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Dissertation No. 2374

Logistics Organization Design for Building Contractors

Petter Haglund

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Abstract

Construction logistics management is crucial for timely and cost-effective project delivery. While studies highlight improved project performance with a strategic and long-term approach to construction logistics management, there is a tendency to pursue project-centric logistics planning, hindering long-term, strategic approaches. Building contractors often prioritize dedicated solutions for specific projects, resulting in a lack of focus on company-wide efficiency. In the context of project-oriented building construction, where the logistics organization governs the planning, coordination, and control of resource flows, there is little known about how to tailor logistics strategies for the context of building contractors. While studies highlight the potential of strategic approach to logistics on project and supply chain performance, the adaptation of logistics strategies in the construction sector, especially considering influential contextual factors, remains largely unexplored.

Current logistics strategy literature predominantly draws from the repetitive manufacturing industries, often in the United States, failing to account for the distinct challenges posed by project-oriented construction. This thesis addresses how building contractors should strategically design their logistics organizations, accounting for building contractors' specific contextual factors and subsequently proposing logistics organization design configurations that align with their unique characteristics.

The purpose is to investigate building contractors' logistics strategy content and process with a focus on how to design the logistics organization. To fulfil the purpose, the following three research questions are formulated:

- RQ1. What contextual factors influence the design of building contractors' logistics organizations?*
- RQ2. How do the identified contextual factors influence the design of building contractors' logistics organizations?*
- RQ3. How should building contractors design their logistics organizations in response to the contextual factors?*

In response to RQ1, a combination of conceptual research, case studies, and a questionnaire study were undertaken to identify contextual factors influencing building contractors' logistics organizations, including the number of strategic business units (SBUs), product characteristics, and production process characteristics. These factors influence logistics organization design elements in terms of the degree of centralization, formalization, integration, and division of labour.

To answer RQ2, a mix of conceptual research, case studies, and a questionnaire study were undertaken to investigate how contextual factors influence the logistics organization design element. The findings indicate that while product and production process characteristics influence logistics organization design, the impact of company size remains inconclusive. The findings challenge conventional understanding regarding the influence of company size on logistics organization design, emphasizing the central role of product characteristics, production processes, and the number of SBUs among building contractors.

In response to RQ3, case studies were used to classify several logistics organization design configurations determined by the building contractors' product characteristics, production process characteristics, and the number of SBUs. These configurations outline responses to product characteristics, production process characteristics, and the number of SBUs. For instance, configurations reflecting single business unit contractors with high logistics predictability favour a centralized logistics organization, while those involving multiple SBUs lean towards divisional logistics function structures. Furthermore, the findings highlight the feasibility and preference for hybrid configurations in aligning logistics organization design with the unique characteristics of building contractors, contributing insights valuable for adapting organizational structures in diverse operational contexts.

This thesis contributes to logistics organization design literature by explaining how contextual factors shape building contractors' logistics organizations. The focus on construction-specific contextual factors, such as the degree of pre-engineering (product characteristics) and off-site fabrication (production process characteristics), broadens the scope beyond repetitive manufacturing contexts. The suggested logistics organization structures and configurations provide a foundation for understanding logistics strategy in construction and similar engineer-to-order industries. However, generalization to other engineer-to-order sectors requires additional research.

The thesis highlights a lack of formalized logistics strategies among building contractors. The identified logistics organization structures and design configurations offer practical insights for initiating a strategic logistics process, thus contributing to construction logistics practice. However, while the thesis advances logistics organization design understanding, the need for further research remains. Future research avenues include investigating the impact of company size, exploring misfit consequences, developing key performance indicators, and refining the implementation process. The methodological approach suggests the need for practice-oriented research designs to actively apply and evaluate the thesis' concepts in real-world scenarios.

Populärvetenskaplig sammanfattning

Genom att undersöka logistikstrategier hos byggentreprenörer tar denna avhandling upp en kritisk fråga inom byggindustrin, nämligen hur byggentreprenörer kan och bör arbeta strategiskt och långsiktigt med logistik. Bygglogistik spelar en avgörande roll för att säkerställa att byggprojekt levereras i rätt tid och kostnadseffektivt genom en effektiv hantering av resursflöden. Traditionellt har logistikhantering inom byggprojekt varit projektcentrerad och har saknat koppling till den långsiktiga planeringen. Det finns en tendens hos byggentreprenörer att fokusera på dedikerade logistiklösningar för enskilda projekt, särskilt i stadsområden med komplexa logistikutmaningar. Detta leder till att en byggentreprenörs logistikarbete karaktäriseras av provisoriska lösningar i ett fåtal projekt, vilket ger en begränsad effekt på den övergripande företagsnivån. Framväxten av tredjepartslogistikleverantörer inom byggsektorn betonar behovet av dedikerade logistiklösningar. Däremot så ersätter inte dessa tjänsteleverantörer de interna logistikförmågorna hos byggentreprenörer fullt ut. För att bedriva en proaktiv och långsiktig hantering av logistiken behövs mer permanenta lösningar och en strategiskt ansats. Samtidigt finns det en bristande förståelse av hur byggentreprenörer bör organisera logistik på företagsnivå för att förbättra projektleverans med avseende på tid, kostnad, kvalitet, säkerhet och hållbarhet och sin tur stärka den övergripande konkurrenskraften.

Denna avhandling syftar till att adressera utmaningen med att främja en strategisk ansats till logistikhantering bland byggentreprenörer inom byggindustrin och betonar behovet av långsiktig utveckling av logistiken. För att uppnå detta syfte så har forskningen fokuserat på byggentreprenörs logistikorganisation och hur denna bör utformas för att kunna bedriva en effektiv logistikhantering. Den grundläggande tesen i avhandlingen är att det inte finns en universal lösning för hur logistikorganisationen bör utformas för alla typer av byggentreprenörer.

Forskningsresultatet lyfter fram att logistikorganisationens utformning beror på vad som byggs (produkttyp), hur de byggs (val av produktionsprocess) samt inom vilka branschsegment byggentreprenören är verksam inom. För att illustrera detta ges två exempel nedan, där det första exemplet är en industriell byggare och det andra är ett byggföretag som är verksam inom olika branschsegment med flertalet verksamhetsområden.

Det första exemplet är en industriell byggare som enbart bygger standardiserade enfamiljshus som tillverkas med en hög grad av prefabricering och hanterar logistiken genom en dedikerad logistikfunktion på företagsnivån. Resursflödet skiljer sig inte nämnvärt mellan projekten eftersom det finns en hög grad av repetition i produktionen.

Detta innebär att formella rutiner och processer kan tillämpas i hanteringen av logistiken. Den centrala logistikfunktionen sätter tydliga ramar för logistikhanteringen och projektets logistikorganisation bedriver den dagliga planeringen och styrningen.

Det andra exemplet är ett större byggföretag med en betydligt större variation i hur logistik måste hanteras. Projekten kan variera från att omfatta ett tiotal lägenheter i ett flerfamiljshus till stora komplexa projekt i stadsmiljöer. I detta fall behöver projekten, framför allt de som har störst logistiska utmaningar, ta ett större ansvar för att ta fram logistikplaner, boka och synkronisera leveranser av projektspecifikt material med aktiviteter i tidplanen, hantera lagernivåer av förbrukningsmaterial och så vidare. En central logistikfunktion i detta fall kan bidra med en övergripande mall för projektens logistikplaner. Däremot behöver projektet en dedikerad logistikfunktion som tar fram och genomför den projektspecifika logistikplanen.

Sammanfattningsvis kan dessa två typer av byggentreprenörers utformning av logistikorganisationen härledas till deras produkttyp(er), val av produktionsprocess och vilka typer av byggverksamheter de är verksamma inom. Karaktärsdragen hos de två ovannämnda exemplen har under forskningsprojektet kunnat identifieras hos industriella byggare och större byggföretag verksamma inom en rad olika branschsegment. Forskningen har förankrats i byggbranschen och gjorts tillsammans med byggföretag, likt de som beskrivs i de två exemplen. Totalt har två industriella byggare och tre ”traditionella” byggföretag deltagit i de fallstudierna som genomförts under projektets gång. Utöver fallstudier så har även en enkätstudie gjorts på medelstora till stora byggentreprenörer i Sverige, Norge, Finland och Danmark. Detta har bidragit med en djup förståelse om logistikstrategier hos svenska byggentreprenörer, men även ett bredare perspektiv som sträcker sig utanför den svenska byggindustrin.

Foreword

Although I feel proud of myself of how I have taken on the challenge of pursuing a PhD, I could not have done it without the support of the people around me. The next few lines are dedicated to the people that have supported me throughout my PhD-journey.

First, I would like to thank my two supervisors, Martin Rudberg and Ahmet Sezer. You have been amazing supervisors, both individually and as a team. I feel fortunate to have had you as my supervisors and I could not have wished for a better supervisor-duo.

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Petter Haglund

Norrköping, February 2024

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Thesis Outline

This doctoral thesis is titled *Logistics Organization Design for Building Contractors*. It is a compilation thesis (thesis by publication) and consists of two parts: the compilation part (“kappa”) and the papers. The first part includes the introductory chapters and describes the background to why this thesis is necessary, together with the formulation of the research problem, purpose, and research questions. It also includes the theoretical frame of reference and the methods used in the studies that this thesis builds upon. Furthermore, the first part answers the thesis’ research questions followed by a discussion of the thesis’ findings and contributions. Finally, the conclusions of the thesis are outlined along with suggestions for further research. The second part consists of the five papers that the thesis is based on, which are listed below along with the authors’ contributions in each paper.

Paper 1

Haglund, P., M. Rudberg, and A. A. Sezer (2022). “Organizing logistics to achieve strategic fit in building contractors: a configurations approach”. *Construction Management and Economics* 40(9): 711-726.

Contribution: Haglund conducted the literature review and took main responsibility of generating the overall research ideas with support from Rudberg and Sezer. Research design and data collection was a shared effort between Haglund, Rudberg, and Sezer. Haglund took main responsibility for the data analysis and wrote most of the original draft, but Rudberg and Sezer contributed with revising the manuscript during the final review rounds.

Paper 2

Haglund, P. and A. A. Sezer (2024). “Revealing patterns of logistics organization design among residential building contractors in the Nordic countries”. *Working paper* previously presented as a conference paper at the CIB International Conference on Smart Built Environment in 2021.

Contribution: Haglund conducted the literature review and took main responsibility of generating the overall research ideas with support from Sezer. Haglund took main responsibility for developing the questionnaire with support from Sezer and the main supervisor. Haglund administered the survey and prepared the data for analysis. Sezer took main responsibility for analyzing the data. Haglund took the lead in writing the early drafts and the final version of the manuscript, but Sezer contributed with parts of the method and analysis, as well as review and editing on other parts of the manuscript.

Paper 3

Haglund, P., Wikner, J., and M. Rudberg (2024). “Flow design in site-based production using decoupling thinking: The case of industrialized housebuilding”. *Working paper* previously presented as a conference paper at the APMS Conference: Production

Management Systems for Responsible Manufacturing, Service, and Logistics Futures in 2023.

Contribution: Haglund conducted the literature review, data analysis, and writing the draft and final version of the manuscript with review and editing from Wikner and Rudberg. Data collection was a shared effort between Haglund and Rudberg. Idea generation and development of conceptual models was a shared effort between Haglund, Wikner, and Rudberg.

Paper 4

Haglund, P. and M. Rudberg (2023). "A longitudinal study on logistics strategy: the case of a building contractor". *The International Journal of Logistics Management* 34(7): 1-23.

Contribution: Haglund conducted the literature review and took main responsibility of generating the overall research ideas with support from Rudberg. Research design and data collection was a shared effort between Haglund and Rudberg. Haglund took main responsibility for the data analysis and wrote the manuscript with review and editing from Rudberg.

Paper 5

Haglund, P. and M. Janné (2024). "Organizing construction logistics outsourcing: a logistics strategy perspective". *Construction Innovation* 24(7): 223-238.

Contribution: Haglund and Janné developed the overall research idea together throughout the research process. Haglund conducted the literature review, the on-site visits during the data collection phase, and took main responsibility for analyzing the data. Research design, online interviews, writing the draft, and revising the final version of the manuscript was shared between Haglund and Janné.

Arbetet utförs av förnuftet, inte av styrkan.

— *Finskt ordspråk*

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1. Introduction

This thesis concludes a doctoral project on logistics strategies in building contractors, specifically emphasizing logistics organization design, which is an important component in the logistics strategy. It covers logistics organization design elements, contextual factors, and how building contractors can design their logistics organization to suit their specific circumstances. This initial section introduces the research problem, its motivation, the purpose, and research questions, as well as the thesis' scope and structure.

1.1 Background

The construction industry is important for the societal development, constituting around 10% of the total employment in Sweden (Statistiska Centralbyrån, 2021). The industry provides individuals and various types of organizations with premises and infrastructure that are necessary to satisfy their housing needs and to conduct their operations, respectively. Logistics has a central role for the delivery of construction projects efficiently and effectively by ensuring timely and cost-efficient supply of materials, equipment, personnel, and other types of resources. Logistics refers to planning, implementing, and controlling the time and place transformation of resources, which is affected by the quantities, type, and the physical attributes of the resources (Pfohl, 2023). This includes the flow of resources from the supply process, through production, and to the distribution to the final customer. From the building contractor's perspective, logistics thus refers to the process of planning and controlling the flow of resources from suppliers, distribution to production sites (both construction sites and more permanent production sites, e.g., factories, in control of the contractor), and in the final assembly at the construction site. Studies show that a more deliberate and methodical approach to logistics management by building contractors improves performance both in the parts controlled by the building contractors (typically in construction site operations) and in the flow upstream of the building contractor in the construction supply chain (Le *et al.*, 2020).

The building contractor has a key role in managing logistics in construction projects since they oversee construction operations and all the sub-contractors, consultants, and suppliers that are involved in the project. From the building contractor's perspective, construction logistics management refers to planning, organizing, coordinating, and controlling the flow of transformed resources (e.g., materials and components) and transformation resources (e.g., construction workers, equipment, machines) from the establishment of the site, through the production phase, and to the final assembly and handover of the building (Agapiou *et al.*, 1998, Vrijhoef and Koskela, 2000). Logistics management in construction has traditionally been approached on a project-by-project basis, meaning that logistics plans have to be developed for each project with limited consideration of long-term planning at a strategic company level (Guffond and Leconte, 2000, Ying *et al.*, 2018). However, in recent years, there has been a trend that large and complex projects have allocated more

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resources to manage logistics properly, often using services from third-party logistics (TPL) providers (see, e.g., Ekeskär and Rudberg, 2016). Unfortunately, this is not the norm in all types of projects where logistics management is still carried out in an *ad hoc* manner (Ying *et al.*, 2018).

For many building contractors, the focus has been on setting up dedicated logistics solutions for the individual project with a focus on the construction site (Dubois *et al.*, 2019). However, when the responsibility of developing logistics solutions are delegated to projects, which typically have a low level of logistics competency, a dilemma occurs in which logistics is not prioritized (and therefore the incentive to prioritize logistics is reduced further) (Elfving, 2021). Some projects may therefore have dedicated logistics solutions, typically urban construction projects that are more complex in terms of space constraints surrounding and at the construction site (Janné and Fredriksson, 2022), while the other “less complex” projects do not. There is thus a need to address logistics at a strategic, company level where all projects, regardless of the logistical complexity, are provided with good conditions to manage logistics.

The typical building project in Sweden has a relatively low level of logistical complexity (in contrast to large urban development projects). For instance, the majority of residential building projects in Sweden has contract sum between €5-30 million¹, which is considered as small to medium-sized projects by Swedish standards. This means that the typical building project is much smaller than those where a more structured approach to logistics management is considered crucial. Furthermore, it means that logistics is not managed properly in the projects that account for most of the typical building contractor’s revenue. The project-oriented way of organizing building construction further amplifies the issue since smaller projects have tight budget frames in which a logistics solution might not be the top priority (Elfving, 2021).

