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Strategic supplier selection of system integrators

Study on system integrators' supplier selection in the marine industry

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ABSTRACT:
This thesis investigates the strategic supplier selection process of system integrators in the marine industry, aiming to understand how they choose their suppliers both in terms of their overall supplier pool and specific systems. System integrators play a critical role in the marine industry, acting as intermediaries that integrate various systems and products into the vessels. Given the complexity and importance of their role, their supplier selection process is crucial for ensuring high-quality, reliable, and cost-effective solutions. This study delves into the specific strategies and criteria used by these system integrators to select their suppliers, providing a comprehensive view of the decision-making process, factors, and influencers in this unique industry context.

The study is constructed around a qualitative framework, utilizing semi-structured interviews with senior managers from various system integrators. The methodology is rooted in a case study approach, allowing for an in-depth exploration of the supplier selection process within specific organizational contexts. The collected data was analyzed to create a cross-sectional analysis to capture the decision-making processes and factors influencing them.

Primary data for the study was gathered though in-depth semi-structured interviews with senior managers and executives from system integrators, providing insights into their decision-making processes. Secondary data sources included information about the interviewed system integrators, their strategies, and financial figures. However, the interviewed system integrators remain anonymous in this study.

This thesis contributes to the existing literature on supplier selection that focuses on supplier selection mainly within manufacturing company context and extends it to system integrator context, where there is limited amount of literature. The findings of this thesis reveal several key aspects of supplier selection for system integrators. Firstly, categorizing products and suppliers is crucial as system integrators differentiate between various product types and their specific supplier requirements. The process of in-house manufacturing versus outsourcing by single sourcing or multi-sourcing are critical decisions that influence supplier selection. Furthermore, the new supplier approval process is identified as a critical step, especially regarding so called pre-approval process that is done by sales and technical functions. The study also highlights key factors and dimensions influencing supplier selection. Additionally, external factors, such as market conditions, ship owners, shipyards, and ship designers play a significant role in shaping supplier selection decisions. Overall, this study underscores the complexity and subjectivity within the supplier selection process for system integrators, illustrating the interplay between internal strategies and external pressures.

KEYWORDS: Supplier selection, Supply chain management, system integrator

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TIIVISTELMÄ:
Tämä tutkielma tutkii merenkulkualan järjestelmäintegraattoreiden strategista toimittajien valintaprosessia, pyrkien ymmärtämään, kuinka he valitsevat toimittajansa sekä kokonaisvaltaisesti toimittajakannan että tiettyjen järjestelmien osalta. Järjestelmäintegraattoreilla on keskeinen rooli merenkulkualalla, toimien välittäjinä, jotka integroivat erilaisia järjestelmiä ja tuotteita aluksiin. Ottaen huomioon heidän roolinsa monimutkaisuuden ja tärkeyden, heidän toimittajien valintaprosessinsa on ratkaiseva korkealaatuisten, luotettavien ja kustannustehokkaiden ratkaisujen varmistamiseksi. Tämä tutkimus syventyy erityisiin strategioihin ja kriteereihin, joita nämä järjestelmäintegraattorit käyttävät valitessaan toimittajiaan, tarjoten kattavan näkemyksen päätöksentekoprosessista, tekijöistä ja vaikuttajista tässä ainutlaatuisessa teollisuusympäristössä.

Tutkimus rakentuu kvalitatiivisen viitekehyksen ympärille, hyödyntäen puolistrukturoituja haastatteluja eri järjestelmäintegraattoreiden vanhempien johtajien kanssa. Metodologia perustuu tapaustutkimuslähestymistapaan, joka mahdollistaa toimittajien valintaprosessin syvällisen tarkastelun tietyissä organisaatiollisissa konteksteissa. Kerätty aineisto analysoitiin luodakseen poikkileikkausanalyysin, joka kattaa päätöksentekoprosessit ja niitä vaikuttavat tekijät.

Ensisijainen aineisto tutkimusta varten kerättiin syvällisillä puolistrukturoiduilla haastatteluilla vanhempien johtajien kanssa, tarjoten näkemyksiä heidän päätöksentekoprosesseistaan. Toissijaiset tietolähteet sisälsivät haastateltujen järjestelmäintegraattoreiden julkisia tietoja kuten strategioita ja taloudellisia lukuja. Haastatellut järjestelmäintegraattorit pysyvät kuitenkin anonyymeinä tässä tutkimuksessa.

Tämä tutkielma täydentää olemassa olevaa kirjallisuutta toimittajien valinnasta, joka keskittyy pääasiassa valmistusyritysten kontekstiin, ja laajentaa sitä järjestelmäintegraattoreiden kontekstiin, jossa kirjallisuutta on vähän. Tutkielman löydökset paljastavat useita keskeisiä näkökohtia järjestelmäintegraattoreiden toimittajien valinnassa. Ensinnäkin tuotteiden ja toimittajien luokittelu on ratkaisevan tärkeää, koska järjestelmäintegraattorit erottelevat tuotteet eri ryhmiin ja eri ryhmillä on erilaiset toimittajavaatimukset. Sisäisen valmistuksen ja ulkoistamisen prosessi joko yksittäisen tai useamman toimittajan käytöllä ovat kriittisiä päätöksiä, jotka vaikuttavat toimittajien valintaan. Lisäksi uuden toimittajan hyväksymisprosessi tunnistetaan kriittiseksi vaiheeksi, erityisesti niin sanotun esihyväksymisprosessin osalta, jonka suorittavat myynti- ja tekniset toiminnot. Tutkimus korostaa myös keskeisiä tekijöitä ja ulottuvuuksia, jotka vaikuttavat toimittajien valintaan. Lisäksi ulkoiset tekijät, kuten markkinaolosuhteet, aluksen omistajat, telakat ja laivasuunnittelijat, vaikuttavat merkittävästi toimittajien valintapäätöksiin. Kaiken kaikkiaan tämä tutkimus alleviivaa järjestelmäintegraattoreiden toimittajien valintaprosessin monimutkaisuutta ja subjektiivisuutta havainnollistaen sisäisten strategioiden ja ulkoisten paineiden välistä vuorovaikutusta.

AVAINSANAT: Toimittajien valinta, toimitusketjun hallinta, järjestelmäintegraattori

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Abbreviations

AHP	Analytical Hierarchy Process
AI	Artificial Intelligence
IPR	Intellectual Property Rights
LNG	Liquefied Natural Gas

R&D	Research and Development
SI	System Integrator
SMP	Senior Manager Procurement
SMS	Senior Manager Sales
SMT	Senior Manager Technical
SRM	Supplier Relationship Management
SWOT	Strengths Weaknesses Opportunities Threats
TCE	Transaction Cost Economics
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution

1 Introduction

Supplier selection has been extensively studied across various industries, providing insights into the decision-making processes and criteria that organizations use to choose their suppliers. According to Wetzstein et al. (2016), the literature on supplier selection has significantly grown since the 1990s, peaking around 2012. Most of this literature, however, relies on simple and generic selection approaches, with only a small fraction applying robust theoretical foundations. Wetzstein et al. (2016) claim that only 9 % of the supplier selection literature applies some theory. Various studies highlight the importance of multiple criteria in supplier selection, such as price, quality, reliability, and stability (Boone et al., 2020). Additionally, recent trends emphasize the significance of sustainability, risk management, and technology adaptation in supplier selection process (Sapturo et al., 2022). Despite the extensive body of research, many studies still lack theoretical foundations and practical applicability, which remains a critical gap in literature.

However, there is also limited literature on supplier selection on supplier selection specifically within the context of system integrators. Most research focuses on manufacturing companies, overlooking the unique challenges and requirements faced by system integrators. System integrators deliver customized packages of products and services as integrated systems tailored to meet customer needs (Davies et al., 2007; Mahapatra & Mamatha, 2020). System integrators purchase individual hardware and software components from multiple different suppliers and integrate them into a single customized system that fulfills their customers' needs (Mahapatra & Mamatha, 2020). The roles of system integrators and product suppliers have been recognized in the literature for well over three decades, with the first foundational works dating back to the 1990s (Dalziel & Zhang, 2008). According to Paasi et al. (2010) system integration was first developed in the 1950s in military landscape, but rapid development began in 1990s and 2000s.

The purpose of this study is to explore the supplier selection process of system integrators within the marine shipbuilding industry by answering the following research question:

How do system integrators select their suppliers in the marine industry?

This study aims to understand how system integrators choose their suppliers, both in terms of their overall supplier pool and for specific systems. The study employs a qualitative research methodology, utilizing semi-structured interviews with senior managers and executives from various system integrators. The case study approach enables an in-depth exploration of the supplier selection process within specific organizational and industry context. The data collected through these interviews will be analyzed to create a cross-sectional analysis, highlighting the decision-making processes and influencing factors in supplier selection for system integrators in the marine industry. The understanding of supplier selection is particularly important given the unique nature of the marine system integration business, where the complexity and interconnectivity of systems demand a carefully coordinated approach in managing supplier relationships. The marine industry plays a crucial role in today's highly competitive global market, experiencing rapid growth due to substantial investments made by ship owners to meet the sustainability requirements of their vessels (Oloruntobi et al., 2023; Islam, 2017). According to Rabetino and Kohtamäki (2013) the shipbuilding value systems can be defined from top to down as ship operators and owners (in this study referred only as ship owners), shipyards, system integrators, product suppliers, and raw material suppliers. Ship designers also play a part in this value chain by providing ship designs and specifications to ship owners and shipyards (Langemann et al., 2024). Shipyards require thousands of suppliers supplying all kinds of goods, including for example mechanical equipment, navigation equipment, shipboard systems, automation, electrical systems, steel, paint, isolation, furniture, decoration, and cargo equipment (Rabetino & Kohtamäki, 2013). Historically, some shipyards concentrated on internally developing their systems. However, they have shifted away from this approach due to the increasing complexity and interconnectivity

of systems (Mello & Strandhagen, 2011; Manno, 2014, p. 49–50). Shipyards have shifted their focus on project management and cost efficiency (Rabetino & Kohtamäki, 2018, p. 329). This has created a need for system integrators.

The contribution of this study is threefold. First, it provides an empirical framework that extends the existing literature on supplier selection by incorporating the system integrator context. This framework offers a comprehensive view of the factors and processes involved in supplier selection for system integrators. Second, the study evaluates how system integrators select their supplier pool, focusing on the criteria and strategies they use to identify and collaborate with suppliers. Additionally, the study assesses how system integrators choose suppliers for specific systems, providing insights into the decision-making process for individual projects. These contributions not only fill a critical gap in the literature but also offer practical implications for system integrators and their supplier management strategies in the marine industry.

This study is split into five sections. It begins with an introduction that reviews the contextual background and the purpose of the study. In addition, the introduction outlines the research question and study structure. The second part explores the theory of the study and concentrates on prior research from the areas of system integrators and supplier selection. The third part explains the research methodology, data collection, data analysis methods, and assesses the quality of data. The fourth part presents the results from the empirical part. Finally, the last part discusses the findings, highlighting the theoretical and managerial implications, as well as the limitations of the study and suggestions for future research.

2 Theoretical background

2.1 Characteristics of system integrators

According to Rabetino and Kohtamäki (2013) system integrators bring together various products and technologies to create comprehensive and integrated solutions for their customers. System integrators must understand and meet customer needs by providing efficient customer-centric solutions. In addition to customer-centric solutions, they also supply knowledge and lifecycle services. Lifecycle services consist of training, the provision of spare parts, equipment repair, maintenance, and advanced services such as remote services, asset, and information management. Lifecycle services can also include financial services, consultancy, operational and performance services, and turnkey solutions. Lastly, system integrators must be able to recognize and adapt to early industry trends to position themselves strategically in the industry, master key technologies, and provide innovative solutions ahead of competitors. According to Huikkola et al. (2022) company's innovation capability is created through implementation of various routines. These routines include for instance literature scanning, customer contacts, trade shows, competitor price check, customer input, supplier input, reverse engineering, and prototype development (Jones & Craven, 2001).

While system integrator is a widely recognized term, various other terms are employed in the literature to describe entities fulfilling similar roles. Among these is the concept of system sellers. According to Helander and Möller (2008) system sellers are entities that specialize in selling complete systems to customers, often incorporating hardware, software, and services to a complete package. They categorize system sellers into three roles: equipment supplier, solution provider, and performance provider. Equipment supplier provides only activities which directly support the equipment business. These activities can include for instance maintenance, emergency support, and training. Solution provider offers end-to-end approach to customer's needs while offering support activities. Performance provider manages technical operations and system optimizations, identifies customer's future needs, and offers guaranteed performance and results. System

sellers provide in-house manufactured single-vendor systems while system integrators provide multi-vendor systems (Davies et al., 2007; Paiola, 2013). According to Davies et al. (2007) advantages of system sellers include extensive control over system components, streamlined coordination within the organization, reduced transaction costs, security of product supply and capabilities. On the other hand, system integrators excel in integrating outsourced products, offering modular products and standardized interfaces, comparing market prices while having the possibility to use market leading product suppliers and their capabilities.

Kohtamäki et al. (2018, p. 12) place solution providers to be between system suppliers and operators in the value chain. This means that solution provider and system integrator entities are at least partly overlapping. According to Rabetino and Kohtamäki (2018, p. 330) system integrators can also transition into becoming solution providers. Solution providers also provide combinations of products and services that meet the technical, business, and operational requirements of the customer (Sunholm & Hellström, 2021, p. 151). Töytäri (2018, p. 283) states that ideally, a solution integrates customer's and supplier's resources, such as knowledge, skills, technology, thereby achieving a solution that maximizes long-term value. In solution sales customers develop a solution vision while suppliers develop solution proposal. Often, the customer's solution vision and supplier's solution proposal do not match. Solution providers key task is to help the customer to arrive at a joint solution vision. Value based solution selling integrates customer value into sales by quantifying and communicating the offering's value, involving segmentation, value research, proposition, communication, negotiation, and verification stages, which require a deep involvement in customer business development (Sundholm & Hellström, 2021, p. 152–153). Successful system integrators leverage their supplier networks to gain competitive advantages and improve customer relationships, benefiting both parties involved (Huikkola & Kohtamäki, 2017). In this study, some companies identify as both system integrators and solution providers, depending on the context. For consistency, these companies are referred solely as system integrators.

System integrators generally have far fewer suppliers compared to manufacturing companies. According to Baumgartner et al. (2020), auto manufacturing companies typically have around 250 tier-one suppliers expanding to 18000 across the entire value chain, aerospace manufacturing companies average 200 tier-one suppliers totaling 12000 across all tiers, and technology companies generally have about 125 tier-one suppliers reaching over 7000 across all tiers. In contrast, system integrators typically have fewer suppliers because they procure products and subsystems from their suppliers, focusing primarily on integrating the complete system and system control (Rabetino & Kohtamäki, 2013).

2.2 Characteristics of the marine shipbuilding industry and its system integrators

The marine shipbuilding industry has been characterized by cyclical fluctuations in demand and capacity, influenced by global economic conditions (Shin & Lim, 2013). China, Korea, and Japan are the leaders in vessel quantities, with China taking the lead in recent years. China's rapid growth in market share has been driven by aggressive investments in expanding production capabilities and adopting advanced manufacturing technologies, allowing it to dominate the global shipbuilding industry by producing a substantial portion of the world's commercial ships. The Asian shipbuilding industry, particularly in China and Korea, has focused on producing the highest quantity of ships, primarily low value-added ships, although there has been an expansion into high value-added ships (Shin & Lim, 2013). In contrast, Europe has experienced a decline in overall market share but continues to emphasize high value-added sectors. European shipbuilders have strategically avoided competing in low value-added segments, instead focusing on niche markets that require specialized skills and high-quality products (Shin & Lim, 2013). Therefore, the shipbuilding industry is segmented not only by geographical area of manufacturing but also by the types of ships produced.

The marine shipbuilding industry has undergone a significant transformation, moving from a model of vertical integration to extensive outsourcing (Mello & Strandhagen,

2011). Outsourcing adds another layer of complexity, necessitating robust coordination mechanisms to manage activities across different entities and locations (Mello et al., 2013). This shift has turned shipbuilding into a global business, involving a complex network of companies across various countries (Mello & Strandhagen, 2011). As a result, effective supply chain management has become crucial. The industry predominantly operates on an engineer-to-order basis, producing customized vessels with deep and complex structures, often requiring both customized and standardized products and system. According to Mello and & Strandhagen (2011) efficiently integrating and coordinating suppliers, system integrators, and subcontractors are vital.

As the systems and operations in ships become more complex, the role of system integrators is increasingly critical (Manno, 2014, p. 49–50). System integrators streamline procurement processes during both shipbuilding and operational phase of the vessel, simplifying supply chain hierarchies. They may also offer consultancy services and vertically integrate into their end customer's value chain. In shipbuilding phase, system integrators simplify the management of hardware and software components, creating hierarchical systems to form equipment, subsystems, and complete systems. During shipbuilding phase, system integrators' customers are usually shipyards. In ship operations, system integrators offer onshore support for diagnostics and emergency guidance. They facilitate cost savings through enhanced crew competence and improved resource allocation. Moreover, system integrators are nowadays often collecting data from ships, observing the system in operation, predicting events, and preventing failures. This means that during ship operations phase system integrators' customers are ship owners. The rough value system from raw material suppliers to ship owners is presented in figure 1. The primary focus entities of this study are highlighted in dark grey while secondary focus entities of this study are highlighted in light grey.

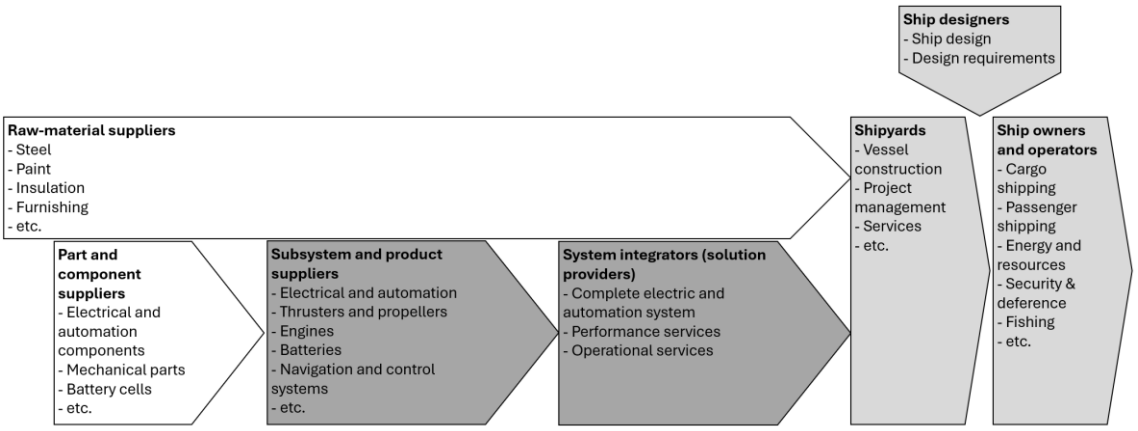

Figure 1. Rough value system from raw material suppliers to ship owners in the marine shipbuilding industry (Rabetino & Kohtamäki, 2013). The figure has been modified from the original one.

2.3 Make-or-buy decision-making of system integrators

Make-or-buy decisions represent the choices made by organizations regarding whether to produce goods internally (in-house) or purchase them from external suppliers. Johnson et al. (2010, p. 123–130) highlight that these decisions are fundamental to organizational operations and can significantly impact productivity and competitiveness. The alternatives available to companies involve insourcing, which involves previously outsourced activities back in-house, and outsourcing, which means contracting external suppliers for activities previously performed internally. Traditionally, many large organizations favored “make” option, leading to extensive ownership of manufacturing facilities. However, recent trends emphasize flexibility, core competency focus, and cost reduction, driving a shift towards outsourcing and seeking external suppliers.

The make-or-buy decision-making process is influenced by various factors including buyer experience, technological uncertainty, market competition, volume uncertainty, and supplier production advantage (Walker & Weber, 1984). The process also requires cross-functional collaboration among departments such as purchasing, sales, and engineering. These collaborative efforts aim to gather relevant information, assess production capabilities, and weigh the advantages and disadvantages of internal production

versus outsourcing. Tadelis (2002) highlights that during make-or-buy decisions organizations must understand transaction costs, and supplier incentives as well as product complexity. Generally, the more complex the product is, the more likely it is to be produced in-house, while simpler products are more likely to be procured from external suppliers (Tadelis, 2002; Bustinza et al., 2019; Kalaignanam et al., 2017). However, outsourcing of complex products can still yield benefits. Kalaignanam et al. (2017) claim that outsourced products have a positive significant impact on immediate product quality, while in-house developed products have a positive significance on future product quality. Humphreys et al. (2000) argue that make-or-buy decisions are frequently made without a comprehensive strategic outlook and often lack careful consideration for the long-term competitiveness of organizations.

