERP failures can hurt a supplier's willingness and capability. They can cause financial stress for the supplier due to the costs of fixing the problems or losing customers because of long lead times (Xue et al., 2005). This can make the supplier more hesitant, or less willing, to take on additional commitments or risks since it could cost the supplier additional money or time to solve these issues. This can distract the supplier from new opportunities. Technically, failures can disrupt a supplier's normal operations, affecting their production capacity and delivery schedules and lowering their capability to meet quality standards consistently (Xue et al., 2005). The resources needed to deal with technical challenges can limit a supplier's overall capability to adapt to market demands and handle more projects effectively. Therefore, it can be concluded that suppliers facing a long period of technical failures are less capable. It can be assumed that because of this, their willingness is also impacted significantly negatively.

Similarly, the suppliers that had threats due to capacity utilization issues are in the inept segment. This is more difficult to generalize since there is only one supplier that faces capacity utilization issues in this research, however, capacity utilization is one of Kraljic's PPM supplier strength evaluation criteria, which can be seen in Table 2.3. This means that having capacity utilization issues is a supplier weakness.

Similar to the technical failures, these suppliers may face a dilemma between their willingness and capability due to capacity utilization issues. Capacity utilization affects productivity and profitability, therefore, capacity utilization issues will adversely affect this (Kurokawa, 2011). On one side, they may be reluctant to take on new commitments because they need to focus on their existing obligations

since taking on more work would worsen their capacity utilization problems further. On the other side, the capacity issues also limit their capability directly. They may not have enough resources, such as manpower or production facilities, to meet their current and future buyer's needs. They may also have to compromise on quality control processes, which would lower their capability to deliver high-quality outputs consistently. Therefore, even though drawing conclusions by analyzing just one supplier that faces capacity utilization issues, the conclusions are logical and much like those of suppliers facing technical failures. By not being able to deliver or meet buyers requirements, their capabilities drop and because of this, their willingness to cooperate will likely drop as well.

Suppliers facing raw material issues, like those facing capacity utilization issues and technical failures, belong to the inept segment. This means that they have low willingness and low capability. This is consistent with what Kraljic stated in 1983, that the scarcity of raw materials increases the competition, and technological change accelerates the need for innovation (Kraljic, 1983). These factors create challenges and uncertainties for the suppliers, affecting their performance and reliability (Kraljic, 1983). Issues with raw materials are not something that can be easily overcome, unlike rules and regulations. They are similar to capacity utilization issues or technical failures, which also pose significant challenges for the suppliers and are things suppliers have no to little influence on.

When raw materials are scarce, suppliers face financial pressure from higher costs and possible production disruptions. This is a market-wide problem. This pressure can reduce their capabilities and willingness to take on new risks or commitments, as they are more focused on solving the raw material shortages and may not know when the raw materials may arrive in order to continue producing products. The shortage affects their production capacity, which causes uncertain lead times. Since raw materials shortages are market-wide problems, low willingness, and low capabilities are generalizable results for suppliers facing raw material issues.

Finally, the supplier that has a risk due to the product uniqueness is in the overeager segment. This means that suppliers that offer a unique product or service and are often sole suppliers, are willing but often not capable. This conclusion is probably due to the challenges associated with managing and fulfilling the unique requirements of a specialized product. Suppliers dealing with unique products may be more eager or willing to secure long-term contracts or partnerships as a means of ensuring a stable demand for their specialized offerings. However, the term implies that these suppliers might be more prone to taking risks or making concessions in their eagerness to secure business opportunities, possibly exposing themselves to potential pitfalls or uncertainties associated with managing unique products.

Low capabilities may be because these suppliers face challenges in meeting the specific demands of their product, or because they lack the benefits of economies of scale or network effects that more common products have, which has been explained earlier in this chapter. However, the capabilities of these suppliers may vary depending on the product and the expert that is evaluating these suppliers. Some may consider them highly capable because of their expertise in a niche market, while others may see them as less capable compared to more diverse or standard suppliers. Therefore, the placement of these suppliers' capabilities in the matrix may not be consistent across different experts. However, their high levels of willingness is likely to be accurate and generalizable, as it reflects their desire to maintain a stable demand for their unique offerings.

6.2.10 Few Willingness Criteria in Supplier Pre-Qualification

There are few willingness criteria in the supplier pre-qualification questionnaire. Pre-qualification processes are designed to be objective, ensuring a standardized and fair evaluation across multiple suppliers. Willingness is a relatively subjective concept and poses challenges in quantification and objective assessment. Attitude or business ethics, for example, are both criteria that are difficult to quantify. Prioritizing concrete and easily measurable criteria helps maintain consistency and comparability in evaluations. Ad-

ditionally, more willingness criteria might create ambiguity and be subject to varying interpretations. Allseas chooses that the focus of pre-qualification is often on assessing core competencies, capabilities, and compliance with specific requirements, with willingness being considered a secondary factor in the initial stages.

6.2.11 The Procurement Department vs. the Technical Department

The procurement department has used the BWM to allocate new weights to supplier evaluation criteria. However, the procurement and the technical departments should be involved in this process since both departments work with these forms.

While involving both the procurement and technical departments in the process of allocating weights for supplier evaluation criteria is an ideal scenario, there are situations where relying on the expertise of the procurement department alone is justifiable. The procurement department typically possesses in-depth knowledge of market conditions, negotiation dynamics, and the organization's overall strategic goals. They also choose the suppliers at the end of the day since they purchase or subcontract goods and services. They can make sure that factors such as cost-effectiveness, contractual terms, and supplier relationships are given the right priority in the weighted assessments.

Moreover, the procurement department is often responsible for managing supplier contracts and maintaining a pulse on supplier performance. This practical experience equips them with valuable insights when determining the importance of various criteria in the evaluation process.

However, it is important to work together with the technical department. The technical department has specialized knowledge about product specifications and quality standards. They can provide technical input that the procurement department may not have. To achieve a balance, regular collaboration meetings or feedback sessions between the two departments should be arranged to discuss the findings of this report and the weight change.