The short-term, project-oriented focus where logistics solutions are tailored for each project means that the efficiency and effectiveness at the company and supply chain level is neglected (Dubois *et al.*, 2019). It is therefore necessary to investigate how building contractors can take a more strategic approach to logistics. With the slow uptake of logistics management practices in construction (Ying *et al.*, 2018, Tetik *et al.*, 2022), it is rare to find logistics strategies among building contractors. Furthermore, within building contractors, it is uncommon to find specialized logistics roles (Elfving, 2021). Instead, new types of businesses have emerged, for instance, construction TPL providers (Ekeskär and Rudberg, 2016, Sundquist *et al.*, 2018). However, it is necessary to possess in-house logistics capabilities to ensure a more proactive and long-term approach to logistics management, even when parts of the logistics function is contracted out (Selviaridis and Spring, 2007). This suggests that it can be feasible to investigate how building contractors organize logistics at a strategic company level. Most studies so far have looked at the project level (e.g., Ekeskär and Rudberg, 2016) or the supply chain (e.g., Dubois *et al.*, 2019). There is less known about how individual building contractors should organize logistics from a company perspective so that their logistics resources and capabilities

¹ According to Bygghattas report on residential housebuilding until May 2021. The figures apply to new production of multifamily residences. The report can be downloaded from <https://www.bygghattas.se/>.

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contribute to efficient and effective delivery of their projects, as well as the company's competitiveness.

1.2 Research Problem

Logistics strategy literature suggest that the efficiency and effectiveness of a company's logistics system is dependent on a close fit between the business strategy and logistics organizational structure (Chow *et al.*, 1995). This is in line with the strategy-structure-performance paradigm where the organizational structure is determined by strategy (Chandler, 1962). The logistics organization design can also be viewed as a component of the logistics strategy content, i.e., a decision area. Several logistics decision areas are mentioned in literature (Ballou, 1981, Rao and Young, 1994, Gattorna and Walters, 1996), where the most common are: customer/delivery service levels, inventory policy, transportation modes and routes, supply and distribution channel, facility location, information management, and organization.

The focus in this thesis is on the latter decision area, the logistics organization. More specifically, the thesis addresses the design of the logistics organization. The logistics organization within a building contractor refers to the coordinated structure and processes responsible for managing the movement, storage, and distribution of resources. It encompasses the functions and roles, whether they are centralized or distributed across departments or projects, that ensure the efficient flow of resources, including activities such as warehousing, transportation, material handling, inventory management, and order fulfilment. As such, the logistics organization is the overall arrangement of activities related to the physical flow of resources, whether it is performed by a dedicated logistics function or dispersed across several departments, teams, or projects within the building contractors. The overall arrangement of how logistics is organized is in turn determined by the logistics organization design, comprising several design elements, namely the degree of centralization, division of labour, degree of formalization, and degree of integration.

Studies show that projects with dedicated logistics solutions and an appropriate organization can increase project and supply chain performance (Dubois *et al.*, 2019, Janné and Rudberg, 2022). The design of the logistics organization plays a main role here in creating ideal conditions for logistics personnel to perform logistics management activities efficiently and effectively (Persson, 1978). The logistics organization design is in this thesis considered both in terms of the logistics strategy content and process. Strategy content and process are well-established concepts within manufacturing strategy, but the notions of strategy content and process can also be applicable for the other functional strategies (Leong *et al.*, 1990), such as logistics strategy.

Although prior research has advocated for building contractors to adopt a strategic and long-term approach towards managing logistics (Thunberg and Fredriksson, 2018), there is a lack of knowledge regarding the specific adaptation of a logistics organization design for the building contractor's unique circumstances. In terms of the content of the logistics organization, it remains unclear how the design elements should be configured to align with the type of flows to be managed by the building contractor's logistics organization. Prior

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research suggest that the type of flows can be derived from two main contextual factors facing the logistics organization: product characteristics and production process characteristics (Persson, 1978, Christopher, 1986, Pfohl and Zöllner, 1997). Additionally, the size of the company is mentioned as a third contextual factor that influence the logistics organization design (Dröge and Germain, 1998).

When it comes to the logistics strategy process, there is a lack of knowledge regarding how to develop and implement logistics strategies, specifically about the process of designing and establishing the logistics organization. This highlights the need for further research on tailoring the logistics organization design to the context of building contractors. Most studies of logistics strategy, focusing on the logistics organization, have been made in more repetitive manufacturing industries in the United States (Rao *et al.*, 1994, Clinton and Calantone, 1996) where managing logistics is different from the project-oriented construction industry. Therefore, there is a need to extend these studies by investigating logistics strategy in building contractors with consideration of the characteristics of the construction industry.

Building construction is organized around projects in which temporary project organizations, comprising different stakeholders, are set up to deliver new products or services (Ballard and Howell, 1998). Building contractors are typically project-oriented organizations, meaning that revenues are generated directly from projects. This differs from project-based organizations where revenues come from the permanent structure and processes (Miterev *et al.*, 2017). However, some building contractors with a higher degree of repetitiveness can arguably be labelled as project-based organizations, for instance industrialized housebuilders. Nonetheless, most contractors' core business revolves around executing projects to deliver buildings or infrastructure to its clients. The project-oriented way of organizing means that the logistics strategy needs support from the permanent part of the building contractor's organization, which contrasts with managing logistics in the temporary parts, i.e., the construction projects.

Furthermore, building construction has at least some degree of on-site production combined with fixed-position layout (Ballard and Howell, 1998). The site-based type of production with fixed-position layout means that the transformed resources are fixed into its final place of use and the transformation resources need to be moved to the place where the final assembly is performed (Hill and Hill, 2009). This type of production system is very different from those found in more repetitive manufacturing, where transformation resources are fixed (or semi-fixed) and the transformed resources are movable. The logistical task is thus very different in construction compared to manufacturing with a lot of resource flows converging to the construction site, which is set up as a temporary factory. Furthermore, the end-product is typically designed and engineered according to the client's requirements, which means that building construction can be categorized as a one-off, engineer-to-order (ETO) type of operation. This can range from more complex ETO where the product is developed and linked to a customer order to a more basic ETO (sometimes referred to as "configure-to-order") where the adaptations of an already existing product is made to a customer order (Willner *et al.*, 2016). However, from a flow perspective, building contractors resemble other ETO types that use the fixed-position layout to some extent (i.e.,

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at least in the final assembly), such as ship building, oil and gas, and specialized medical imaging equipment. These types of production are associated with less predictable resource flows compared to make-to-stock production (Persson, 1978).

Aside from the differences between logistics management in building construction and manufacturing, the logistical preconditions also differ within the building construction trade. Building contractors are a heterogeneous group with different production systems, products, and supply chains (Jonsson and Rudberg, 2014). It is therefore unlikely that two different building contractors can be equally effective using equivalent logistics strategies. In line with previous logistics strategy research (Persson, 1978, Christopher, 1986, Chow *et al.*, 1995), a contingency approach to the design of a building contractor's logistics organization appears to be a more promising alternative than the "one size fits all" approach. This entails that logistically relevant contextual factors need to be identified along with logistics organization design elements that are adapted to the characteristics of the building contractors.

1.3 Purpose and Research Questions

In this thesis the logistics organization design is viewed as one of several logistics strategy decision areas. The purpose of this dissertation is to *investigate building contractors' logistics strategy content and process with a focus on how to design the logistics organization*.

1.3.1 Research Question 1

Prior research on logistics strategy and organization design suggests that there is a need to identify industry-specific contextual factors that determine the feasible logistics organization design (Persson, 1978). Most studies have focused on manufacturing in the United States and to author's best knowledge, few or none have focused on the construction industry. To determine how contextual factors influence the design of the logistics organization, it is first necessary to identify what factors that are relevant for a building contractor in the design of the logistics organization. Therefore, the first research question is formulated as:

RQ1: What contextual factors influence the design of building contractors' logistics organizations?

1.3.2 Research Question 2

The two parts of logistics strategy, the content and process, can be considered as two operationalizations of "fit", which is a central concept in contingency theory (Venkatraman and Camillus, 1984). Logistics strategy content refers to the "content of fit", where the focus is on the contextual factors and logistics organization design elements to be aligned with the contextual factors. In contrast, the logistics strategy process refers to the "process of establishing fit" between the contextual factors and logistics organization design elements. It is important to consider both perspectives to advance logistics contingency research and to address managerial issues related to what a logistics strategy should contain (i.e., strategy content) and how it should be formulated and implemented (i.e., strategy

Logistics Organization Design for Building Contractors

process) in a building contractor's organization. Therefore, the second research question is formulated as:

RQ2: How do the identified contextual factors influence the design of building contractors' logistics organizations?

1.3.3 Research Question 3

Contingency theory suggests that there should be recurring patterns of so-called *organizational configurations* that refer to similar characteristics in terms of contextual factors and organization design elements between companies (Meyer *et al.*, 1993). This is the main argument of the configurational approach, an extension of contingency theory, which advocates researchers to consider several contextual factors and organization design elements rather than being limited to bivariate studies (Klaas and Delfmann, 2005). For a building contractor, the configurational approach can be used to identify feasible logistics organization design configurations that are based on the company size, target market, production strategy, etc. In other words, it is a way of synthesizing how building contractors should design the logistics organization in response to contextual factors. Suggestions of ideal logistics organization design configurations can thus support building contractors in selecting an appropriate logistics organization design that suits their specific company's conditions. Therefore, the third research question is formulated as:

RQ3: How should building contractors design their logistics organizations in response to the contextual factors?

1.4 Scope

The primary construction type addressed is building construction, specifically residential (multi-family residencies) and non-residential buildings (hotels, schools, commercial buildings, and office buildings). Infrastructure and industrial construction (e.g., factories, power plants, and warehouses) were excluded because they pose different logistical challenges, mainly related to the physical properties of the construction site. Therefore, to control for these differences, these types of construction were not explicitly considered in the thesis. However, the research includes data from companies that pursue infrastructure and industrial construction, but further studies are required to generalize the findings for these types of construction.

The thesis targets medium-sized and large contractors with a workforce of over 100 employees and/or an annual turnover exceeding €10 million. This focus on medium-sized and large contractors is due to their (potentially) larger pool of resources for logistics development and access to logistical expertise. Nevertheless, the insights generated in this thesis can be applicable to small and medium-sized enterprises (SMEs). It is important to note that SMEs often have limited resources and may lack the same level of logistics expertise, so caution should be exercised when applying the findings to them.

The scope of this research excludes other forms of ETO operations, despite the potential similarities they may share with building construction and its associated challenges. Nonetheless, building construction can be viewed as an illustrative model for devising

1. Introduction

logistics organizational designs tailored to project-oriented organizations falling within the broader ETO framework, especially those involving elements of site-based production.

1.5 Disposition

This first introductory section provides the background, motivation, and purpose of the research, including the research problem and questions, followed by a delineation of the thesis' scope.

The second section provides the theoretical frame of reference, covering logistics strategy, the contingency approach to logistics organization design, and contextual factors highlighted in literature, such as, company size, product characteristics, and production process characteristics. It also outlines elements of logistics organization design and describes the concept of "fit."

The third section outlines the research design, including the research process and the studies performed during this process. This encompasses a multiple case study, a questionnaire study, a conceptual study, a longitudinal single case study, and a cross-sectional single case study.

The fourth section presents the research results, primarily focused on how contextual factors impact logistics organization design and the ideal logistics organization configurations.

The fifth section engages in a discussion of the results, critically analyzing the findings in the context of the theoretical frame of reference and the thesis findings.

The sixth and final section offers conclusions drawn from the research, highlights its contributions to research and practice, and suggests areas for future research.

2. Theoretical Frame of Reference

This section outlines the concepts and theoretical foundation used in this thesis. First, logistics strategy and related concepts are described. This is followed by a description of the contingency approach to logistics organization design, including definitions of contextual factors and logistics organization design elements. Finally, the concepts of “fit” and logistics organization design configurations are described.

2.1 Logistics Strategy – Definition and Concepts

A logistics strategy can be defined as “strategic directives formulated at the corporate level [...] used to guide more efficient and effective logistics activities at the operational level of the organization” (Autry *et al.*, 2008, p. 27). It is a functional strategy, which concerns how a logistics unit, department, or similar, will contribute to achieving strategic objectives set by the overall business strategy. Here the purpose of the functional strategy is to break down the business strategy into strategic decision within the logistics function of the company (Pfohl, 2023). The logistics strategy must also consider other relevant functional strategies, which in producing companies typically are marketing and manufacturing strategies (Rao *et al.*, 1994). A related type of strategy is supply chain strategy, which differs from logistics strategy in that the former is more concerned with the overall design of the supply chain and the latter with the company’s internal logistics function (Hofmann, 2010).

To distinguish between different dimensions of a functional strategy (e.g., logistics strategy or manufacturing strategy), it is typically broken down into smaller parts, referred to as strategy *content* and *process* (Leong *et al.*, 1990). Strategy *content* contains two main parts: competitive priorities and decision areas. Competitive priorities are the result of breaking down the strategic objectives derived from the business strategy. Which competitive priorities that are prioritized then determine the focus of the strategy and subsequently what logistical capabilities that are required. Decision areas constitute the pattern of decisions required to build these capabilities to realize the focus of the strategy set by the competitive priorities. Logistics strategy content only considers the parts that constitute the logistics strategy, but not how these contents are to be realized in the organization. To distinguish the content from the realization of the strategy, the concept of the logistics strategy *process* is used. A typical question in the logistics strategy process is how should be formulated and implemented, for instance, whether it should be derived from the business strategy or should be the foundation of the business strategy (Fabbe-Costes and Colin, 2003).

The most common logistics strategy decision areas and their typical elements found in literature are outlined in Table 1. In this thesis, the logistics organization is in focus (the

last decision area in Table 1). Although all decision areas are important in terms of establishing an efficient and effective logistics system, the importance of the logistics organization design cannot be stressed enough since it constitutes the preconditions required to perform, for instance, inventory management, supply, and distribution (Persson, 1978, Christopher, 1986). As such, logistics organization design is a central decision area within logistics strategy and is in focus in this thesis. Hence it is described further in the following sub-sections.

Table 1 Logistics strategy decision areas (Based on: Ballou, 1981, Rao and Young, 1994, Gattorna and Walters, 1996).

<i>Decision area</i>	<i>Elements</i>
<i>Customer/delivery service levels</i>	Delivery lead time, delivery reliability, delivery quality, percent of fill, information availability, and flexibility.
<i>Inventory policy</i>	Buffers, stock levels, stock location, and stock replenishment methods.
<i>Transportation</i>	Mode of transportation, transportation capacity, and vehicle routes
<i>Supply and distribution channel</i>	Number of and relationship with suppliers and distributors.
<i>Facility location</i>	Logistics infrastructure, e.g., stock points, capabilities of supply consolidation and distribution facilities
<i>Information management</i>	Information systems used for planning, controlling, and exchanging information with suppliers, customers, and internally of the organization related to the flow of resources.
<i>Organization</i>	The overall design of the logistics organization in terms of the degree of centralization, division of labour, degree of formalization, and degree of integration.

2.2 Logistics Organization Design

Organization design concerns finding a suitable organizational structure given the type of task that this organization should perform. Organizational design has a long tradition that goes back to the “one best way” approach in the early 20th century. Many recognize this as scientific management proposed by Fredrick Taylor (Taylor, 1911) in which the focus is on creating economically efficient production systems through mass production. By the middle of the 20th century, this approach lost ground in organizational research in favour of contingency theory, which rejected the notion that there is one best way of organizing (Woodward, 1958). The development of contingency theory emphasized that the most effective organizational form is thus dependent on the internal and external situation of the company (Thompson, 1967).

Logistics organization design research has followed a similar path to the general organization design research. First it was the “one best way” that dominated logistics organization design research where it was suggested that companies should hire a logistics

2. Theoretical Frame of Reference

manager that oversee logistics activities across functional boundaries. The matrix organization type was advocated within this stream of research (De Hayes and Taylor, 1972). This was then followed by the lifecycle approach that saw different needs for logistics organization designs depending on how mature the company is in their logistical capabilities (Bowersox and Daugherty, 1987). The contingency approach was introduced because there were limited empirical evidence for the “one best way” and the lifecycle approach, and the contingency theory was well-developed by the time it was introduced in the logistics research field (Persson, 1978).

Most logistics contingency studies address the “fit” between the business strategy and the logistics organization structure (Chow *et al.*, 1995). This relationship is, however, vaguely defined in logistics contingency literature and tend to focus of contextual factors external to the organization. This limits the understanding of how this fit is created and which outcomes that can be expected of achieving such fit. Furthermore, most studies on logistics strategy and organization design have been done in the manufacturing industry with predominantly manufacturing firms from the United States (Clinton and Calantone, 1996). These companies face a significantly different logistics context than project-oriented companies do, and one should take precaution in generalizing this prior research beyond US manufacturing companies. As such, prior logistics strategy research does not adequately account for contextual factors that are logistically relevant for project-oriented companies, since the focus is on how the business strategy within manufacturing companies influence logistics organization design. It is therefore necessary to complement this stream of research on logistics organization design while controlling for logistically relevant contextual factors internal of the organization that are specific to building contractors.