Williamson (2008) underscores the importance of considering transaction costs, governance structures, and credible commitments in the outsourcing decision-making process, particularly in the context of Transaction Cost Economics (TCE). Hybrid transactions represent a compromise between two extremes of market-based coordination and internal integration within a company's hierarchy. Hybrid transactions are contractual agreements that serve as a middle ground between buying products or services from external suppliers or producing them in-house. These transactions prioritize continuity and cooperation between parties while still allowing flexibility and negotiation. Three leading styles of managing the contractual interface for hybrid transactions are muscular, benign, and credible. Muscular buyers are strict with their suppliers and do not allow much flexibility or negotiation. Benign buyers believe that parties will work together when unexpected problems arise and ensure smooth cooperation. Credible buyers do not assume parties will always cooperate when problems arise, nor are they aggressive, instead they understand that contracts cannot cover every situation. Therefore, they anticipate, identify problems, and build safeguards into the contract to deal with them. Araujo et al. (1999) categorize buyer-supplier relationships into four types: specified, translation, interactive, and standardized interfaces. These interfaces offer different benefits and costs to the local customer. Specified interfaces involve detailed customer specifications, while

translation interfaces require suppliers to translate functionality into product specifications. Interactive interfaces foster joint learning but demand significant investments. Standardized interfaces offer cost benefits but limit customization.

The decision-making process for system integrators regarding whether to make or buy involves evaluating the best approach to procure the necessary products for their integrated solutions. Unlike traditional manufacturers or system sellers, system integrators focus on coordinating the integration of externally supplied products to a cohesive system (Davies et al., 2007). This approach required careful consideration of factors such as product complexity, technological compatibility, and supplier reliability. System integrators may produce some products internally but mostly they procure products from external suppliers. This strategy allows system integrators to leverage the expertise and specialized capabilities of external suppliers, expanding the range of products available for integration (Davies et al., 2007). Additionally, it allows system integrators to stay flexible and responsive to customer needs by tailoring procurement strategies to each project. Thus, the make-or-buy decision for system integrators requires balancing internal capabilities with external expertise to achieve smooth integration and system delivery. However, Paiola et al. (2013) stress the importance for system integrators to evaluate their capacity to integrate each supplier into their value chain before starting cooperation with them.

2.4 Characteristics of suppliers and their cooperation with system integrators

A supplier is an individual or an organization that provides products or services to another individual or organization (Lavelle, 2024). Given the focus of this study is on system integrators within a business-to-business framework, suppliers refer to organizations that provide goods to other businesses for incorporation into their own products, systems, solutions, or services. Since system integrators primarily acquire subsystems and products (Rabetino & Kohtamäki, 2013), raw and bulk material providers are consequently excluded from the scope of this study.

There are multiple ways to categorize suppliers. Andersson (2002) classify three distinct supplier types: simple suppliers, advanced suppliers, and own product suppliers. Simple suppliers focus primarily on cost competitiveness, offering standard products specified by the buyers. In contrast, advanced suppliers contribute to product development and offer more integrated solutions, while own product suppliers develop and market their own products. In the international business landscape, simple suppliers face challenges in high-cost environments and often seek lower-cost production locations abroad. Meanwhile, advanced suppliers, relying on close customer relationships, encounter complexities in internationalization. Own product suppliers, developing their unique products, may find international landscape easier. Laserer and Ramdas (2002) propose categorizing suppliers based on the products they supply and their involvement in product development. Four groups emerge: critical systems, hidden products, invisible subassemblies, and simple differentiators. Critical systems refer to complex, high-cost products that need early supplier engagement. Hidden products are low-cost, simple, and require less integration. Invisible subassemblies fall between critical systems and hidden products. Simple differentiators are highly differentiating, moderately costly products demanding early involvement. Certain supply professionals also separate suppliers into two categories: new suppliers and current suppliers (Johnson et al., 2010, p. 353). New suppliers lack any established track record, are striving to fulfill initial contract obligations, and are subject to close monitoring. Current suppliers have demonstrated their ability to meet minimum requirements and undergo routine evaluation.

In system integration business, suppliers and system integrators play distinct yet independent roles (Dalziel & Zhang, 2008). There are more suppliers than system integrators in the market due to lower entry barriers. System integrators generally require more substantial resources and consequently raise more venture capital. Additionally, system integrators, being closer to end customers, are influenced more by market-based shocks compared to suppliers. System integrators frequently leverage their supplier network to decrease production and transaction costs, and to increase the number of innovations

and value for end users (Huikkola & Kohtamäki, 2017). Suppliers can maintain and extend their roles by coordinating proactive actions towards their customers (Helander & Möller, 2008). Finne et al. (2015) explain how system integrators and suppliers strategically shape their power within business networks. For instance, they illustrate how integrators strive to gather information about customers and their installed base of products to enhance their power. Additionally, they discuss how integrators may face challenges in gaining a substantial power advantage over their suppliers. For example, integrators gather end customer data, but suppliers can also invest in similar technologies. The risk in system integrator perspective is that the supplier becomes their competitor (Finne et al., 2015; Paasi et al., 2010; Paiola, 2013). Suppliers can also simplify the cooperation with their main customers by making frame agreements that give the buyer the right, but not the obligation, to purchase at pre-specified terms for a set period, reducing sales and administrative costs while increasing flexibility and efficiency (Rognes, 1995).

System integrators seeking advanced technological solutions that are not available from external suppliers can access state-of-the-art technology through strategic avenues such as joint ventures, licensing agreements, or contractual research and development (R&D) partnerships (Kim et al., 2022). Joint ventures facilitate collaboration, resource pooling, and risk sharing with other companies to access new technologies and markets. Licensing agreements offer access to patented technologies without extensive internal development, enabling rapid adoption of innovations. Contractual R&D partnerships involve collaboration with external entities to outsource specific R&D tasks, accelerating technological development while focusing internal resources on core competencies. An illustration of collaborative R&D efforts includes cooperative development strategies and information sharing, for instance using a common technology roadmap (Kim, 2006). These strategic avenues also enable system integrators to acquire technologies efficiently while minimizing risks. However, Paasi et al. (2010) highlight that intellectual property rights developed through collaboration bring challenges in innovation management.

In the marine shipbuilding industry, system integrators usually provide for example propulsion systems, control and automation systems, switchboard systems, and navigation systems (Rabetino & Kohtamäki, 2013). For some of these subsystems, such as propulsion systems, there is a limited number of suppliers (Rabetino & Kohtamäki, 2018, p. 330). Only a few can be considered powerful suppliers, others are relatively small suppliers with limited power. This increases the bargaining power of suppliers. System integrators are usually using dual sourcing strategy to lower the bargaining power of suppliers and switching costs of suppliers. System integrators are also making exclusivity agreements and co-operation contracts with suppliers to stand out from their own competitors. Alternatively, they can also acquire their key suppliers. Huikkola and Kohtamäki (2017) point out that system integrators have often worked with same suppliers for a long time and have created close collaboration characterized by, for instance, close social and physical cooperation, open and active knowledge sharing practices, moderate independence, and a high level of trust. Key suppliers are viewed as strategic partners who contribute to the system integrator's operations and competitiveness by understanding customer expectations and offering innovative solutions. However, for many system integrators, the capacity to exploit their supplier network is a bottleneck (Huikkola & Kohtamäki, 2017).

After-sales market is a crucial part in system integration. According to Paiola et al. (2013) suppliers often handle the provision of basic after-sales services such as documentation, diagnosis, spare parts, and repair services, primarily aimed at maintaining the functionality of the products they supply. On the other hand, system integrators offer more advanced after-sales solutions and services. They primarily focus on providing comprehensive maintenance, revamping, and retrofitting services that go beyond basic repairs to prevent product failures and ensure the long-term efficiency of the integrated solutions. However, sometimes system integrators can also resell suppliers' spare parts to their own customers. Tuli et al. (2007) state that after-sales support in system integration business is more than providing spare parts, operating information, and routine

maintenance. Tuli et al. (2007) suggest that many customers believe after-sales support is a significant area of weakness for suppliers.

2.5 Supplier selection process, strategy, and factors

Typically, the production cost for materials and components makes up around 60–80 % of the total production cost, especially for advanced technological products (Saputro et al., 2022). Selecting the right suppliers and engaging them in strategic supply chain management activities can lead to a 20 % decrease in material costs and product development time, along with a 20 % increase in material quality. In industrial companies, purchasing often accounts for 50–90 % of total company turnover (de Boer et al., 2001). Suppliers also have direct impact on delivery capabilities, flexibility, and innovativeness of the buying organization (Nair et al., 2015). Supplier selection can be treated as one of the most fundamental and important decisions for any buyer organization (Sarkis & Talluri, 2002). Companies have several alternatives for supplier selection, including sourcing from in-house capabilities, existing suppliers, finding new suppliers, or using supplier development to create a new supplier (Johnson et al., 2010, p. 314–341). Supplier development means purchasers actively engaging to create or enhance potential suppliers when suitable sources are lacking, aiming to benefit both parties. Companies may engage with manufacturers or distributors, choose local or foreign suppliers, and consider the size of the supplier in relation to their needs.

Supplier selection is the process of identifying, evaluating, and choosing suppliers to meet an organization's procurement needs (de Boer et al., 2001). Supplier selection involves several stages, including problem definition, criteria formulation, qualification of potential suppliers, and the final selection among qualified suppliers. This process is crucial for organizations, especially considering increasing dependencies on suppliers, globalization of trade, and changing customer preferences, demanding a systematic and transparent approach to decision-making in supplier selection (de Boer et al., 2001). Supplier selection process follows the assessment of make-or-buy decision in case the

organization decided to buy their goods from external suppliers (Johnson et al., 2010, p. 316–317). Figure 2 presents a process for identifying potential sources of goods.

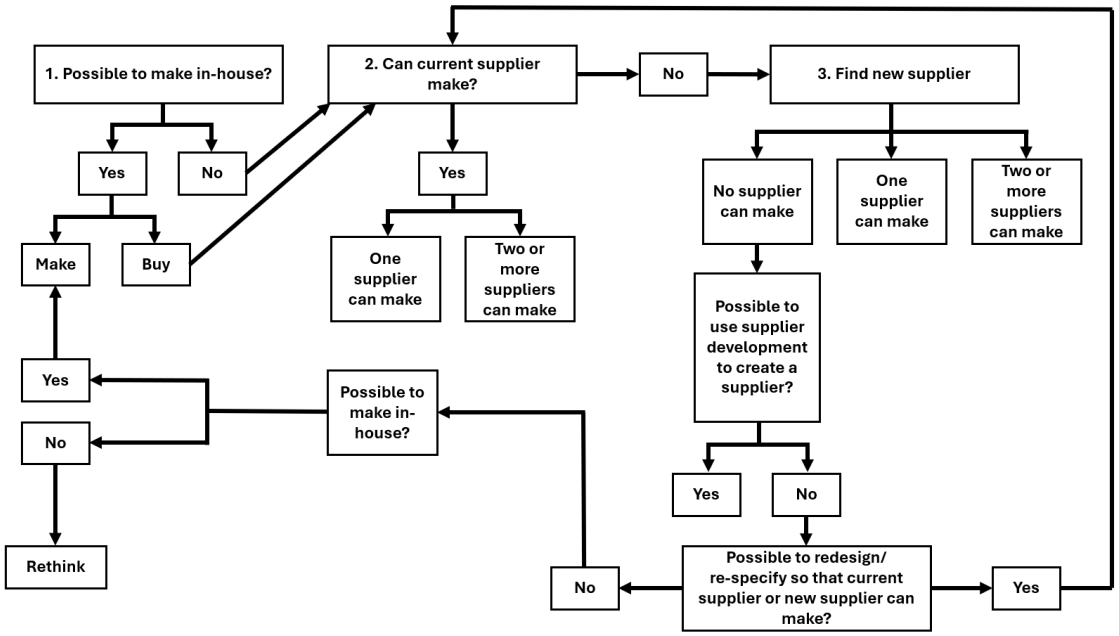

Figure 2. Identification process of potential sources of goods (Johnson et al., 2010, p. 317). The figure has been modified from the original one.

Sarkis and Talluri (2002) highlight that prior to starting supplier selection process, the buying organization must confirm top management support for initiating the supplier selection process. According to Sapturo et al. (2022) the supplier selection process begins by problem definition, then identification of criteria, followed by the pre-qualification of suppliers, and finally making the selection. Problem definition involves the strategic determination of sourcing strategy and outlining decision-making environment and scope. Supplier selection criteria include both qualitative and quantitative assessments. These assessments can be for instance cost, quality, delivery, technology, sustainability, risk, flexibility, service, relationship factors and social factors. There has been a shift away from heavy cost-centric supplier evaluation because the price of the supply is not the sole determinant of business performance (Özdemir et al., 2014; Sarkis & Talluri, 2002). According to Sapturo et al. (2022) pre-qualification and final selection involve the application of strategic approaches, such as multi-criteria decision-making and simulation-

optimization frameworks. Multi-criteria decision-making is a technique to evaluate and prioritize suppliers based on various factors. Simulation-optimization methodology integrates simulation modeling and optimization algorithms to optimize supplier selection decisions under uncertainty and complexity by simulating different supply chain scenarios and identifying the best possible solutions. Nowadays, Artificial Intelligence (AI) is used to identify patterns, trends, and correlations, aiding decision-makers in formulating more insightful supplier selection decisions. Nonetheless, decision-making remains a hybrid AI approach as human judgement is still indispensable in the process.

However, there is no single process framework for supplier selection. Kshirsagar et al. (2014) outlined the following steps in their lean process for choosing suppliers: recognize the need for a supplier, determine procurement strategy, identify criteria, assign weights to criteria, define technique, prequalification, evaluation of potential suppliers, final selection, monitoring. Their lean supplier selection process is presented in figure 3.

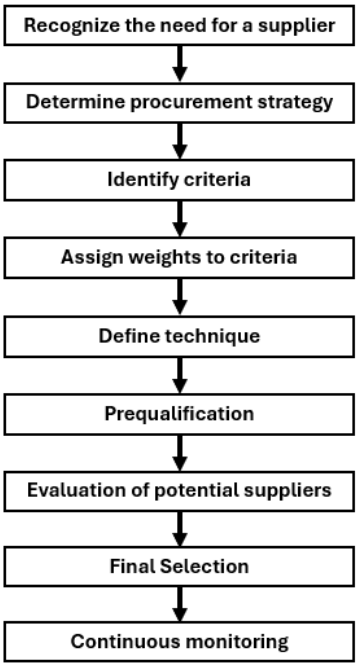

Figure 3. Supplier selection process (Kshirsagar et al., 2014). The figure has been modified from the original one.

Supplied items can be categorized into four groups from the buyer's perspective: non-critical, leverage, bottleneck, and strategic items, each classified based on the complexity of supply, and the importance of purchasing (Kraljic, 1983). Vlachakis et al. (2016) have labelled the complexity of supply axis as profit impact, and importance of purchasing axis as supply risk. Although many purchasers are unaware of the purchasing classification model, they label their supplier similarly as in Kraljic's matrix (Hudnurkar et al., 2016). These groups are presented in figure 4.

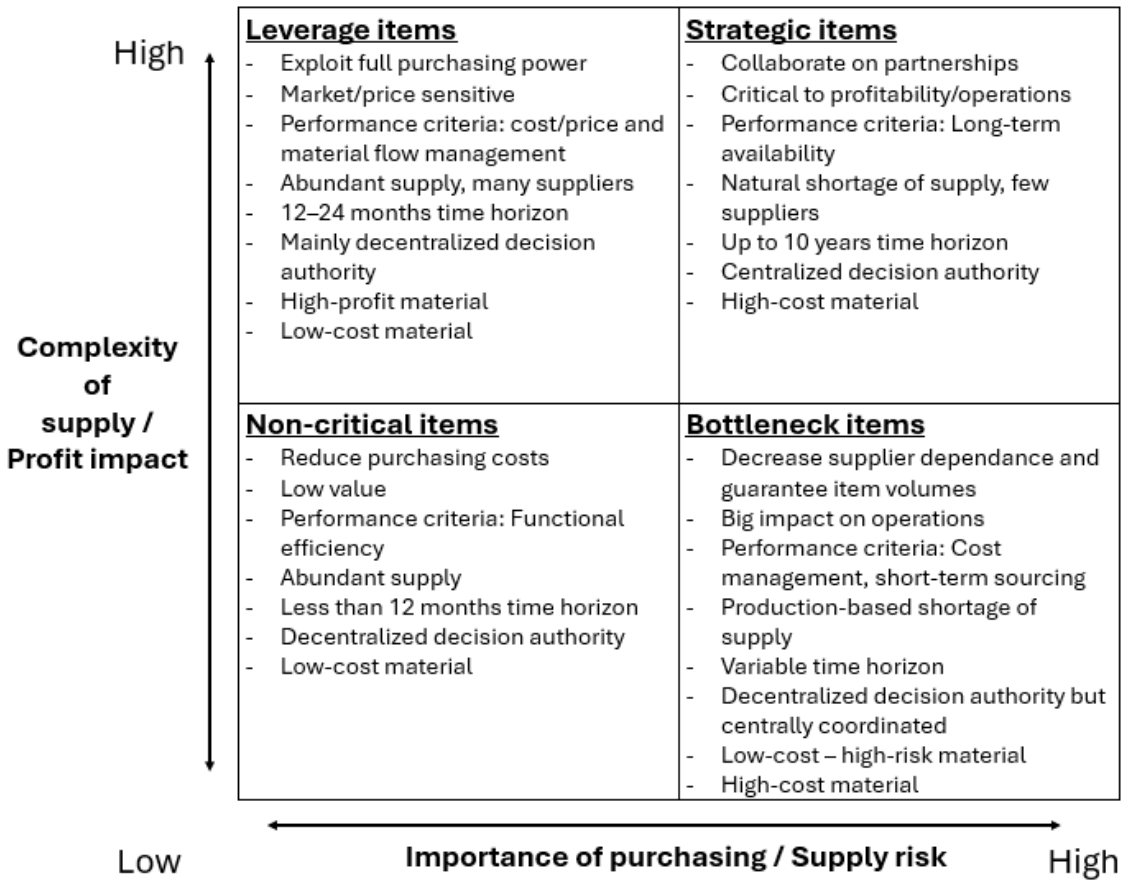

Figure 4. Purchasing classification (Kraljic, 1983; Greene, 2022; Sapturo, 2022; Vlachakis et al., 2016). The figure has been modified from the original ones.

Strategic items are crucial for organizational profitability and operational efficiency, necessitating collaborative partnerships with suppliers and centralized decision-making (Kraljic, 1983; Greene, 2022). These items are critical for the organization's profitability and operations, demanding long-term commitments from both suppliers and buyers to

ensure their uninterrupted availability and quality. In general, strategic items are high cost (Vlachakis et al., 2016). It is common that purchasing organizations share resources and risks with strategic suppliers (Hudnurkar et al., 2016). In contrast, bottleneck items, despite their decentralized but centrally coordinated decision-making, hold significant influence over operations, forcing companies to reduce reliance on suppliers and ensure steady item volumes (Kraljic, 1983). Bottleneck items include low-cost–high-risk items as well as high-cost items (Vlachakis et al., 2016). Leverage items are sensitive to market and price sensitive, and the aim is to cut costs and handle movements effectively. Their procurement relies mainly on decentralized decision-making. Leverage items include high-profit and low-cost items (Vlachakis et al., 2016). Non-critical items, while holding lower value, still play a role in cost reduction and functional efficiency. With decentralized decision-making, organizations prioritize short-term goals and cost-effectiveness in managing these items. According to Boone et al. (2020) purchasers often assess supplier stability, reliability, pricing, and quality. For strategic items, purchasers prioritize stability, reliability, and quality over pricing. For non-strategic items, competitive pricing takes highest priority, although all attributes are considered.

Wetzstein et al. (2016) reviewed supplier selection literature and its future directions. They assessed over 200 papers published in major journals from 1990 to 2015. They identified six research streams of supplier selection strategies: generic selection approach, investigation of criteria, strategy-oriented supplier selection, R&D-oriented supplier selection, operations-oriented supplier selection, and sustainable supplier selection. Generic solution approaches include a wide range of techniques for evaluating and choosing suppliers, such as single and multi-sourcing approaches. Investigation of criteria assesses supplier selection depending on application, collection, and classification of suppliers. Strategy-oriented supplier selection strategy emphasizes the alignment of supplier selection with overall organizational strategy. R&D-oriented strategies focus on the unique technical requirement processes. Operations-oriented supplier selection strategy targets specific organizational evaluation criteria. Sustainable supplier selection strategies prioritize environmental considerations. Supplier sustainability means

assessing, promoting, and collaborating environmentally and socially responsible practices among suppliers (Gimenez & Tachizawa, 2012). Supplier sustainability management involves overseeing and coordinating efforts to improve supplier's environmental, social, and economic performance, ensuring sustainability, facilitating opportunities, and risk mitigation throughout the supply chain (Carter & Rogers, 2008; Patil et al., 2022).

