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Logistics Organization Design for Building Contractors

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LINKÖPING UNIVERSITY

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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 verksamt 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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Finally, a big thank you goes out to my all my friends and my family. Thanks to my mom, my dad, my brother, and my grandparents. Thank you, Fanny, for supporting me and being patient although you don't think that decoupling points are "that advanced" or as interesting as I do. I love you all!

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 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 million[1], 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 contactor’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 *Byggfaktas* report on residential housebuilding until May 2021. The figures apply to new production of multifamily residences. The report can be downloaded from https://www.byggfakta.se/.

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 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 contactors 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 adaptions 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., 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 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 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).

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

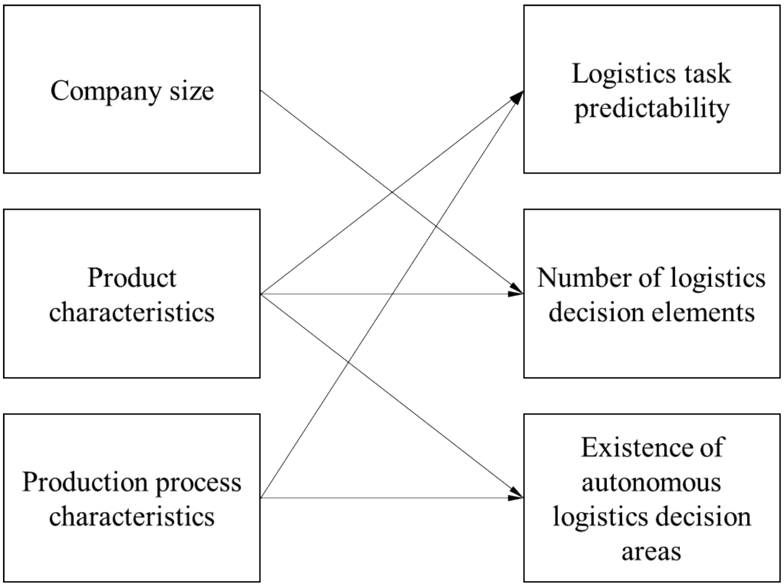

Figure 1 The correspondences between Persson's (1978) generic contextual factors and construction-related contextual factors.

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 flow[1] 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 adaptions for a specific customer order, whereas full customization means that all activities can be linked to performing adaptions 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 organization design configuration alone, but it can help to reinforce the business strategy and contribute to competitive advantage.

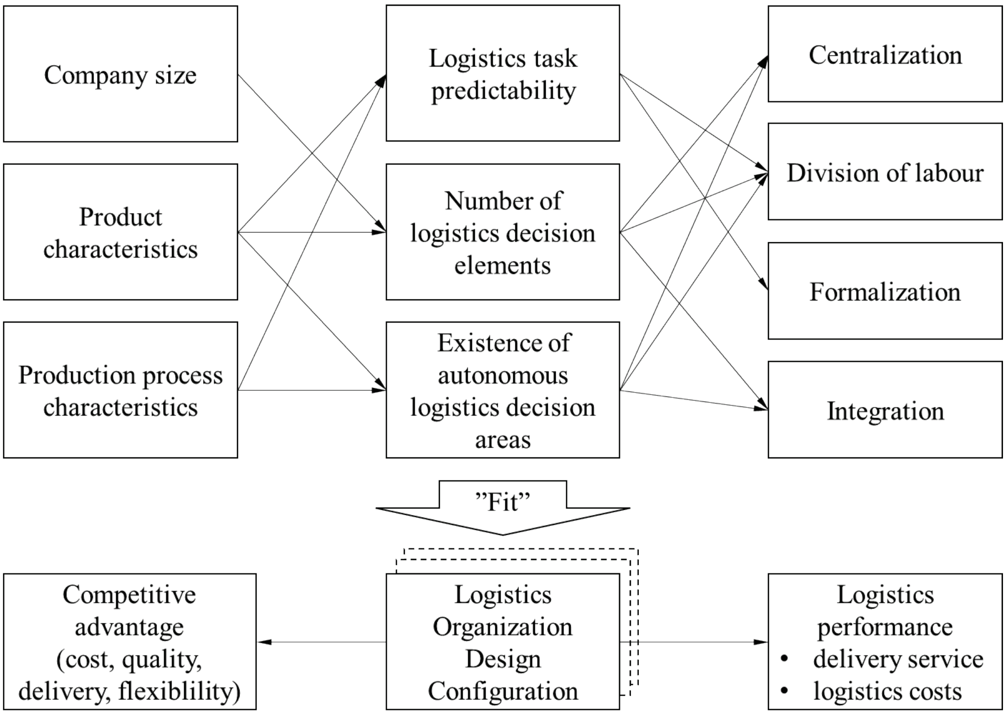

Figure 2 Elements of logistics organization design configurations and the concept of "fit".

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.