Although business strategy can influence what type of logistics organization structure that is appropriate, logistics contingency studies have proposed that logistically relevant contextual factors that are industry-specific should be considered instead. The general starting point is that the design of the logistics organization is determined by three main factors: the logistics task predictability, the number of logistics decision elements, and the presence of autonomous logistics decision areas (Persson, 1978). These three factors must then be followed by an organizational response, which is the design of the logistics organization that should perform logistics tasks and make logistics-related decisions. The three factors that affect the logistics organization design are sometimes referred to as uncertainty (related to the logistics task predictability), complexity (related to the number of logistics decision elements), and business or market diversification (implying the existence of autonomous logistics decision areas) (Pfohl and Zöllner, 1997, Nakano and Matsuyama, 2021, Nakano and Matsuyama, 2022). However, in this thesis, the original formulations suggested by Persson (1978) are used.

Organization design (or sometimes referred to as “organization design strategies”) is a concept that views organizations as information processing systems (Galbraith, 1974). The system is made up of work roles, formal hierarchies, and processes with the purpose to execute information processing tasks, typically meaning some form of decision-making. For the organization to function efficiently and effectively, the system needs to possess a

level of information processing capacity that matches the level of information processing requirements (Tushman and Nadler, 1978). Different types of organizational design strategies possess different levels of information processing capacity and therefore it is the level of information processing requirements generated by contextual factors that determine the feasible organization design. The appropriate logistics organization design for a given situation therefore stems from contextual factors internal of the organization that determine the logistics task predictability, the number of logistics decision elements, and the existence of autonomous logistics decision areas. Since the contextual factors can differ across industries, it is also necessary to control for these differences (Klaas and Delfmann, 2005).

2.3 Contextual Factors

In this section, three internal contextual factors are derived from the three generic contextual factors presented in Persson (1978). Based on the three general factors, it is possible to identify one industry-generic contextual factor highlighted in literature and two corresponding construction-specific contextual factors: company size, product characteristics (the degree of pre-engineering), and production process characteristics (the degree of off-site fabrication). The latter two are adapted to the ETO, site-based type of production that characterizes building construction (Ballard and Howell, 1998). The degree of pre-engineering refers to the product specification process. A typical ETO specification process relies on existing codes and standards in developing building design specifications for a specific client, whereas a configure-to-order uses predetermined parts and modules that are combined into the final product (Hansen, 2003).

Company size is an industry-generic factor, but that does not imply that company size can be measured in the same way across industries. However, the typical way of defining company size is through the number of employees and financial measurements, e.g., annual turnover, assets, etc. (Child, 1973, Dröge and Germain, 1998). This will serve as the initial basis for establishing and evaluating company size in the thesis. However, these assumptions will be investigated to determine their applicability to building contractors as well.

Logistics task predictability is mainly determined by the extent to which the products are designed, engineered, and produced to stock. Therefore, logistics task predictability can be derived from both product and production process characteristics. The number of logistics decision elements is mainly determined by company size and the number of product variants and the number of components in these products (i.e., product characteristics). The presence of autonomous logistics decision areas is determined by product and production process characteristics, where a wide range of products or production groups promote grouping of logistics tasks for each product variant or production group. The correspondences between the generic and construction-specific contextual factors are illustrated in Figure 1.

2. Theoretical Frame of Reference

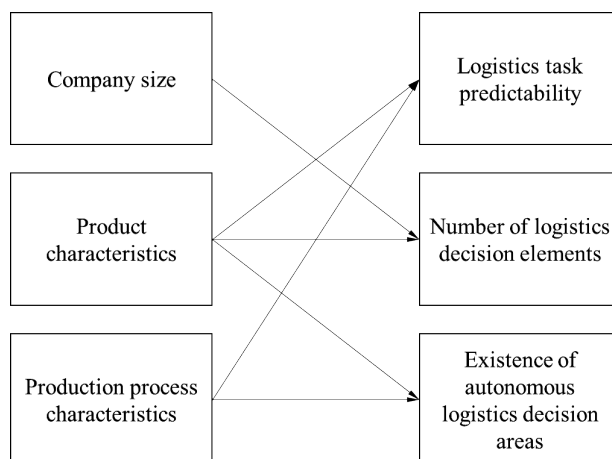


Figure 1 The correspondences between Persson's (1978) generic contextual factors and construction-related contextual factors.

A main driver of logistics task predictability is whether the company produces to stock or to customer orders. Hence, the customer order decoupling point (CODP) has been considered one key factor in determining the ideal design of a company's logistics organization (Persson, 1978, Christopher, 1986). By moving the CODP upstream in the flow, companies can pursue design, engineering, production, distribution, etc., under certainty to a customer order rather than to pursue these activities on speculation. However, this comes at the cost of reducing logistics task predictability due to inherent uncertainties with make-to-order and ETO production (Persson, 1978). On the other hand, logistics task predictability can be reduced in make-to-stock cases, e.g., due to uncertain demand, low level of standardization in production processes, and by allowing changes to customer orders late in the order-to-delivery process (Amstel and Starreveld, 1993).

The positioning of the CODP is, however, only one factor that influences logistics task predictability and subsequently logistics organization design. It only provides a partial explanation for why a certain logistics organization design is feasible. This is due to that it only considers the relationship between the supply lead time S (the cumulative lead time to supply a product) and the delivery lead time D (the required lead time delivering the product to customer) (Wikner, 2014). The CODP does not say anything about the level of customization or where the physical flow¹ takes place. These two factors are essential in logistics management and are mentioned in literature as logistically relevant contextual factors for logistics organization design (Persson, 1978, Christopher, 1986). Furthermore, it is possible to consider other relevant aspects related to product and production process characteristics, such as product range, production volumes, and the amount of value-adding performed off-site and at the construction site (Jonsson, 2018). Other contextual factors mentioned in literature are production technology (often used interchangeably with

¹ The CODP is often associated with a physical stock point and although it can be feasible to position a speculation buffer at the CODP, it is by no means necessary.

production layout), environmental uncertainty (demand fluctuations), and company size (Dröge and Germain, 1998). Therefore, the CODP concept needs to be complemented with additional contextual factors that determine the ideal logistics organization design for a building contractor.

The number of logistics decision elements is mainly related to the company size and product characteristics (Persson, 1978, Dröge and Germain, 1998). Large companies with a wide range of products and/or complex products (in terms of the number of components or raw materials) have a more diverse logistical task than smaller companies with few and relatively simple products (Persson, 1978). Therefore, as company size, product range, and product complexity increase, it can be necessary to create separate logistics functions through divisionalization to handle the increasing number of logistics decision elements.

The existence of autonomous logistics decision areas is a result of the number of products or production groups (Persson, 1978). It is similar to the second contextual factor, the number of logistics decision elements, but the existence of autonomous logistics decision areas refers to separate product groups and not just the number of products, components, or materials used. An example of the existence of autonomous logistics decision areas is a contractor with multiple strategic business units (SBUs). One business area focuses on producing low-cost production using off-site construction methods. Another business area focuses on delivering highly complex, one-off projects using “traditional” on-site construction methods. A third business area pursues infrastructure construction, and thus operates in a different sub-industry than the other two business areas. Due to these differences, the three business areas can be structurally autonomous from each other, and thus this situation typically results in the establishment of separate logistics functions for each business area.

2.3.1 Company Size

Company size refers to the number of employees within an organization, the number of sites within the company’s boundaries (e.g., production sites, distribution centres, and sales branches), assets, or turnover (Child, 1973). There have been different opinions on whether company size is as influential as product and production process characteristics, but the most common view is that it has a noticeable effect on organization design.

Logistics organization design literature suggests that this also holds for logistics organizations. In a study of manufacturing companies in the United States, Dröge and Germain (1998) found that when the company size increases, the logistics organization tend to have more hierarchical layers leading to a larger span of control. Furthermore, with increasing size comes a higher degree of decentralization since it is difficult for logistical executives to manage a vast number of employees. The company size is also associated with higher degrees of formalization, specialization, and integration. In larger companies, it is more likely to find written rules, process descriptions, and formal logistics strategy documentation. The larger company size also tends to promote sub-division of logistics tasks, while integrating logistics function with other functional areas to avoid functional silos arising due to the relatively large sizes of each functional area.

Noteworthy is that company size does not appear to have a noticeable effect on the overall performance of the logistics organization (Spillan *et al.*, 2010). Therefore, companies can be expected to pursue different logistics organization designs depending on the company size, while experiencing comparable performance levels. The level of performance does however vary depending on the level of fit between contextual factors and logistics organization design elements.

2.3.2 Product Characteristics

Product characteristics can be defined in numerous ways, but from a logistical perspective, the most relevant definitions are related to the product range, production volumes, and level of customization (Persson, 1978, Pfohl and Zöllner, 1997). Product range and production volumes are straightforward and refer to the number of product variants offered to the market and how many of each product variant that is produced. The level of customization can be defined in several ways, in which the most common way is based on volume and variety measures (Jonsson and Rudberg, 2015). A high level of customization is associated with many product variants and typically low volumes of each product variant. In building construction, it is common to find so called “lot size one”, where each product variant is produced only once. In these situations, the product is typically also unique to a customer order. On the contrary, a low level of customization (i.e., standardized products) are produced in relatively high volumes, and in few variants that are generic to a market segment.

Unlike the volume/variety-based approach, an alternative perspective on product customization involves taking a lead time-based approach (Wikner and Bäckstrand, 2018). A lead time-based approach differs in that it measures the level of customization by comparing the lead time for customization and standardization activities. Standardization here means that the activities undertaken, whether it is design, engineering, production, distribution, or in on-site assembly, are generic to a particular market segment (Schoenwitz *et al.*, 2017). Hence, full standardization means that no activities are linked to making adaptations for a specific customer order, whereas full customization means that all activities can be linked to performing adaptations for a particular customer order (Wikner, 2014). Furthermore, a middle-ground exist where the activities are linked to a particular customer, but not a customer order.

The relationship between the supply lead time and delivery lead time defines the position of the CODP in the flow. However, the CODP does not consider whether the product is standardized or customized. Therefore, the introduction of adapt lead time A is necessary, representing the time required for performing activities that are unique to a customer order. The relationship between the adapt lead time and the delivery lead time determines the position of the customer adaption decoupling point (CADP) in the flow. The position of the CODP in the flow limits the proportion of activities dedicated to adaption since customization towards speculation is not feasible.

2.3.3 Production Process Characteristics

Production process characteristics can, in a similar vein to product characteristics, be defined in several ways. However, the logistically relevant features of the production system are primarily related to the location of value-added transformation and lead time of activities at each location (like the lead-time-based approach to product customization). For the value-added-based approach, the concept of process choice is used to denote the amount of value-added transformation performed off-site. This can then be compared with the total amount of value-added transformation, which determines the degree of off-site fabrication (Jonsson and Rudberg, 2015).

For the lead time-based approach, the lead time of activities performed at the final delivery site (i.e., on-site) is compared with the total delivery lead time. This relationship determines the degree of off-site fabrication (sometimes referred to as the degree of prefabrication) in a similar way to the value-added-based approach, except for that lead times are used over the amount of value-adding. The location of the flow can also be viewed as a form of place customization (Wikner and Tiedemann, 2019). The terms “delivery site” and “supply site(s)” can be used to denote where the final delivery is made and which activities that are performed upstream of this delivery site (Rudberg *et al.*, 2024). This use of lead times can be beneficial from a logistical perspective because time is a critical factor in planning and controlling material, information, and other resource flows. However, the value-added-based approach is still a relevant measure, especially when it is coupled with the lead time-based approach.

It is possible to consider the production process characteristics in greater detail than the distinction between the supply site(s) and delivery site. The delivery site layout design is one of the main challenges since it needs to be adapted to the characteristics of the construction site and its surroundings. On the other hand, when the building contractors uses some degree of off-site fabrication, the supply site layout is a strategic decision that is influenced, for instance, by the available space in the facility, the size and weight of the product produced affecting the convenience of transportation between stations, and the dependency between work stations (Yang and Lu, 2023).

2.4 Logistics Organization Design Elements

Contingency theory posits that organization design elements are affected by contextual factors. Contextual factors determine required level of information that needs to be processed by the organization. The organization then needs to be designed so that it has sufficient information processing capacity to perform its tasks efficiently and effectively (Tushman and Nadler, 1978). This matching of the level of information processing requirements and capacity is commonly known as “fit”. As such, contextual factors can predict whether a logistics organization should be centralized or decentralized, possess formalized plans and policies, and sub-divide logistics tasks (Persson, 1978, Dröge and Germain, 1998). The logistics organization design elements that determine the level of information processing capacity are described in the following sub-sections.

2.4.1 Centralization

Within logistics organization design literature, the degree of centralization contains two dimensions: the degree to which decision-making authority is concentrated into a single unit and the proximity of logistics decision-making authority to the top management of a company, business unit, division, etc. (Chow *et al.*, 1995). Centralization is used to streamline decision-making, i.e., reduce the time and resources necessary to make decisions. On the other hand, decentralization can be used to promote a more distributed decision-making process, although at the expense of prolonging decisions and utilizing more resources. The concentration of logistics decision-making refers to whether logistics decisions are made by a single unit, for instance an organization-wide logistics department, or is dispersed throughout the organization allowing for local decision-making among these logistics sub-units. In a building contractor, the proximity of logistics decision-making authority to top management refers to whether it is located near top management or located in the contractor's temporary project organizations.

2.4.2 Division of Labour

The division of labour (or sometimes called the degree of specialization) refers to the extent to which specialized roles exist for an organization's different tasks (Pugh *et al.*, 1968). The primary purpose is to decide whether to have individuals that focus on specific tasks or generalists that perform a variety of tasks. The division of labour can include administrative logistics tasks, such as having a logistics specialist that coordinate transports from suppliers to the construction site (Dubois *et al.*, 2019) or physical tasks, such as carry-in services by logistical staff (Lindén and Josephson, 2013).

2.4.3 Formalization

Formalization refers to the extent to which logistics roles, processes, procedures, and strategies are documented (Daugherty *et al.*, 2011). Its primary purpose is to achieve consistency and reduce ambiguity in the organization. A low degree of formalization can, however, allow for more flexibility and make better use of the competencies among individuals. Formalization can thus be used in a logistics context to prescribe how activities should be carried out independently of the logistics personnel's individual traits (Chow *et al.*, 1995). Formalization is thereby closely related to the standardization of logistics tasks. In a construction context, formalization can be present at the project level through policies that are part of construction logistics setups (Janné and Rudberg, 2022) or within the building contractor's permanent organization through standardized logistics solutions that span across the company (Elfving, 2021).

2.4.4 Integration

Integration can be viewed both as a structural element of the logistics organization and as an outcome of pursuing a certain logistics organization structure. It is defined as the "degree to which logistics tasks and activities within the firm and across the supply chain are managed in a coordinated fashion" (Chow *et al.*, 1995, p. 291). In line with previous logistics organization design literature, integration is in this thesis viewed as an outcome of the logistics organization design (and partly due to company size as described in section 2.3.1) and includes integration of both intra- and interorganizational activities. Typically,

logistics organization designs that are characterized by a high degree of centralization, specialization, and formalization tend to have a high degree of integration (Abrahamsson *et al.*, 2003, Turkulainen *et al.*, 2017).

2.5 The Concept of “Fit”

Fit is a way of saying that the level of information processing capacity is equal to the level of information processing requirements (Tushman and Nadler, 1978). A higher or lower level of information processing capacity compared to information processing requirements, indicates that there is a “misfit”, which could have a negative effect on the performance of the logistics organization. However, there are studies that question whether all types of misfit are equally detrimental for performance, i.e., whether the performance drop-off is equally large in situations where the organization possesses too much or too little information processing capacity (Luo and Donaldson, 2013). “Overfitting”, i.e., possessing too much information processing capacity, is proposed to generate a slightly better performance levels than “underfitting” because overfitting allows the organization to still perform its tasks, although not as efficiently as if it would exhibit a fit. Underfit thus reduces performance more drastically than overfit because the organization cannot perform tasks adequately.

Furthermore, variations in contextual factors require different levels of information processing capacity at various levels of the organization. For example, a low degree of off-site fabrication means that more value-adding is performed at the construction site. This means that the information processing capacity needs to reside at the project level, implying a higher degree of decentralization. In contrast, a high degree of off-site fabrication requires more information processing to be carried out by logistical executives at the company level. The response in terms of the logistics organization design is then to pursue a higher degree of centralization. Hence, standardization and centralization are typically associated with higher information processing requirements at the strategic level because the purpose is to reuse information for multiple projects (Gerth, 2013).