Sapturo et al. (2022) also conducted a literature review about supplier selection assessing over 300 papers. They claim that supplier selection strategies involve the integration of sourcing strategies, selection criteria, decision scope, and decision environment, each tailored to the specific characteristics of items within the organization's procurement portfolio. Hybrid approaches can combine these strategies, and they stand out as effective methods for accommodating both qualitative and quantitative criteria, handling uncertainties, and integrating multiple phases of decision-making. The choice of supplier selection strategy depends on factors such as supply complexity, purchasing importance, and production policy. For example, hybrid approaches are well-suited for addressing high-complexity supplier selection scenarios, while standalone approaches usually suit well for low-complexity supplier selection scenarios. Moreover, emerging trends in supplier selection strategies emphasize the importance of supply chain resilience, sustainability goals, integrating supply chain processes, and adopting distributed ledger technology to enhance transparency and trust in supplier relationships.

Supplier selection strategy and selection criteria should align with both organizational strategy view and organization's operations view (Nair et al., 2015). Operations view means day-to-day optimization of procurement strategies, while strategy view means long-term viability and innovation. By actively engaging in strategic decision-making, the purchasing function aligns supply management with organization goals, fostering cooperative relationships with suppliers. Strategic supplier selection facilitates robust supplier performance evaluation across operational and strategic dimensions. The evaluation improves purchasing performance, shows close connection between strategic supplier participation, supplier selection criteria, and overall purchasing effectiveness.

According to Johnson et al. (2010, p. 353–357) supplier evaluation involves assessing supplier performance through key indicators such as on-time delivery, quality, and contract terms. These indicators measure supplier effectiveness and identify areas for improvement. Evaluation methods range from informal assessment based on internal user feedback to formal weighted point systems that assign importance to specific criteria. Informal evaluations allow for fast feedback, while formal methods ensure objectivity and consistency.

Johnson et al. (2010, p. 357–358) present a framework to rank suppliers into the following ranks: unacceptable suppliers, acceptable suppliers, preferred suppliers, and exceptional suppliers. Unacceptable suppliers fail to meet both operational and strategic requirements, often necessitating a transition to better alternatives. Acceptable suppliers fulfill contractual obligations but do not provide a competitive edge. Preferred suppliers work closely with the buying organization, making transactions smooth and improving processes together. They meet both operational and strategic needs, responding positively to initiatives for enhancement. Exceptional suppliers not only anticipate and meet operational and strategic needs but also exceed them, offering significant competitive advantages. Developing exceptional relationships demands investments, patience, and persistence from both parties.

Sarkis and Talluri (2002) provide a graphical representation of Analytical Hierarchy Process (AHP) for strategic supplier selection highlighting both organizational factors and strategic performance metrics. Key organizational factors are culture, technology, and relationship, while key strategic performance metrics are cost, quality, time, and flexibility. This kind of model is mostly used for suppliers of strategic items. Their AHP is presented in figure 5.

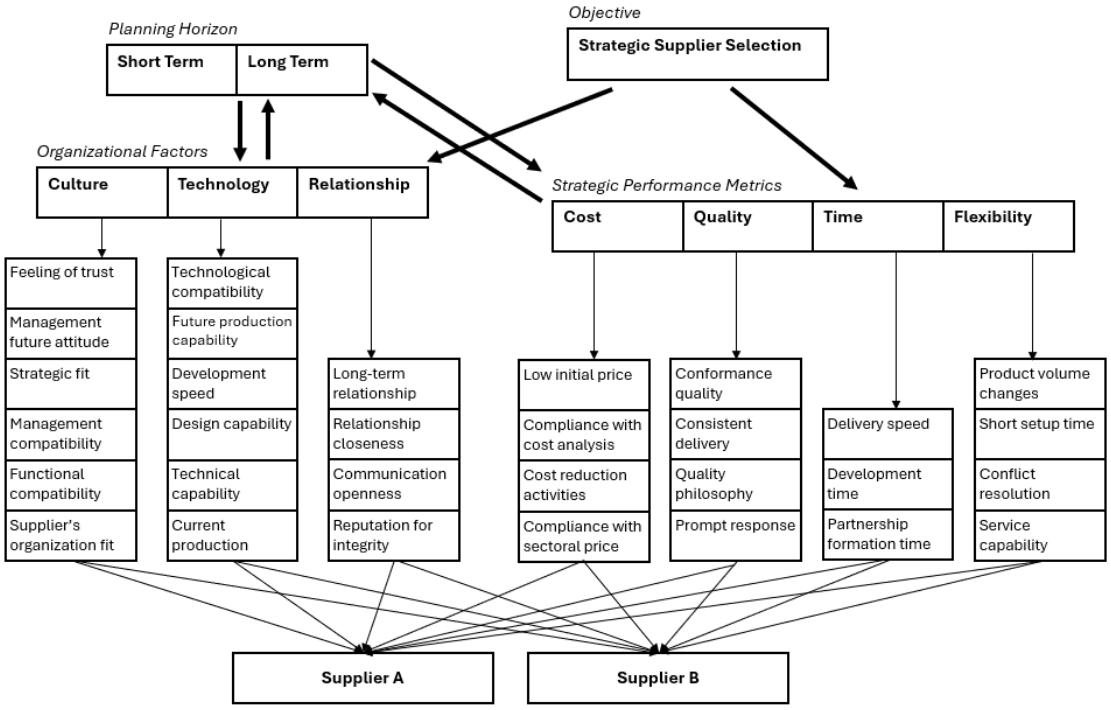

Figure 5. Graphical representation of AHP for strategic supplier selection (Sarkis & Talluri, 2002). The figure has been modified from the original one.

Based on the AHP created by Sarkis and Talluri (2002), organizations can score suppliers based on various factors. One key aspect is the desirability index, which combines the weights from a matrix calculation and product sums, providing a comprehensive assessment of supplier performance. This index allows decision-makers to rank suppliers based on their general suitability regarding both organizational factors and strategic performance metrics. The AHP streamlines supplier selection through hierarchical framework, enabling decision-makers to compare factors and metrics systematically, with an eye on both immediate and future needs. In real life application, it provides a clear method for assessing supplier performance, promoting data-driven decisions and strategic alignments that boost competitive advantage. For example, the AHP's flexibility allows organizations to prioritize factors based on strategic needs, such as emphasizing time-to-market by adjusting weights accordingly.

In the shipbuilding industry, supplier selection is a critical process that significantly impacts the efficiency and success of shipyard operations (Vlachakis et al., 2016). The

industry generally uses structured approach to supplier selection, utilizing frameworks like Kraljic's matrix. Categorization helps in identifying the strategic importance of different suppliers and goods, ranging from high-profit, standardized products to strategic, high-cost systems that are critical for the ship's operation and performance. The selection process is not just about finding the lowest cost option, but it also involves evaluating suppliers on their ability to deliver quality on time and their potential for long-term partnerships. Pribadi et al. (2021) highlight that also financial stability and geographical location of the supplier are valued as selection criteria in the shipbuilding industry. Strategic items, such as engines and control systems, require suppliers that can offer customized solutions and are willing to engage in close cooperation to meet the specific needs of the shipyard and its customers (Vlachakis et al., 2016). Usually, these strategic turnkey systems are delivered by system integrators.

Celik (2010) presents a decision-making process for marine supplier selection through a case study. He claims that supplier selection problem requires a systematic research methodology that ensures group consensus among managers from diverse departments, such as technical, commercial, and procurement, and integrates operational strategies into the research methodology to ensure high compliance with company priorities. Additionally, it must accommodate the assessment of multiple criteria through the verification of both quantitative and qualitative data. Celik (2010) initiates the supplier selection process by identifying relevant factors and conducting an industry-based survey to monitor the performance of existing supplier firms. Following this, the Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis stage involves structuring an evaluation framework that includes internal and external assessment factors, including data source types and their polarities. Moving forward, the AHP methodology is used to calculate the priority weights for the identified assessment factors. Finally, in Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) stage, suppliers were ranked based on their final performance scores. TOPSIS is a decision-making method used to rank alternatives based on their similarity to an ideal solution. A summary of Celik's (2010) marine supplier selection framework example is presented in figure 6.

Assessment	SWOT Factors (1st level)	Code	SWOT factors (2nd level)	Evaluation data type	Priority weight	Supplier alternatives (Normalized and weighted)						Ideal solutions	
						A1	A2	A3	A4	A5	A6	I+	I-
Internal	Technical	I11	Production capacity	Subjective	0,010	0,0047	0,0048	0,0030	0,0041	0,0030	0,0036	0,0048	0,0030
		I12	Problems in verification and marine certification	Subjective	0,031	0,0078	0,0163	0,0154	0,0142	0,0084	0,0099	0,0163	0,0078
		I13	Non-recipients of reconditioned spare parts	Subjective	0,010	0,0040	0,0033	0,0044	0,0043	0,0041	0,0031	0,0044	0,0031
		I14	Reliability of communication system	Subjective	0,011	0,0035	0,0046	0,0058	0,0048	0,0042	0,0041	0,0058	0,0035
		I15	Product quality and economic life cycle	Subjective	0,008	0,0036	0,0037	0,0028	0,0040	0,0029	0,0035	0,0040	0,0028
		I16	Number of branch offices	Objective	0,030	0,0104	0,0059	0,0134	0,0163	0,0119	0,0134	0,0163	0,0059
		I17	Number of active vessels with equipment	Objective	0,025	0,0062	0,0150	0,0125	0,0100	0,0075	0,0087	0,0050	0,0062
	Operational	I21	Performance level in previous operations	Subjective	0,015	0,0067	0,0064	0,0058	0,0065	0,0050	0,0068	0,0068	0,0050
		I22	Number of environmental issues	Objective	0,033	0,0112	0,0089	0,0223	0,0149	0,0118	0,0074	0,0223	0,0074
		I23	Recorded conflicts between order/delivery quantities	Objective	0,029	0,0111	0,0050	0,0069	0,0111	0,0184	0,0138	0,0184	0,0050
		I24	Quality of labor force	Subjective	0,027	0,0107	0,0103	0,0097	0,0119	0,0112	0,0121	0,0121	0,0097
		I25	On-time delivery	Subjective	0,020	0,0052	0,0081	0,0055	0,0090	0,0110	0,0095	0,0110	0,0052
External	Managerial	E11	Bureaucracy level in documentary procedures	Subjective	0,012	0,0041	0,0043	0,0039	0,0045	0,0065	0,0065	0,0065	0,0039
		E12	Reputation in maritime industry	Subjective	0,0220	0,0076	0,0084	0,0076	0,0072	0,0086	0,0093	0,0093	0,0072
		E13	Warranties and claims policies	Subjective	0,020	0,0069	0,0071	0,0088	0,0076	0,0092	0,0087	0,0092	0,0069
		E14	Compliance with company procedures	Subjective	0,036	0,0139	0,0121	0,0151	0,0132	0,0167	0,0174	0,0174	0,0121
		E15	Training support about products	Subjective	0,005	0,0016	0,0018	0,0023	0,0021	0,0027	0,0023	0,0027	0,0016
		E16	Socio-cultural compliance between organizations	Subjective	0,031	0,0140	0,0113	0,0118	0,0147	0,0140	0,0099	0,0147	0,0099
	Financial	E21	Credit rating	Subjective	0,025	0,0117	0,0077	0,0096	0,0088	0,0115	0,0096	0,0117	0,0077
		E22	Suitability of products' prices	Subjective	0,032	0,0155	0,0135	0,0124	0,0124	0,0097	0,0140	0,0155	0,0097
		E23	Flexibility in payment options	Subjective	0,011	0,0061	0,0050	0,0046	0,0039	0,0036	0,0040	0,0061	0,0036
		E24	Cost of additional repair services	Subjective	0,010	0,0033	0,0042	0,0041	0,0042	0,0039	0,0048	0,0048	0,0033
		E25	Price increase request over sector-based average	Subjective	0,024	0,0069	0,0092	0,0114	0,0099	0,0086	0,0114	0,0114	0,0069
		E26	Additional expenses due to delivery delays	Subjective	0,023	0,0065	0,0058	0,0088	0,0081	0,0166	0,0069	0,0166	0,0058

$$C_i = \frac{d_i^-}{d_i^+ + d_i^-}$$

Ci = Evaluation criteria
di+ = distance to I+
di- = distance to I-

TOPSIS	Supplier alternatives					
	A1	A2	A3	A4	A5	A6
d+	0,0235	0,0260	0,0170	0,0164	0,0180	0,0216
d-	0,0125	0,0139	0,0210	0,0182	0,0213	0,0161
C	0,3463	0,3482	0,5255	0,5255	0,5429	0,4269
Rank	6	5	1	3	2	4

Figure 6. Marine supplier selection framework summary example (Celik, 2010). The figure has been modified from the original one.

Celik (2010) classified problems in verification certification (*I12*), the number of branch offices (*I16*), the number of environmental issues (*I22*), compliance with company procedures (*E14*), and suitability of products' prices (*E22*) to be most dominant factors in his marine supplier selection process. This means that these factors have the highest weights. Each supplier is scored for each factor, and the score is normalized. On the far-

right side of figure 6, ideal solution boundaries are selected for each factor. Finally, suppliers are ranked using the TOPSIS method and supplier 3 is chosen to be the best alternative. Nevertheless, while Celik's (2010) supplier selection framework offers a systematic approach to decision-making, it is important to acknowledge that many of the factors involved are subjective, making it challenging to achieve clear and unambiguous scoring.

Shipyards want to manage risks by following their supply chain processes. Shipyard supply chain processes present a comprehensive overview of the following stages: design process, approval of material and components process, purchasing process, procurement process, assembly and testing process, and after-sales and maintenance process (Vlachakis et al., 2016). Suppliers of system integrators are mostly involved in the approval of material and components process, purchasing process, and procurement process. In approval of material and components process the suppliers must prove that their goods fulfill classification society requirements. Classification societies are organizations that establish and maintain technical standards for the construction and operation of ships, ensuring their safety, security, and environmental compliance (Hormann, 2006). In the purchasing process the suppliers are included in the supplier selection and coordination process. In the procurement process the suppliers and supplier quality are being evaluated by shipyards and system integrators. In the assembly and testing process the suppliers support the commissioning of system integrators if needed. Shipyard supply chain processes are presented in figure 7.

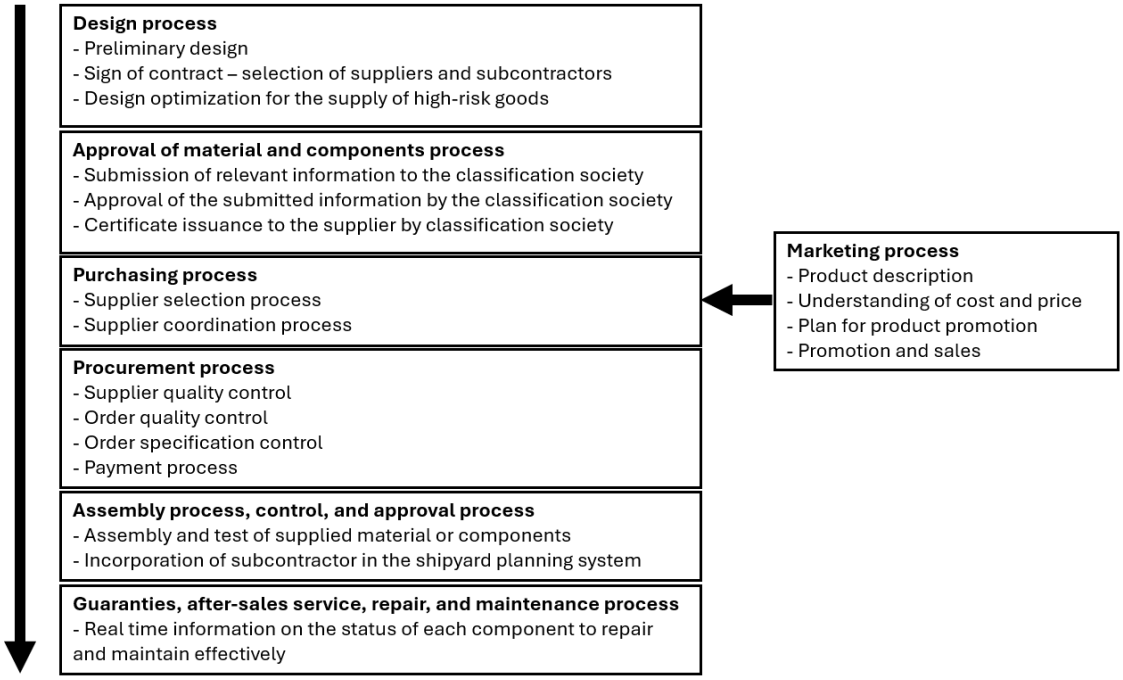

Figure 7. Shipyard supply chain processes (Vlachakis et al., 2016). The figure has been modified from the original one.

Bruce (2020, p. 10–11) presents an activity map outlining all stages of contracts and all functions within shipyards. Suppliers of system integrators are only connected to a few of these activities. System integrators are involved in most of these activities. The activities that suppliers of system integrators are generally involved in are highlighted in dark grey. The activity map of shipyards is presented in figure 8.

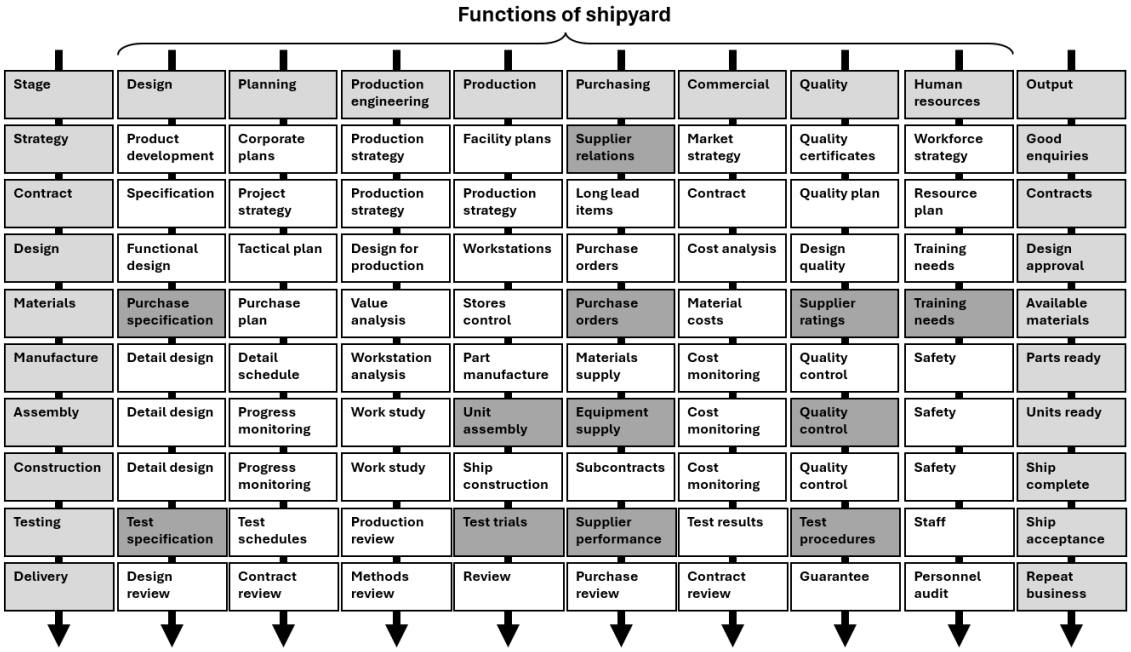

Figure 8. Activity map of shipyards (Bruce, 2020, p. 11). The figure has been modified from the original one.

In the design function, suppliers receive purchase specification and test specifications. In the production function, suppliers assemble the goods that they supply and perform trial tests, also known as Factory Acceptance Testing (FAT) at their own facilities (Verma et al., 2018). In the purchasing function, suppliers are involved in supplier relations between them and shipyards, receive purchase orders from system integrators, supply the goods to the shipyard, and finally their performance is evaluated. In the quality function, supplier ratings are checked, supplier quality is controlled, test procedures are assessed. In the human resource function, suppliers must provide training to both system integrator and shipyard personnel.

2.6 Theoretical framework: Strategic supplier selection of system integrators

Based on the literature on supplier selection, which primarily focuses on the manufacturing company context, a theoretical framework for supplier selection of system integrators can be formed. This framework integrates the key concepts discussed in chapter

two, addressing the unique characteristics and strategic decision-making processes of system integrators. The following theoretical framework, illustrated in figure 9, synthesizes these discussions and will serve as a guide for the subsequent research steps. It aims to provide a comprehensive understanding of strategic supplier selection of system integrators in the marine industry. This figure will be filled with empirical data and insights from the interviews in chapter 4.7.