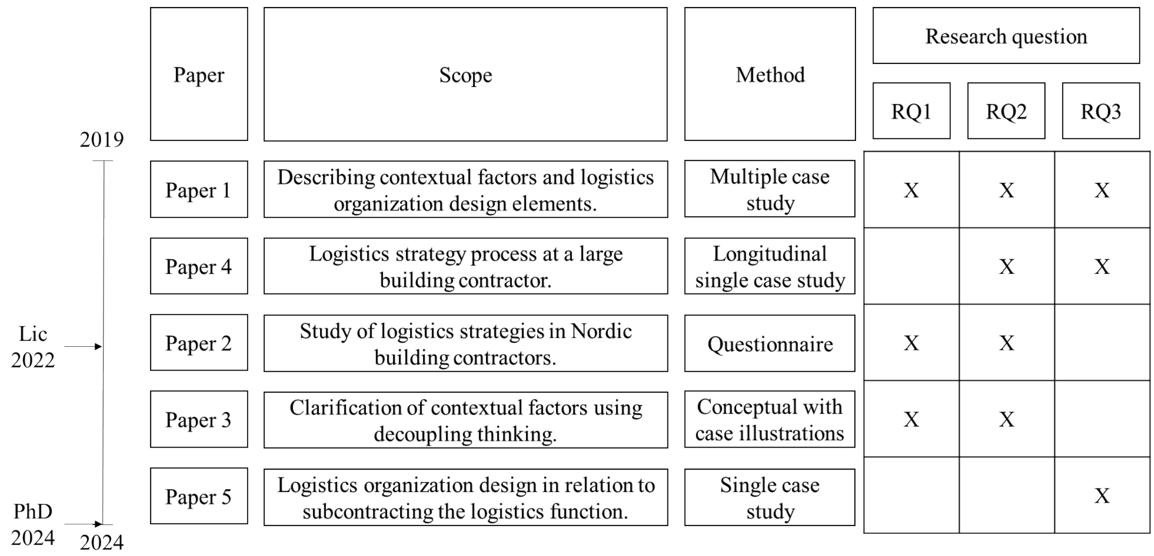

Figure 3 Illustration of the research process, including scope, method, and the corresponding thesis research question(s) of each paper.

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 contactor 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.

Paper	*Data collection methods*	*Type of data*	*Analysis method*
Paper 1: Multiple case study	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.
Paper 2: Questionnaire study	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.
Paper 3: Conceptual study with case illustrations	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.
Paper 4: Longitudinal single case study	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).
Paper 5: Single case study	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.

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. The 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 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 form 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.

Factor/element	*Summary of findings*
Product characteristics	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.
Production process characteristics	Mainly related to the level of repetition in production, which influences logistics task predictability.
Company size	No clear effect on the logistics organization design could be identified, mainly due to the operationalization of company size as the number of employees.
Centralization	Centralization refers to whether logistics decision-making is concentrated in the permanent part of the organization or distributed across projects.
Division of labour	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).
Formalization	Refers to the presence of formal rules, procedures, and processes that are documented, standardized, and enforced in the building contractor's logistics function.
Integration	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.

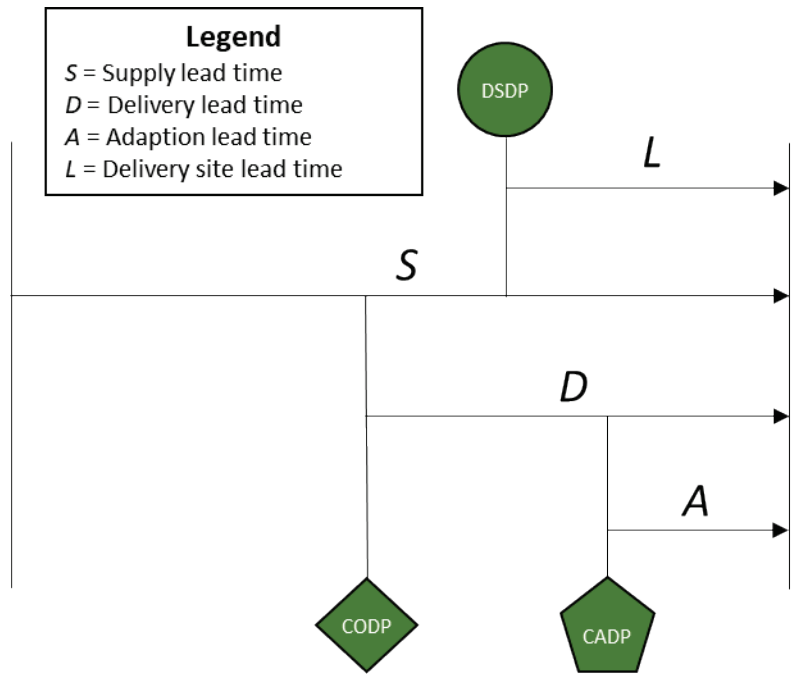

Figure 4 The typology of flow driver, flow differentiator, and flow location.

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 adaptions 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 adaptions (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 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 contactor’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 suggests 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 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.