2.6 Logistics Organization Design Configurations

Figure 2 illustrates the proposed relationships detailed in sections 2.3 and 2.4, mapping the relationships between the three contextual factors (left part of Figure 2), the three generic contextual factors (middle part of Figure 2) suggested by Persson (1978), and the logistics organization design elements (right part of Figure 2). The lower segment of Figure 2 contains the concept of fit outlined in section 2.5, along with logistics organization design configurations that is described in this section. Moreover, the lower part of Figure 2 illustrates that distinct logistics organization design configurations exhibit unique strengths and weaknesses concerning delivery service and logistics costs. Consequently, to reinforce a building contractor's competitive advantage, it is imperative to design the logistics organization in a way that aligns its strengths with the overarching business strategy. However, it should be stated that competitive advantage does not stem from the logistics

2. Theoretical Frame of Reference

organization design configuration alone, but it can help to reinforce the business strategy and contribute to competitive advantage.

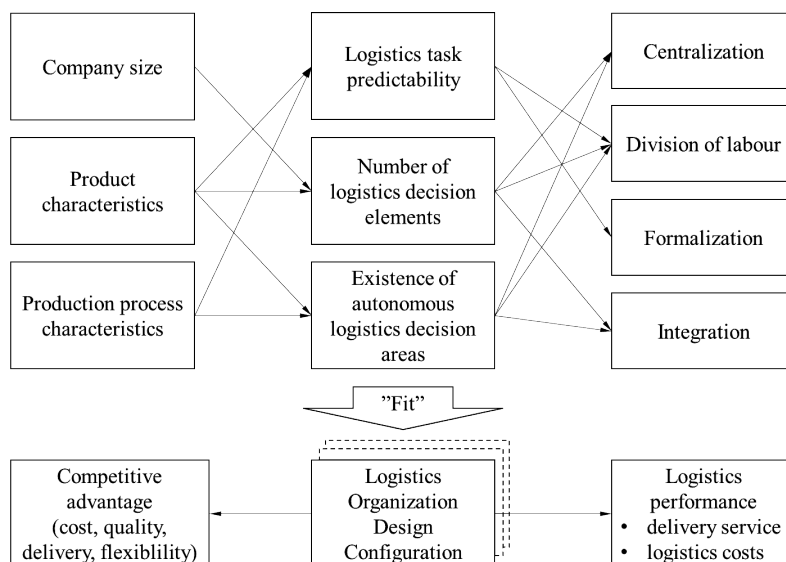


Figure 2 Elements of logistics organization design configurations and the concept of "fit".

The concept of fit entails that there can be an endless number of variations in logistics organization designs. However, in practice, some logistics organization designs appear to be identical with only minor differences, especially when considering contextual factors and organization design as a coherent whole. Mintzberg (1979) proposes that organization designs are best understood as a system of interrelated contextual and organizational elements. This is known as the "configurational view" within contingency theory and it aims to overcome the issue with oversimplified contingency models, while acknowledging that changing from one configuration to another takes substantial effort in terms of time and resources (Miller, 1986). The configurational view thereby suggest that the contextual factors described in section 2.3 and the logistics organization design elements described in section 2.4 should be considered as parts of a complex system that is stable in the short-term, but adaptable in the long-term.

The configurational view further suggest that a fairly small number of configurations with more or less similar characteristics should exist and that these exhibit similar patterns in their response to contextual factors via the logistics organization design (Klaas and Delfmann, 2005). Hence, these configurations need to be identified in empirical investigations, where they can provide both more nuanced explanations of how context influences organization design and provide better guidance for managers.

3. Research Design

In this section, the overall research design is described, including the research process, what methods were used for each study and why. It also describes how each study was conducted in terms of the studies' research design, data collection methods, and analysis procedures.

3.1 Overview of the Research Process

Figure 3 illustrates the research process, where each paper represents a dedicated study addressing specific aspects of logistics strategy with a focus on logistics organization design within building contractors.

The research process unfolded in two distinct parts. The initial phase, encompassing Paper 1, Paper 2, and Paper 4, spanned from late autumn 2019 to the spring of 2022. These papers were part of a licentiate thesis (Haglund, 2022), which was defended on May 20th, 2022. The first part primarily adopted a descriptive approach, aiming to understand current practices among building contractors concerning logistics strategies. Despite its descriptive nature, the first part resulted in preliminary explanations and recommendations regarding how building contractors should structure their logistics organizations in response to contextual factors. These normative statements were based on the understanding of current practices among building contractors, which were used to suggest how they should design their logistics organizations.

The second part of the research process built upon the findings of the first. Mainly comprised of Paper 3 and Paper 5, this phase also involved refining the final version of Paper 2. The focus of the second part shifted towards explaining how contextual factors influence logistics organization design elements. Based on these insights, the research output from the second part presented more normative results, offering guidance on how various types of building contractors should design their logistics organizations in response to contextual factors.

	Paper	Scope	Method	Research question		
				RQ1	RQ2	RQ3
2019	Paper 1	Describing contextual factors and logistics organization design elements.	Multiple case study	X	X	X
	Paper 4	Logistics strategy process at a large building contractor.	Longitudinal single case study		X	X
Lic 2022	Paper 2	Study of logistics strategies in Nordic building contractors.	Questionnaire	X	X	
	Paper 3	Clarification of contextual factors using decoupling thinking.	Conceptual with case illustrations	X	X	
PhD 2024	Paper 5	Logistics organization design in relation to subcontracting the logistics function.	Single case study			X
2024						

Figure 3 Illustration of the research process, including scope, method, and the corresponding thesis research question(s) of each paper.

3.2 Research Design

This section provides a brief explanation of how the papers contribute to answering the research questions. The purpose of this doctoral thesis was to *investigate building contractors' logistics strategy content and process with a focus on how to design the logistics organization*. The purpose thus includes several aspects of logistics organization design, namely contextual factors and logistics organization design elements (RQ1), the fit between contextual factors and logistics organization design elements (RQ2), and how building contractors should design their logistics organization to create ideal conditions for an efficient and effective logistics system (RQ3). The five papers contribute towards answering different research questions (see Figure 3) and the purpose is fulfilled by answering the three research questions.

Paper 1 is related to all three research questions and is a multiple case study of four building contractors' logistics organization designs. This was the first study performed and the first paper published during the doctoral research project. The paper was descriptive in its character and aimed to investigate the status regarding logistics strategies in the Swedish construction industry. The paper describes logistically relevant contextual factors along with logistics organization design elements. Furthermore, the concept of fit between the two is discussed. The paper is published in *Construction Management and Economics* (Haglund *et al.*, 2022).

Paper 2 builds upon Paper 1 and is mainly related to RQ1 and RQ2 and is a questionnaire-based study of building contractors' logistics organization designs in Sweden, Norway, Finland, and Denmark. In addition to the contextual factors and logistics organization design elements included in Paper 1, Paper 2 employed a questionnaire study encompassing cases from medium-sized and large building contractors, which enabled an analysis of the effect of company size on the logistics organization design. Paper 2 therefore extended the

findings of Paper 1. The paper is a working paper where an early version was presented at the *2021 CIB International Conference on Smart Built Environment* (Haglund, 2021).

Paper 3 is mainly related to RQ1 and RQ2 and is a conceptual study with two case examples. The paper investigates product and production process characteristics using decoupling thinking, which refers to separating the flow into two distinct parts based on the properties of the flow that is upstream and downstream of the decoupling point (Wikner, 2014). The most well-known example of decoupling thinking is the driver of the flow, which is separated into speculation driven and customer order driven (Hoekstra and Romme, 1992). Decoupling thinking can also be applied to other properties of the flow that can be separated into an upstream and downstream domain. As such, in Paper 3, it complements the volume/variety-based and resource-based approaches to product and production process characteristics used in Paper 1. The paper is a working paper. An earlier version of the paper was presented at the *2023 APMS Conference: Production Management Systems for Responsible Manufacturing, Service, and Logistics Futures* (Haglund et al., 2023).

Paper 4 is mainly related to RQ2 and RQ3 and is a single case study of a large building contractor operating primarily in the Swedish construction industry. The paper takes a longitudinal approach and investigates the logistics strategy process at the contractor between 2008-2019. In contrast to Paper 1-3, which considered fit from a static perspective, the paper takes the perspective of the process of establishing fit. The paper provides insight into the logistics strategy process, focusing on how a building contractor's logistics organization design evolved over a period of 11 years. The paper also provided reasons why (and why not) certain changes were made to the logistics organization, thus complementing the findings from Paper 1-3. The paper is published in the *International Journal of Logistics Management* (Haglund and Rudberg, 2023).

Paper 5 is mainly related to RQ3 and is a single case study of a large building contractor and its subsidiary that offers construction equipment rental services and logistics services. The paper investigates what type of logistics organization design that is feasible when parts of the logistics function is contracted out (in this case to the building contractor's subsidiary). It is common in the construction industry to rely on sub-contractors, and logistics is not an exception in this regard (Fredriksson *et al.*, 2021). As such, it provides additional insight to the findings from Paper 1-4 regarding the logistics organization design and the internal logistics capabilities of building contractors, particularly in situations when parts of the logistics function are managed by a sub-contractor. The paper is published in *Construction Innovation* (Haglund and Janné, 2024). An early version of the paper was presented at the *34th NOFOMA Conference, Reykjavik, Iceland, June 8-10, 2022* (Haglund and Janné, 2022).

3.3 Overview of the Data Collection and Analysis Methods

Table 2 provides a summary of the data collection method, type of data, and analysis methods used in the five papers. The main method used throughout the research process is

case study, but this has been complemented with a questionnaire study (Paper 2), and a study based on conceptual modelling with case illustrations (Paper 3).

Table 2 Data collection methods, type of data, and analysis methods.

<i>Paper</i>	<i>Data collection methods</i>	<i>Type of data</i>	<i>Analysis method</i>
<i>Paper 1: Multiple case study</i>	Semi-structured interviews	Information about the case companies' product and production process characteristics, and their logistics organization design.	Predetermined case study questions were answered using interview data. The cases were then classified using strategic profiling.
	Workshops	Verification interview data by case participants.	Used for strategic profiling.
	Logistics plans (documents)	Logistics plan templates used in projects.	Used for strategic profiling.
<i>Paper 2: Questionnaire study</i>	Web-based questionnaire	5-point Likert scale data measuring agreement level related to contextual factors, logistics organization design elements, and operational performance.	An index was created to determine the degree of pre-engineering and off-site fabrication of each case. Means were used to compare the level of fit for each case.
<i>Paper 3: Conceptual study with case illustrations</i>	Project time plans	Information about lead times and production process descriptions.	Time-phased work breakdown structure.
	Process descriptions	Information about production process descriptions.	Time-phased work breakdown structure.
	Semi-structured interviews	Verification and additional information about lead times and production process descriptions.	Time-phased work breakdown structure.
	Site visits	Observations of off-site production facilities.	Time-phased work breakdown structure.
<i>Paper 4: Longitudinal single case study</i>	Semi-structured interviews	Information about time and sequence of events identified through archival data.	Thematic analysis.
	Archival data	Meeting minutes, project reports, project time plans, strategy documentation.	Visual mapping followed by thematic analysis (combined analysis of archival and interview data).
<i>Paper 5: Single case study</i>	Semi-structured interviews	Information about the process of developing logistics services, the collaboration between the contractor and rental company.	Thematic analysis.
	Presentations	Description of logistics services.	Complementary/verifying interview data.
	Site visit	Detailed information on how the contractor and rental company collaborated in the contractor's projects.	Complementary/verifying interview data.

3.4 Paper 1 – Multiple Case Study of Building Contractors' Logistics Strategies

3.4.1 Research Design and Case Selection

The study relied on a mix of conceptual research and a multiple case study. The conceptual part of the research was about developing a logistics strategy configuration profiling template to describe the characteristics of building contractors' logistics strategies. The profiling template was based on strategic profiling, which is a method used to create a simple illustration of a company's strategic fit (Hill, 1985). Strategic profiling was originally developed to illustrate the marketing-manufacturing link in a company's manufacturing strategy, but it has since then been applied to other areas, such as service organizations and logistics (Semini *et al.*, 2004, Hill and Brown, 2007). As such, it can be used to identify strategic configurations based on multiple contextual factors and logistics organization design elements.

The multiple case study was used to refine the profiling template and its presumed relationships between contextual factors and logistics organization design elements. The case study design was used to gain in-depth knowledge about the current logistics strategy practices among building contractors. Including multiple cases in the research design allowed for comparison between the cases. The cases were selected based on a combination of theoretical and literal replication (Yin, 2018), in which three contractors were large general-purpose contractors (i.e., they operate in several business areas) and one industrialized housebuilder. The general-purpose contractors were expected to exhibit similar characteristics in terms of the contextual factors and subsequently their logistics organization design. On the other hand, the industrialized housebuilder's logistics organization design was expected to differ due to their significantly different contextual factors. The case selection thus enabled an assessment of whether the profiling template could aid the understanding of similarities and differences in logistics organization design in response to contextual factors across the cases.

3.4.2 Data Collection and Analysis

The case study data were collected using semi-structured interviews, workshops with the case participants, and documents obtained from the case companies. The semi-structured interviews were held early in the research process with one participant from each case company. In total, four interviews were performed, lasting 1,5-2 hours each. The reason for using the semi-structured interviews in this phase of the research process was to provide focus of the subsequent data collection, while allowing the respondents to talk freely beyond what was stated in the interview guide. The interviews covered the characteristics of the case companies' contextual factors (i.e., product characteristics, and production process characteristics) and their logistics organization. The interview data and any documents obtained from the case companies were entered into a case protocol that was structured with case study questions in order to maintain the chain of evidence throughout the case study, as suggested by Yin (2018). The case protocol also served as a database and provided the basis for the case study descriptions. To verify the authors' interpretation of

the cases and to facilitate cross-case comparisons, three workshops were held with the case participants. During these workshops, the researchers and case participants discussed the respective profiles of the case companies and got feedback that was used to further refine the logistics strategy configuration profiles of the case companies.

3.5 Paper 2 – Questionnaire Study of Residential Building Contractors' Logistics Strategies

3.5.1 Research Design and Sample

Paper 2 extended the insights derived from Paper 1 by introducing a third contextual factor, that is, company size. In contrast to the multiple case study design employed in Paper 1, Paper 2 adopted a questionnaire-based approach. This allowed for methodological triangulation in this doctoral thesis and generalization of the results of Paper 1 by investigating the relationship between contextual factors and logistics organization design elements using both the case study and questionnaire research designs.

The questionnaire targeted residential building contractors. However, building contractors, i.e., contractors that carry out construction of residential *and* non-residential buildings (Barbosa *et al.*, 2017), were included in the study to enable a comparison of residential and non-residential building construction. The sample was selected through the database *Orbis* containing information about companies' financial information. The database search was limited to construction companies with NACE code 412 *Construction of residential and non-residential buildings*. However, no limitation was applied for companies that also pursued other types of construction. Companies that exclusively pursued other types of construction than building construction were excluded.

The questionnaire targeted medium to large enterprises, hence excluding small enterprises according to the EU recommendation 2003/361 for classifying small and medium enterprises. Small enterprises were excluded since they can be expected to not possess sufficient resources or a need to properly address logistics at a strategic level. Hence companies with a turnover of less than €50 million per year and with less than 50 employees were excluded from the study. These criteria were then used as determinants for company size in the analysis. No upper bound limit for company size was used. The sample consisted of companies from Sweden, Norway, Finland, and Denmark.

3.5.2 Questionnaire Development

The questionnaire was divided into five main parts: personal information about the respondent, information about the respondent's company, the company's production strategy, logistics organization design, and operational performance. Although the study focused on building construction, the respondents also received questions regarding the production and supply strategies for the company's other types of construction. This was to control whether the other types of construction also could affect the logistics organization design and subsequently the operational performance.

3. Research Design

A five-point Likert scale was used for the main parts of the questionnaire (i.e., about the companies' production and supply strategies, logistics organization design, and operational performance). However, the questions regarding the production strategy used "Never" to "In all projects" to account for that different strategies might be used in different projects. For the questions about logistics organization design and operational performance, "Completely disagree" to "Completely agree" were used as anchors.

The questionnaire was translated from Swedish to Norwegian, Finnish, and Danish as a measure to increase the response rate. The questionnaire was first translated using an artificial intelligence assistant based on a language model and then validated by three different academics with Norwegian, Finnish, and Danish as their mother tongue. To ensure the validity and overall salience of the questionnaire, it was first pre-tested with a panel of academics within construction management, which was followed by a pilot with participants from the construction industry. The target respondent was primarily someone working as a logistics manager, operations manager, specialist within logistics, or similar, and the panel that took part in the pilot had similar profiles as the target respondent. The pre-test and pilot resulted in that some questions were omitted and some reformulated to better suit the target respondents.