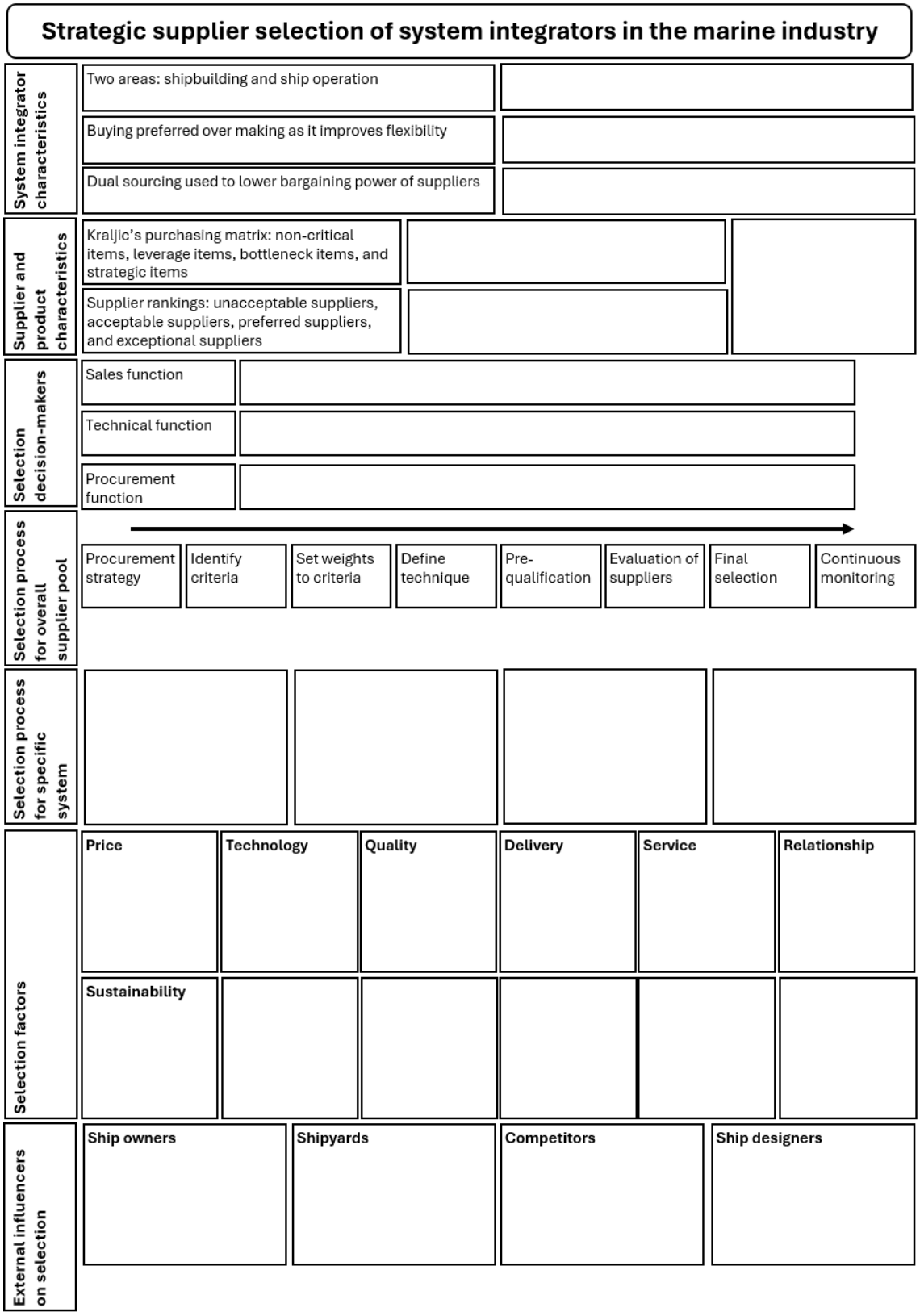

Figure 9. Theoretical framework.

3 Methodology

3.1 Research approach

Empirical research relies on theoretical research methods that have been improved and developed over time. Irrespective of the data type employed, ensuring methodological alignment is essential in scientific research. In business and management research, getting better results depends on finding and using the most appropriate combination of theory, research design, data, and analytical technique. This approach enables reliable and valid findings, and the development of theory that is relevant, responsible, rigorous, and valid (Knight et al., 2021; Grodal et al., 2021). The research approach used in this study can be explained by through the research onion framework presented by Saunders et al. (2019). The research onion framework offers a detailed illustration of the six layers or stages for developing a robust methodology. Each layer represents a distinct aspect of the research process. Moving from the outer layer inward, the layers are as follows: philosophies, approach to theory development, methodological choice, strategy, time horizon, and techniques and procedures. The research onion is presented in figure 10.

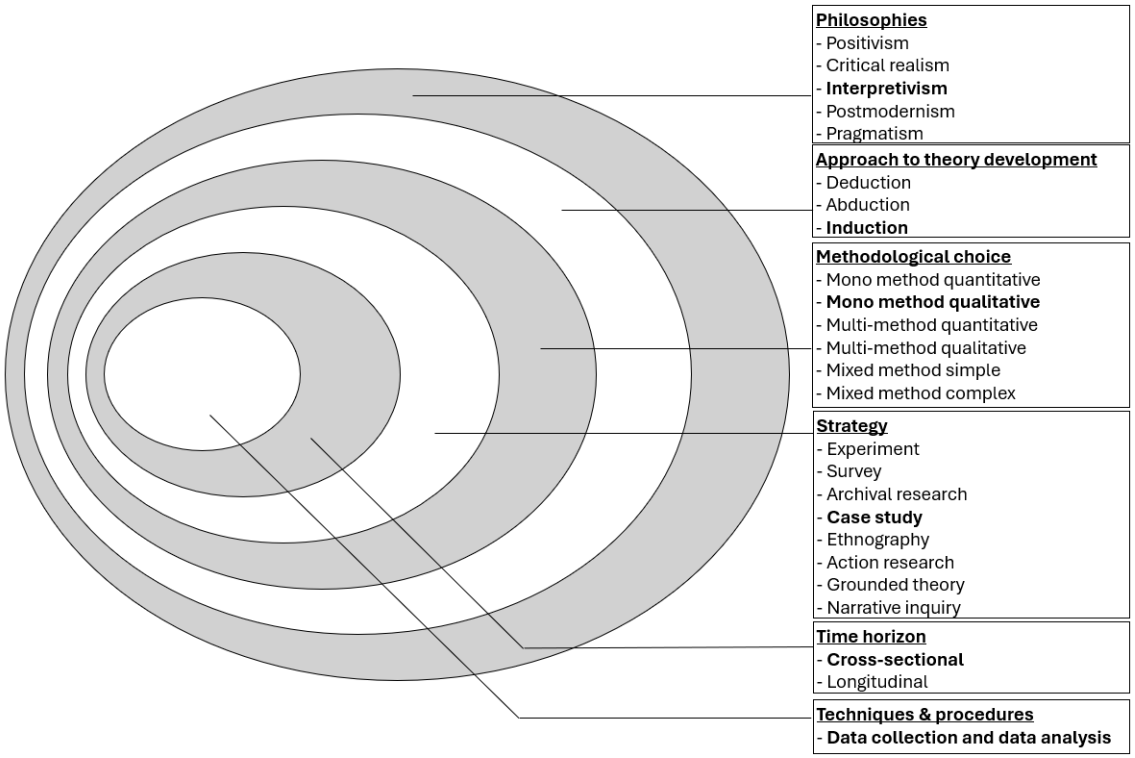

Figure 10. Research onion (Saunders et al., 2019, p. 130). The figure has been modified from the original ones.

At the outermost layer are philosophies, reflecting researchers' fundamental views of the world (Saunders et al., 2019). Positivism emphasizes observable facts, while critical realism acknowledges reality as shaped by social and cultural contexts. Interpretivism views reality subjectively, while postmodernism challenges universal truths. Pragmatism prioritizes practical solutions over theoretical purity. Approach to theory development, the second layer, involves deduction, starting with theory to form hypotheses, induction, where theory arises from data analysis, and abduction, combining both to seek the best explanation. Methodological choice, the third layer, includes mono method, either quantitative or qualitative, multi-method, using multiple methods of one type, and mixed methods, integrating quantitative and qualitative approaches. Strategy, the fourth layer, dictates the research plan. Experimentation, surveys, archival research, case studies, ethnography, action research, grounded theory, and narrative inquiry offer diverse strategies to suit different research questions. Time horizon, the fifth layer, considers whether the research is cross-sectional, conducted at a single point, or longitudinal, spanning

time to observe changes. Finally, techniques and procedures, the innermost layer, guide practical aspects of data collection and analysis, shaping the research's execution and reporting.

As this study focuses on strategic supplier selection of system integrators, interpretivism is chosen as the research philosophy due to its emphasis on understanding social phenomena through subjective interpretations. Interpretivism is grounded in subjectivist ontological assumptions that entities are constituted of discourse, therefore existing or social constructed reality may only be researched through social consciousness or language (Melnikovas, 2018). For theory development, an inductive approach is chosen, because the aim of it is to verify theories by searching for the facts and to establish description of patterns (Rashid et al., 2019). While existing research focuses on supplier selection, the system integration business model differs significantly from traditional manufacturing companies, where much of the research has been conducted. This study seeks to investigate how system integrators choose their suppliers and whether the findings from existing supplier selection research are applicable within the context of system integration. The inductive research approach of this study is presented in figure 11.

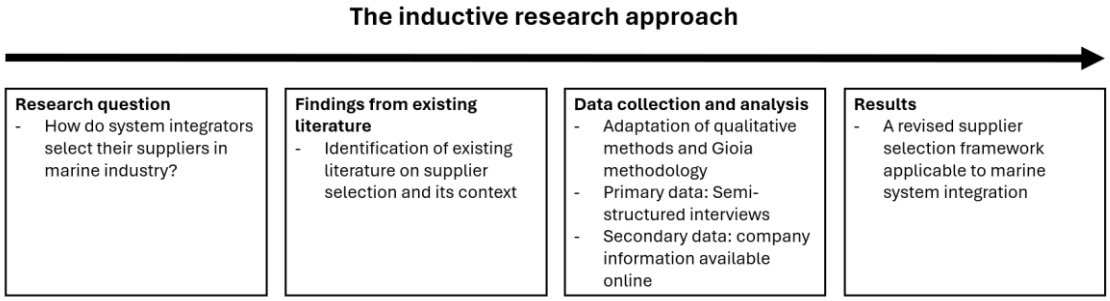

Figure 11. Inductive research approach of this study (Saunders et al., 2019; Rashid et al., 2019).

Regarding methodological choice, mono method qualitative study is chosen. As the objective of the study is to investigate how system integrators choose their suppliers, and the data is collected by semi-structured interviews, qualitative data is needed. The

qualitative method enables researchers to conduct an in-depth exploration of complex phenomena within a specific context while also allowing interviewees to use their own voice and draw on their own concepts and experiences (Rashid et a., 2019; Eisenhardt & Graebner, 2007; Grodal et al., 2021). This is important in this study because supplier selection includes highly subjective criteria.

Regarding strategy selection, a case study is chosen. This is because case studies allow for deep analysis within a specific context (Rashid et al., 2019). According to Starman (2013) case studies are strong in qualitative studies where high precision is needed. They perform by offering conceptual validity, deriving new hypotheses, exploring causal mechanisms, and assessing complex causal relations (Starman, 2013; Grodal et al., 2021). They also work well with semi-structured interviews, which are commonly used to gather data in case studies. Rashid et al. (2019) stress the importance of understanding the case thoroughly before finalizing the list of participants and holding the interviews. Before the interviews were held, the theoretical background had already been written. While it's recommended to record interviews, many interviewees preferred not to. Hence, interview notes became the primary source of data. It's essential to acknowledge the drawbacks of case studies, such as potential confusion, time consumption, and the risk of making incorrect decisions (Rashid et al., 2019). However, Eisenhardt and Graebner (2007) argue that drawbacks in case studies can be mitigated through research design, including clear justification, theoretical sampling, minimizing informant bias, rich evidence presentation, and clear theoretical arguments, ensuring robust and credible findings that bridge qualitative data to the research.

In the determination of the time horizon for this study, a cross-sectional approach is selected. This decision is primarily made by the academic context in which the study is conducted, being a thesis undertaken in the Master of Science program. Additionally, the nature of case studies, as they frequently investigate phenomena within real-time and often abbreviated time frames, further justifies this choice (Rashid et al., 2019). In alignment with these considerations, the collection of material was executed over as

brief a period as feasible. Interviewees were invited for interviews over a four-week period, and the interviews took place between March and June 2024.

3.2 The case company (supplier) and customers (system integrators)

During the study, the researcher is employed by a supplier company in the marine industry that sells to various system integrators. The interviewed companies, which are customers of this supplier company, are all system integrators. These system integrators are designated as SI1, SI2, SI3, and so on. Some of these system integrators are a subdivision of a larger corporation, some are independent companies. The size of each system integrator is classified as small, medium, or large, with small indicating a workforce of about a dozen employees, medium a few dozen, and large over a hundred. While these categories are somewhat abstract, they provide a general sense of the scale of the system integrators involved.

Interviews were conducted with senior managers and executives from five system integrator companies across sales, technical, and procurement functions. Interviewees held titles such as VP of sales, Chief Technology Officer, VP of procurement, General Manager, Product Manager, and Senior Bid Manager, though in text and Appendix 2, these titles are anonymized as Senior Manager Sales (SMS), Senior Manager Technical (SMT), and Senior Manager Procurement (SMP) to maintain confidentiality. The interviewees are referred to as SMS1, SMS2, SMT1, SMT2, SMP1, SMP2, and so forth. Moreover, financial indicators, such as yearly revenue, which could aid readers in identifying the companies, are not disclosed. Additionally, the duration of activity in system integration business is presented on a vague scale. The company data was gathered from the company websites as well as asked from the interviewees. However, to secure the anonymity of these system integrators, the company websites are not included in the reference list. The interviewed system integrators and the number of interviews conducted are presented in table 1.

Table 1. Interviewed system integrators

	SI1	SI2	SI3	SI4	SI5
System integration company size	Large	Medium	Small	Small	Small
Geographical market area	Global	Global	Global	Global	Global
Part of a larger manufacturing company with own products	Yes	Yes	Yes	No	Yes
Years in system integration business	30+	20+	10+	<5	<5
Number of interviews (sales)	4	1	1	1	1
Number of interviews (technical)	3	1	2	0	1
Number of interviews (procurement)	2	0	0	0	1
Total interviews	9	2	3	1	3

Due to the limited number of system integrators and suppliers in the marine industry, all participants remain anonymous. This anonymity is crucial for safeguarding privacy, business interests, and the strategies of the supplier company, system integrators, and interviewees. Oates et al. (2022) underscore the importance of safeguarding both interview and company privacy, asserting that the researcher bears the critical responsibility of protecting the information of interviewees and companies. Anonymity fosters fairness, upholds confidentiality, and builds trust between the researcher and interviewees. Despite the anonymization, the insights gained from these interactions offer valuable perspectives on the complexities of supplier selection within the marine system integrator context.

3.3 Data collection

In this study, the data collection process is designed to align with the unique dynamics of the supplier-system integrator relationship, recognizing the importance of making a clear distinction between academic research and any commercial interests. It is crucial to acknowledge that the researcher is employed by a supplier company and the interviewees are working for system integrator companies that purchase products from the given supplier company. Acknowledging the sensitivity surrounding the products manufactured by the supplier, the semi-structured interview questions were crafted to exclude direct references to these products, ensuring the focus remained on the objective of the study. This approach underscores the non-commercial intent of the interviews, a

crucial factor in establishing trust and openness with the interviewees (Eisenhardt & Graebner, 2007).

Following the guidelines suggested by Yow (2015), a conscious decision was made to not record the interviews. This choice was made by the preference of the interviewees, primarily senior managers and executives who wish to remain anonymous and have demanding schedules. They were reluctant to permit recording. To respect their time and privacy, and to avoid the additional burden of reviewing recordings, interviews were conducted over Teams, with data collected through detailed notetaking. This method not only accommodated the interviewees' time constraints but also aligned with Oates et al. (2022), who assert that the mode of online non-recorded interviews does not significantly impact the validity or data equivalence, thus allowing the selection of data collection method that prioritized logistical ease and participant comfort.

Opting for non-recorded interviews facilitated a more open exchange of information, enabling interviewees to discuss the system integrator business and supplier selection more freely. This method provided valuable insights into the operational realities of the companies, beyond what is typically disclosed through official processes and statements. The absence of recording, perceived by participants as a gesture of respect for their privacy and confidentiality, encouraged a depth of discussion that might not have been achievable otherwise.

A total of 18 interviews were conducted, each following a semi-structured format. The combined duration of these interviews was approximately 15 hours. The interview notes, which were thoroughly proofread, resulted in 56 pages of documentation. Key quotations and significant insights were formalized immediately following each interview session. Due to the absence of recorded audio, it was not feasible to document all key answers in quotations. Consequently, some essential points were documented in bullet point format. Detailed profiles of the interviewees, including their reference abbreviations, and the durations of their respective interviews are provided in Appendix 2. To

ensure the anonymity of the participants, the duration of their employment in the marine industry is reported using a three-step scale: less than 10 years, 10–20 years, and more than 20 years.

3.4 Data analysis

In qualitative case study research, data analysis is a critical phase that involves interpreting and making sense of the empirical material collected from the case study. Rashid et al. (2019) emphasize the importance of thorough data analysis, as it not only contributes to understanding the phenomenon under investigation but also shapes the quality of the study (Eisenhardt & Graebner, 2007). The first step in data analysis involves the interpretation and analysis of the raw empirical data collected during the case study. Rashid et al. (2019) advocate for a systematic approach to data analysis, which involves organizing and coding the data into identify patterns and themes. Additionally, they highlight the importance of triangulating data from different sources to enhance the credibility of the findings. In this study, the data credibility is improved by conducting multiple interviews with various individuals in different roles and functions within the same system integration company.

This study also incorporates the approach proposed by Gioia et al. (2012) for organizing qualitative data. This data analysis method emphasizes the importance of creating an initial data structure that categorizes findings into first-order concepts using interviewees' terms and then abstracting these into second-order themes that that the researcher identifies. These second-order themes can point to overarching dimensions and a grounded foundation for a comprehensive framework for understanding the strategic supplier selection of system integrators in the marine industry. Also, by organizing the data in this manner, deeper insights can be drawn into the strategic and contextual factors that influence decision-making instead of listing findings purely based on the interview questions.

Preliminary first-order categories, second-order themes, and overarching dimensions can be derived from interview questions and adjusted if needed after the final interview analysis. Figure 12 graphically illustrates how first-order categories, second-order themes, and overarching dimensions are connected. Each second-order theme is color-coded, and these same color codes will also be used in the revised framework to ensure that preliminary categories, themes, and overarching dimensions are represented. Supplier management and engagement theme is colored light grey, sourcing strategies and processes theme is colored dark grey, supplier selection and decision-making theme is colored light blue, and external and competitive factors theme is colored dark blue. Table 2 presents a table where some key answers from interviewees will be filled in. These answers shall also be color-coded and are used for revising the theoretical framework.