6.2.12 Supplier 56

In Chapter 5, it was discussed that a risk interview with an expert revealed that Supplier 56 was a preferred and reliable supplier for analysis, despite having a unique product that could pose a supply risk. This seemingly contradictory situation prompts questions about how a supplier with a high potential for risks and disruptions can still be considered an ideal supplier. Several factors might explain the apparent contradiction. Firstly, Supplier 56 might offer products or services that are crucial to the operations or value proposition of the company, making them difficult to replace. Their uniqueness could be a strategic advantage, and despite the associated risks, the value they bring to the organization may outweigh the potential disruptions.

Additionally, the expert's identification of Supplier 56 as a reliable and preferred supplier might be based on historical performance, where the supplier has consistently met or exceeded expectations in terms of product quality, delivery timelines, or other critical factors. The expert may also consider the supplier's responsiveness to communication, overall capabilities, and willingness to collaborate in addressing challenges. The expert may have considered Supplier 56's unique offerings and their ability to navigate potential risks, making them an irreplaceable partner despite the acknowledged challenges.

6.3 Reliance on Qualitative Data

This research was based entirely on experts' opinions from the procurement department due to the lack of quantitative data and the nature of the research topic. The interviews faced some challenges, such as the limited availability of experts and the potential bias of the selected ones. However, these limitations

were alleviated by the fact that the interviews reached a saturation point quickly, indicating that the experts had similar views on the issue and that others would likely concur. For the PPM, the supply risk was calculated only based on the number of available suppliers, as this was the preference of the two experts who helped with this task. This was the only feasible way to measure supply risk, given the absence of other data sources and the expertise of the two experts. However, this method was inaccurate, as other factors, such as rules and regulations and geopolitical factors influenced supply risk. This was evident from the PPM for the selected suppliers (Figure 4.10), which showed that suppliers could move to different quadrants based on factors other than the availability of suppliers. This contradicted the assumption that the number of available suppliers solely determined supply risk. This difference in definition on what supply risk is and what it should entail is due to the poor definition of supply risk of the PPM by Kraljic, which leaves the definition open to interpretation. The results of the PPM are not considered to be inaccurate because of the way supply risk was measured, as it was defined consistently for all suppliers. However, the suppliers in the matrix are not static, as they can change their position due to other factors, such as the risks mentioned in the previous section.

Chapter 7

Conclusion

This research project has addressed the central question of how supplier relationship management (SRM) strategies can effectively mitigate supply chain risks. Using a novel approach by incorporating the Best Worst Method, a multi-criteria decision-making method, the study meticulously ranked and assessed supply chain risks, observing their impacts on the overall supply chain. The research laid a foundation for developing proactive and practical SRM strategies intended to preemptively address potential risks and enhance supply chain performance and resilience by effectively mitigating these risks.

This thesis highlights its limited risk mitigation capabilities by reconsidering lean management, a foundational concept in recent supply chain management. It suggests that a more relationship-based, agile, and communicative approach may prove more beneficial in the face of more recent, severe operational and disruption risks. The effectiveness of such an approach depends on the positioning of the buyer and its suppliers on the Purchasing Portfolio Matrix (PPM), the bargaining power the buyer and its suppliers possess, and the likelihood and severity of the associated supply risks.

The case study conducted at Allseas has provided a practical context for formulating strategic SRM recommendations, offering valuable insights applicable to the maritime industry. The multifaceted nature of SRM has been explained, emphasizing the pivotal role of communication in facilitating information exchange and early risk identification. Trust-building emerges as a fundamental component, fostering an environment of shared commitment to overcome challenges. Collaborative problem-solving is highlighted as a key feature, transforming suppliers into strategic partners with long-term contracts, actively finding innovative solutions to unforeseen disruptions, and improving trust and communication strategies for timely risk mitigation.

Furthermore, the study underscores the significance of segmentation and prioritization of suppliers based on supply risk, profit impact, capabilities, and willingness, utilizing the Integrated Supplier Matrix (ISM). These factors are deemed essential for determining whether to invest in suppliers to enhance their capabilities where most needed and to direct targeted risk mitigation efforts effectively. Continuous performance monitoring, flexibility, and adaptability are crucial for ongoing assessment and the swift implementation of corrective actions. Regularly reevaluating important trade-offs and ensuring that criteria on pre-qualification and evaluation forms accurately reflect the capabilities and willingness of a supplier are crucial. Given that high-risk suppliers, on average, exhibit lower capabilities and willingness and have a larger profit impact than low-risk suppliers, it is recommended to focus efforts on understanding and developing tailored SRM strategies for these suppliers. Considering the relatively low percentage of high-risk suppliers (13% in the case of Allseas), the study suggests that time and effort should be directed toward scrutinizing these suppliers, while for suppliers with minimal risk and high levels of substitutes, buyers should adopt dual-sourcing strategies to ensure resilience.

Integrating SRM and risk mitigation is recommended in ERP implementations and/or through collaborative initiatives between buyers and suppliers. Actively integrating communication, trust-building, and

collaborative problem-solving, SRM contributes to a resilient procurement supply chain well-equipped to navigate uncertainties and build enduring partnerships with suppliers. For smaller or larger companies, incorporating risk mitigation through supplier relationship management is essential for maintaining a robust and adaptable supply chain.

7.1 Sub-Question 1

- How can procurement-related risks be identified and prioritized?

Data collection methods such as interviews and surveys were used to identify and prioritize procurement-related risks. Ten experts from the procurement department with different backgrounds and roles were interviewed about the risks they perceived and faced in their work. A risk was defined as any disruption to the supply chain. The interview questions (see Appendix E) covered the risks' types, impacts, and mitigation strategies. The interview data was coded and analyzed using Delve, turning the qualitative data into quantitative data. The perceived risks were compared with the encountered risks. The experts frequently mentioned four risks: uniqueness of product, rules and regulations, external factors, and communication. However, communication was found to be a result of other risks, not a risk itself. Therefore, only three risks were selected for the ranking, based on the criterion that they had to be repeatedly mentioned by more than one expert. This ensured that the risks were credible and generalizable, as they represented the common challenges and issues that the procurement department faced in the supply chain. After the seventh interview, no new risks emerged, indicating interview saturation.

The ranking of the risks was based on the simplest definition of risk: the severity and the probability of the disruption. Three experts not interviewed before were asked to rank the three risks using the BWM, a MCDM method. The average scores of the experts showed that the uniqueness of a product was the most important risk (49%), followed by rules and regulations (32%) and external factors (19%). However, all the risks mentioned in the interviews should be considered, as they may still affect the supply chain flow, even if the procurement department at Allseas has not experienced them.