3.5.3 Data Collection and Analysis

The data was collected using a web-based key informant questionnaire. This is a cost-efficient method of gathering large amounts of data, but with downside that respondents can misinterpret questions and provide responses that provide limited depth of information and clarity. However, it is a generally accepted method used in logistics and operations management research (Forza, 2002).

The questionnaire was mailed to one person at each company working in a logistics-related or top management position. Respondents working solely at the project level (e.g., site managers) were avoided since the focus of the study was on the strategic level. The questionnaire was sent out to 365 companies and 52 complete responses were returned, resulting in a response rate of 14%. Out of these 52 responses, 37 companies pursued residential building construction, and this was the final sample included in the analysis.

The final sample size of 37 companies from a population of 365 medium-sized to large building contractors across Sweden, Norway, Finland, and Denmark was chosen to reflect the specific characteristics of the target group. Unlike large-scale questionnaires that may involve a much larger population, the focus was on a niche population, which required a more targeted approach. As such, the size of the population is relatively low ($N = 365$) and the response rate of 14% is still deemed acceptable, particularly for web-based questionnaires that typically yield a lower response rate (Forza, 2002). The companies were identified in a database containing comprehensive information, and thus allowed for a precise identification of a specific subset of building contractors relevant to the study. Although the sample size is relatively low in absolute numbers, given the specific geographical and size criteria, it is still meaningful for the purpose of the study, providing insights into medium-sized and large contractors in the Nordic region.

The analysis began with creating indexes for the degree of pre-engineering and off-site fabrication. In the questionnaire, the respondents reported how often they used a particular degree of pre-engineering and off-site fabrication. Based on this frequency, each case was given a score for the degree of pre-engineering and off-site fabrication, where a negative score indicated that they mostly used a low degree of pre-engineering and off-site fabrication, respectively. A positive score thus meant that a high degree of pre-engineering and off-site fabrication was used in most projects. Based on this score, the cases were assigned to categories with other cases exhibiting similar characteristics. Some companies pursued several types of construction in terms of the degree of pre-engineering and off-site fabrication. These were assigned to a separate category based on their indexes. This resulted in a total of seven categories based on the degree of pre-engineering and off-site fabrication.

In the next step of the analysis, the different elements of company size were analyzed. This included turnover, number of employees and the geographical spread of the contractors' projects. Thereafter, the logistics organization design configurations for the different categories were analyzed by comparing the means across the seven categories. Finally, the operational performance of the companies in terms of cost, quality, time, and flexibility were compared across the cases to identify potential high performers in one or several performance areas.

3.6 Paper 3 – Conceptual Study of Contextual Factors Using Decoupling Thinking

3.6.1 Research Design

The study was mainly conceptual where the researchers used decoupling thinking (Wikner, 2014) to investigate site-based production from a flow perspective. The paper extends the findings of Paper 1 and Paper 2 by investigating product and production process characteristics using decoupling thinking, in contrast to the value-adding-based approach. A typology was developed using logical reasoning comprising three interrelated dimensions: flow driver, flow differentiator, and flow location. The former two were identified in literature and the latter was developed by the researchers. The typology was then applied to two cases in order to illustrate its usefulness in describing the differences between various site-based production systems from a flow perspective. As such, the research falls under *analytical conceptual research*, in which new insights to a problem are added through logical reasoning, often with the help of case illustrations (Wacker, 1998).

The two cases were industrialized housebuilders and were selected due to the challenges related to combining off-site and on-site production. Case company 1 was a housing developer pursuing land acquisition, design and engineering, factory production, site assembly, and construction of the surrounding residential area facilities (e.g., recycling rooms, courtyard facilities, bike storage). Their building system comprises standardized volumetric modules that are produced in their off-site factory, which are then transported and installed at the construction site. Case company 2 is a building contractor that deliver their projects to external clients, much like a typical building contractor. Their projects

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involve construction of residential properties (condominiums, rental housing, student apartments, senior apartments) and hotels. Their building system comprises production of volumetric modules in their off-site factory but is more flexible than in case company 1. Each volumetric module in case company 2 is project unique and is limited only by size and load bearing constraints.

3.6.2 Data Collection and Analysis

The two cases were seemingly identical on the surface (both were industrialized housebuilders) but had different approaches to product customization (related to flow driver and flow differentiator). Both had a relatively high degree of off-site fabrication and hence they were considered suitable candidates for illustrating the typology's usefulness. The data were collected mainly through internal documents about their products and information about typical projects, including project time schedules, lead times from suppliers, and process and activity descriptions. In addition, the researchers performed two interviews with representatives from case company 2, lasting 1-2 hours each, and a half-day site visit at the off-site factory, and one interview with the head of research and development from case company 1, lasting two hours. The purpose of the interviews and the site visit were to verify the data retrieved from the internal documents and to complement any missing data that was needed for the analysis.

The data were analyzed by creating a time phased work-breakdown structure (WBS) for a typical project in each of the two case companies. The time phased WBSs were based on activity lead times (and related information about their building process). The WBSs illustrated the activity lead times through the length of the arrow, which is a method typically used for creating time phased bill-of-materials (Bäckstrand and Wikner, 2013). In addition, the project delivery lead time, adapt lead time, and delivery site lead time were used to determine the positions of the decoupling points in the WBSs.

3.7 Paper 4 – Longitudinal Study of the Logistics Strategy Process

3.7.1 Research Design and Case Selection

Paper 4 addresses the process of establishing a fit between contextual factors and logistics organization design elements. Therefore, it serves as a complement to the other studies conducted during the doctoral research project, which primarily concentrated on the content of fit. Due to the focus of the study being the logistics strategy process, the study was designed as a longitudinal single case study. Longitudinal case study designs are highlighted in strategic management literature as important means of investigating the strategy process, either in real time or in retrospect, since they capture this process as it unfolds in contrast to cross-sectional studies (Van de Ven, 1992). Longitudinal designs enable the researchers to collect process data, which describes the relevant decisions, activities, and events that can be used to describe and explain the outcomes of the strategy process (Langley, 1999).

The case company was selected due to three main reasons: 1) the company had made a deliberate effort to formulate and implement a logistics strategy, which is unusual among large building contractors with a heavy project-oriented way of operating, 2) the authors had access to extensive documentation and key persons in the logistics strategy process, 3) the accessible data was of the type process data. The use of process data thus enabled the researchers to investigate the decisions, activities, and events that led up to the outcome of the logistics strategy process.

3.7.2 Data Collection and Analysis

The dataset encompassed both primary and secondary data sources. Primary data included participatory observation and semi-structured interviews, providing insights from people involved in the logistics strategy process. In total, six interviews were held, lasting one to one and a half hour each. Due to the ongoing pandemic at the time, the interviews were held online. The interviewees were the logistics developer currently working at the company, the former logistics manager at the company, and the former project manager for the logistics strategy process. Secondary data were drawn from internal documentation, encompassed meeting minutes, implementation plans, pilot project reports, records, and presentations from strategy meetings, along with a comprehensive description of the logistics strategy.

Recognizing the inherent uncertainty in secondary data regarding accuracy and the level of detail, the primary data collection was used as a triangulation method. This approach was important for enhancing the study's reliability by cross-verifying information from different sources, thereby strengthening the rigorousness of the findings.

The analysis was performed in two main steps. The first step was for the researchers to familiarize themselves with the vast amount of data available. Here a technique called “visual mapping” was used, which is a way of illustrate the sequence of decisions, activities, and events that led up to an outcome (Langley, 1999). The first iteration of the visual map was based on the secondary data. In the second step, the researchers analyzed the interview data with the key persons involved during the logistics strategy process. In this step, thematic analysis was used to identify the main reasons for the outcomes of the logistics strategy process. First, 82 open codes were formed based on the interview data and documentation. They were then reduced to 15 axial codes. Finally, three main themes could be identified among the 15 axial codes that could explain the reasons behind the outcome of the logistics strategy process.

3.8 Paper 5 – Organizing Construction Logistics Outsourcing

3.8.1 Research Design and Case Selection

The study was designed as a single case study design of a building contractor and its subsidiary within construction equipment rental services and logistics services. The study thus exemplifies current practices in the construction industry, which can affect the building contractors' logistics organization designs. However, to the authors' best knowledge, this

is a unique case where the rental company had developed logistics service offerings, while also being part of the same corporation as the contractor. This meant that the case provided unique insights into an integrated rental and logistics service provider and a building contractor. Although the subsidiary is part of the same corporation as the contractor, the two organizations operate separately of each other. The single case study design enabled the researchers to analyze the interface between the two organizations.

3.8.2 Data Collection and Analysis

The data consisted of both longitudinal data in retrospect and cross-sectional data in “real time”. The longitudinal data was used to contextualize the study since the building contractor had been working with internal logistics development for over a decade before the subsidiary started to offer logistics services. The longitudinal data consisted of documents and archival records from the building contractor, with information regarding their logistics strategy, implementation plan for the strategy, pilot projects, etc.

The cross-sectional data consisted primarily of interview data with key persons at the building contractor and the subsidiary. In total, eight interviews were performed online or in-person with five people from both companies, lasting 30 minutes to two hours per interview. Since the purpose of the study was to investigate how to organize logistics outsourcing at the strategic, tactical, and operational level, the aim was to talk to at least one person from each level in both companies. The interviewees had the roles of logistics developer (contractor), business developer (subsidiary), operations manager (subsidiary), project logistics specialist (contractor), and regional manager (subsidiary). However, there were essentially no one working with logistics at the tactical level in the contractor. Besides interview data, the cross-sectional data consisted of site observations from a representative construction project where the contractor used logistics services from the subsidiary, logistics service descriptions, strategy documentation, and organizational charts and routines.

After an initial screening of documentation and the first interview with key persons at the building contractor and its subsidiary, it became clear that there was a need to look at how the two companies had organized its logistics function and logistics service delivery, respectively. This meant that the analysis proceeded as thematic coding (Flick, 2018), where the authors created short case descriptions for the strategic, tactical, and operational level in both organizations.

4. Results

This section addresses the three thesis research questions by explaining how the appended papers relate to and answer them. Firstly, it describes contextual factors and logistics organization design elements, mainly from Papers 1, 2, and 3. Secondly, it discusses the connection between these contextual factors and design elements, primarily found in Papers 1, 2, 3, and 4. Lastly, it outlines ideal logistics organization design configurations, mainly from Papers 1, 4, and 5.

4.1 Contextual Factors and Logistics Organization Design Elements

This section addresses RQ1: *What contextual factors influence the design of building contractors' logistics organizations?* The research findings answering RQ1 are summarized in Table 3 below:

Table 3 Summary of key findings for RQ1.

<i>Factor/element</i>	<i>Summary of findings</i>
<i>Product characteristics</i>	Determines the level of uncertainty and complexity (i.e., number of components) about the final design, which in turn influences the logistics task predictability, the number of logistics decision elements. Having several distinct product groups can also promote the existence of autonomous logistics decision areas.
<i>Production process characteristics</i>	Mainly related to the level of repetition in production, which influences logistics task predictability.
<i>Company size</i>	No clear effect on the logistics organization design could be identified, mainly due to the operationalization of company size as the number of employees.
<i>Centralization</i>	Centralization refers to whether logistics decision-making is concentrated in the permanent part of the organization or distributed across projects.
<i>Division of labour</i>	Division of labour refers to whether the organization has specialized logistics roles or integrate logistics tasks in existing roles (e.g., site managers or supervisors).
<i>Formalization</i>	Refers to the presence of formal rules, procedures, and processes that are documented, standardized, and enforced in the building contractor's logistics function.
<i>Integration</i>	The extent to which the logistics function work together in a coordinated manner with other functional areas and external partners (e.g., suppliers and sub-contractors).

4.1.1 Contextual Factors

The first research question addresses what contextual factors that influence building contractors' logistics organization design. The contextual factors and logistics organization design elements presented in section 2 are based on prior research and were identified

through a literature review. The appended papers, mainly Paper 1-3, contribute to empirically and conceptually verifying the contextual factors and logistics organization design elements.

In Paper 1, two key contextual factors were identified: production process characteristics (in the paper, the equivalent term “production process choice” was used) and product characteristics. Production process characteristics determines where value-adding activities occur. A high degree of off-site fabrication (prefabrication) is characterized by factory production, where the final assembly is carried out at the construction site. Conversely, a low degree of off-site fabrication implies that most of the production and assembly activities take place directly at the construction site.

The findings of Paper 1 suggest that the type of production processes requires different approaches in the design of the logistics organization. A high degree of off-site fabrication typically reduces the number of planning points and is characterized by predetermined sequences between activities due to the use of more repetitive and product-oriented layouts. A low degree of off-site fabrication leads to more reciprocal interdependency between activities, requiring more day-to-day planning at the construction site and decentralized logistics.

The degree of off-site fabrication, as defined in Paper 1, is based on the amount of value-adding that is performed off-site and on-site. While this approach to production process choice takes the place where production and assembly activities are performed into consideration, it does not address time, which is critical for managing logistics.

In Paper 3, the degree of off-site fabrication is considered from a flow perspective, which uses decoupling thinking to distinguish the lead times required to perform off-site and on-site activities. As such, it is possible to directly relate the production process characteristics to logistics activities such as, purchasing and in the positioning of different types of inventory buffers, where lead times play a critical role for ensuring supply of materials and resources to the production. Furthermore, the lead time-based approach enables a comparison of the lead times for off-site and on-site activities to the amount of value-adding performed off-site and on-site. Using the lead time-based approach, the degree of off-site fabrication is determined by the relation between the lead time for on-site activities (referred to as the more generic term “delivery site” in the paper) and the supply lead time. In Paper 3, this is referred to as the $L:S$ -relation, where the L represents delivery site lead time, and the S represents the supply lead time. The $L:S$ -relation is illustrated in Figure 4, where the delivery site lead time is decoupled from upstream activities at the supply site(s) (a more generic term for “off-site”) by the delivery site decoupling point (DSDP). Furthermore, Figure 4 illustrates the DSDP’s relation to two other decoupling points. CODP, which separates the speculation-driven and the customer order-driven flow and the CADP, which separates the standardized and the customized flow.

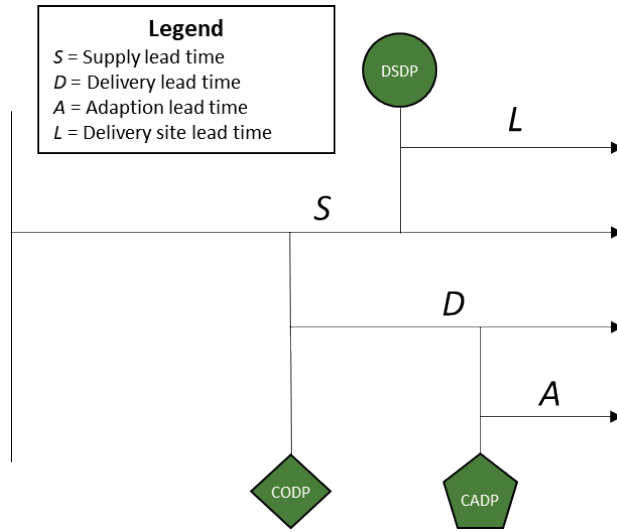


Figure 4 The typology of flow driver, flow differentiator, and flow location.

In Paper 1, product characteristics are defined as the level of customization and the degree of pre-engineering. These two aspects are sometimes used interchangeably, but customization typically refers to the product's volumes and the number of product variants. The degree of pre-engineering refers to the degree to which design and engineering work is completed before a customer order has been received. Product customization was investigated further in Paper 3, where a lead time-based approach was used to highlight the lead time required to make design and engineering adaptations according to a customer order. This approach has been used in prior research (e.g., Bäckstrand and Wikner, 2013) to determine, from a demand perspective, the time required to make engineering adaptations (i.e., it is a way to divide the delivery lead time into standardized and customized flow). Using the lead time-based approach, product customization is determined by the $A:D$ -relation (see the middle part of Figure 4), where A is the adapt lead time and D is the delivery lead time. By making a combined analysis of the relative positions of the CADP and DSDP in the flow, it is possible to determine where (at the supply site(s) or delivery site) customization activities take place.