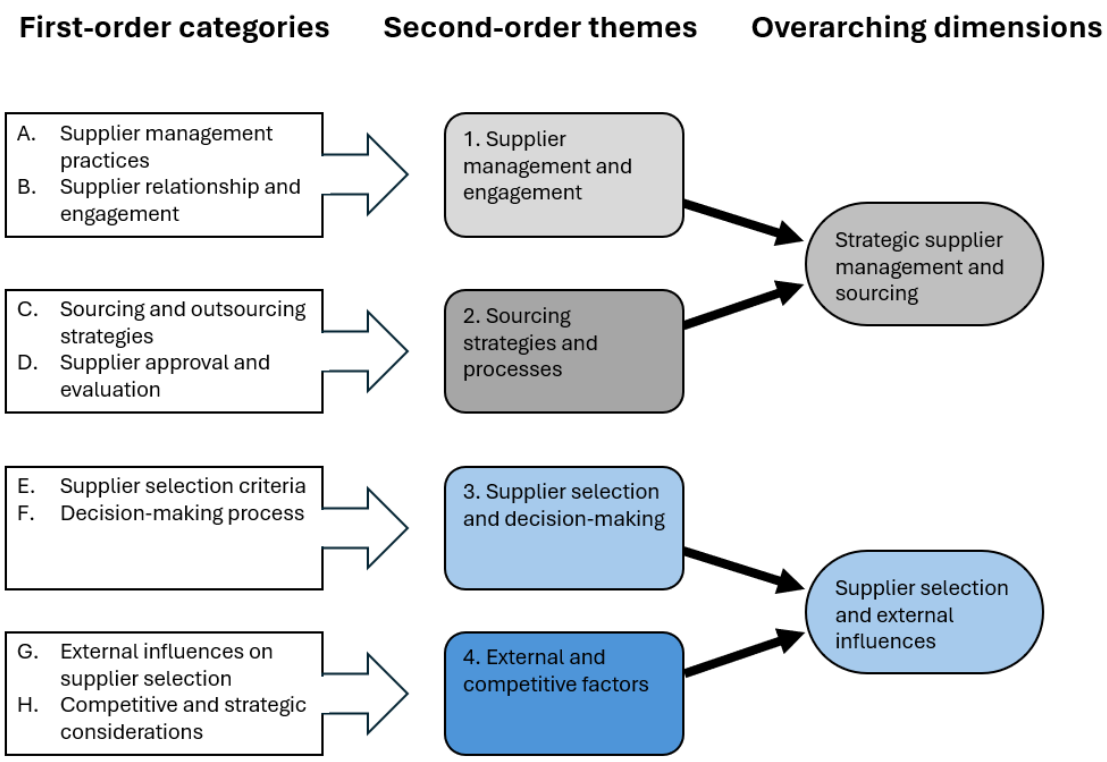

Figure 12. Connections between first-order categories, second-order themes, and overarching dimensions

Table 2. Blank table where key interview answers will be filled in

Second-order themes and first-order categories	Interviewee answers
1. Supplier management and engagement	
A. Supplier management practices	
B. Supplier relationship and engagement	
2. Sourcing strategies and processes	
C. Sourcing and outsourcing strategies	
D. Supplier approval and evaluation	
3. Supplier selection and decision-making	
E. Supplier selection criteria	
F. Decision-making processes	
4. External and competitive influences	
G. External influences on supplier selection	
H. Competitive and strategic considerations	

3.5 The assessment of the quality of data

Quality of the data and the study in general refers to the consistency and stability of measurements over time and across different conditions. Unreliability is generally caused by four main causes: participant error, observer error, participant bias, and observer bias (Robson & McCartan, 2016, p. 106–107). Participant error occurs when variations in individual performance occur due to factors like fatigue or time of day. The interviews were held during office hours at varying times of the day. Some interviews were conducted while the interviewee was driving or engaged in other activities, which could negatively impact the quality of the collected data. Observer error occurs when the one collecting data makes mistakes in recording or interpreting information, leading to inconsistent results (Robson & McCartan, 2016, p. 106–107). The researcher prepared for each interview well beforehand by preparing the template for note taking and reserving a long enough time slot for both the interview and summarizing the answers to the table. However, Oates et al. (2022) claim that with increased privacy, anonymity, and non-recorded interviews, the risk of low data quality increases.

Participant bias occurs when participants consciously or unconsciously alter their behavior or responses to align with perceived expectations or desires, affecting the accuracy

of the data collected (Robson & McCartan, 2016, p. 106–107). Observer bias occurs when the personal beliefs, preferences, pr prejudices of the observer influence their interpretation or assessment of the data, potentially distorting the findings. Both the participants and the researcher can be considered partly biased due to supplier–customer relationship. Interviewees could have withheld information that would directly benefit the case supplier company that the researcher is employed by. The risk of false information was mitigated by cross checking the answers from interviewees working for the same system integrator company. Multiple interviewees working for the same system integrator company, partly also in the same function, also improves the quality of the gathered data.

The quality of research is determined not only by the collection of empirical material but also through analysis and reporting (Rashit et al., 2019; Eisenhardt & Graebner, 2007). Gibbert et al. (2008) further elaborate that the quality of the study can be evaluated based on internal validity, construct validity, external validity, and reliability. Internal validity refers to the causal relationships between variables and outcomes, emphasizing the importance of these relationships in both data collection and analysis phases. Construct validity concerns the adequacy with which a concept is operationalized. External validity addresses the generalizability of the findings suggesting that the conclusions should be applicable even in contexts not specifically studied. Reliability involves the degree to which the study is free from random errors that could prevent future researchers from replicating the research.

The assessment of internal and construct validities in this study involved a comparison with existing literature to ensure there are no significant differences between previously established data and the current findings. External validity can be tested by contrasting these results with studies of system integrators outside the marine industry, where supplier selection practices are theoretically expected to be similar. However, at the time of this study, robust research in this specific context was lacking. The reliability of the study

has been significantly enhanced by conducting multiple interviews, thereby strengthening the research framework, and contributing to the overall integrity of the findings.

4 Findings

4.1 Supplier pool of system integrators

Based on the interviews, system integrators have fewer than 50 suppliers, with around 10 considered key suppliers. Many interviewees highlighted the distinction between total suppliers and key suppliers, often referring to key suppliers as partners (SI3, SMS7; SI4, SMS8).

> *"We have around 40 suppliers of which around 10–15 can be considered as key suppliers or partners." (SI4, SMS8.)*

Generally, larger system integrators have more suppliers in their pool, though there are exceptions. For instance, SI4, a small system integrator, works with various systems without focusing on a specific market segment or vessel type, resulting in a relatively high supplier pool of 40 suppliers despite its small size (SI4, SMS8). Increasing the supplier pool raises costs and offers diminishing returns beyond a certain point

> *"We have around 20–30 key suppliers. This is the range of suppliers we want to keep. Increasing the number of suppliers increases costs and does not yield much more benefits." (SI1, SMT2.)*

However, if a system integrator plans to expand into a new market segment or vessel type, they may need to find new suppliers with products that fit the specific requirements of that market (SI3, SMT5).

4.2 Product and supplier categorization

Based on the interviews, it is evident that system integration companies generally do not have clear and visible product groups. Most system integrators group the same products from different suppliers into a single group. For instance, transformers with different power ratings from various suppliers are all categorized under a single transformer group. In larger system integration companies, each product group typically has a dedicated product owner responsible for ensuring that the products meet requirements and maintaining supplier cooperation (SI, SMT1; SI1, SMP1; SI2, SMT4).

> *"There are no clear product or supplier groups. Each product in practice can be considered as a group and each group has a dedicated product owner." (SI1, SMT1.)*

> *"Yes. Our supplier relationship management system is based on Kraljic's purchasing matrix for categorizing products and suppliers based on their risk and profit impacts. Also, all products have dedicated product owners." (SI1, SMP1.)*

This practice indicated that, aside from the procurement function, system integrators discuss products as single units rather than grouping them into subsystems at a company level. An exception to this is SI2, which segments its products into five groups: complex electrical, simple electrical, navigation, communication, and control groups (SI2, SMS5; SI2, SMT4). These groups are further divided into easy-to-switch and hard-to-switch products (SI2, SMT4).

> *"Yes. All products are segmented into five groups: complex electrical products, simple electrical products, navigation products, communication products, and control products. Each segment is split into easy-to-switch and hard-to-switch products." (SI2, SMT4.)*

SI4 categorizes its products into three groups: under 1000 kW power-rated products, over 1000 kW power-rated products, and software products (SI4, SMS8).

Interviewees also mentioned the existence of unofficial product groupings. Most common grouping divides products into important/complex products and not important/commodity products (SI1, SMS1; SI1, SMS3; SI3, SMS6). Important/complex products include items like power electronics, while not important/commodity products include products like transformers (SI1, SMS1). Another unofficial grouping differentiates products by lead time, categorizing them into long lead time and short lead time items (SI1, SMT2). Control system hardware can be treated as bottleneck items due to their procurement challenges (SI1, SMP1). However, other interviewees, apart from SI1, SMP1, did not mention bottleneck items or leverage items.

> *"In practice we mostly discuss important products and not important products. However, we do have leverage and bottleneck items as well. Take control system hardware – little complexity of supply but highly important. Traditionally these are short lead time off the shelf items but also difficult to change supplier because of*

> *engineering obstacles. Easy to fall into the trap of not making a strategy for them." (SI1, SMP1.)*

> *"I have conducted a survey internally about categorizing products, but to be honest, there are many different opinions on the topic and no single way to look at things." (SI1, SMP1.)*

The four interviewed system integrator companies that function as separate business units under larger manufacturing companies share the same procurement systems with their parent companies. SI1 and SI2 have their own procurement teams, while SI3 and SI5 have single individuals handling procurement for the system integration business unit. SI4 does not have a dedicated procurement person, but procurement duties are managed by personnel from sales and technical functions. SI1 uses the same Supplier Relation Management (SRM) system as its parent company, which is based on Kraljic's (1983) purchasing matrix.

> *"All of our suppliers have a rank in our supplier relationship management system. Key metrics for rank determination are for example quality, on time delivery, and supplier response time." (SI1, SMP2.)*

SI2 also utilizes an SRM system that ranks suppliers into three groups (A, B, and C) based on metrics such as price and delivery time. Group A consists of 3–5 preferred suppliers for a single product, group B includes most suppliers, and group C comprises a few backup suppliers.

> *"Suppliers for each product are ranked in three groups, A, B, and C on our supplier relationship management system. A group has 3–5 suppliers. These can be considered as key suppliers. B group has many suppliers. These can be considered alternative suppliers. C group has few suppliers. These can be considered as back-up suppliers." (SI2, SMS5).*

Despite these SRM system rankings, interviews with most sales and technical functions reveal that there are no clear supplier groups. Unofficial supplier groupings include suppliers categorized by location (SI1, SMS1; SI1, SMS2), suppliers with and without frame agreements (SI1, SMS2), approved and non-approved suppliers (SI1, SMS4; SI3, SMT5; SI5, SMS9; SI5, SMP3). Products can also be categorized as long and short lead time items (SI1, SMT2). Additionally, suppliers can be unofficially grouped into those providing serial

production products, and those offering tailor-made customizable products (SI3, SMS6; SI3, SMS7; SI4, SMS8). Generally, large supplier companies offer serial production and little customization while smaller supplier companies offer more customization (SI4, SMS8).

4.3 In-house manufacturing, outsourcing, single sourcing, and multi-sourcing

Most system integrators opt to make control systems in-house while procuring all other products. The primary motive for maintaining control systems in-house is their critical role in system integration, providing a competitive edge and differentiation. Control systems can also be too critical to outsource due to quality and development prioritization reasons. In-house manufacturing also allows prioritization, reducing delays from development to implementation. Lastly, control systems are always included in the system integrator's scope leading to high volumes.

> *"Customizable in-house developed control systems allow more control on the product and the overall development. It also helps us differentiate ourselves from the competition. Control systems are also always included in our delivery scope so the volume is high." (SI3, SMT5.)*

> *"In-housing improves quality control, enables prioritization, and can shorten time from development to practice. In-housing is never done to cut costs in western system integrator companies." (SI3, SMS7.)*

> *"Buy hardware, make software!" (SI2, SMT4.)*

> *"It is impossible to do system integration without own control system." (SI1, SM4.)*

> *"Control systems are too important to be outsourced." (SI1, SMS2.)*

SI1 has experimented with outsourcing control systems but ultimately decided to retain their control systems in-house (SI1, SMP1). The strategy of "buy hardware, make software" (SI1, SMT4) highlights the importance of control systems in system integration. Some system integrators have parent companies that manufacture certain products,

which these integrators can utilize. However, based on the interviews, they are usually not restricted to using only these products and have the flexibility to procure from the entire market.

> *"Procuring products from all suppliers allows flexibility which is critical in system integration." (SI1, SMS1.)*

Furthermore, the production volume for individual products with certain power ranges is typically too low to justify in-house manufacturing.

> *"We make control systems in-house while buy all other products from various suppliers. The main reason for buying products from suppliers is that the volume for each single product in a certain power range is too low for in-house manufacturing to make sense." (SI1, SMT1.)*

Occasionally, system integrators enter into licensing agreements with external suppliers to offer exclusive products to shipyards and ship owners, thereby retaining Intellectual Property Rights (IPR). An example of this is SI4, which has utilized such agreements for certain products (SI4, SMS8).

All interviewed system integrators aim to multi-source all outsourced products. SI1, for instance, multi-sources everything except some control system hardware (SI1, SMT2; SI1, SMT3).

> *"All outsourced products are multi-sourced except some control system hardware, computers, and so forth. These are outsourced due to the difficulty of switching suppliers and high switching costs caused mostly by engineering." (SI1, SMT3.)*

Additionally, SI1 occasionally engages in joint development projects with single suppliers to create new products with advanced technologies and functionalities.

> *"Joint development projects are first single sourced from the supplier we are doing joint development with. However, the long-term goal is to transition to multi-sourcing these products when other suppliers can offer the same technology or functionalities." (SI1, SMS2.)*

The intention behind multi-sourcing is to mitigate risks and enhance flexibility even further in the supply chain, ensuring a more robust competitive approach to procurement.

Single sourcing, while sometimes necessary, increases risk (SI1, SMT1; SI4; SMS8; SI5; SMT6) and can lead to higher unit prices (SI1, SMT1).

> *"Single sourcing a certain product from a supplier that goes out of business, can leave system integrator to a bad situation." (SI5, SMS9.)*

> *"There are two reasons why single sourcing is avoided. Firstly, it significantly increases risks because the supplier can become unavailable for one reason or another. Secondly, it is hard to push down the price if there is just one supplier for that specific product and that supplier knows it." (SI1, SMT1.)*

Therefore, by having multiple suppliers for the same product, integrators can reduce unit prices. Sometimes system integrators can develop new suppliers for a product that they see that they have too few suppliers.

> *"New suppliers can be developed in case there are too few suppliers for a certain product." (SI1, SMS3.)*

> *"We also try to develop our suppliers. This can include things like customer feedback sharing, functionality improvement requests, finding possible ways to cost-optimize, as well as sometimes motivating to make new products." (SI1, SMT1.)*

Smaller system integrators may be forced to single source due to limited resources for supply chain management and insufficient volumes. Transitioning from single sourcing to multi-sourcing is typically pursued as system integrators aim for growth.

> *"Single sourcing is avoided but sometimes necessary due to low volumes for certain products and limited resources for supplier interaction and product integration." (SI3, SMS6.)*

> *"At the moment some products are single sourced but as we aim to grow in volume, revenue, and personnel, we are transitioning to multi-sourcing all products." (SI3, SMT5.)*

However, in some instances, even smaller system integrators are required by their parent companies to adopt a multi-sourcing strategy. For example, SI5 follows a guideline from its parent company mandating three suppliers for each product (SI5, SMT6).

Based on the interviews, there is very little intentional balancing of supplier shares among large (SI1) and medium-sized (SI2) system integrators. There is no strict threshold for the highest allowed share for a single supplier before it is considered single sourcing. The distribution of shares among suppliers is typically determined by market conditions, and occasionally, one supplier may dominate for some period.

> *"We don't have a set maximum supplier share value that we do not want to cross. Strategic supplier share balancing can sometimes be evaluated but it does not happen often. Supplier shares mostly depend on the market conditions. Sometimes there can only be a single supplier that may dominate its competitors for some period until the competitors catch up and become competitive again. During this domination period, it is natural that the supplier gets a high share of the volume." (SI1, SMP1.)*

For larger system integrators (SI1 and SI2), a single supplier rarely exceeds 50–60 % of the share for a multi-sourced product (SI1, SMS2; SI1, SMT3; SI2, SMS5; SI2, SMT4). While strategic supplier sharing is sometimes evaluated, there is generally no intentional sharing among suppliers. In contrast, for smaller system integrators, the share for a single supplier can be high. For example, for SI3, the most dominant supplier accounted for 35 % of the turnover in the system integration business unit, although this supplier provided many different products

> *"Annual share for each supplier depends heavily on business volumes. Sometimes we have a large project with multiple vessels where many different products are supplied by a single supplier. This can temporarily give a high share for certain suppliers. For example, one year the biggest supplier received 35 % of the entire turnover of our system integration business unit." (SI3, SMS6.)*

Sometimes, system integrators may become temporarily extremely dependent on certain suppliers. This can be considered as a significant risk. Also, some small system integrators, such as SI4, may intentionally balance supplier shares to maintain suppliers' interest in them.

> *"We are sometimes intentionally balancing the share between some suppliers. As we are a small system integrator, it is not granted that all suppliers, especially large supplier companies, remain interested in us if we don't bring any volume for them for a long time period." (SI4, SMS8.)*

4.4 New supplier approval process

The new supplier approval process varies significantly based on product complexity and the size of the system integrator. Complex and strategic products need a longer approval process than simpler products. Larger system integrators, like SI1, may take several months to approve suppliers for complex products, while simpler products might only take a few weeks (SI1, SMS2).

> *"New supplier approval process depends on product complexity. The more complex the product is, the longer the approval process." (SI2, SMS5.)*

> *"Approval process depends on product complexity. For tailor made complex product suppliers, the approval process can be considered as starting a partnership. In addition to the official approval process, personal relationships with the supplier are also built." (SI3, SMS6.)*

> *"Product complexity is one of the key determinants of the approval process duration. For simple products the approval process can be done in 1–2 weeks if needed while for strategic and critical products it can take around 3 months." (SI1, SMS2).*

In contrast, medium-sized system integrators such as SI2 and smaller ones like SI3 may only require a few days to approve suppliers of simple products (SI2, SMS5; SI2, SMT4).

> *"Simple product suppliers can be approved in a day." (SI2, SMT4.)*

> *"Supplier approval can take anything from few hours to few weeks, depending on product complexity, travelling schedules for audits etc." (SI4, SMS8.)*

In extreme cases, the approval process can take years and sometimes the supplier is never approved.

> *"One terrible example was a supplier that we were evaluating for two years. We had many people working on the supplier approval doing a lot of work, travelling multiple times to the supplier etc. The end result was that the supplier was never approved." (SI1, SMT2.)*

Most potential new suppliers are usually identified by the sales function (SI1, SMS4).

For SI1, SI2, and SI5, there are strict approval processes that must be followed before purchasing any products. The approval process typically begins with a technical and commercial evaluation of the product (SI1, SMS1; SI1, SMS2; SI1, SMP1; SI2, SMT4). This phase can be considered as a pre-approval phase.

> *"New supplier approval begins with a technical and commercial pre-approval done by sales and technical departments. After the pre-approval, procurement department takes over and completes the approval process. If a supplier passes the pre-approval process, they are usually approved sooner or later." (SI1, SMT3.)*

If the product passes this pre-approval, the procurement function then handles the official approval process, which includes supplier audits, quality control evaluations, service assessments, production capacity checks, and documentation quality reviews (SI1, SMT2). Additional evaluations include financial evaluations, such as credit ratings as well as future business plans and organizational structure assessments (SI1, SMP1; SI2, SMS5). Supplier reference lists are also closely assessed during supplier evaluation and approval process (SI5, SMT6).

Smaller system integrators, like SI3 and SI4, often have lighter approval processes. SI3 prefers to establish partnerships and build personal relationships with suppliers (SI3, SMS6). SI4 assesses supplier size and prefers to collaborate with suppliers of similar size.

> *"We have quite light approval processes. It still includes things like commercial and technical evaluation, health and safety audit, quality audit, supplier capability evaluation etc. One thing we also evaluate is the supplier size. We prefer to work with smaller suppliers that are similar to our size. With similar size suppliers the ways of working match well and we can both be flexible." (SI4, SMS8.)*

SI5, despite being flexible in reaching out to various suppliers quite freely, requires that all suppliers go through an official approval process by the procurement function of their parent company before purchasing their products.

> *"We are allowed to operate and interact with any suppliers very freely. However, we must follow the parent company supplier approval process before sending any purchase orders. This process includes things like audits, financial evaluation, checking supplier's reference lists, production capabilities etc." (SI5, SMS9.)*

Occasionally, parent company strategies may restrict the use of certain suppliers, especially if the supplier competes with the parent company in other business areas (SI1, SMS1; SI1, SMS2). Risks associated with integrating products from new suppliers are mitigated by thorough testing in a test facility or through a pilot project, which may need to be in operation for some time before the supplier's products are approved for further use.

> *"We prefer to test products in a separate test environment or in a pilot project before officially approving the supplier. Sometimes we want to wait until the pilot project is delivered and in operation before the supplier is approved. Sometimes there can be parallel projects with the supplier but this is all based on case by case risk evaluation." (SI1, SMP1.)*

> *"New suppliers of critical products are often tested during their approval process to mitigate risks on the first project together." (SI1, SMT3.)*

4.5 Supplier selection process, factors, and decision-making for a specific system

When a system integrator is asked by a shipyard to quote a system, the sales function usually reviews the system specifications and selects a few suppliers that can provide the necessary products (SI1, SMS1; SI1, SMS2). For larger system integrators like SI1, which have more resources dedicated to supply chain management, the general practice is to request quotes from at least two suppliers for each product in the specific system. Often suppliers of standard products provide price lists for system integrators that they can utilize when estimating budgetary system price to shipyard. System integrator's technical function typically maintains a list of suppliers that are well-suited to specific systems and power ratings.

> *"For a budgetary bid we usually ask quotes from minimum two suppliers for each product. This is done by our sales engineers." (SI1, SMS1.)*

> *"On early sales phase our sales team is often using price lists from our standard product suppliers. For complex project tailored products we have to either ask for quotes, estimate a price based on previous offers, or sometimes we can use configurators provided by the supplier." (SI1, SMT1.)*

> *"Technical department provides lists of suppliers that are a good fit for certain systems. In practice we give recommendations whose products fit well to which kind of vessel and system type with its specific requirements and needs. The preliminary supplier selection is based on how well the supplier's power steps match the system's power steps." (SI1, SMT2.)*

In contrast, smaller system integrators, such as SI3, may only request quotes from the supplier whose product they think fit best to the system specifications. In some cases, only one supplier can meet the most complex system specifications.