To conclude, to identify and prioritize procurement-related risks, a case study at a procurement department should be done using interviews, and repeated risks from the interviews should be compared and prioritized using a MCDM method, such as the BWM.

7.2 Sub-Question 2

- What is the relationship between supplier segments and the identified risks?

Suppliers were segmented using the Integrated Supplier Matrix (ISM) based on capabilities, willingness, profit impact, and supply risk. Using the supplier segments from the ISM, general and specific conclusions can be drawn on relationships between supplier segments and identified risks.

General conclusions can be drawn from relationships between supplier segments and risks. Firstly, suppliers classified as high risk, with a supply risk exceeding 50%, have lower average levels of willingness and capability compared to their low-risk counterparts, with supply risks equal to or less than 50 %. Interestingly, on average, high-risk suppliers contribute four times more to profit impact than their low-risk counterparts.

During the interviews, the risks the procurement department at Allseas had experienced were explained, as well as the reason for this risk, the consequence of this risk, and the supplier involved. After seven interviews, the interviews reached a point of saturation, and the conclusion was that seven suppliers have been notable (and all have been repeated more than once) during the interviews that can be seen

as risky due to the possible disruptions they can and have caused to the supply chain at Allseas. These seven suppliers were segmented separately on the ISM with their corresponding risks.

Even though limited data is available, the following relationships between supplier segments and identified risks can be considered generalizable after comparing the results using literature and logical reasoning. The suppliers that faced or still face risks due to rules and regulations are in the upper segments of the matrix, in both the overeager and reliable segments. This means that the suppliers, on average, have the highest willingness of high-risk suppliers and relatively high capabilities. Suppliers that had risks due to technical failures are found in the inept segment, meaning they have low willingness and low capabilities. Similarly, the suppliers with threats due to capacity or raw material issues are also found in the inept segment. Finally, the supplier that has a risk due to the uniqueness of their products is in the overeager segment, which means that these suppliers have high willingness but lower capacities. The generalizability of the capabilities of suppliers with a unique product is debatable. The rest of the conclusions can be assumed to be generalizable.

7.3 Sub-Question 3

- What SRM recommendations can be implemented to mitigate the identified risks effectively?

Navigating the intricacies of supply chain dynamics requires a nuanced approach to Supplier Relationship Management (SRM). The PPM serves as a crucial starting point, delineating power imbalances and signaling the potential for long-term partnerships. Fostering meaningful relationships lies at the core of effective SRM strategies, particularly when dealing with suppliers located on the right-hand side of the PPM, possessing unique products and heightened bargaining power.

The ISM enhances the SRM toolkit, offering a comprehensive framework to assess suppliers based on capabilities, willingness, supply risk, and profit impact. Recognizing the trade-offs within SRM, such as the willingness-capability balance, aids in strategic supplier selection. Regular supplier risk assessments are paramount, ensuring adaptive SRM strategies that align with the evolving risk landscape.

Allseas focuses on moving to the strategic quadrant of the PPM. This presents an opportunity to consolidate suppliers and cultivate deeper relationships, emphasizing communication and trust. However, to effectively navigate this transition, the ISM plays a crucial role in evaluating supplier willingness to engage in a more strategic partnership with the buyer.

While the PPM provides a broad strategic direction, the ISM delves deeper, considering economic value, supply risk, supplier capabilities, and willingness. The willingness of suppliers becomes particularly significant when contemplating a shift towards strategic collaboration. Suppliers positioned in the strategic quadrant should not only have the capability to deliver but also demonstrate a willingness to engage in a more collaborative, long-term relationship.

Building robust relationships with key suppliers through targeted trust and communication emerges as a pivotal risk mitigation strategy. This approach establishes an early warning system, facilitating proactive risk mitigation by promptly addressing potential issues. Trust enables collaborative problem-solving, fostering innovative solutions to unforeseen challenges. The adaptability and flexibility inherent in trusted relationships become instrumental in navigating uncertainties in the business environment. Continuous communication and feedback contribute to ongoing performance improvement, mitigating the likelihood of performance-related risks.

For Allseas, a company operating in a complex maritime environment, long-term contracts and dual sourcing emerge as favourable options, providing stability and flexibility. Incorporating the ISM into procurement practices, aligning with the pre-qualification and evaluation criteria, can offer a more nuanced understanding of supplier dynamics. Recognizing the significance of supplier willingness in developing SRM strategies aligns with industry practices and literature. Timely information exchange, facilitated

through trust, emerges as a linchpin in risk reduction, enabling proactive decision-making and enhancing the overall resilience of the supply chain.

7.4 Research Limitations and Recommendations for Future Research

The primary research limitation arises from the predominant reliance on qualitative data obtained through expert interviews. This approach demanded considerable time and effort from experts, who faced challenges in allocating valuable time amid their engagement in a significant procurement project during the second week of November (the 6th week of this thesis). The time-consuming nature of the process underscores the inherent challenge of depending on individuals for information, creating a sense of discomfort in recurrently seeking additional information or interviews due to substantial workloads and time constraints.

For instance, the limitation is evident in the context of the supplier evaluation form. While it was conceivable to complete 62 forms (for 62 suppliers) individually during the thesis period for enhanced accuracy, the impracticality of relying on multiple experts to contribute to all 62 forms became apparent. Time limitations and the demanding workloads of the experts rendered this approach unfeasible.

Another limitation in this thesis is the inherent bias towards the procurement department, assuming it is the sole department engaged with suppliers, even though the technical department is also strongly involved in supplier evaluations. The recommendation for future research includes a revision of the BWM supplier evaluation criteria weights, particularly through engaging the technical department. While this is a recommendation for future research, time constraints prevented the execution of this additional research. Next to this, the thesis's focal point within the procurement department of Allseas naturally led to an emphasis on procurement-related aspects.

Another notable limitation stems from the absence of relevant literature on certain (specific discussion points) discussion points in Chapter 6, necessitating conclusions through logical reasoning. The scarcity of existing research in specific areas highlights the need for further exploration to build a better foundation for future discussions and analyses.