The lead time-based approach enables an important distinction, from a logistics point of view, between the customer order driven flow that is standardized and customized, and whether the activities take place at the supply site(s) or the delivery site. For instance, in many cases the final design of a building or other type of construction is decided late in in the design process, or even when production has started. The contractor can therefore perform activities related to standardized products/services (i.e., activities related to customer generic products/services) under certainty before the final design has been decided, which enables them to make early estimations of material requirements and delivery plans early in the construction process. Hence, product and production process

characteristics in terms of lead times can be used to offer more accurate suggestions of how building contractors should organize and manage logistics.

A third contextual factor was identified in Paper 2, namely company size. In literature, it is a multifaceted factor that is determined by the employees within an organization, the company's number of sites (e.g., production sites, distribution centres, and sales branches), assets, and turnover. The findings of Paper 2 did, however, reveal that it can be misleading to use the number of employees as a determinant for the size of a building contractor. Sub-contracting is a common approach used by building contractors to achieve a high turnover with relatively few employees. Building contractors with such approaches rely heavily on sub-contracting to deliver their projects and to gain competitive advantage. It is therefore necessary to consider the possible use of sub-contracting when determining company size. The annual turnover should also indicate the "true" size of a building contractor if the number of employees is low relative to other building contractors with similar turnovers. In general, the findings suggest that company size should be considered and measured as a multi-factor construct, especially when investigating its effect on the logistics organization design.

4.1.2 Logistics Organization Design Elements

In Paper 1, five logistics organization design elements were identified: formal structure (the degree of centralization), physical structure (the location of logistics infrastructure), division of labour, specialization, and integration. Physical structure can be questioned whether it should be a part of the logistics organization design or a separate decision area. In conventional organization design literature, physical structure is not commonly listed as an element of organization design. Logistics organization design literature sometimes includes this as an element of organization design, but it is typically regarded as a separate decision area, which is in line with the conventional organization design literature. Physical structure is therefore in this thesis omitted as an element of the logistics organization design but is included as a decision area in the logistics strategy that is related to the logistics organization design (see Table 1). Therefore, in Paper 2, physical structure was removed as a logistics organization design element. The four remaining elements are thus the degree of centralization, division of labour, the degree of specialization, and the degree of integration. These four elements are described in more detail in the following paragraphs, mainly based on the findings of Paper 1 and 2.

The degree of centralization in building contractors' logistics organization refer to whether logistics decision-making is concentrated within a single department and how close this department is to the top management. A heavily centralized logistics organization bears a resemblance to a project management office, that can take on multiple roles such as overseeing project logistics, offering support, and serving as direct supervisors.

The division of labour denotes the extent to which individual logistics activities are performed by employees with relevant expertise and dedicated roles. A common example in the construction industry is removing material handling as a part of the construction workers tasks and instead using dedicated material handling teams to carry-in material to

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its final assembly location. Other examples of logistics activities and responsibilities that can be sub-divided are inventory management, logistics coordination, and material requirements planning.

The degree of formalization refers to the extent to which rules, procedures, and processes are documented, standardized, and enforced in the building contractor's logistics function. Formalization influences how tasks are performed, decisions are made, and communication is conducted. This can involve standard operating procedures for logistics activities, formal role descriptions, standardized communication practices, the use of standardized performance measures, etc.

The degree of integration in a construction company's logistics organization refers to the extent to which different parts within the logistics function, between the logistics function and other functional areas, and between the logistics function and external partners (suppliers and sub-contractors) work together in a coordinated manner. High integration implies close coordination, while low integration suggests a more fragmented approach, which is characterized by functional silos.

4.2 The Link Between Contextual Factors and Logistics Organization Design Elements

This section addresses RQ2: *How do the identified contextual factors influence the design of building contractors' logistics organizations?*

Figure 2 in the theoretical frame of reference illustrates the proposed relationships between the three contextual factors (company size, product characteristics, and production process characteristics) and the four logistics organization design elements (centralization, division of labour, formalization, and integration). In this section, these proposed relationships are addressed by discussing the findings of the appended papers, mainly focusing on the findings of Papers 1-4.

4.2.1 The Influence of Company Size

As illustrated in Figure 2, when the number of employees, the annual turnover, and the geographic dispersion of the building contractor's increase, it is expected that the number of logistics decision elements increase. This promotes a decentralized logistics organization, and thus, a need for integration between the logistics function and other functional areas. Furthermore, larger building contractors are also expected to sub-divide logistics tasks to a greater extent than smaller building contractors.

The findings from Paper 2 indicated a slight tendency for larger building contractors to pursue a more decentralized logistics organization (and vice versa for smaller building contractors). However, the findings regarding company size warrant for further research with an alternative operationalization of company size. The companies with the highest turnover were the most decentralized, unspecialized, and with a low level of integration, whereas the companies with the greatest number of employees were more centralized, specialized, and integrated. Furthermore, the most locally/regionally focused contractors

were the most decentralized, whereas those whose market was at the national or international level were more centralized.

These findings suggest that company size does not affect the logistics organization design as clearly as the degree of pre-engineering and production process characteristics. One explanation for the contradictory results could be that the logistics organization design is not entirely a conscious choice. The findings of Paper 4 show that a large multi-national building contractor's deliberate attempt to establish a logistics organization was affected by other factors, such as managers' educational and professional backgrounds, the support for "investing" in logistics from top-management, and conflicts of interests with other functional areas (e.g., purchasing) and employees (e.g., regional managers) in the organization. As such, it can be expected that the logistics organization design configuration is not made purely for efficiency/effectiveness reasons. Moreover, the results presented in Paper 2 suggest that relying on the number of employees as a measure of company size can be misleading when sub-contracting is involved. Therefore, it is suggested to use the total value of the contractor's project portfolio as a measure of company size over the number of employees. However, further studies are necessary to determine whether this is a recurring pattern among other large building contractors, as well as among small and medium-sized building contractors.

4.2.2 The Influence of Product Characteristics

Product characteristics are typically associated with the physical properties of the product, such as volume and weight. Here, however, the product characteristics are mainly related to the properties of the product specification process since they have a considerable effect on all three generic contextual factors outlined in Figure 2: logistics task predictability, the number of logistics decision elements, and the existence of autonomous logistics decision areas. Hence, overall, the product characteristics are expected to have a significant effect on the logistics organization design.

In Paper 1, product characteristics were found to mainly affect the degree of centralization and formalization. A high degree of pre-engineering entails that the building contractor has more information about the final building design, its sub-assemblies, components, and materials before the customer enters the process. The predictability of logistics tasks is therefore high for high degrees of pre-engineering, and vice versa. This typically means that the logistics organization can develop formal procedures for logistics tasks (e.g., material handling, packaging, storage, transportation, etc.) since the number of unique products, sub-assemblies, components, and materials are low. Furthermore, Paper 1 highlights that the complexity of the final product (in terms of the number of sub-assemblies, components, and materials used) influences the degree of centralization. Complex products, typically characterized by the depth and width of the product structure, lead to a high number of logistics decision elements, which promotes decentralization.

In Paper 3, a lead time-based approach to product customization was used. The primary reason for using this approach was to more clearly highlight how product customization influences logistics task predictability in construction projects. This approach involves

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time-phasing project activities, and an example of a time-phased work breakdown structure of a construction project is illustrated in Figure 5. As seen in Figure 5, all of the project's activities are performed after the CODP. However, the eight first weeks of the project does not involve any customization since these activities occur before the CADP. This indicates that the degree of pre-engineering is relatively high, which results in a high logistics task predictability. From the project's perspective, this means that the type of raw materials, components, and sub-assemblies required can be determined before the CODP, but the exact material requirements need to be updated after the CADP when the final design has been determined. Considering that there are four customized activities performed at the delivery site in the W-branch, corresponding to the volumetric module sub-flow (W, X, Y, Z) in Figure 5, the contractor needs to order the materials and components required for these activities for the specific project. Furthermore, they should be delivered to the construction site when it is time for the site assembly team to perform these activities.

Using a lead time-based approach gives a more detailed view of the degree of pre-engineering by not only considering which activities that are performed prior to the CODP, but also which activities that produce standardized outcomes (generic products in a market segment) and customized outcomes (specific to a customer order). The example illustrated in Figure 5 shows that the predictability of logistics tasks can be increased by using a high degree of pre-engineering. Hence, the findings of Paper 3 suggest that product characteristics influence the predictability of logistics tasks, which in turn determine the degree to which logistics tasks can be sub-divided into specialized roles and the extent to which formalized logistics processes, policies, and procedures can be used.

In addition to the level of pre-engineering, the findings of Paper 2 revealed that building contractors that engaged in multiple construction types demonstrated a notable decentralization. The findings further indicated that these building contractors were less formalized, integrated, and had a low division of labour. On the other hand, building contractors that only pursued residential construction were more centralized, formalized, integrated, and with a high division of labour. Therefore, when considering the findings of Paper 1-3, product characteristics appear to influence all four logistics organization design elements.

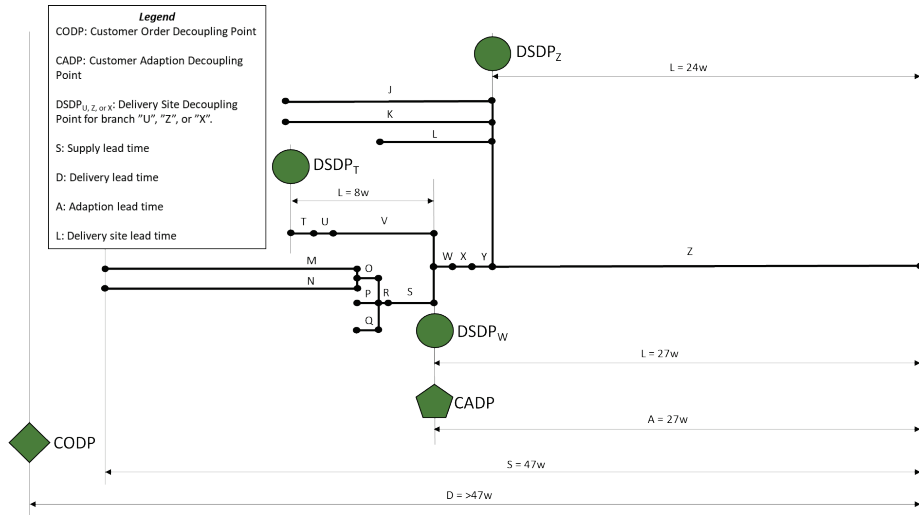


Figure 5 A simplified example of a time-phased work breakdown structure for a typical construction project.

4.2.3 The Influence of Production Process Characteristics

In similar vein to product characteristics, Figure 2 proposes that production process characteristics influence the predictability of logistics tasks and the existence of autonomous logistics decision areas. As such, it influences all four logistics organization design elements.

In Paper 1 it was argued that the production process choice determines the level of routines in logistics activities. A high level of repetition in logistics activities is typically associated with a high degree of off-site fabrication, although the level of repetition in off-site production activities depends on the production layout. For instance, an off-site factory using a line flow layout exhibit a higher level of routines than in batch flow, or flow shop layouts. Nonetheless, off-site construction will typically have a higher level of repetition than on-site construction in logistics activities. Therefore, in general, a higher degree of off-site fabrication will increase the predictability of logistics tasks, and vice versa. As illustrated in Figure 2, the production process characteristics thereby influence, via the predictability of logistics tasks, the division of labour and the degree of formalization in the logistics organization.

It is important to recognize that the level repetition in logistics activities are still relatively low in comparison to other types of production (e.g., automotive). Building construction will always carry some element of on-site production, regardless of the degree of off-site fabrication. In Paper 3, the degree of off-site fabrication was considered from a lead time perspective (in similar vein to the degree of pre-engineering), showing that most of the project delivery lead time constitutes of on-site activities, even in production systems with a relatively high degree of off-site fabrication. This is illustrated in Figure 4 by the DSDP,

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which decouples off-site and on-site activities for each branch representing a work package in the work breakdown structure.

In the example depicted in Figure 5, the building contractor manufactures volumetric modules within a factory setting, and subsequently transports them to the construction site for final assembly. This construction method is commonly known as "Modular Building," characterized by a high degree of off-site fabrication. Paper 3 highlights both planning and logistical challenges with using a high degree of off-site fabrication. The separation of the factory and on-site assembly creates distinct planning points, which can increase the predictability of logistics tasks in the factory production by using a line flow layout with sequential interdependencies between production activities. However, despite using a line flow layout for module production, multiple planning points persist, increasing the unpredictability in both planning and in the physical flow at the construction site.

The unpredictability stems from the approach of treating off-site and on-site construction as distinct sub-production systems. In terms of logistics, handling the mix of off-site and on-site production involves carefully addressing various interdependencies among production activities. This encompasses the establishment of time and inventory buffers, the oversight of finished goods inventory (including ready-to-ship volumetric modules) and ensuring the correct sequencing of off-site activities to deliver components and sub-assemblies in the correct order to the construction site. Therefore, while a high degree of off-site fabrication increases the predictability of logistics tasks, there is still a high level of uncertainty in on-site logistics activities.

Production process characteristics can also influence logistics organization design if a building contractor uses different types of production systems, e.g., to target different market segments or for various types of construction. The findings of Paper 2 revealed that a building contractor that pursue several types of construction will typically also use different production methods for each type of construction. Therefore, in similar vein to product characteristics, the logistics organization design in a building contractor with several SBUs that have different production process characteristics will likely promote the existence of autonomous logistics decision areas. This suggests a more decentralized logistics organization with a low degree of formalization and division of labour. Among niche contractors (e.g., homebuilders), there is little to no need for autonomous logistics decision areas, which then results in a more centralized, formalized, integrated logistics organization, along with a high division of labour.

4.2.4 Other Influencing Factors of Logistics Organization Design

The findings of Paper 4 revealed other reasons than the three contextual factors (company size, product characteristics, and production process choice) that could explain a building contractor's logistics organization design. For the building contractor in Paper 4, the design of the logistics organization was not exclusively shaped by the three contextual factors. Rather, it emerged because of a sequence of activities, decisions, and unforeseen events. These included economic downturns leading to downsizing, conflicts of interest between

logistics and purchasing, insufficient support from top management, and a lack of incentives and resources at the project level for effective logistics management.

Although these findings are specific for the studied case company, the findings of Paper 4 suggest that managerial discretion, environmental uncertainty, and poor logistics management practices contribute to shaping the logistics organization design. Managerial discretion refers to the managers' freedom of choice in making strategic decisions, e.g., the logistics organization design. It acknowledges the idea that managers, as individuals or as a management team, possess a degree of discretion in choosing among various strategic alternatives. Therefore, not all decisions made by managers will be made solely for efficiency and effectiveness reasons. The three contextual factors discussed in this thesis can therefore be seen as influences, but not sole determinants, of logistics organization design.

Environmental uncertainty also played a role in shaping the decisions made within the building contractor in Paper 4. Environmental uncertainty refers to the lack of predictability and stability in the external environment surrounding an organization. It reflects the challenges and difficulties that are outside the organization's control, making it challenging for managers to accurately plan for the future. The economic downturn during the building contractor's logistics strategy process significantly influenced the possibility to change the logistics organization due to the subsequent downsizing decision. Environmental uncertainty is thus critical as it influences building contractors' strategic choices, investment decisions, and overall adaptability.

The building contractor's logistics manager also believed that their level of logistics management practices was poor. This was the main reason for initiating the logistic strategy process in the first place. Therefore, it was not necessarily that the logistics manager was conscious of an existing misfit between contextual factors and the logistics organization design, but instead reacted upon a low level of performance in logistics management practices.

4.3 Typical Logistics Organization Design Configurations

This section addresses RQ3: *How should building contractors design their logistics organizations in response to the contextual factors?*

4.3.1 Identifying the Logistics Organization Design Configurations

Although no building contractor's logistics organization will resemble that of another building contractor, the configurational approach suggests that there will be a limited number of configurations that exhibit similar characteristics. The findings of Paper 1 introduced a profiling template (seen Figure 6) with a floating scale, which was divided into four ideal logistics organization design configurations. The profiling template included three contextual factors (competitive priorities, the product characteristics, and production process choice) and five logistics organization design elements (formal structure, physical structure, division of labour, formalization, and integration). Note that competitive

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priorities are not explicitly treated in this thesis as they primarily influence the product and production process characteristics. As such, they have an indirect effect on the logistics organization design, which also explains why they were part of Paper 1.