> *"All of our suppliers have certain sweet spots where their products fit the best. Usually, we ask for quotations from the key suppliers that we think are the best fit for that specific system." (SI3, SMS6.)*

> *"All our suppliers have certain sweet spots where they perform the best and are the most cost-effective. For example, on simple systems, we tend to use simple suppliers but for complex systems, we prefer to use the best suppliers. For simple systems there are many suppliers to choose from. For complex systems, there are only 1–2 suppliers that can fulfill the technical requirements." (SI3, SMS7.)*

The shipyard aims to build the vessel as cost-effectively as possible, while ship owners generally focus more on total costs including both building and operational costs. The shipyard proposes the most affordable system integrator to the ship owner. If the ship owner prefers a different, more expensive system integrator or wants to have a certain supplier, the shipyard requires the ship owner to pay a premium.

> *"Shipyards want to build the vessel as cost-effectively as possible while ship owners are also interested in operational costs so there is some controversy between shipyards and ship owners. This means shipyards aim to fulfill the design requirements with as little initial cost as possible and they do not pay too much attention to operational costs. After the final bidding round, the shipyard recommends the cheapest system integrator bid with their supply chain to the ship owner. If the owner wants to select another integrator or change some suppliers, they need to pay a premium to the shipyard." (SI5, SMS9.)*

The goal of the system integrator is to fulfill system specifications at the lowest initial and life-cycle cost (SI1, SMP1). However, approaches vary among system integrators. For instance, SI4 does not offer global after-sales and spare parts services (SI4, SMS8), while SI1 and SI5 closely assess life-cycle costs due to their specialization in life-cycle solutions

(SI1, SMP1; SI5, SMT6). SI2 and SI3 are seldom the cheapest but strive to convince ship owners of the superiority of their solutions (SI2, SMS5; SI3, SMS6).

> *"Most often, our goal is to meet the system specifications for the lowest initial cost and/or life-cycle cost. We offer a wide range of life-cycle solutions to ship owners. However, there are differences between vessel types and ship owners. Some pay more attention to life-cycle costs than others." (SI1, SMP1.)*

> *"Our core business is not based on life-cycle solutions. In practice this means that we are not focusing on reselling spare parts and providing on-site support. We do most of our support remotely and value suppliers whose products can be remotely accessed." (SI4, SMS8.)*

> *"We are rarely the cheapest system integrator in the race. However, we aim to provide the very best system out there to the ship owners. Often, ship owners are willing to pay a premium to get our system into their vessel." (SI3, SMS6.)*

In simpler markets, such as Liquefied Natural Gas (LNG) carriers, competition is primarily focusing on price, while in advanced luxury markets, such as mega yachts and cruise ships, ship owners are willing to pay more for additional technological features (SI3, SMS6; SI5, SMS9). This implies that usually system integrators who primarily compete based on lowest system price tend to concentrate on simpler markets. In contrast, those who emphasize system superiority typically target more advanced and sophisticated markets. Consequently, it can be assumed that the market a system integrator targets may influence the type of suppliers they choose.

Based on the interviews conducted, the two most important factors in the supplier selection process for a specific system are technical fit and price. Technical fit includes factors such as efficiency, protection, size, weight, and power rating (e.g. SI1, SMS1; SI1, SMT2, SI1, SMT3). Supplier's product compatibility with system integrator's control systems is also part of the technical fit (SI4, SMS8). Product power ratings are a crucial factor in determining technical fit.

> *"Power rating can be a key determinant for the supplier selection. For instance, if Supplier A's product is rated and optimized for 1000 kW and Supplier B's product is rated and optimized for 1200 kW, but the system specification requires 1100 kW, Supplier A would need to use their next higher power step, let's say 1500 kW while Supplier B can meet the requirement with their 1200 kW. This often makes supplier*

> *B's product a significantly better fit because Supplier A's product would be more over-dimensioned." (SI1, SMT2.)*

Additionally, price is a critical factor in supplier selection, as system integrators strive to fulfill system specifications at the lowest initial and life-cycle costs, despite minor variations between system integrators, ship owners, and vessel types. Price was mentioned by every interviewee as a key factor in supplier selection. For simple products, pricing can even be the only factor in supplier selection.

> *"Of course, price is important. For simple products, competitive pricing is the one key factor if delivery time and marine classification requirements are met. For complex products, price is a bit less important, but with too high prices, we cannot win project." (SI3, SMS7.)*

In addition to technical fit and price, other significant factors in supplier selection include delivery time and reliability as well as supplier's reference list on similar projects (SI1, SMP1; SI1, SMP2; SI1, SMS4; SI5, SMS9). Supplier reference lists are especially important for new system integrators who do not have an established reference list of their own yet (SI5, SMS9). This means that new system integrators may prefer suppliers with long and proven reference lists to build credibility towards shipyards and ship owners.

> *"In addition to price and technical fit, we also assess delivery time, supplier location, quality, and supplier's reference list on similar projects." (SI1, SMS1.)*

> *"Supplier's reference list in the same country as the yard, preferably in the same vessel type, can help us convince shipyards and ship owners to select us as the system integrator as we do not have a reference list of our own on that market yet." (SI5, SMS9.)*

Product quality is also crucial, although it is usually assessed at a general supplier level rather than for specific projects (SI1, SMP1). Smooth collaboration and strong personal relationships between the system integrator and supplier are vital, especially for complex products (SI1, SMS1; SI1, SMS3; SI1, SMS4). Supplier's fast response time is important for smooth collaboration. For complex products smooth collaboration and quality can even be considered one of the most important factors in supplier selection (SI3,

SMS7). Furthermore, suppliers who provide valuable feedback on system optimization are highly valued (SI1, SMS3).

> *"Product quality is also one of the key factors but it is mostly evaluated by procurement and after-sales on a general supplier level instead of project specifically." (SI1, SMP1.)*

> *"Smooth collaboration is key and can help the supplier to be chosen as a supplier, especially for complex products. For example, if I reach out to two suppliers and one of them answers within a day, provides feedback on system optimization, and is a nice person to work with and we get along well, while the other supplier comes back in a week with just a budgetary quote, I'm going to be somewhat in favor of the first supplier, aren't I?" (SI1, SMS4.)*

> *"For complex products, supplier's competence, support, smoothness in collaboration, and response time can even be considered as key factors." (SI3, SMS7.)*

Supplier location can be critical in certain projects. In some countries, shipyards may heavily favor local suppliers and exclude certain foreign suppliers, whereas in other countries, shipyards may not place as much importance on the supplier location. In addition to supplier location, supplier size is also part of the supplier selection factors as smaller system integrators and ship owners may favor suppliers close to their size while large ship owners may prefer to work with globally known suppliers.

> *"Supplier location is a tricky one. For example, some Chinese shipyards might require local suppliers, while Korean shipyards may exclude Chinese suppliers. Conversely, some yards do not care at all where the supplier is located." (SI5, SMS9.)*

> *"We prefer to work with suppliers close to our size. As we are a small system integrator, we tend to favor smaller suppliers because then we can all be flexible. (SI4, SMS8.)"*

> *"Size of the supplier matters. We might favor smaller suppliers as we are also somewhat small. This same logic can also happen at ship owners. For example, some major ship owners may favor globally well known supplies, while smaller and family-owned ship owners may prefer smaller local suppliers." (SI3, SMT5.)*

The supplier's after-sales strategy, including the sale of spare parts, is also a significant factor for some system integrators. This aspect is particularly important for system

integrators who focus on after-sales service or life-cycle solutions and do not want to compete against their suppliers in this market.

> *"As we deliver life-cycle solutions, we prefer that our suppliers do not provide extensive life-cycle services or, ideally, even spare parts directly to the ship owners. Some smaller suppliers may sell spare parts exclusively through system integrators and let us handle the entire after-sales business, while some suppliers might offer their own system integration and life-cycle solutions." (SI5, SMS9.)*

The supplier's sales strategy is similarly significant. Both SI1 and SI2 prefer that suppliers do not sell their products directly to shipyards, circumventing system integrators, as this can disrupt system integration and diminish the system integrator's scope (SI1, SMT3; SI2, SMS5). However, there are differences between system integrators, for instance, SI5 does not object to shipyards purchasing products directly from suppliers, as SI5's business is centered on system control and life-cycle solutions instead of reselling products.

> *"We value suppliers that don't sell their products directly to shipyards. We've had cases where, before signing, shipyards reached out to our suppliers and got offered products at a lower price. This allowed the shipyard to come back to us, saying they would purchase the product themselves and we had to integrate it into the system. This not only reduces our scope but also risks leaving out some critical product options required in the system." (SI1, SMT3.)*

> *"We are okey with shipyards purchasing products directly from the suppliers instead of us. In some cases, we might even encourage them to do so. This is because our main focus is not on reselling hardware but more on system integration and life-cycle solutions." (SI5, SMS9.)*

Supplier financial stability is another assessed factor, particularly for large projects that span multiple years and vessels. Ensuring that a supplier is financially stable mitigates the risk of them going out of business during the project (SI3, SMS7; SI5, SMS9; SI5, SMP3). Also, on some system specifications, certain suppliers can be pre-named based on the ship owner's preference. However, system integrators can suggest alternative suppliers (SI1, SMT1; SI2, SMS5, SI3, SMS7).

> *"Some suppliers have brilliant products, but their financial stability is too low for us to commit to them as the risk of them going out of business during the project is too high." (SI3, SMS7.)*

> *“ I would say in around 20–30 % of projects, some suppliers are pre-named on the makers list. We can suggest alternative suppliers, but with varying results.“ (SI1, SMT1.)*

Finally, the importance of sustainability in supplier selection is noted, though it is typically addressed during the supplier approval process and may not be a primary factor in specific project decisions. Meeting sustainability standards such as ISO are generally considered sufficient for supplier approval (SI1, SMP1; SI2, SMS5). Suppliers who significantly exceed ISO standards typically do not receive additional credit in supplier selection.

Based on the interviews, the sales function plays the most significant role in supplier selection, often making decisions independently. The technical function typically creates a list of suppliers that the sales can use while also providing them guidance on system optimization, including supplier selection. The procurement function is also involved but their power over supplier selection is limited. The procurement function may also handle the purchasing of simple products and possibly bundling projects to negotiate better terms. For large and strategic projects, the company’s top management may also approve the supply chain

> *“Sales function plays a key role in supplier selection because they have the best market knowledge including insights on shipyards, ship owners, competitors, preferences, and potential exclusions. While they have certain limits set by the technical and procurement functions, they are allowed to make fairly independent decisions within those boundaries.“ (SI1, SMP1.)*

> *“Sales function is selecting suppliers quite independently during the sales phase. They may ask our technical team for input or approval for systems that have something new in them. However, some of our input may be ignored.“ (SI1, SMT3.)*

> *“The sales team is selecting suppliers from the list of suppliers we in technical team have listed and recommend for certain systems. The procurement team may handle purchasing simple products and possibly bundle projects together to increase order volumes from suppliers.“ (SI2, SMT4.)*

> *“For some strategic and large projects, our top management might decide part of the supply chain.“ (SI1, SMS1.)*

Generally, technical and procurement functions are allowed to express their opinions and approve the supply chain, but ultimately, the primary decision-makers are in the sales function. However, the decision-making process within the sales function can sometimes overlook certain factors while leaving factors like supplier performance on on-going projects and supplier rating on SRM system unacknowledged.

> *"Sales team is making supplier selection decisions quite independently. We in procurement are not too involved but I wish we were because the sales function is not necessarily always up to date with issues on on-going projects, nor can they see the supplier rating in our SRM. Our role in supplier selection is to give input and check frame agreements with our suppliers etc." (SI1, SMP2.)*

Four high-level phases characterize the sales cycle on the system integrator side: the budgetary bidding phase, the binding bidding phase, contract signing, and starting the project (e.g. SI1, SMS2; SI1, SMS4; SI2, SMS5). Generally, the sales function selects suppliers independently during the early budgetary stage until the binding stage (e.g. SI1, SMS1; SI1, SMS2; Si3, SMS7). At binding stage at latest, also technical and procurement function review the supply chain. At this stage they may check frame agreements with suppliers for the project or possibly evaluate bundling projects. However, the procurement function's power regarding supplier selection is limited, especially for strategic products. Before SI1 submits a binding bid to the shipyard, the sales, technical, and procurement functions have all reviewed the supply chain. If the system integrator has dedicated product owners, they can also affect supplier selection regarding their product (SI1, SMT1; SI3, SMS6). Typically, at least two suppliers for each product are kept in consideration until the contract is signed with the shipyard. Once the contract with shipyard is signed, the project is handed over to technical and project management functions who handle the delivery of the system (e.g. SI1, SMS2; SI1, SMP1; SI4, SMS8).

> *"During the early sales phase or so-called budgetary bidding phase, we in sales select the possible suppliers for the system. Usually there are multiple suppliers for each product in the system. Once we move to the binding bidding phase, product owners, the technical team, the procurement team, as well as sales team management review the supply chain before submitting the bid. At this stage some of the suppliers are disqualified and we are left with just a few back-up suppliers. If we*

> *win and sign the contract, we hand over the project to our technical and project management teams who handle the project delivery.“ (SI1, SMS2.)*

Throughout the sales phase, multiple suppliers for each product are considered. As the sales phase progresses towards contract signing, some suppliers are eliminated (SI2, SMS5). In complex systems, suppliers of complex products are chosen in the early sales phase and are rarely changed (SI1, SMP2; SI2, SMT4). However, there are differences among system integrators. SI2 and SI4 select suppliers for complex products during the binding stage, while for simpler products, multiple suppliers are still considered (SI2, SMT4; SI4, SMS8). The final decision on normal projects regarding supplier selection rests with the sales function’s management (SI1, SMS1; SI1, SMS4; SI1, SMT3).

> *“On a general note, the key decision-maker for supplier selection is the sales team’s management, mainly the head of sales.“ (SI1, SMS1.)*

> *“Usually, the more complex the product is, the less suppliers we ask for quotations and consider for the system. Suppliers of complex products are rarely changed after the first binding quote.“ (SI2, SMT4.)*

> *“During the early sales phase, we consider multiple suppliers for each product in the system. By the binding bidding phase we have usually selected all key product suppliers and have only a few simple product suppliers left to decide on.“ (SI4, SMS8.)*

SI5 is an exception in its supplier selection procedures as the technical function has created a short list of preferred suppliers for each system type that they offer (SI5, SMS9). This approach reduces the resources needed for supply chain management during the sales cycle and aims to standardize the supply chain for each system type.

> *“We do quite little supplier selection during the sales cycle. Our technical department has created a short list of preferred suppliers for each system and vessel type. We simply try to stick to these preferences as much as possible and save resources on supply chain management. This list of preferred suppliers is reviewed and approved with our business unit’s management.“ (SI4, SMS9.)*

Generally, all interviewed system integrators revealed that the supplier list is revealed to the shipyard and ship owners as late as possible (e.g. SI1, SMS1; SI1, SMS2; SI1, SMT1; SI3, SMS7). This strategy prevents shipyards from contacting suppliers directly and

bypassing the system integrator (SI1, SMT3). If not required, suppliers are not mentioned in the contract with the shipyard (SI1, SMT1; SI1, SMT2; SI1, SMS7). System integrators, mostly the team handling project delivery, can also change suppliers after signing the contract with the shipyard (SI4, SMS8). Additionally, shipyards can assist system integrators if their chosen supplier fails to deliver on time, as shipyards often have alternative suppliers they can recommend (SI5, SMP3).

> *"If there are issues during the project, our project management team can still change some suppliers during the project." (SI4, SMS8.)*

> *"If a supplier fails to deliver on time or the risk of it gets too high, we can change suppliers during the project, but this is not something we wish to do. In some cases, shipyards can help us by recommending suppliers they know. If this happens, it is usually simple products with local suppliers." (SI5, SMP3.)*

4.6 External forces affecting supplier selection

The supplier selection process for system integrators is influenced by external factors, including shipyards, ship owners, ship designers, and system integrator's competitors. Shipyards, particularly those in Asia, often show preference for local suppliers or exclusions of other areas of Asia (SI1, SMS1; SI1, SMT1; SI5, SMS9). Certain system integrators and product suppliers may also be blacklisted by shipyards based on previous experiences (SI1, SMS1; SI1, SMT3; SI3, SMS7). These preferences and blacklists, although sometimes lacking solid reasoning, are usually grounded in past performance and complaints received from ship owners. However, if a system integrator is listed in the ship design specification as a potential system integrator, they generally are allowed to suggest their preferred suppliers, even blacklisted ones.

> *"Shipyards can affect our supplier selection as they often have preferences on some suppliers. They may also have blacklists for certain suppliers' products. Both preferences and blacklists are usually based on shipyard's own history with the supplier as well as ship owner's feedback and may not always have the best reasoning behind them." (SI2, SMS5.)*

> *"Shipyards may have preferences for some suppliers while also blacklists for other suppliers. But as the shipyards rely on our expertise to integrate complex systems*

> *into their vessels, we may propose any suppliers to them, sometimes even blacklisted ones. Although, there are differences between shipyards." (SI1, SMS4.)*

However, shipyards vary in their technical engagement as some are deeply interested in technical details while others defer to the expertise of system integrators (SI1, SMT1; SI1, SMS4; SI2, SMT4). Occasionally, some shipyards might also affect supplier and system integrator selection by providing false information to ship owners to influence their opinions.

> *"There is a massive difference between shipyards. Some shipyards are very into technical details while others do not get involved too much into system integration technicalities." (SI1, SMT1.)*

> *Shipyards can affect both system integrator and product supplier selection. We have had cases where shipyards have given false information about a supplier or a system integrator to ship owner, and drastically affected the selection process." (SI1, SMT2.)*

Ship owners are another critical factor in supplier selection, often having strong preferences and presumptions (e.g. SI1, SMS1; SI3, SMT5; SI4, SMS8; SI5, SMS9). Their involvement is crucial because they must operate the vessel with the selected products for many years. Consequently, ship owners tend to have extensive blacklists for suppliers, driven by a desire to avoid past issues and ensure reliability. While shipyards usually blacklist system integrators more than suppliers, ship owners' blacklists focus more on product suppliers.

> *"Ship owners can for sure affect the supplier selection. They may have very strong preferences for certain product suppliers. They may also blacklist suppliers if they have performed poorly in operation. It makes sense that ship owners care a lot about the products inside their vessel because they need to operate the vessel for the next 30 years." (SI1, SMS3.)*

> *"Usually system integrators are blacklisted by shipyards while product suppliers are blacklisted by ship owners." (SI1, SMT1.)*

Relationships between system integrators, shipyards, and ship owners can also affect the supplier selection. Long-standing relationships between ship owners and certain system integrators can also influence supplier selection, with trusted system integrators often

given the authority to make these decisions. Similarly, some ship owners develop strong ties with specific shipyards, granting them more flexibility in areas outside the ship owner's primary concerns (SI1, SMT2).

> *"We have long and solid relationships with certain ship owners. With these owners we are trusted and very well listened about the vessel operation, system integration, as well as our supplier selection." (SI1, SMS4.)*

> *"Some ship owners have good relations with certain shipyards and they might allow shipyards to do most of the decisions that they do not care too much about." (SI1, SMT2.)*

Ship designers, although having a less direct impact, still play a role in supplier selection through design specifications that include size and weight reservations (e.g. SI1, SMS1; Si1, SMS2; SI2, SMT4; SI3, SMS7). For instance, small size or weight reservations can favor suppliers with more compact or lighter products. Additionally, ship designers might incorporate specific functionalities into the system specifications that could exclude certain suppliers (SI1, SMT1). Some ship designers are influenced by lobbying from suppliers and system integrators (SI1, SMS2; SI1, SMT1; SI3, SMS6), although most designers maintain neutrality (SI1, SMS1; SI1, SMS3; SI2, SMS5).

> *"Ship designers may have some minor indirect affect on supplier selection due to weight and size reservations. However, in general, they are fairly neutral." (SI4, SMS8.)*

> *"Ship designers may rule out certain suppliers by basic system design or including some technical functions into the system specifications. Both system integrators and product suppliers often provide input into their designs, some may also try to influence or lobby them. But at the end of the day ship designers are quite neutral." (SI1, SMT1.)*

The influence of competitors' supplier selection is acknowledged by most interviewees, though it is generally not considered a primary factor. However, it can become significant in certain contexts. For instance, in price-driven, if competitors are utilizing cheaper suppliers, a system integrator might be forced to also utilize more cost-effective suppliers to remain competitive (SI1, SMS1; SI3, SMT5; SI5, SMT6). Additionally, there are cases where competitors have successfully convinced the shipyard and ship owner to use a

particular supplier, thereby forcing other system integrators to adopt the same supplier to comply with the project requirements.