Moving to recommendations for future research, a crucial aspect involves substantiating the generalizability of findings. A comparative analysis between regular suppliers and subcontractors at Allseas, supported by gathering supplier evaluation forms for a sample of 62 randomly selected suppliers, could empirically assess the hypothesis that lower-risk suppliers demonstrate higher willingness and capabilities. Interview saturation during this research limits the ability to segment and compare risks across a broader spectrum of suppliers within a company like Allseas. To enhance robustness and generalizability, it is recommended that future research includes more case studies from similar maritime companies. This is because relying on a single supplier per segment for conclusions is challenging, and multiple case studies are crucial for a more generalizable analysis.

An alternative approach for future research involves interviewing experts about suppliers with minimal to no risk. Although this approach couldn't be implemented in this thesis due to workload constraints, the provided interview script in Appendix F is a valuable resource for future researchers exploring this alternative research direction.

Another avenue to enhance generalizability is to compare the evaluation scores of suppliers before and after a supply chain disruption occurred. Unfortunately, constraints during this research, such as the unavailability of supplier evaluation forms for suppliers before the disruption had occurred, prevented such an analysis. For future research, it is recommended to determine the supplier's locations on the ISM, specifically their willingness and capabilities, and compare it after a risk occurrence to understand the influence of a supply chain disruption on the supplier's location on the ISM.

Furthermore, the reliance on the BWM as the chosen MCDM method opens up avenues for further investigation. Future research could explore alternative MCDM methods and compare their results with those obtained from the BWM. This comparative analysis can enhance the validity and reliability of decision-making frameworks in supplier evaluation, providing valuable insights into the sensitivity of results to the chosen decision-making model.

Another limitation is the perception-based nature of this thesis. As was previously explained in Chapter 6, Allseas operates within a dynamic and complex environment where the perception of risk can be as influential as the tangible risks themselves. Recognizing the subjective nature of risk assessment, particularly in SRM, is fundamental to understanding the findings and recommendations uncovered in this research.

Next to buyers' perceptions, the reliance on second-hand data from supplier evaluation forms is also a limitation. The absence of first-hand data introduces a potential source of bias to this report. Relying solely on secondary data may have limited the depth and accuracy of the case study results and analysis, as it might not capture the suppliers' perspectives, experiences, or nuances that can only be obtained through direct interactions. Additionally, if criteria for supplier willingness and capabilities were chosen for this report, they would probably be different to the supplier evaluation form criteria provided by Allseas. As discussed in Chapter 6, the supplier evaluation form has limitations, including criteria that may not be universally relevant to all suppliers, thereby influencing their willingness and capabilities scores. A comprehensive list of criteria is proposed for future research to enhance the findings and promote fairness in the results by ensuring relevance to all suppliers. There are notably more willingness criteria than on the supplier evaluation form. This decision aims to prevent a single low score in willingness criteria from disproportionately impacting the overall supplier scores. This criteria table is available in Appendix H.1.

By its very nature, procurement is susceptible to individuals' subjective interpretations and judgments. This can be seen in the scoring of the supplier evaluation forms, which could vary per individual. Factors such as personal experiences, communication dynamics, and internal pressures contribute to the perception-based nature of the thesis. While the study has tried to maintain objectivity, it is crucial to acknowledge the inherent subjectivity of risk evaluations, particularly in a field where human judgments significantly impact decision-making. This is why one of the recommendations in Chapter 5 is to use an AI-driven data system to alert experts on worldwide risks and to adjust supply risk accordingly; this way, decision-making can become more data-driven. A recommendation based on this would be to provide training and awareness programs on risk management and perception biases to stakeholders and experts at both the technical and procurement departments, which can enhance the awareness of individuals involved in the decision-making process. By creating a culture of data-driven decision-making, collaboration, and continuous improvement, Allseas can navigate the challenges posed by the perception-based nature of supply risk, ultimately improving the resilience of its supply chain.

7.5 Recommendations for Allseas

The supplier evaluation forms had two main problems, which were mentioned in Chapter 6. The first issue is that the forms span from 2018 to 2023, and it would have been better to have all been done more recently, preferably within the span of this research, as this could have made the results more accurate. Using the same form and a short time frame, it can be assumed that the results are as accurate as given the time constraint. However, due to time individual time constraints as well as the limited time experts had to assist with the project, this was not realistic to do in the time allocated for the thesis. However, in an ideal situation or for further research, it is recommended to redo the supplier evaluation forms per subcontractor, and it would be interesting to compare the placement of subcontractors on the ISM regarding time since suppliers may have shifted.

The second issue with the form is that where a criterion does not apply to a supplier, the score given to the supplier is a 0, which is taken into account and reduces the supplier's overall score. This is often unfair to the supplier's score. As a recommendation to Allseas, the supplier evaluation form template should be revised to ensure scores where the subcontractor's score is not applicable, this should not be considered when scoring the subcontractor. Next to this, possible revision of the criteria weights should be looked into since Chapter 4 showed clear differences in preference of criteria weights using the BWM.

To ensure that the weights reevaluated using the BWM with experts at the procurement department are accurate enough to be applied, the technical department should be involved and also take part in the weighing of the criteria using the BWM. To ensure a balance, the two departments should have regular meetings or feedback sessions to discuss this report's findings and the change in weight.

Communication should be included in the supplier evaluation forms as an expert suggested that it was lacking, and timely communication of supply chain disruptions can help reduce the overall impact of the disruption by enabling quick risk mitigation or activation of contingency plans.

Looking at the supplier pre-qualification form, similar to the evaluation form, when a supplier gets a score of 0 where the criteria are not applicable, it reduces their overall score. Some experts at Allseas do not use the pre-qualification form to select and score suppliers. Instead, they use it as a reference for the tendering process. This creates inconsistency in the application of the form. Therefore, Allseas may benefit from establishing a common guideline on how to use the form properly.

The pre-qualification form also assigns a sector to each supplier based on the terms and conditions they meet, such as heavy lifting. However, the form does not change its format according to the sector selected, even though some criteria are specific to certain sectors. This means that some suppliers may get a score of 0 for criteria that are not applicable to their sector because the document is unclear or irrelevant. This lowers their overall score unfairly due to Allseas' lack of customization of the form. This is an issue that needs to be addressed to improve the pre-qualification process.

Allseas' pre-qualification questionnaire lacks three criteria that are prominent in the literature: appropriate insurance coverage, attitude, knowledge, and compliance with government regulations. This is a significant gap, as the experts at the procurement department at Allseas identified rules and regulations as the second highest risk factor. Therefore, adding this criterion to their evaluation form may be very beneficial.