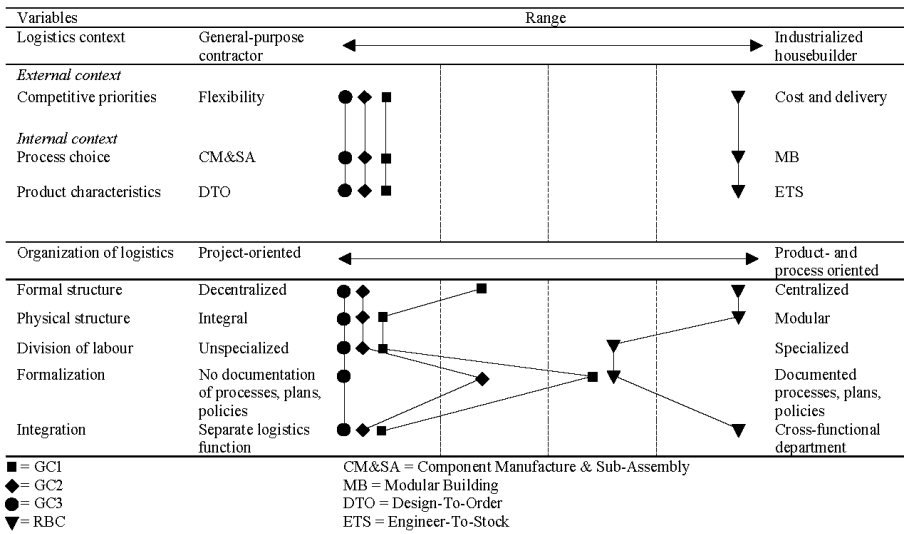


Figure 6 Logistics Organization Design Configurations (Haglund *et al.*, 2022).

Based on the contextual factors (top part of Figure 6) and the logistics organization design elements (bottom part of Figure 6), four ideal logistics organization design configurations (indicated by the dashed lines for the contextual factors and logistics organization design elements) were identified. The left part of Figure 6 represents general-purpose contractors that are heavily project-oriented when it comes to their logistics organization. They are typically heavily decentralized without specialized logistics personnel and little to no use of predetermined logistics solutions. As a result of the project-oriented approach to logistics, the logistics organization is typically also less integrated, both internally and with other functional areas.

At the right part of Figure 6, the typical industrialized housebuilder is found. Due to the focus on cost and delivery efficiency with a standardized product that is produced using a high degree of off-site fabrication (which is typically performed in-house), their logistics organization is highly centralized with specialized roles that perform highly formalized logistics tasks. The high degree of pre-engineering enables logistics plans, procedures, and solutions to be standardized to a high extent. It can therefore be necessary to distinguish between “strategic” and “operational” logistics tasks, where strategic decisions are made at the corporate, company, or business unit level, and where operational tasks are performed by the project logistics function.

The four cases are shown as profiles, where a straight profile indicates a fit and a dogleg indicates a misfit (whereas the width of the dogleg indicates the level of misfit). However, the findings of Paper 1 suggested that a slight misfit is not necessarily a problem. For

instance, the GC1's profile shows a high level of fit, but during the workshops conducted with the case participants, it was revealed that in practice, this contractor experienced problems arising from a lack of clear roles and an absence of standardized logistics processes. This suggests that a highly project-oriented logistics organization design configuration still requires some level of support from a central logistics function. In contrast to the GC1, the RBC were not as heavily centralized as expected and delegated the execution of logistics tasks to the projects, while planning was primarily performed in the centralized logistics function.

The findings from the questionnaire study, Paper 2, further supports the findings from Paper 1. The building contractors with a high degree of off-site fabrication and a high degree of pre-engineering tend to have a more corporate-/company-level approach to logistics. The building contractors with the lowest degree of pre-engineering and off-site fabrication had the most project-oriented logistics organizations. Furthermore, Paper 2 extended the findings from Paper 1 by investigating the effect of company size on the logistics organization design.

The logistics organization design can also be affected by sub-contracting parts of the logistics function to a logistics service provider. The findings of Paper 5 suggests that the extent to which the building contractor uses logistics service providers can influence the logistics organization design. A heavily centralized logistics organization without project logistics functions will typically need support from a logistics service provider to perform operational (project) logistics activities. The studied case company in Paper 5 used this approach for operational logistics in projects, but where strategic logistics decisions were made at a central level. In a decentralized logistics organization, the need for support from a logistics service provider at the project level will typically be lower. However, the findings of Paper 5 revealed that other logistics organization design elements than the formal structure come in to play. For instance, when the division of labour is low for logistical tasks at the project level, logistics tasks typically fall under conventional roles, such as site managers, supervisors, and construction workers. In this situation, it can be beneficial to use a logistics service provider to support in the project logistics. Furthermore, sub-contracting of logistics services can be a means of achieving specialization and economies of scale without using internal capabilities exclusively.

4.3.2 Typical Logistics Organization Structures

In the next three sub-sections, three typical logistics organization structures in building contractors are proposed. The three organization structures exemplify a heavily decentralized logistics organization (project-logistics function structure), a divisionalized logistics organization (divisionalized logistics function structure), and a heavily centralized logistics organization (corporate logistics function structure). The three organization structures represent building contractors with multiple SBUs since the findings of Paper 1 suggested that they can be expected to vary the most in terms of their logistics organization design. Building contractors operating within one type of construction will therefore pursue either a project-logistics function structure or a corporate logistics function structure

(although the latter would perhaps be referred to as a “company logistics function structure”).

Project-Logistics Function Structure

Figure 7 illustrates a project logistics organization. This logistics organization design is preferred for building contractors that operate within different types of construction. A divisionalized structure with multiple SBUs typically results from pursuing multiple types of construction. However, within each SBU, the projects are one-off with a high level of uniqueness. The differences in product and production process characteristics between projects (but within an SBU) promotes a highly project-oriented logistics organization. The information processing requirements are high due to lack of routineness, that is a result of the one-off, unique character of the SBUs’ projects. This leads to a low predictability of logistics tasks that can require logistics solutions that are highly customized to suit the specific needs of the project. The overall design of the logistics organization will thereby be in the form of project logistics function structure.

However, the project logistics functional structure does not rule out the existence of a “corporate” logistics function. In fact, it can sometimes be beneficial to have a corporate logistics function that sets the “rules of the game” for the project logistics functions. This was apparent in Paper 1 in which three case companies combined a project-logistics function structure with centralized support in developing project logistics plans. Nevertheless, when the project-oriented logistics function is used, this indicates that logistics tasks (e.g., material planning, purchasing, etc.) are primarily carried out by project logistics personnel. The projects are also highly autonomous in making logistics-related decisions (e.g., in acquiring logistics infrastructure, planning systems used, etc.). The “rules of the game” set by a corporate logistics function are thereby in this configuration more of the general guidelines-type rather than detailed descriptions of logistics tasks.

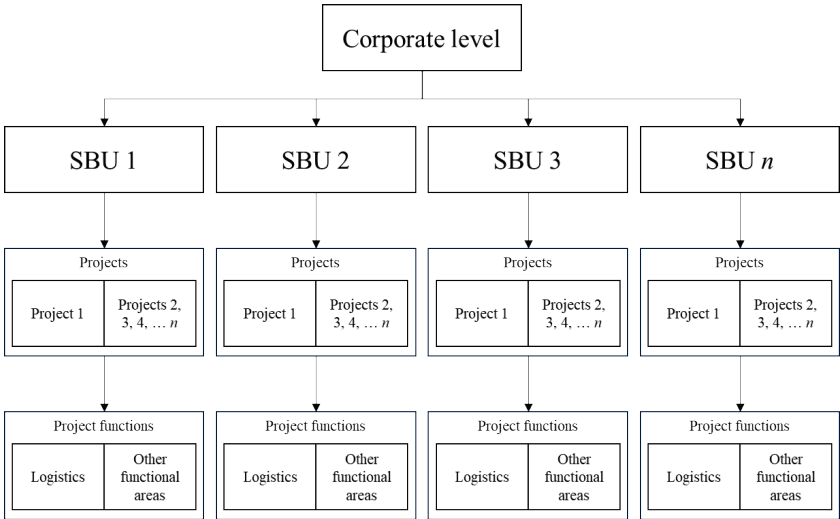


Figure 7 A project logistics function structure, generally referred to as “project structure”.

Divisionalized Logistics Function Structure

Figure 8 illustrates a divisionalized logistics function structure. This logistics organization design is, like the project logistics function structure, preferred for building contractors that operate within different types of construction. Likewise, it typically has a divisionalized structure with multiple SBUs. However, in contrast to the project logistics function structure, the projects within each SBU are more similar due to a higher degree of pre-engineering (i.e., less product customization) and a higher degree of off-site fabrication. Since the projects within each SBU are relatively routine, it is possible to have a divisional logistics function. The information processing requirements within each SBU are relatively low due to the high level of routineness. However, the types of construction between the SBUs are too diverse in terms of product and production process characteristics to use the corporate logistics function structure. The overall design of the logistics organization will thereby be in the form of a divisionalized logistics function structure.

The logistics organization of each SBU can be expected to be autonomous in their decision-making. However, there can be potential benefits with combining this approach with a centralized logistics function to exploit synergies between the SBUs. For instance, centralized logistics may focus on the long-term development of the logistics functions, like the role of a research and development department, whereas the divisional logistics function focus on maintaining efficient operations within their respective business area. Furthermore, this logistics organization structure can be combined with the project-logistics function structure for projects with a high level of logistical complexity. Such hybrid logistics organization structures can be feasible when the building contractor's projects are characterized by a high level of congestion surrounding the construction sites, highly intricate project time plans, or unusually complex products in terms of the number and uniqueness of materials, components, and sub-assemblies.

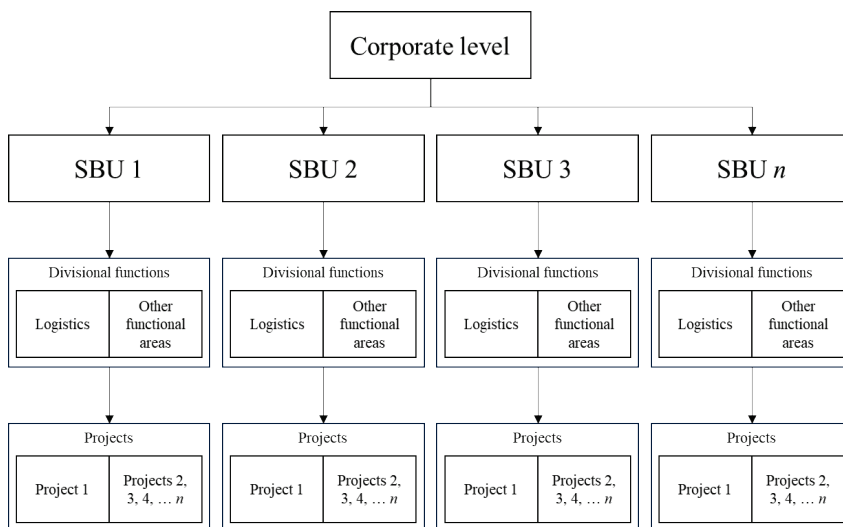


Figure 8 A divisionalized logistics function structure, generally referred to as “divisional structure”.

Corporate Logistics Function Structure

Figure 9 illustrates a centralized logistics function structure. This logistics organization design is, like the project logistics function structure, preferred for building contractors that operate within similar types of construction. This logistics organization is suitable when the building contractor operates in multiple types of construction, but with similar product and production process characteristics. The potential for synergy effects by concentrating the logistics function to a corporate function are high, but it requires the types of construction to exhibit similar characteristics.

In its pure form, this structure is unsuitable when the contractor’s operations are within highly diverse construction operations. The risk is that the corporate logistics function will become consultants within their own company. The findings from Paper 1 indicate that the large contractors with this type of logistics organization had to prioritize which projects that they set up a logistics solution for. One contractor had determined a threshold based on project size, where any project below this threshold did not require a dedicated logistics solution. Hence, if this logistics organization is used in contractors operating in highly diverse types of construction, the risk is that some projects will not prioritize logistics at all. In this case, a hybrid of the centralized and project logistics function structure can be preferred over a heavily centralized structure. Otherwise, the centralized logistics function must carefully assess in which SBUs, and which projects it is best to allocate its resources to. On the other hand, this type of logistics organization can be suitable for niche contractors operating in one type of construction if the product and production process characteristics do not vary too much between their projects.

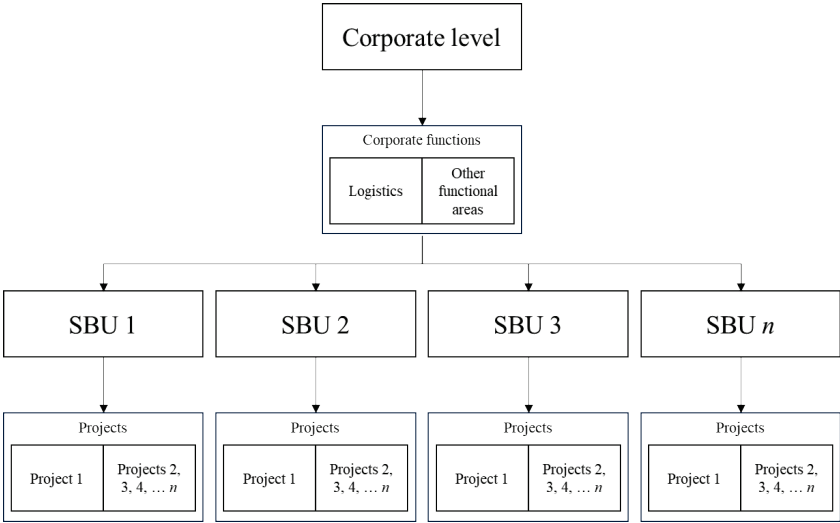


Figure 9 A corporate logistics function structure, generally referred to as “centralized functional structure” or “centralized support structure”.

5. Discussion and Contributions

In this section, the research findings are discussed regarding the theoretical and practical contributions of the thesis. Additionally, the discussion extends to reflections on related topics beyond the thesis scope.

5.1 The Link Between Contextual Factors and Logistics Organization Design Elements

Figure 2 illustrates how company size, product characteristics, and production process characteristics influence the logistics task predictability, the number of logistics decision elements, and the existence of autonomous logistics decision areas. The research findings indicate that product and production process characteristics influence the logistics organization design, whereas the effect of company size remains inconclusive. Logistics organization design literature suggests that larger organizations are expected to have a more decentralized logistics organization (Dröge and Germain, 1998, Pfohl, 2023). There are two problems with this notion. The first problem is a debated topic within the general organization design literature. The studies postulating a relationship between company size and organization structure have not accounted for the direction of this interrelationship (Woodward, 1958, Blau, 1970). Therefore, it cannot be asserted whether company size is an outcome of the organization structure or a contextual factor. Nevertheless, it is assumed within logistics organization literature that company size affects the logistics organization design. This assumption warrants for further research on the topic with consideration of the direction of the relationship.

The second problem relates to using sub-contractors being the norm in the construction industry (Kristiansen *et al.*, 2005). By using sub-contractors that specialize within different areas of construction, building contractors typically take a more overarching role in construction projects, whereas sub-contractors deliver specialized services, typically for assembly and installation works. Some building contractors even use sub-contractors as an alternative to having their own construction workers. The use of sub-contractors can thus hide the “true” size of a building contractor (even though sub-contractors are not part of the contractor’s employees) because their projects, in total, employ many more people than there are employed at the building contractor. This enables building contractors that extensively use sub-contractors in their projects to have a higher turnover per employee than those that have more capabilities in-house. Furthermore, it is not uncommon for these sub-contractors to source their own suppliers of materials and machinery, which further adds to the logistical complexity, requiring more decentralized coordination of logistics. However, studies suggest that centralized coordination of logistics, especially in logistically complex projects has a greater efficiency potential than decentralized coordination, but the former poses greater challenges as it necessitates sub-contractors to

adhere to the rules and policies established by the main contractor (Dubois *et al.*, 2019). In summary, the number of employees should not be regarded as a determinant of the logistics organization design and the findings of Paper 2 suggest some alternative measures.

There are a few empirical studies of logistics organization design that have analyzed the effect of company size, and these are typically of large manufacturing companies and were conducted mainly during the 1990s (e.g., Dröge and Germain, 1998). For a building contractor, the findings of Paper 2 suggest that a better measure of company size can be, besides the annual turnover, the total value of the contractor's project portfolio. This captures the building contractor's total project turnover, including the use of sub-contractors in projects, which can be a more accurate measure of company size.

In summary, logistics organization design literature does not ascertain whether the overall company size influences the logistics organization design, despite its purported effect on the logistics organization design. The findings of this thesis suggest that it is primarily product and production process characteristics that influence the predictability of logistics tasks and the number of logistics decision elements. Furthermore, Paper 2 revealed that the existence of autonomous logistics decision areas can be related to the number of different types of construction pursued by the building contractor. Consequently, the findings suggest that building contractors' logistics organization design is contingent upon product characteristics, production process characteristics, and the number of SBUs.