> *"In some cases, our competitors have utilized cheap local suppliers, drastically lowering the system price, also forcing us to use cheaper suppliers with less features to be able to come closer to their price level." (SI3, SMT5.)*

> *"On some projects another system integrator might have convinced the shipyard or the ship owner of a certain product supplier. In these cases we may be forced to also use the same product supplier as the other system integrator." (SI3, SMS7.)*

Strategic differentiation among system integrators typically occurs at a high level and is not often project specific. Nonetheless, some system integrators aim to partly distinguish themselves during the sales cycle by altering their supply chain to stand out from their competition (SI1, SMT1; SI1, SMT3).

> *"Strategic differentiation regarding supply chain is considered on a high level when choosing the key suppliers of strategic products, but not that much on project level." (SI1, SMS3.)*

> *"We rarely want to present identical system to the shipyard and ship owner as our competitors." (SI1, SMT3.)*

It is important to note that system integrators primarily compete based on system solutions and control, rather than solely on their supply chain. Typically, system integrators know what suppliers their main competitors are using for specific systems for strategic products. Moreover, when integrators face competition from suppliers who also offer system integration, they may avoid using those suppliers' products to maintain a competitive edge (SI1, SMT1).

> *"The suppliers that we select for the system are not everything. Even with the same supply chain, two system integrators can have quite a different solution." (SI4, SMS8.)*

> *"We usually know what suppliers our competitors are using, especially for strategic products. However, this does not affect our supplier selection for a specific project too much." (SI1, SMS4.)*
> *"One example when we try to avoid using the same supplier for a certain product as our competitor is when that supplier is also our competitor." (SI1, SMT1.)*

Smaller system integrators may possess an advantage over larger ones due to lower overhead costs (SI1, SMS2; SI4, SMS8). In response, larger system integrators often negotiate frame agreements with suppliers to secure better terms and leverage their volumes to reduce unit prices (SI1, SMS2; SI1, SMP2; SI2, SMS5).

> *"We love competing against large system integrators! We have quite a bit lower overhead costs and we can be much more agile. This allows us to customize each system very specifically for that exact vessel." (SI4, SMS8.)*

> *"It can be challenging for us to compete on price against smaller system integrators with smaller overheads. However, us being well-known and our volumes being high, we can typically get good frame agreements with key suppliers, covering part of that price gap." (SI1, SMS2.)*

Based on the interviews, ship owners have the greatest influence on supplier selection, followed by shipyards, while system integrator's competitors and ship designers have comparatively less impact.

4.7 Summary of the findings and the revised framework

The preliminary first-order categories, second-order themes, and overarching dimensions of the Gioia methodology derived from the interview questions did not need to be altered as the interview answers were well aligned with the framework and no new themes or dimensions were mentioned. The interviews with various system integrators revealed several critical insights across both overarching dimensions, strategic supplier management and sourcing, and supplier selection and external influences. Some of the key answers organized to first-order categories and second-order themes are presented in table 3. These answers play a critical role in revising the theoretical framework.

Table 3. Interviewee answers organized to first-order categories and second-order themes

Second-order themes and first-order categories	Interviewee answers
1. Supplier management and engagement	
A. Supplier management practices	A1. System integrators have fewer than 50 suppliers, with around 10 considered key suppliers A2. Increasing the supplier pool raises costs and offers diminishing returns beyond a certain point A3. Most system integrators group the same products from different suppliers into a single group A4. In larger system integration companies, each product group typically has a dedicated product owner A5. Products are generally considered to be either complex or simple A6. SRM system assesses various metrics and categorizes products and suppliers by risk and profit implications
B. Supplier relationship and engagement	B1. Most system integrators opt to make control systems in-house while outsourcing other components B2. Control systems can also be viewed as too crucial to outsource B3. Products are often outsourced to maintain flexibility, which is crucial in system integration B4. By having multiple suppliers for the same product, integrators can reduce unit prices and reduce risk B5. Smaller system integrators may be forced to single-source due to limited resources and insufficient volumes
2. Sourcing strategies and processes	
C. Sourcing and outsourcing strategies	C1. While strategic supplier sharing is sometimes evaluated, there is generally no intentional sharing C2. Large supplier companies may lose interest in the system integrator if they get low sales for a long period
D. Supplier approval and evaluation	D1. Risks associated with new supplier's product can be mitigated by testing in a test facility or through a D2. The new supplier approval process varies based on product complexity and the size of the system integrator D3. More complex and strategic products need a longer approval process D4. Most potential new suppliers are identified by the sales function D5. The approval process typically begins with a technical and commercial evaluation of the product D6. If the product passes this pre-approval, the procurement function then handles the official approval process D7. Parent company strategies may restrict the use of certain suppliers
3. Supplier selection and decision-making	
E. Supplier selection criteria	E1. The general practice is to request quotes from at least two suppliers for each product in the specific system E2. System integrators may only request quotes from the supplier whose product they think fit best to the system specifications E3. Technical function maintains a list of suppliers that are well-suited to specific systems and power ratings E4. The two most important factors in the supplier selection process for a specific system are technical fit and price E5. Other significant factors in supplier selection include delivery time, reliability, and supplier's reference list E6. Close collaboration and good personal relationships are crucial, especially for complex products E7. Supplier location can be critical in some projects
F. Decision-making processes	F1. The sales function plays the most significant role in supplier selection, often making decisions independently F2. For simple products, procurement function can handle the purchasing F3. Supplier selection process appears to be subjective, with no pre-set frameworks or models being utilized F4. The technical function supports the sales function in creating an optimal technical solution if needed F5. The procurement function typically becomes involved when the sales project reaches the binding stage but their power regarding supplier selection is limited F6. In complex systems, suppliers of complex products are chosen in the early sales phase and are rarely changed
4. External and competitive influences	
G. External influences on supplier selection	G1. Certain system integrators and product suppliers may be blacklisted by shipyards or ship owners G2. Ship owners are another critical factor in supplier selection, often having strong preferences and presumptions G3. While shipyards usually blacklist system integrators more than suppliers, ship owners focus on suppliers G4. Ship designers influence supplier selection indirectly by specifying size and weight requirements G5. Based on the interviews, ship owners have the highest influence on supplier selection, followed by shipyards with ship designers having the least impact. G6. If competitors are utilizing cheap suppliers, a system integrator might be forced to also utilize more cost-effective suppliers to remain competitive
H. Competitive and strategic considerations	H1. System integrators primarily compete based on system solutions and control, rather than solely on H2. Smaller system integrators may possess an advantage over larger ones due to lower overhead costs H3. Larger system integrators often negotiate frame agreements with suppliers to secure better terms and leverage their volumes to reduce unit price

System integrators typically manage a limited number of suppliers, with a focus on maintaining strong relationships with key suppliers. This management approach allows for better control over supply chain dynamics and ensures the quality and reliability of the products sourced. Flexibility is maintained through outsourcing all products apart from control systems, enabling system integrators to adapt quickly to changing project requirements and market conditions. Effective supplier relationship management practices are crucial, as they help mitigate risks and ensure smooth operation of supply chains.

Findings highlight the varied approaches to sourcing and outsourcing among interviewed system integrators. Larger system integrators often leverage their brand and frame agreements with suppliers to secure favorable terms and reduce costs, while smaller integrators may rely on single sourcing due to limited resources. On the other hand, smaller system integrators have less overheads and this can improve their competitiveness in terms of price. The approval process for new suppliers is comprehensive and varies based on the complexity of the product and the size of the system integrator. Criteria for evaluating new suppliers include aspects such as technical capabilities, commercial viability, and risk assessment.

The selection of suppliers is influenced by several key factors, such as price and technology, quality, delivery, service, relationship, reference list, and supplier location. Decision-making processes within system integrators involve multiple stakeholders and are often structured to ensure that all relevant factors are considered. The involvement of sales, technical, and procurement functions ensure a balanced approach to supplier selection. However, sales functions typically have the highest authority on supplier selection.

External forces such as market conditions, regulatory requirements, and technological advancements play a significant role in shaping supplier selection strategies. Competitive pressures also influence decisions, as system integrators aim to at least partly

differentiate themselves through unique supply chain and strategic supplier partnerships. The need to stay competitive drives integrators to continuously evaluate and refine their supplier selection processes. Significant differences exist between market segments, with some being more cost-centric than others.

Based on the organized empirical findings, the initial theoretical framework has been revised to better reflect the realities of strategic supplier selection of system integrators in the marine industry. The revised framework incorporates the insights gained from the interviews, emphasizing the importance of flexibility, strategic partnerships, and comprehensive evaluation processes. To summarize, figure 13 gathers the synthesis of theory empirical findings.

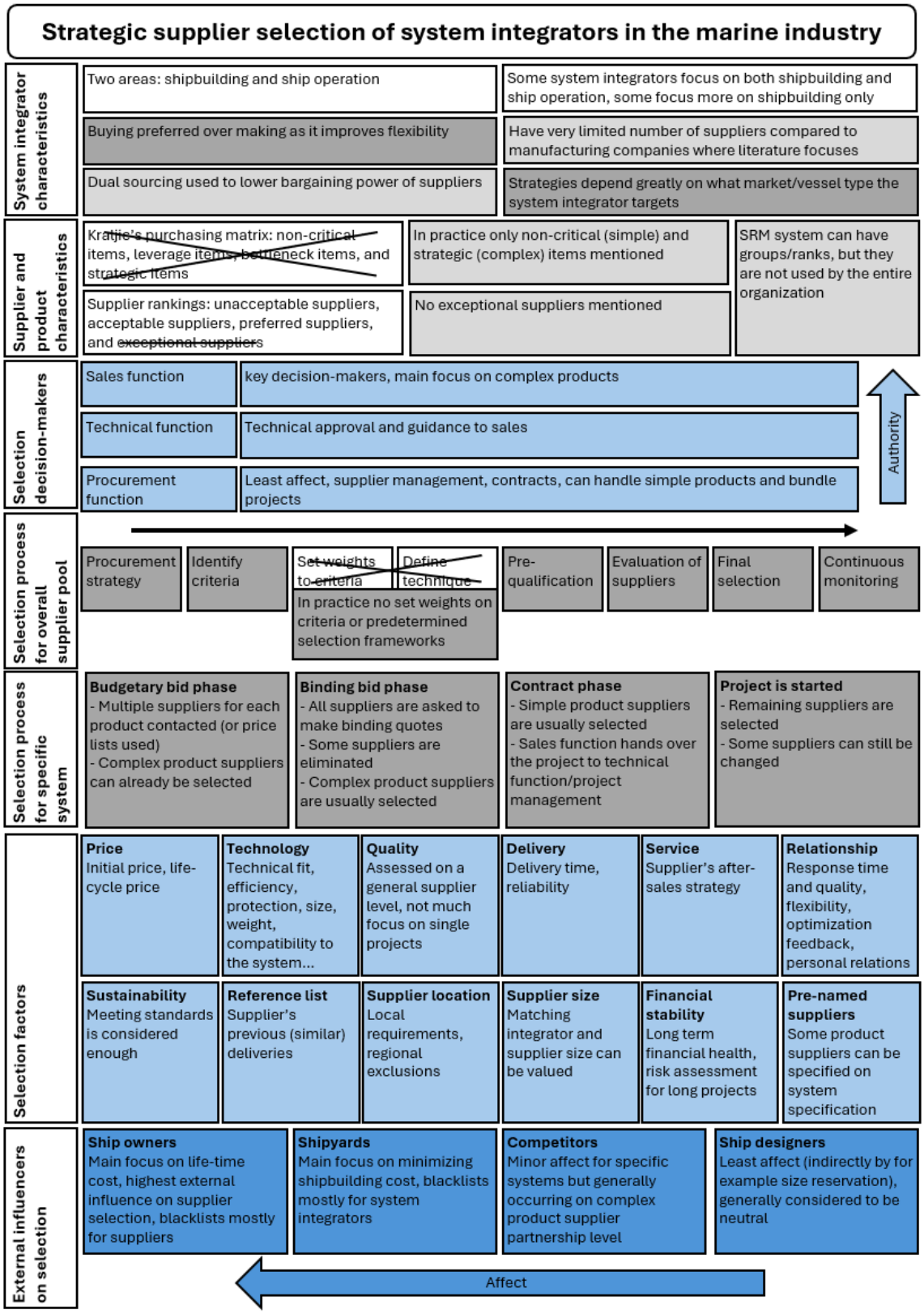

Figure 13. Synthesis of the theory and empirical findings.

5 Discussion

5.1 Theoretical contributions

The theoretical implications of this study draw from key areas explored in the literature as well as gained insights from the interviews with senior managers working for system integrators. Firstly, the characteristics of system integrators are critical. System integrators, as described by Rabetino and Kohtamäki (2013), procure various products and technologies to deliver comprehensive systems tailored to customer needs. This requires a deep understanding of customer requirements and the ability to offer life-cycle services, which include training, maintenance, spare parts, and advanced services like remote diagnostics and management. The existing supplier selection literature focuses mainly on manufacturing company context, where according to Baumgartner et al. (2020 there can be thousands of suppliers. However, in the system integrator context, there are generally fewer than 50 suppliers. Therefore, the existing theoretical frameworks of supplier selection cannot be directly transferred into the system integrator context.

Tadelis (2002), Bustinza et al. (2019), and Kalaignanam et al. (2017) claim that more complex products are likely to be produced internally. Conversely, Davies et al. (2007) claim that system integrators procure most of the products from external suppliers to be flexible and responsive to customer's specific needs. Based on the interviews system integrators tend to only produce control systems in-house while purchasing all other products, even the more complex ones, from various suppliers. Huikkola and Kohtamäki (2017) claim that many system integrators face constraints in exploiting their supplier network. However, based on the interviews, these constraints seem to be visible only in smaller system integrators with limited resources and volumes, causing single sourcing and lack of bargaining power. Larger system integrators seem to be able to exploit their supplier network due to their recognition in the market, large volumes, and frame agreements.

Categorization of suppliers and products is also a significant aspect of supplier selection. According to Kraljic's et al. (1983), products can be categorized into four groups based on their complexity of supply and importance of purchasing. The four groups are: strategic items, leverage items, bottleneck items, and non-critical items. Hurnurkar et al. (2016) state that although many purchasers are unaware of formal purchasing models and frameworks, in practice, they do categorize products based on the complexity of supply and importance of purchasing. Vlachakis et al. (2016) categorize products in marine industry based on Kraljic's (1983) matrix as: strategic items, such as main engines and control systems, which are highly customized, high-cost, and crucial to ship quality; leverage items, like auxiliary generator sets and cranes, which are standardized and low-cost; non-critical items, like water pumps, which are mass-produced and widely used; and bottleneck items, such as propellers, which are inexpensive but vital to product performance and require careful management. Based on the interviews in this study, system integrators categorize most of the products into two categories, complex products and simple products, although the interview questions were formalized to be on a general level instead of focusing on single products. Johnson et al. (2010, p. 357–358) claim that suppliers can be ranked into unacceptable suppliers, acceptable suppliers, preferred suppliers, and exceptional suppliers. The interviewees cited different unofficial groupings, such as non-approved suppliers, approved suppliers, preferred suppliers, but none of the suppliers were deemed to be exceptional, nor did any of the suppliers seem to get very high share of a multi-sourced product.

Supplier selection processes are also a critical component of the theoretical framework. As highlighted by Wetzstein et al. (2016), while there is extensive literature on supplier selection, there is a lack of theoretical grounding. This study aligns with them concluding that supplier selection on system integrator context does not have theoretical framework, especially for system specific selection. There tend to be new supplier approval processes but no predetermined processes for system specific supplier selection, and in general, the system integrators' sales functions seem to have a higher authority over technical and procurement functions on supplier selection. Despite the absence of

predetermined processes, the interview responses included nearly all the organizational factors and strategic performance metrics mentioned in the AHP model presented by Sarkis and Talluri (2002). Therefore, in practice the decision-makers appear to follow some of the selection models presented in the literature, even if they are unaware of them.

Supplier selection is a complex process that depends on a variety of critical factors. While some scholars, such as Özdemir et al. (2014) and Sarkis and Talluri (2002), argue for a shift away from cost-centric evaluations, price remains a key consideration, as even the system integrators who prioritize system superiority consistently cite price alongside technical fit. Boone et al. (2020) claim that for strategic products, reliability and quality are valued over pricing, but based on the interviews, this cannot be verified. For strategic items the price is slightly less significant, while for simple products, the price can be the only significant factor if delivery time and minimum requirements are met. The product's technical fit into the system requirements is also paramount.

Quality and reliability are non-negotiable, as they directly impact the performance of the system. On-time delivery and service are also factors that play a role in the selection process. A supplier's after-sales strategy, including services and spare parts, play a critical role in the partnership creation between the supplier and the system integrator. However, Paiola et al. (2013) claim that suppliers are often handling the provision of basic after-sales services to their end customers. Therefore, finding suppliers that only sell through system integrators can be challenging. Strong relationships also foster trust and collaboration. Sustainability is mentioned as one of the significant factors in the literature, for example by Patil et al., (2022) and Sapturo et al. (2022), but based on the interviews, supplier's sustainability is mainly assessed during the initial approval process and has no effect on project specific decision-making. Supplier location influences price, logistics, lead times, and customer preferences, making it a significant factor. The supplier's reference list can also be important in some projects. Financial stability is crucial

for risk management. Lastly, in some projects, some of the product suppliers can be pre-named by the shipyards or the ship owners.

5.2 Managerial implications

Several managerial implications can be drawn from this study. Firstly, it can help managers of supplier companies to become a preferred supplier for system integrators. Firstly, the supplier should identify whether the system integrator views their products as complex or simple products. Building and maintaining robust relationships with the system integrators' sales and technical functions is crucial. For complex products, the sales function holds significant weight in supplier selection. Therefore, suppliers must invest in personalized interactions and collaborative engagements with the sales function. This could include regular meetings, joint problem-solving sessions, and customized training programs to help sales function better understand and promote the supplier's products. Additionally, suppliers should foster close technical relationships to ensure that their products are seamlessly integrated into system designs, thereby enhancing technical fit and reliability.

The technical and procurement functions also play essential roles, although with varying influence depending on product complexity. For complex products, the procurement function's influence is limited, and the focus shifts to ensuring technical fit and sales alignment. Suppliers should provide detailed technical documentation, offer extensive technical support, and be available to address any concerns that may arise during the sales process. Conversely, for simpler products, procurement has a more significant role, emphasizing the importance of competitive pricing and possibly bundling projects.

Therefore, suppliers should tailor their strategies based on the type of product they offer. Pricing strategies must reflect the complexity of the product. For simple products, competitive pricing is crucial, while for complex products price remains important, other factors such as technical fit, long-term relationships and quality are valued more. Suppliers could develop comprehensive price lists and ensure transparency in their pricing to

facilitate easier decision-making for system integrators. However, price lists can be considered as losing track of what is being offered and how much. Therefore, suppliers should insist on getting updates from their system integrators regularly even when price lists are provided.

Technical fit, particularly regarding power ratings, is another critical consideration. Suppliers should either offer products with short power rating steps or gather and utilize market intelligence to identify the most common power steps used by system integrators. Aligning product offerings with these common power ratings can significantly enhance the appeal of the supplier's products.

The role of ship owners and shipyards in the supplier selection process is also critical. Suppliers could prioritize building strong relationships with these stakeholders by regularly engaging them, understanding their specific needs and preferences, and demonstrating how their products can add value to their operations. This proactive engagement can influence especially ship owners to favorably view the supplier's offerings.

By strategically focusing on these areas, relationship building, understanding the influence of various functions within the system integrator, and aligning pricing and technical specifications with market needs, suppliers can position themselves more effectively to become the preferred choice for system integrators. This comprehensive approach not only meets the immediate needs of system integrators but also fosters long-term partnerships built on trust and mutual benefit.

5.3 Limitations

Due to the significant reliance on semi-structured interviews, this study has certain limitations. The focus on system integrators operating in the marine industry means that the findings may not be directly applicable to other industries. This industry-specific focus limits the generalizability of the results to broader contexts. Additionally, the limited

sample size and partly lacking diversity among interviewed functions may not fully represent the variety of practices and perspectives within the marine industry itself.

Research bias is another consideration, as the findings might be influenced by the researcher's perspective on supplier selection, potentially steering the interviews in a particular direction. The researcher's employment with a supplier company and pre-existing relationships with the most interviewees could have influenced the responses, introducing potential bias. Moreover, the study was conducted as a single case study, and all system integrators were customers of the same supplier. This may have excluded some system integrators with different supplier selection strategies or different marine industry segments.

The timing of the collection also poses a limitation. Market conditions and industry dynamics at the time of the study may have influenced the findings, and these conditions can change over time. Additionally, the geographic scope of the study, which may have limited to a specific region, could impact the applicability of the results to system integrators operating in different regions.

5.4 Suggestions for future research

Further research could delve into the suppliers' perspective to uncover strategies that can enhance their likelihood of being selected by system integrators. A longitudinal study could offer a detailed examination of suppliers' strategies and operations over an extended period. At the same time, it would be valuable to explore suppliers' relationships with various entities, including aspects such as trust development, collaboration intensity, and the influence of personal connections. By identifying and analyzing specific suppliers, researchers could gain insights into how suppliers evolve and adjust their practices to align with the demands of system integrators.