The supplier pre-qualification form should include more willingness criteria, as they are part of the supplier evaluation form. The most important willingness criterion to include is supplier attitude since this criterion scored the highest weight of criteria in the evaluation form. Willingness criteria are important for assessing the supplier's suitability and compatibility for a long-term relationship. The two forms should be consistent and coherent, as they are both used to select and monitor the suppliers. Therefore, the pre-qualification form should be revised.

This report shows that PPM is insufficient for segmenting suppliers and determining SRM strategies, as it overlooks the social aspect of relationships, the varying definitions of supply risk, and the importance of willingness and capabilities of suppliers. The PPM is rigid and not risk-mitigating. This report shows that the ISM provides a more comprehensive and well-rounded overview for SRM recommendations, as it considers the possible risks and trade-offs in each segment. Therefore, it is recommended to look into different ways of segmenting, specifically by using the ISM in the future to develop more well-rounded SRM strategies.

As the implementation of the new ERP system is currently underway at Allseas, it is advisable to introduce a dedicated risk widget or icon as part of the system's interface. This feature would serve as a visual representation to highlight and manage potential risks associated with various aspects of the system and its integration. The risk widget could be designed to provide instant access to a dashboard displaying critical risk factors, such as data integrity issues, system vulnerabilities, or potential disruptions during the implementation phase. This, alongside an integrated sophisticated monitoring system integrated

into the ERP, could analyze daily global news and maritime forums, promptly alerting the procurement department through automated notifications when significant events, such as the emergence of pandemics like COVID-19, geopolitical disasters or changing maritime rules and regulations, occur. This way, the risk level and risk score of suppliers can be changed accordingly. Within the intranet, specifically on SharePoint, a visual indicator in the form of colored balls can be incorporated alongside supplier names to represent their associated risk levels visually.

7.6 Scientific Contributions

This thesis makes several significant scientific and managerial contributions to the field of SCM, particularly in the context of procurement and SRM in the maritime industry.

Firstly, this research advances the understanding of procurement-related risks in maritime supply chains. By analyzing the industry-specific risks faced by Allseas and categorizing them into disruption and operational risks, this study provides a better view of the challenges inherent in procuring goods and services critical to the maritime industry. These findings contribute to the broader literature on supply chain risk management by offering insights into the maritime sector's unique supply chain and procurement challenges posed by procurement-related issues.

Furthermore, this thesis introduces a novel approach to risk prioritization using the BWM. By employing this multi-criteria decision-making model, the research enhances the toolbox available to supply chain practitioners and academics to identify and rank supply chain risks based on probability and severity. This methodological contribution aids the practical identification of risks and offers a structured approach for decision-makers to allocate time and resources for risk mitigation effectively.

Additionally, this research presents an innovative application of supplier segmentation models, including the PPM and the SPM, to the procurement context in the maritime industry, even going as far as developing a newly revised model, the ISM to systematically categorizing suppliers based on their strategic importance and performance potential. This study offers guidelines and recommendations for organizations like Allseas to optimize and better manage their supplier relationships. This contributes to the body of knowledge in SRM by demonstrating how such segmentation can be applied practically to enhance supplier performance and reduce risks.

Lastly, the thesis provides a set of actionable SRM strategies tailored to address the identified procurement-related risks and procurement challenges. These strategies encompass supplier selection criteria, collaboration frameworks, and supplier evaluation and management processes. By offering concrete recommendations grounded in empirical research, this work bridges the gap between theory and practice in SRM, equipping maritime procurement professionals with practical tools to strengthen supplier relationships and enhance supply chain resilience.

In summary, this research contributes to the field of SCM by shedding light on the complexities of procurement-related risks and challenges in maritime supply chains, introducing a novel risk prioritization methodology, showcasing the practical application of supplier segmentation models, and providing actionable SRM strategies.

7.7 Academic Reflection

This research project significantly contributes to the existing literature by addressing a knowledge gap related to the practical implementation of supplier relationship management strategies. The study bridges theoretical insights, drawn from an extensive literature review in Chapter 2, with real-world applications through a comprehensive case study at a company. By integrating supply chain theories and concepts, the thesis transforms theoretical knowledge into practical applications, providing valuable insights into

the implementation of strategic procurement strategies. The developed SRM framework, introduced in Chapter 2, combines insights from various sources, enriching our understanding of risk and resilience in procurement and supply chain management.

The strategic procurement approach adopted in this thesis not only focuses on risk mitigation but also identifies and leverages opportunities for enhanced resilience within the supply chain. The exploration of trade-offs in SRM, including the pros and cons of decisions such as long or short-term contracts, emphasizes a holistic perspective. Additionally, a novel approach to supplier segmentation involves redefining and enhancing the Supplier Potential Matrix (SPM) by incorporating coloured bubbles in a bubble chart which leads to the creation of the Integrated Supplier Matrix (ISM). This redesign, accompanied by clear segment titles (reluctant, inept, overeager, and reliable), enhances the clarity and analytical capability of the ISM and the SPM.

The ISM introduces links between supplier segments and associated risks, facilitating the development of a practical plan and guidelines for strategic risk mitigation. Moreover, incorporating MCDM methodologies in the decision-making process for risk mitigation enhances the evaluation and selection of strategies to improve supply chain resilience.

Reflecting on perspectives from diverse academic disciplines, such as management, economics, and decision-making, provides a comprehensive understanding of the thesis topic. This interdisciplinary approach ensures a well-rounded exploration of the complexities within procurement, supplier relationship management, and supply chain resilience.

Looking ahead, the thesis suggests future implications and research directions, emphasizing the need for more substantial efforts in the field of procurement, supplier relationship management, and supply chain resilience. This research lays the groundwork for further exploration and advancements in these critical areas by reducing the knowledge gap and contributing to the existing literature.

7.8 Managerial Implications

The findings of this study offer crucial insights for managers, specifically in the maritime industry, and particularly those involved in procurement and supply chain management. Managers should prioritise effective risk management strategies to address modern supply chains' escalating vulnerabilities and disruptions. By integrating theoretical SRM approaches with the MCDM methods, such as the BWM, managers can fortify the resilience of maritime supply chains. This involves a shift from the conventional lean management framework to an agile supply chain management approach, emphasizing collaborative relationships, trust-building, and enhanced communication to effectively navigate the dynamic nature of supply chain risks.