5.2 Logistics Organization Design Configurations

This sub-section presents eight logistics organization design configurations (illustrated in Figure 10) using the general framework presented in Figure 2, and the three typical logistics organization structures presented in section 4.3 (Figure 7, 8, and 9). Furthermore, the research findings indicate that hybrids of the three typical logistics organization structures are often the most feasible option, which is further supported in logistics organization design literature (Pfohl, 2023).

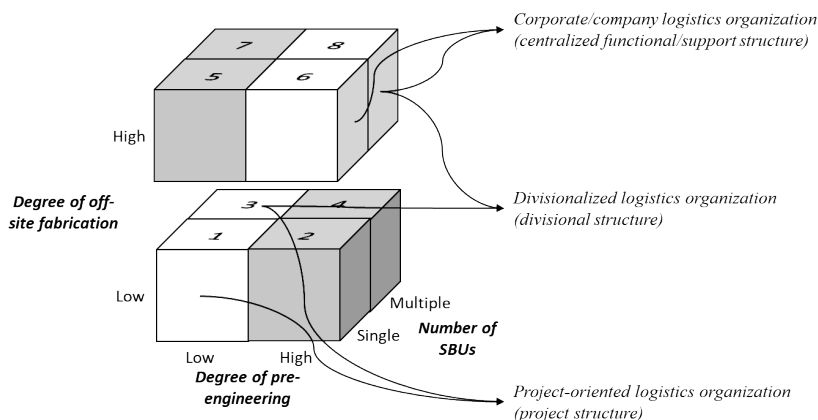


Figure 10 Logistics organization design configurations.

5. Discussion and Contributions

In Figure 10, each of the eight boxes represents a unique context for the logistics organization. Each context requires a different response in terms of the logistics organization design by one, or hybrids, of the typical logistics organization structures described in section 4.3. When the logistics organization design is matched to the degree of pre-engineering, the degree of off-site fabrication, and number of SBUs, this is referred to as a logistics organization design configuration. However, it should be noted that the combinations of the degree of pre-engineering and off-site fabrication configurations 2, 4, 5, and 7 are mismatched (the grey boxes in Figure 10) and are thus not typically preferred (Jonsson and Rudberg, 2015). Thus, the following discussion address configuration 1, 3, 6, and 8 (the white boxes in Figure 10).

Configuration 1 represents a single business building contractor with a low degree of pre-engineering and off-site fabrication. The preferred logistics organization is a project logistics function structure. However, the single business focus allows the building contractor to pursue a hybrid form, combining the project logistics function structure with a central support function. The project logistics functions do however have a higher influence over logistics tasks, whereas the central support function provide guidelines.

Configuration 3 is similar to configuration 1 but has multiple SBUs. It is thus not likely that a central support function is feasible. However, in Paper 1, three out of the four cases fall under this configuration and all three had hybrids of a central support function and project logistics function structures. Yet, the findings of Paper 2 and Paper 5 reveal a tendency that such a central support function within this type of contractor possesses little control over the project logistics functions. The central support function's role in providing guidelines in this configuration is therefore of limited effect.

Configuration 6 in Figure 10 represent a niche building contractor that pursues a single type of construction. In this configuration, the contractor has a single business area (e.g., homebuilding) or a strategic business group (i.e., multiple business areas with similar characteristics in terms of strategic approaches, shared resources, customer base, etc.). The single business, or similarity within the strategic business group, entails that it is unlikely to find autonomous logistics decision areas. Hence, a company logistics organization (Figure 9) is feasible, although a hybrid of the project logistics function structure (Figure 7) can be necessary if the degree of off-site fabrication is not very high.

In configuration 6, the degree of pre-engineering and off-site fabrication is high. The product and production process characteristics therefore lead to a high logistics task predictability and few logistics decision elements, which further suggests a central logistics function. It is also expected that these types of contractors will sub-divide labour and have formalized logistics processes since the level of routineness in logistics tasks is high.

The strength of this configuration is its ability to reduce total costs. Due to the high logistics task predictability, it is typically easier to achieve high service levels compared to configurations with a lower logistics task predictability. However, it is still important to note that some service elements (e.g., delivery reliability) should not be intentionally

compromised and that they still demand a satisfactory level of performance, irrespective of the logistics configuration in use.

Configuration 8 exhibits similar characteristics to configuration 6 in terms of product and production process characteristics. However, in configuration 8, there are multiple SBUs. Typically, this means a divisionalized logistics function structure (Figure 8) is feasible. However, the logistics organization structure in each SBU depend on their specific product characteristics, and production process characteristics.

Pfohl (2023) discusses hybrid logistics organization structures related to centralization/decentralization and function-/process-orientation. The hybrid of centralized and decentralized logistics refers to the existence of multiple logistics functions within a single organization. This can be of varying degrees and resembles the preferred logistics organization structures in configurations 1, 3, 6, and 8.

The hybrid of function and process-oriented logistics refers to whether the logistics is organized in a traditional functional area or follows the process of value-adding phases in the flow (Pfohl, 2023). Although hybrids of function and process-oriented logistics organizations are beyond the scope of this thesis, the feasibility of these hybrids can potentially be determined using the lead-time-based approach used in Paper 3. One of the strengths of the process-oriented logistics organizations is its customer-centric focus and its ability to handle complex interrelationships between activities. Hence, it is typically feasible when the contractor's projects involve making customer adaptations and construction site production. On the other hand, a function-oriented logistics organization is preferred in stable environments, such as when there are few customer adaptations made and significant part of the production lead time is performed in a stable environment (e.g., in an off-site factory).

5.3 Theoretical Contributions

The purpose of this thesis is to investigate building contractors' logistics strategy content and process with a focus on how to design the logistics organization. Due to the focus on the decision area "logistics organization", the main theoretical contribution of this thesis is to the logistics organization design literature. The main contribution is the explanation of how contextual factors influence the design of a building contractor's logistics organization. The thesis' contribution thus extends prior research on logistics organization design that has been conducted mainly within the more repetitive type of manufacturing by considering contextual factors that characterize building construction: the degree of pre-engineering and off-site fabrication.

Moreover, the thesis contributes by suggesting typical logistics organization structures (Figure 7, 8, and 9) along with theoretically ideal logistics organization design configurations (Figure 10 along with the descriptions of the configurations) for building contractors. These have been conceptually derived from previous logistics organization design literature and empirically investigated through the case studies and the questionnaire

5. Discussion and Contributions

study. The predominant use of the case study methodology has enabled the research to be conducted in its natural context and could thus reveal problems in the logistics organization design literature, mainly being related to the prior focus on large manufacturing companies.

A general reflection on the thesis contribution is that construction and the more repetitive types of manufacturing can learn from each other when it comes to how to manage logistics, but the differences in terms of project-based, ETO, and site-based production need to be accounted for. As such, it is suggested that construction logistics research can learn from other manufacturing industries with similar characteristics, e.g., the energy sector with production of oil and gas platforms, wind turbines, etc. This is supported in construction logistics literature arguing that the temptation to compare construction with more repetitive types of production (e.g., automotive) is problematic due to their inherent differences (Ballard and Howell, 1998, Bankvall *et al.*, 2010, Fernie and Tennant, 2013). Yet, in an industry as construction in which the maturity of logistics management practices is generally low, the same fundamental principles of logistics management are still relevant, but they cannot be applied in the same way as for more repetitive types of production.

In addition to the thesis' contributions, the individual papers contribute to an increased understanding of logistics strategy in building contractors, and to the construction logistics body of knowledge. For example, the strategic profiling template (Figure 6) in Paper 1 is a tool that can be used by researchers to investigate logistics organization design configurations among building contractors and other types of project-oriented, ETO companies. The typology introduced in Paper 3 that includes the flow location is developed for any type of company that pursues site-based production, along with customer order driven and customization activities. The typology has been generalized within the ETO context by applying it to other industries with similar characteristics as construction. In Rudberg *et al.* (2024), the typology is used to analyze the flow location in industrial gas turbine manufacturing and complex modular EPC (Engineering, Procurement, and Construction) projects within off-shore, life science, and technical building, thus enabling cross-industry benchmarking. Paper 5 investigates how a building contractor can utilize a logistics service provider and what internal capabilities the contractor needs to effectively use the services offered. The paper also contributes to an increased understanding of the logistics service provider trade in the construction industry, which can increase the awareness of what type of services that should be offered and how they should be delivered.

5.4 Practical Contributions

The focus of the thesis was on the decision area “logistics organization”, which is one of the seven logistics strategy decision areas that are described in Table 1 in section 2.1. As the research findings revealed, few building contractors seem to make a deliberate effort in designing their logistics organization to suit their unique circumstances. Although the findings revealed embryos of logistics strategies in the form of guidelines developed by a central logistics support function, none of the case companies in Paper 1, 4, or 5 or the questionnaire respondents in Paper 2 reported that they had a formalized logistics strategy.

One can question why this seems to be the case among building contractors. Many studies report that the level of maturity of logistics practices is low (Fernie and Tennant, 2013, Ekeskär and Rudberg, 2016, Ying *et al.*, 2018, Janné and Rudberg, 2022). Nevertheless, among the companies with a logistics function, it was evident that logistics, in the majority of instances, suffered from significant underrepresentation concerning the workforce dedicated to logistics in comparison to the overall number of employees. The typical logistics organization structures illustrated in Figure 7, 8, and 9, and the logistics organization design configurations described in section 5.1, can be used among building contractors to initiate a logistics strategy process. The contextual factors can be used here as a starting point to identify what type of logistics organization that can be suitable, which enables managers to develop role descriptions, employ suitable candidates, and in the long run build up a logistics organization that enables the building contractor to develop and implement a logistics strategy.

The thesis' findings also ties back to studies that have explored the use of corporate- or company-level logistics solutions (resembling logistics strategies) compared to setting up project-unique logistics solutions (Elfving, 2021). In the former, the solutions are developed at the strategic company-level for the purpose of reusing solutions, whereas in the latter the purpose is to manage logistics in a single project. A middle-ground between these two extremes exist where overarching guidelines are developed at the corporate or company level and the logistics solution are adapted for each project, i.e., a modularized logistics solution (Rudberg and Maxwell, 2019).

The question of which approach to use in developing logistics solutions is more related to what actually happens within the logistics organization rather than what should happen (which is more related to deciding the structure of the logistics organization). Thus, further research is needed, particularly in the form of use cases demonstrating the strengths and weaknesses of the respective approaches. However, the feasible approach to develop logistics solutions can be related to, in similar vein to the logistics organization design, product and production process characteristics. A high degree of product customization combined with a low degree of off-site fabrication requires logistics solutions that are customized to each project's unique circumstances. The logistics organization will then tend to be more decentralized and less formalized. On the other hand, with a higher degree of product standardization and off-site fabrication, the logistics solutions require less adaption to each project, perhaps only with consideration to site conditions. Hence, the logistics organization will tend to be more centralized with a higher degree of formalization.

6. Conclusions and Further Research

This final section provides the conclusions of the thesis, addressing the thesis' purpose and answering the research questions. The section also contains suggestions for further research.

6.1 Conclusions

The purpose of this thesis was to *investigate building contractors' logistics strategy content and process with a focus on how to design the logistics organization.*

In conclusion, during the doctoral research project that is summarized in this thesis, the decision area “logistics organization” has been investigated, explaining the relationship between contextual factors and logistics organization design elements in building contractors. Furthermore, the findings offer more normative results about how building contractors should design their logistics organization in response to the contextual factors.

In response to RQ1 “*What contextual factors influence the design of building contractors' logistics organizations?*”, the thesis' findings identify a range of contextual factors and logistics organization design elements within the realm of building contractors. The contextual factors include the contractor's number of SBUs, product characteristics, and production process characteristics. The logistics organization design elements include the degree of centralization, formalization, integration, and the division of labour.

In response to RQ2 “*How do the identified contextual factors influence the design of building contractors' logistics organizations?*”, the thesis' findings explain the influence of contextual factors on the logistics organization design. The findings reveal insights into the relationships between contextual factors and logistics organization design elements. The effect of company size was found to be limited or non-existent using the definition of the number of employees and annual turnover. Further research is needed using alternative operationalizations to determine whether it influence the logistics organization design or is an outcome of the overall organization structure of the building contractor. The findings indicated that product and production process characteristics have a significant effect on all four logistics organization design elements: centralization, formalization, division of labour, and integration. As such, the findings provide an understanding for what type of logistics organization design that is feasible under certain circumstances. This understanding is important for building contractors aiming to establish a “fit” between their logistics organizations and the demands presented by their specific logistical context.

In response to RQ3 “*How should building contractors design their logistics organizations in response to the contextual factors?*”, the thesis offers normative results and recommendations aimed towards building contractors. These recommendations are based on a synthesis of the descriptive and explanatory findings from RQ1 and RQ2, respectively. For instance, three typical logistics organization design configurations are proposed: the project logistics function structure, the divisional logistics function structure, and the corporate logistics function structure. In addition to these three configurations, the thesis includes a discussion on hybrid configurations, which can be expected to be feasible across the spectrum of building contractors.

The normative results provide practical guidance for logistics managers, supply chain managers, operations managers, or managers with similar responsibility in the complex task of designing the logistics organization. The thesis’ findings further highlight that it is necessary for building contractors to proactively design their logistics organizations in response to the contextual factors. This is of particular importance in times of turbulent supply chains and low economic growth in which logistics plays a critical role in ensuring efficient and effective construction operations.

6.2 Further Research

While this thesis advances the understanding of logistics organization design within the building contractors, there remains avenues for further research. Future research could extend the research to similar contexts in with similar challenges related to the ETO context and site-based production, delve deeper into the effect of company size, pursue extended studies on fit from different perspectives (e.g., why do some contractors maintain a misfit and still seem to maintain adequate performance?), investigate the effect of “fit” on performance, extend the normative findings with relevant key performance indicators, and pursue a refined investigation on the implementation process of logistics organization design using practice-oriented research methods. The suggestions mentioned are described further in the following paragraphs.

The contextual factors, the degree of pre-engineering and off-site fabrication, can also be found in other types of ETO industries with elements of site-based production, and thus, further research is necessary to generalize the findings for ETO industries. However, construction is a typical ETO industry with a site-based type of production. Similar industries should therefore be expected to encounter similar challenges to the design of the logistics organization. The findings of this research can serve as a starting point for further studies that investigate how contextual factors influence the logistics organization design in industries with similar traits as construction.

The effect of company size on logistics organization design needs to be investigated further since the findings of Paper 2 were inconclusive. It is suggested to pursue questionnaire-based studies with larger samples and of building contractors outside the Nordic countries. Furthermore, since extensive use of sub-contractors can potentially hide the “true” size of

6. Conclusions and Further Research

a building contractor, it is recommended that further studies control for how extensively sub-contractors are used.

Contingency studies often rely on performance levels as a measure of the degree of fit between contextual factors and organization design elements. In Paper 2, performance was not explicitly modelled and the outcome of pursuing an “ideal” configuration in terms of operational performance relies on anecdotal evidence from the paper. Further research should design studies that explicitly analyze whether a misfit leads to reduced performance (and to what extent a misfit reduces performance). Another issue to address in further research is to delve into why misfits occur and sustain over a longer period in building contractors. Misfit was common among the companies in the sample in Paper 2, but most were still successful in their operations. Further research can therefore attempt to handpick “best in class” cases to compare with a group of companies exhibiting a misfit.

Regarding performance, further studies on logistics strategy should also consider developing key performance indicators, offering managers the opportunity to more objectively evaluate logistics performance at the company level. Previous research have developed key performance indicator for measuring the performance of production systems in construction (Jonsson and Rudberg, 2017), but there is a lack of corresponding measures for building contractors’ logistics systems. This is crucial for identifying a withstanding misfit that can be difficult for managers to subjectively observe in daily operations.

A final note relates to the potential limitations with the methodological approach used during this doctoral research project. Although the case study method has been the dominant method used during this doctoral research project, the research findings rely primarily on passive and observatory data collection methods rather than active, change-oriented, and practice-oriented methods. The main data collection methods used were interviews, observations, document analysis, and questionnaire data. Further studies should focus on testing the applicability of the suggested logistics organization design configurations by applying the concepts and ideas generated through this thesis and evaluating the outcomes of such applications. The author encourages further studies building upon the thesis’ findings to pursue practice-oriented research designs (e.g., participatory research, action research, and design-based research).

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Papers

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