Another promising area for future research involves examining how shipyards and ship owners perceive supplier selection within the context of system integrators in the marine

industry. Gaining insight into their viewpoints and decision-making criteria can provide a more comprehensive understanding of the factors that influence supplier selection. This research could reveal the specific preferences and requirements of shipyards and ship owners, thereby highlighting opportunities for suppliers and system integrators to better align their practices with these expectations. Such studies could lead to more tailored strategies that address the specific needs of these key stakeholders.

Another avenue for future research is to investigate regional differences in supplier selection. This study could compare how criteria and processes for selecting suppliers vary across different geographical regions. It would be important to assess factors such as local regulations, cultural influences, and market dynamics, as these elements may significantly impact supplier selection practices. By exploring regional variations, researchers can gain insights how contextual factors shape the decision-making processes of both suppliers and system integrators, thereby contributing to a more nuanced understanding of global supplier selection strategies.

Examining supplier selection processes across different industries could offer valuable insights into best practices and strategic approaches. By comparing how system integrators select suppliers in various industries, researchers can uncover both commonalities and distinctions and selection criteria and processes. Such a comparative analysis would highlight effective strategies and practices that could be adapted by the marine industry. This could lead to improvements in the efficiency and effectiveness of supplier selection for system integrators by integrating successful practices from diverse industrial contexts.

Finally, exploring the integration of digital tools presents a promising avenue for future research. Investigating how various digital platforms and technologies, such as AI, STM systems, data analytics, and automated procurement systems, affect the supplier selection process could provide significant insights. Specifically, research could focus on the advantages these tools offer in enhancing efficiency and prevision of supplier selection, particularly for system or project-specific needs.

References

Andersson, S. (2002). Suppliers' international strategies. *European Journal of Marketing,* 36(2), 86–110. https://doi.org/10.1108/03090560210412719

Araujo, L., Dubois, A. & Gadde, L. (1999). Managing interfaces with suppliers. *Industrial Marketing Management,* 28(5), 497–506. https://doi.org/10.1016/S0019-8501(99)00077-2

Carter, C., R. & Rogers, D., S. (2008). A framework of sustainable supply chain management: moving toward new theory. *International Journal of Physical Distribution & Logistics Management,* 38(5), 360–387. https://doi.org/10.1108/09600030810882816

Celik, M. (2010). A key decision-making process on logistic support to merchant ships based on operational requirements: Marine supplier selection. *Naval Engineers Journal,* 122(1), 125–135. https://doi.org/10.1111/j.1559-3584.2010.00235.x

Baumgartner, T., Malik, Y. & Padhi, A. (2020). *Reimagining industrial supply chains,* McKinsey. Retrieved 10.6.2024 from https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/reimagining-industrial-supply-chains

Boone, D., Steward, M., D., Narus, J., A. & Roehm, M., L. (2020). Tradeoffs in supplier attribute ratings in supplier selection across strategic versus non-strategic purchasers. *Journal of Business-to-Business Marketing,* 27(2), 97–109. https://doi.org/10.1080/1051712X.2020.1748319

Bruce, G. (2020). Ship Construction. In: *Shipbuilding Management. (Eds.).* Springer, Singapore. https://doi.org/10.1007/978-981-15-8975-1_14

Bustinza, O., F., Lafuente, E., Rabetino, R., Vaillant, Y. & Vendrell-Herrero, F. (2019). Make-or-buy configurational approaches in product-service ecosystems and performance. *Journal of Business Research,* 104, 393–401. https://doi.org/10.1016/j.jbusres.2019.01.035

Dalziel, M. & Zhang, S., C. (2008). The main and contingent effects of the system integrator and component supplier roles. *2008 4th IEEE International Conference on Management of Innovation and Technology, Bangkok, Thailand,* 21–24.9.2008. https://doi.org/10.1109/ICMIT.2008.4654478

Davies, A., Brady, T. & Hobday, M. (2007). Organizing for solutions: Systems seller vs. system integrator. *Industrial Marketing Management,* 36(2), 183–193. https://doi.org/10.1016/j.indmarman.2006.04.009

de Boer, L., Labro, E. & Morlacchi, P. (2001). A review of methods supporting supplier selection. *European Journal of Purchasing & Supply Management,* 7(2), 75–89. https://doi.org/10.1016/S0969-7012(00)00028-9

Eisenhardt, K., M. & Graebner, M., E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal,* 50(1), 25–32. https://doi.org/10.5465/amj.2007.24160888

Finne, M., Turunen, T. & Eloranta, V. (2015). Striving for network power: The perspective of solution integrators and suppliers. *Journal of Purchasing and Supply Management,* 21(1), 9–24. https://doi.org/10.1016/j.pursup.2014.08.001

Gibbert, M., Ruigrok, W. & Wicki, B. (2008). What passes as a rigorous case study? *Strategic Management Journal,* 29(13). https://doi.org/10.1002/smj.722

Gimenez, C. & Tachizawa, E., M. (2012). Extending sustainability to suppliers: a systematic literature review. *Supply Chain Management,* 17(5), 531–543. https://doi.org/10.1108/13598541211258591

Gioia, D., Corley, K. & Hamilton, A. (2012). Seeking qualitative rigor in inductive research: Notes on the Gioia Methodology. *Organizational Research Methods,* 16(1). https://doi.org/10.1177/1094428112452151

Gourdon, K. & Steidl, C. (2019). Global value chains and the shipbuilding industry, *OECD Science, Technology and Industry Working Papers,* 2019(08). https://doi.org/10.1787/7e94709a-en

Greene, S. (2022). A model for an optimal procurement strategy: Kraljic's matrix can better ensure a steady supply at favorable costs. *ICE: Industrial & Systems Engineering at Work,* 54(9), 34–39. Retrieved 13.2.2024 from https://www.researchgate.net/publication/368750959_Gain_Competitive_Advantage_Using_Kraljic%27s_Four-step_Strategic_Procurement_Model

Grodal, S., Anteby, M. & Holm, A. (2021). Achieving rigor in qualitative analysis: The role of active categorization in theory building. *Academic of Management Review,* 46(3). https://doi.org/10.5465/amr.2018.0482

Helander, A. & Möller, K. (2008). System supplier's roles from equipment supplier to performance provider. *Journal of Business and Industrial Marketing,* 23(8), 577–585. . https://doi.org/10.1108/08858620810913380

Hormann, H. (2006). Classification societies – What is their role, what is their future? *WMU Journal of Maritime Affairs,* 5, 5–16. https://doi.org/10.1007/BF03195078

Hudnurkar, M., Rathod, U. & Jakhar, S., K. (2016). Multi-criteria decision framework for supplier classification in collaborative supply chains: Buyer's perspective. *International Journal of Productivity and Performance Management,* 65(5). https://doi.org/10.1108/IJPPM-03-2015-0048

Huikkola, T. & Kohtamäki, M. (2017). Solution providers' strategic capabilities. *Journal of Business and Industrial Marketing,* 32(5), 752–770. https://doi.org/10.1108/JBIM-11-2015-0213

Huikkola, T., Kohtamäki, M., Rabetino, R., Makkonen, H. & Holtkamp, P. (2022). Overcoming the challenges of smart solution development: Co-alignment of processes, routines, and practices to manage product, service, and software integration. *Technovation,* 118. https://doi.org/10.1016/j.technovation.2021.102382

Humphreys, P., K., Lo, V., H., Y. & Mclvor, R., T. (2000). A decision support framework for strategic purchasing. *Journal of Materials Processing Technology,* 107(1–3), 353–362. https://doi.org/10.1016/S0924-0136(00)00729-9

Islam, K., Shaikh, A. & Habib, M. (2017). A study of supply chain management in shipbuilding industry. *ICBM 2017-1st International Conference on Business and Management, Dhaka, Bangladesh,* 21–22.9.2017. Retrieved 12.1.2024 from https://www.researchgate.net/publication/320183073_A_Study_of_Supply_Chain_Management_in_Shipbuilding_Industry

Johnson, P., F., Leenders, M., R. & Flynn, A., E. (2010). *Purchasing and Supply Management* (14th edition). McGraw-Hill Irwin.

Jones, O. & Craven, M. (2001). Beyond the routine: Innovation management and the teaching company scheme, *Technovation,* 21(5), 267–279. https://doi.org/10.1016/S0166-4972(00)00042-0

Kalaignanam, K., Kushwaha, T. & Swartz, T., A. (2017). The Differential Impact of New Product Development "Make/Buy" Choices on Immediate and Future Product Quality: Insights from the Automobile Industry. *Journal of Marketing,* 81(6), 1–23. https://doi.org/10.1509/jm.14.0305

Kim, B. (2006). Technology roadmapping: R&D planning coordination between component supplier-system integrator. *2006 IEEE International Conference on Management of Innovation and Technology, Singapore,* 21–23.6.2006. https://doi.org/10.1109/ICMIT.2006.262373

Kim, B., Cho, Y. & Yang, M., G. (2022). Technology acquisition strategy: A Latecomer's perspective on integrating component suppliers with system integrators. *IEEE Transactions on Engineering Management,* 69(6), 2572–2587. https://doi.org/10.1109/TEM.2019.2947698

Knight, G., Chidlow, A. & Minbaeva, D. (2021). Methodological fit for empirical research in international business: A contingency framework. *Journal of International Business Studies,* 53, 39–52.

Kohtamäki, M., Baines, T., Rabetino, R. & Bigdeli, A., Z. (2018). Practices in Servitization. In: *Practices and tools for servitization. (Eds).* Springer International Publishing, 2018. https://doi.org/10.1007/978-3-319-76517-4_1

Kraljic, P. (1983). Purchasing Must Become Supply Management. *Harvard Business Review.* Retrieved 13.2.2024 from https://hbr.org/1983/09/purchasing-must-become-supply-management

Kshirsagar, M., Teli, S. & Gaikwad, L. (2014). Analyzing supplier selection with lean philosophy: A review. *International Journal on Recent Technologies in Mechanical and Electrical Engineering (IJRMEE),* 1(2). Retrieved 26.2.2024 from https://www.researchgate.net/publication/285400617_Analyzing_Supplier_Selection_with_Lean_Philosophy_A_Review

Lagemann, B., Lunnan, R., Brett, P., Agis, I., Solheim, A. & Erikstad, S. (2024). What is a ship design firm, really? *15th International Marine Design Conference (IMDC 2024), Amsterdam, Netherlands,* 2.–6.6.2024. https://doi.org/10.59490/imdc.2024.914

Lavelle, E. (2024). *Supplier vs Vendor: The Key to Differences.* Enable. Retrieved 5.2.2024 from https://enable.com/blog/supplier-vs-vendor-whats-the-difference

Mahapatra, D. & Mamatha, G., S. (2020). A study on the role of channel partners in software industry. *International Journal for Research in Applied Science & Engineering Technology,* 8(6), 789–792. http://doi.org/10.22214/ijraset.2020.6127

Manno, G. (2014). A pathway towards more sustainable shipping in 2050: A possible future for automation and remote operations. *Maritime-Port Technology and Development – Ehlers et al. (Eds)*

Mello, M. & Strandhagen, J. (2011). Supply chain management in the shipbuilding industry: challenges and perspectives. *Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment,* 225(3), 261–270. https://doi.org/10.1177/1475090211406836

Mello, M., Strandhagen, J. & Alfnes, E. (2013). The role of coordination in avoiding project delays in an engineer-to-order supply chain. *Journal of Manufacturing Technology Management,* 26(3). 429–454. https://doi.org/10.1108/JMTM-03-2013-0021

Melnikovas, A. (2018). Towards an explicit research methodology: Adapting research onion model for futures studies. *Journal of Futures Studies,* 23(2), 29–44. https://doi.org/10.6531/JFS.201812_23(2).0003

Nair, A., Jayaram, J. & Das, A. (2015). Strategic purchasing participation, supplier selection, supplier evaluation and purchasing performance. *International Journal of Production Research*, 53(20), 6263–6278. https://doi.org/10.1080/00207543.2015.1047983

Oates, M., Crichton, K., Cranor, L., Budwig, S., Weston, E., Bernagozzi, B. & Pagaduan, J. (2022). Audio, video, chat, email, or survey: How much does online interview

mode matter. *Journal Plos one,* 17(2). https://doi.org/10.1371/journal.pone.0263876

Oloruntobi, O., Mokhtar, K., Gohari, A., Asif, S. & Chuah, L. (2023). Sustainable transition towards greener and cleaner seaborne shipping industry: Challenges and opportunities. *Cleaner Engineering and Technology*, 13. https://doi.org/10.1016/j.clet.2023.100628

Paasi, J., Valkokari, K., Rantala, T., Hytönen, H., Nystén-Haarala, S. & Huhtilainen, A. (2010). Innovation management challenges of a system integrator in innovation networks. *International Journal of Innovation Management,* 14(6), 1047–1064. https://doi.org/10.1142/S1363919610003008

Paiola, M., Saccani, N., Perona, M. & Gebauer, H. (2013). Moving from products to solutions: Strategic approaches for developing capabilities. *European Management Journal,* 31(4), 390–409. https://doi.org/10.1016/j.emj.2012.10.002

Patil, V., Tan, T., Rispens, S., Dabadghao, S. & Demerouti, E. (2022). Supplier sustainability: A comprehensive review and future research directions. *Sustainable Manufacturing and Service Economics,* 1. https://doi.org/10.1016/j.smse.2022.100003

Pribadi, S., R., W., Pribadi, T., W. & Wahidi, S., I. (2021). Supplier selection in shipbuilding industry. *IOP Conference Series: Materials Science and Engineering,* 1052. https://doi.org/10.1088/1757-899X/1052/1/012070

Rabetino, R. & Kohtamäki, M. (2013). System integration, integrated solutions and industry organization: A value system approach. *29th IMP conference, Atlanta, United States,* 30.8–2.9.2013. Retrieved 10.1.2024 from https://www.impgroup.org/uploads/papers/8018.pdf

Rabetino, R. & Kohtamäki, M. (2018). To servitize is to (re)position: Utilizing a porterian view to understand servitization and value systems. In: *Practices and tools for servitization. (Eds).* Springer International Publishing, 2018. https://doi.org/10.1007/978-3-319-76517-4_18

Rashid, Y., Rashid, A., Waseem, A. (2019). Case study method: A step-by-step guide for business researchers. *International Journal of Qualitative Methods,* 18. https://doi.org/10.1177/1609406919862424

Robson, C. & McCartan, K. (2016). *Real World Research: A Resource for Users of Social Research Methods in Applied Settings* (4th edition). John Wiley & Sons Ltd.

Rognes, J. (1995). Negotiating Cooperative Supplier Relationships: A Planning Framework. *International Journal of Purchasing and Materials Management,* 31(3), 12–18. https://doi.org/10.1111/j.1745-493X.1995.tb00210.x

Sapturo, T., E., Figueira, G. & Almada-Lobo, B. (2022). A comprehensive framework and literature review of supplier selection under different purchasing strategies. *Computers & Industrial Engineering*, 167. https://doi.org/10.1016/j.cie.2022.108010

Saunders, M., N., K, Lewis, P. & Thornhill, A. (2019). *Research Methods for Business Students* (8th edition). Pearson.

Sarkis, J. & Talluri, S. (2002). A model for strategic supplier selection. *The Journal of Supply Chain Management*, 38(4), 18–28. https://doi.org/10.1111/j.1745-493X.2002.tb00117.x

Shin J. & Lim, Y. (2013). An empirical model of changing global competition in the shipbuilding industry. *Maritime Policy & Management,* 41(6), 515–527. https://doi.org/10.1080/03088839.2013.856522

Starman, A., B. (2013). The case study as a type of qualitative research. *Journal of Contemporary Educational Studies,* 1, 28–43. Retrieved 8.4.2024 from https://www.researchgate.net/publication/265682891_The_case_study_as_a_type_of_qualitative_research

Sundholm, V. & Hellström, M. (2021). The features of performance measurement systems in value-based selling. In: *The palgrave handbook of servitization (Eds).* Palgrave macmillan. https://doi.org/10.1007/978-3-030-75771-7_10

Tadelis, S. (2002). Complexity, flexibility, and the make-or-buy decision. *The Ametican Economic Review,* 92(2), 433–437. Retrieved 2.2.2024 from http://www.jstor.org/stable/3083446

Tuli, K., R., Kohil, A., K. & Bharadwaj, S., G. (2007). Rethinking customer solutions: From product bundles to relational processes. *Journal of Marketing,* 71(3), 1–17. https://doi.org/10.1509/jmkg.71.3.001

Töytäri, P. (2018). Selling solutions by selling value. In: *Practices and tools for servitization. (Eds).* Springer International Publishing, 2018. https://doi.org/10.1007/978-3-319-76517-4_15

Verma, M., Grinbaum, I., Arnold, J., Nanney, J. (2018). Preparing to witness a multimegawatt motor and adjustable speed drive acceptance test – the basics. *IEEE Transactions on Industry applications,* 54(1), 873–882. https://doi.org/10.1109/TIA.2017.2742466

Vlachakis, N., Mihiotis, A., Pappis, C., P. & Lagoudis, I., N. (2016). A methodology for analyzing shipyard supply chains and supplier selection. *Benchmaking: An international Journal,* 23(2), 443–455. https://doi.org/10.1108/BIJ-08-2013-0082

Walker, G. & Weber, D. (1984). A transaction cost approach to make-or-buy decisions. *Administrative Science Quarterly,* 29(3), 373–391. https://doi.org/10.2307/2393030

Wetzstein, A., Hartmann, E., Benton, W., C. & Hohenstein, N. (2016). A systematic assessment of supplier selection literature – State-of-the-art and future scope. *International Journal of Production Economics*, 182, 304–323. https://doi.org/10.1016/j.ijpe.2016.06.022

Williamson, O. (2008). Outsourcing: Transaction cost economics and supply chain management. *Journal of Supply Chain Management,* 44(2), 5–16. https://doi.org/10.1111/j.1745-493X.2008.00051.x

Yow, V. (2015). Interviewing Techniques and Strategies. In: *The Oral History Reader. (Eds.).* Routledge, London. https://doi.org/10.4324/9781315671833

Özdemir, A., I., Simonetti, B. & Janelli, R. (2014). Determining critical success factors related to the effect of supply chain integration and competition capabilities on business performance. *Quality & Quantity*, 49, 1621–1632. https://doi.org/10.1007/s11135-014-0074-z

Appendices

Appendix 1. Semi-structured interview template for senior personnel of system integrators in sales, technical, and procurement functions

How do system integrators select their suppliers in marine industry?

Interview questions:

A. Interviewee's background

1. How would you describe your present role and the path that led you to it?

B. Background of supplier information

2. Do you classify products (parts of your delivery system) into groups?
3. What products are you purchasing from external suppliers and what are you producing in-house? If you produce something in-house, could you share how you came to the make decision instead of buy decision?
4. How many suppliers do you have in total?
5. Do you classify your suppliers into groups?
6. Which products do you use single sourcing and which products multi-sourcing?
7. How high would you estimate the share for each supplier to be for the main products?

C. Supplier selection process

8. What is the selection process for new suppliers?
    a. How does this process usually go? What are the usual steps in this process?
    b. What is the ideal process like?
    c. What has been the hardest selection process?
9. How do you select suppliers for each system?
10. What are the key factors you consider when selecting suppliers?
11. What functions and/or individuals are involved in the supplier selection process and in which stages?
12. Do shipyards affect the suppliers you use?
13. Do ship designers affect the suppliers you use?
14. Do ship owners affect the suppliers you use?
15. Do your competitors' supplier choices affect your supplier selection?
16. Do you think your supplier selection process and strategy is different compared to your system integrator competitors?

Appendix 2. Interviewee's summary

No.	System integrator	Function	Abbreviation in the text	Years in the marine industry	Interview duration
1	SI1	Sales	SI1, SMS1	20+	45 min
2	SI1	Sales	SI1, SMS2	20+	42 min
3	SI1	Sales	SI1, SMS3	10–20	60 min
4	SI1	Sales	SI1, SMS4	20+	30 min
5	SI1	Technical	SI1, SMT1	20+	46 min
6	SI1	Technical	SI1, SMT2	20+	44 min
7	SI1	Technical	SI1, SMT3	10–20	1h 18 min
8	SI1	Procurement	SI1, SMP1	10–20	31 min
9	SI1	Procurement	SI1, SMP2	>10	41 min
10	SI2	Sales	SI2, SMS5	20+	54 min
11	SI2	Technical	SI2, SMT4	10–20	56 min
12	SI3	Sales	SI3, SMS6	20+	1h 4 min
13	SI3	Sales	SI3, SMS7	10–20	1h 12 min
14	SI3	Technical	SI3, SMT5	10–20	58 min
15	SI4	Sales	SI4, SMS8	20+	59 min
16	SI5	Sales	SI5, SMS9	20+	20 min
17	SI5	Technical	SI5, SMT6	10–20	27 min
18	SI5	Procurement	SI5, SMP3	>10	29 min