Strategic supplier segmentation emerges as a key consideration for managers, and the Integrated Supplier Matrix (ISM) presents a comprehensive framework. By evaluating capabilities, willingness, profit impact, and supply risk, the ISM aids in informed supplier selection, providing managers with valuable decision-making tools. The case study conducted at Allseas offers a practical methodology for real-world application, guiding managers in analyzing and prioritizing risks, understanding relationships between risks and supplier segments, and formulating SRM strategies in a practical context.

Managers should also consider trade-off analyses in SRM, weighing factors such as inventory management, contract duration, sourcing strategies, in-house manufacturing, and investing in or switching incumbent non-performing suppliers. Recognizing the pivotal role of communication and trust-building in these trade-offs is crucial for effective risk mitigation. The SRM framework (Figure 2.8) developed also brings choices and trade-offs into light, which can be used as a starting point for managers to make necessary adaptations. Additionally, the framework integrates risk management practices into SRM.

Incorporating these managerial implications into their practices, managers can navigate the complexities of maritime supply chains, optimize supplier relationships, and establish a more resilient and adaptive

procurement strategy. Additionally, managing the expectations of internal stakeholders is essential for ensuring a cohesive understanding of supplier criticality and risk factors within the organization.

7.9 MOT Perspective

In the course of the management of technology (MOT) journey, there have been various subjects that collectively lay the foundation for this Master's thesis. Upon reflection, each module has provided invaluable tools and perspectives crucial to this thesis research. Notably, the Leadership and Technology Management course broadened the understanding of organizational performance, a key factor in evaluating supplier relationship management strategies. Proficiency in financial policies and analysis, gained through Financial Management, offers insights into financial aspects of procurement decisions. Economic Foundations provided insights into risk management. Research Methods added skills such as market prediction and distribution, forming the basis for data-driven decision-making for this research. Additionally, the Social and Scientific Values course honed data collection and analysis abilities, reinforcing this thesis's empirical foundations. This course also showed the importance of ethical considerations when collecting data from people, like during interviews. The Digital Business Process Management and Inter- and Intra-organizational Decision Making courses played a crucial role in shaping skills in hypothesis testing and understanding accountability and responsibility in supplier relationships. The exposure to various courses has enriched this academic experience, ensuring this thesis was approached with a multifaceted and well-rounded perspective.

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Appendix A

Search Description and Constraints

The constraints can be seen in Table A.1. Next to the constraints found in the Table, smaller things such as if the paper was a full text, the number of citations (minimum of 150 citations), and relevant titles and abstracts were looked at to confirm the sources found using the criteria in the Table were relevant.

I quickly noticed that much supply chain management literature is relatively outdated; the articles I learned most from were published from 1994 onwards. However, I found using these sources for definitions of terms coined in those articles, such as the definition of procurement or supplier relationship management, was a beneficial place to retrieve the correct definition from, and was therefore, used in a few cases. Using the ‘AND’ operator on Scopus and quotation marks on Google Scholar allows me to obtain search results that include all specified terms, effectively narrowing down my search.

Table A.2 shows examples of the key word search on Scopus.

Table A.1: Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Language	English	Anything other than English
Field	Engineering	Not engineering
Document Type	Peer-reviewed journals, books, chapters of books, grey literature	Newspaper articles, blogs
Subject Area	Supply chain management, risk mitigation in supply chain management, procurement, challenges in procurement supply chain management, supplier relationship management strategies	Anything other than supply chain management risk mitigation, procurement or supplier relationship management as central themes
Relevance	Papers including, relating to or discussing the effect of the subject area mentioned	Anything other than supply chain management risk mitigation, procurement or supplier relationship management as central themes
Date	Papers published after 2000, unless it defined a main principle or concept and was referred to often in other literature	Anything irrelevant and older than 2000

Table A.2: Results of online search

Search term	Search Engine	Hits
Procurement AND “Supply Chain Management”	Scopus	23
Procurement AND {Supply chain disruptions}	Scopus	2
Procurement challenges AND “Supply Chain Management”	Scopus	4
{Challenges in procurement} AND “Supply Chain Management”	Scopus	3
{Procurement strategies} AND {Supply Chain challenges}	Scopus	1
“Supplier relationship management” AND Procurement	Scopus	1
“Supplier relationship management” AND {Supply Chain performance}	Scopus	2

Appendix B

Supplier Selection Criteria

Table I Dickson's supplier selection criteria (Dickson, 1966)

Number	Criterion	The importance of criterion
1.	Quality	Very high importance
2.	Delivery	
3.	Performance History	
4.	Warranties & Claims Policies	
5.	Production Facilities and Capacity	Great importance
6.	Price	
7.	Technical Capability	
8.	Financial Position	
9.	Procedural Compliance	
10.	Communication System	
11.	Reputation and Position in Industry	
12.	Desire for Business	
13.	Management and Organization	
14.	Operating Controls	
15.	Repair Service	Medium importance
16.	Attitude	
17.	Impression	
18.	Packaging Ability	
19.	Labor Relations Record	
20.	Geographical Location	
21.	Amount of Past Business	
22.	Training Aids	
23.	Reciprocal Arrangements	Low importance

Table II Elram supplier selection criteria (Elram, 1990)

Number	Criterion	Number	Subcriterion
1.	Financial aspects	1.1.	Economic performance
		1.2.	Financial stability
2.	Organizational culture and strategy issues	2.1.	Trust
		2.2.	Management attitude/outlook for the future
		2.3.	Strategic fit
		2.4.	Top management capability
		2.5.	Capability across levels and functions of buyer and supplier firms
		2.6.	Supplier's organizational structure and personnel
3.	Technology issues	3.1.	Assessment of current manufacturing facilities/capabilities
		3.2.	Assessment of future manufacturing capabilities
		3.3.	Supplier's design capabilities
		3.4.	Supplier's speed in development
4.	Other factors	4.1.	Safety record of the supplier
		4.2.	Business references
		4.3.	Supplier's customer base

Table III Weber's selection criteria (Weber et al., 1991)

Number	Criterion	The importance of criterion
1.	Net price	Great importance
2.	Delivery	
3.	Quality	
4.	Production facilities and capabilities	Low importance
5.	Geographical location	
6.	Technical capabilities	
7.	Management and position in the industry	
8.	Reputation and position in the industry	
9.	Financial position	
10.	Performance history	

Figure B.1: Supplier selection criteria (Stević, 2017, p. 24)

Appendix C

Example Application of BWM

Criteria Number = 5	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5
Names of Criteria	Quality	Delivery	Performanc	Warranties	Price

Select the Best	Quality
-----------------	---------

Select the Worst	Price
------------------	-------

Best to Others	Quality	Delivery	Performanc	Warranties	Price
Quality	1	3	6	7	8

Others to the Worst	Price
Quality	8
Delivery	7
Performance	4
Warranties	2
Price	1

Weights	Quality	Delivery	Performanc	Warranties	Price
	0.52773826	0.21906117	0.10953058	0.09388336	0.04978663

Input-Based CR	0.28571429	The pairwise comparison consistency level is acceptable
Associated Threshold	0.2958	

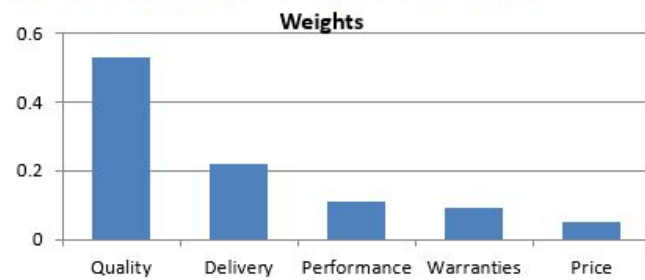


Figure C.1: BWM practice on supplier evaluation criteria by Weber et al. (1991, p.4)

Appendix D

Maritime Risks vs. Supplier Criteria

Table D.1: Maritime risks compared to Kraljic's supplier criteria

Risk	Supplier Strength/ Weakness Criteria	Explanation
Insufficient coordination	(4) Cost and price structure (3) Capacity utilization	(4) There can be potential costs in the event of non-delivery or inadequate quality, as insufficient coordination can lead to quality issues and extra costs. (3) Coordination problems can affect production efficiency.
Inadequate information exchange	(10) Logistics solution	(10) Inadequate information exchange can hinder smooth flow of logistics and information within the supply chain, leading to disruptions.
Organizational inefficiencies	(4) Cost and price structure (3) Capacity utilization	(4) Organizational inefficiencies can lead to higher costs. (3) Organizational inefficiencies can impact a supplier's ability to meet demand efficiently.
Human-related incidents, Labor strikes	(7) Break-even stability (8) Uniqueness of product	(7) Labor strikes and inadequate working conditions could disrupt a supplier's production capacity and stability. (8) These incidents can affect the availability of unique products.
Human-related incidents, Pandemics	(8) Uniqueness of product	(8) These incidents can affect the availability of unique products.
External factors, Geopolitical, Natural disasters	(7) Break-even stability (3) Capacity utilization	(7) Technical failures can affect the supplier's ability to maintain efficient operations. (3) Supplier's production capacity can lead to bottlenecks.
Transportation issues	(10) Logistics solution	(10) If a supplier's transportation system is unreliable or prone to disruptions, it can lead to delays and disruptions in the supply chain, affecting their ability to meet demands.
Raw materials shortage	(7) Break-even stability (8) Uniqueness of product	(7) A raw materials shortage can disrupt a supplier's production stability and capacity utilization, affecting their ability to deliver products on time, impacting operations and costs. (8) Suppliers relying on unique raw materials can be more vulnerable to shortages.
Technical failures, System failures, Cyber attacks	(4) Cost and price structure (8) Uniqueness of product	(4) Potential significant costs as a result of external factors in the event of non-delivery or inadequate quality can happen if supplies are disrupted. (8) Certain suppliers can uniquely be affected by these external factors.

Appendix E

Interview Script on Risks

Please note that risk is defined as any occurrence that disrupts the supply chain in any way (time, profit, quality, etc).

I will be recording and transcribing all interviews for my thesis. However, I will not be including any names in my research. An example of the answer sheet that will be used can be found below, Figure E.

Brief background information

1. Could you briefly describe your role and responsibilities within the procurement department at Allseas?
2. How long have you been working in this role?

Risks perceived

3. From your perspective, what are some of the key types of risks that Allseas faces in its procurement supply chain operations?

Risks/ supply chain disruptions experienced

4. Have you or your team encountered any significant procurement or supply chain disruptions (risks) in the past? If yes, could you share a few examples or describe the situation?

The more risks experienced, the better! Preferably at least 7+ if possible.

- For the given situation, what is the type of risk for this scenario?
- For the given situation, what was the consequence?
- For the given situation, which supplier (or supplier type) was involved?
- When did the given situation occur?

Risk prioritization

5. In your opinion, which of these risks do you consider the most critical or impactful to Allseas' procurement supply chain?
6. Are there any specific factors or criteria that you use to prioritize or assess the severity of these risks?

Risk mitigation

7. What strategies or measures does Allseas currently have in place to mitigate or manage procurement and supply chain risks?

8. Are there any improvements or changes you believe could be made in risk management within the organization?

Other questions

9. Is there anything else related to procurement supply chain risks at Allseas that you would like to share, that we haven't discussed?

Thank you for your time!

It may be possible that I will conduct a second round of interviews to help rank the complete list of risks.

Answer sheet interview round 1

Background information					
Name interviewee					
Question 1					
Question 2					
Risks perceived					
Question 3					
Risks experienced					
Question 4	Risk explained	Type of risk	Consequence	Supplier	Date
Example risk 1					
Example risk 2					
Example risk 3					
Example risk 4					
Example risk 5					
Example risk 6					
Example risk 7					
Example risk 8					
Example risk 9					
Example risk 10					
Question 5					
Risk prioritization					
Question 6					
Question 7					
Risk mitigation					
Question 8					
Question 9					
Other					
Question 10					

Figure E.1: Example interview answer sheet

Appendix F

Interview Script on Supplier Performance

This round of interviews is on identifying suppliers that are not posing significant risks and are performing exceptionally well in the supply chain.

I will be recording and transcribing all interviews for my thesis. However, I will not be including any names in my research. An example of the answer sheet that will be used can be found below, Figure F.1.

Brief background information

1. Could you briefly describe your role and responsibilities within the procurement department at Allseas?
2. How long have you been working in this role?

Supplier Performance Assessment

3. From your perspective, are there suppliers that have consistently performed exceptionally well and have not posed significant risks in Allseas' procurement supply chain operations?
4. What criteria or factors are used to assess the exceptional performance of these suppliers?
5. Can you provide specific examples of suppliers that meet these criteria and explain why they are considered exceptional?
 - For each supplier, what are the key strengths and contributions they bring to Allseas?

Benefits and Impact

6. How have these suppliers positively impacted Allseas' procurement supply chain in terms of reducing supply chain disruptions?

Future Engagement

7. Does Allseas plan to continue engaging with these suppliers, and if so, in what capacity?
8. Are there any strategies or plans in place to maintain and strengthen these supplier relationships?

Other questions

9. Is there anything else related to exceptional supplier performance in procurement supply chain management at Allseas that you would like to share, that we haven't discussed?

Thank you for your time!

Background information		Code
Question 1		
Question 2		
Supplier performance assessment		
Question 3		
Question 4		
Question 5	Supplier name	
Example supplier 1	Strengths/contributions	
Example supplier 2		
Example supplier 3		
Example supplier 4		
Example supplier 5		
Example supplier 6		
Example supplier 7		
Example supplier 8		
Example supplier 9		
Example supplier 10		
Benefits and impact		
Question 6		
Future engagement		
Question 7		
Question 8		
Other		
Question 9		

Figure F.1: Example interview answer sheet

Appendix G

Integrated Supplier Matrix

The full-scale Integrated Supplier Matrix (ISM) can be found on the next page of this Appendix.

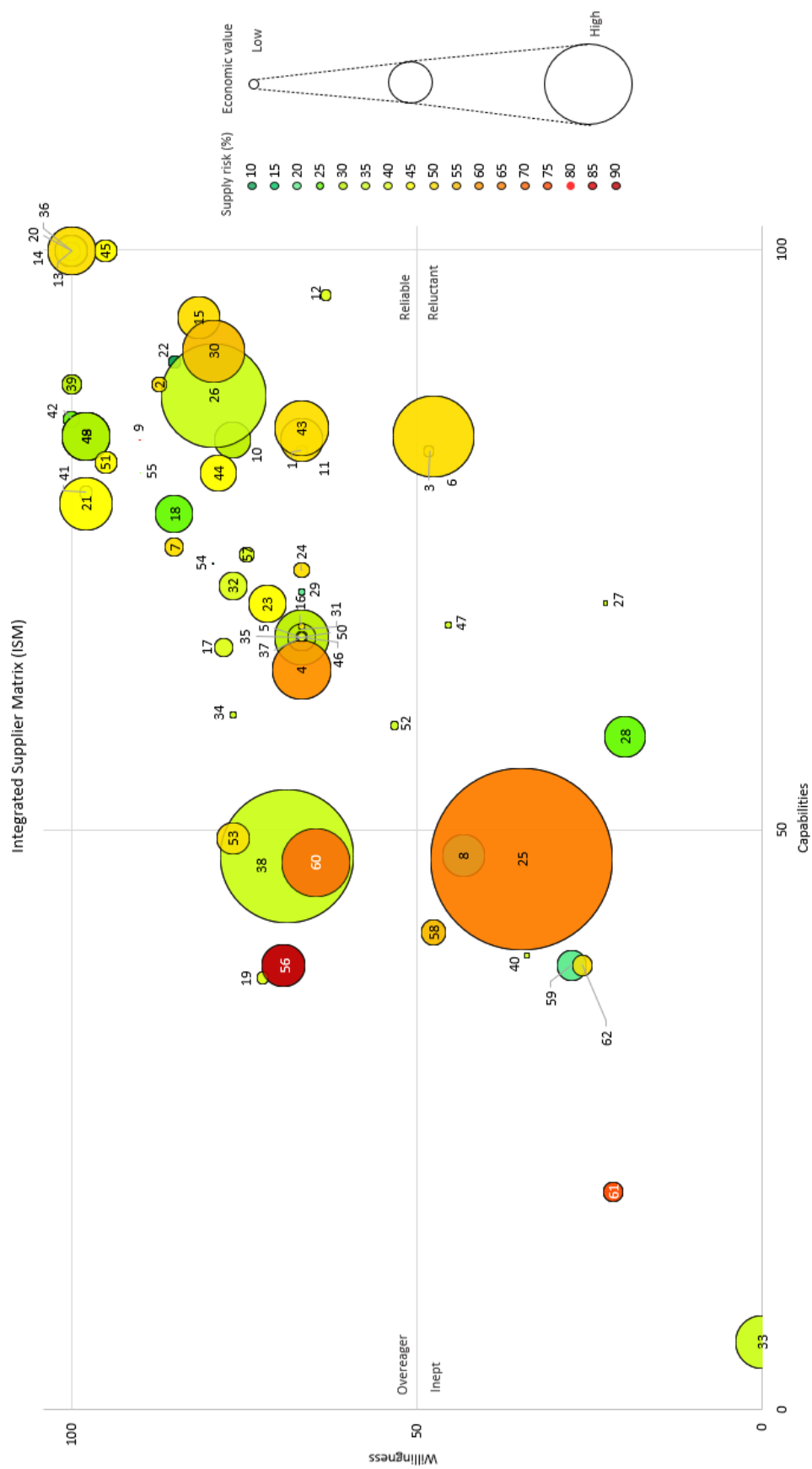


Figure G.1: Full-size Integrated Supplier Matrix

Appendix H

Supplier Willingness and Capabilities Criteria

If a specific criteria table for evaluating supplier willingness and capabilities had been developed for this study, it would have incorporated the following criteria. This selection is derived from a comparison of literature on supplier willingness and capability criteria (Rezaei & Lajimi, 2019) and the consideration of frequently cited supplier evaluation criteria (Kant & Dalvi, 2017), (Kara & Firat, 2016). There are notably more willingness criteria than on the supplier evaluation form. This decision aims to prevent a single low score in willingness criteria from disproportionately impacting the overall supplier scores.

Table H.1: Supplier willingness and capabilities criteria

Willingness	Capabilities
Social responsibility	Price/cost
Attitude	Delivery
Business ethics	Quality
Communication openness	Technical capability
Communication frequency	Reputation and position in the industry
Mutual respect and honesty	Financial position
Ethical standards	Health and safety
Impression	Service capability
Willingness to share information	Environmental performance