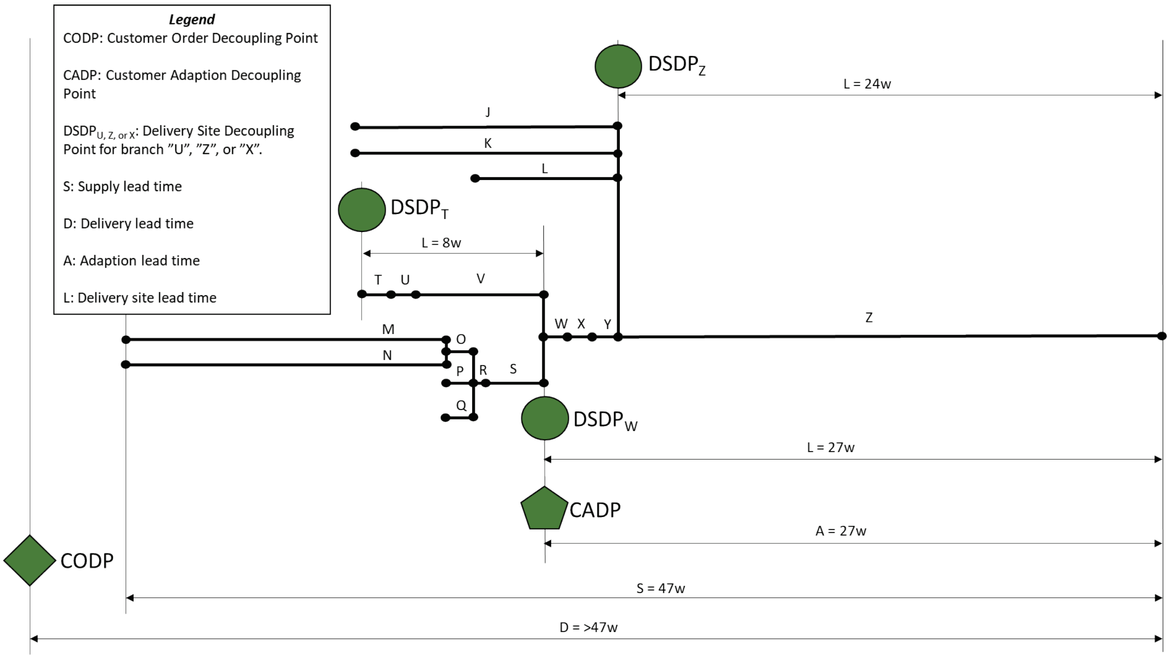

Figure 5 A simplified example of a time-phased work breakdown structure for a typical construction project.

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, 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 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.

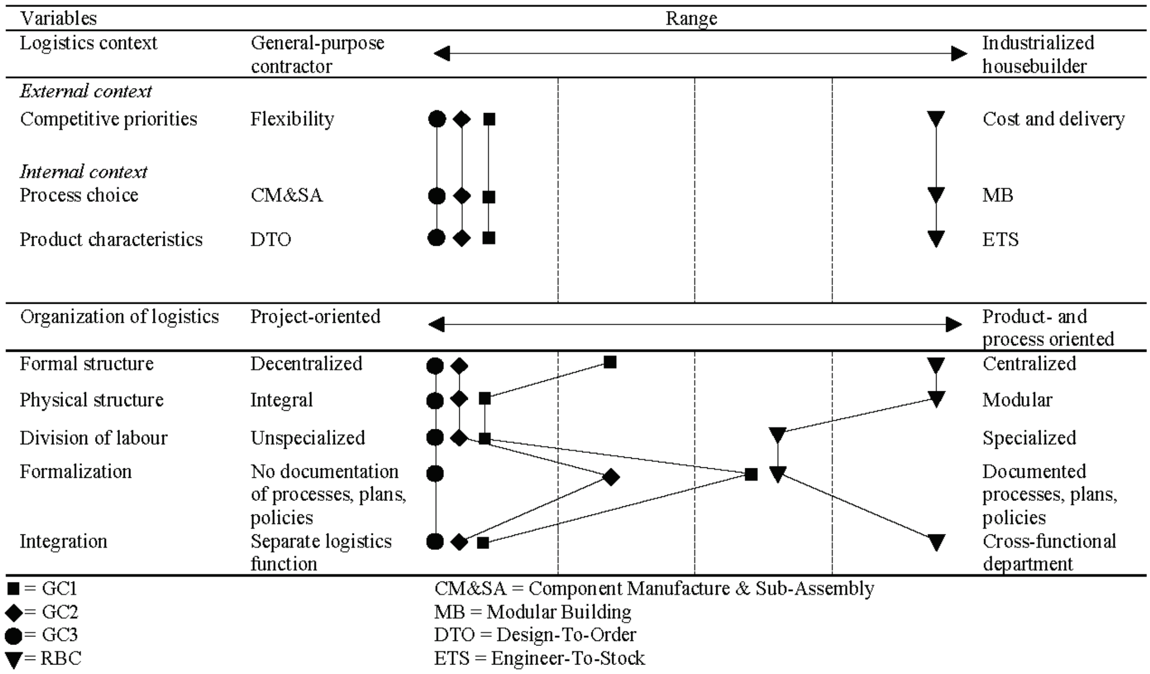

Figure 6 Logistics Organization Design Configurations (Haglund *et al.*, 2022).

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.

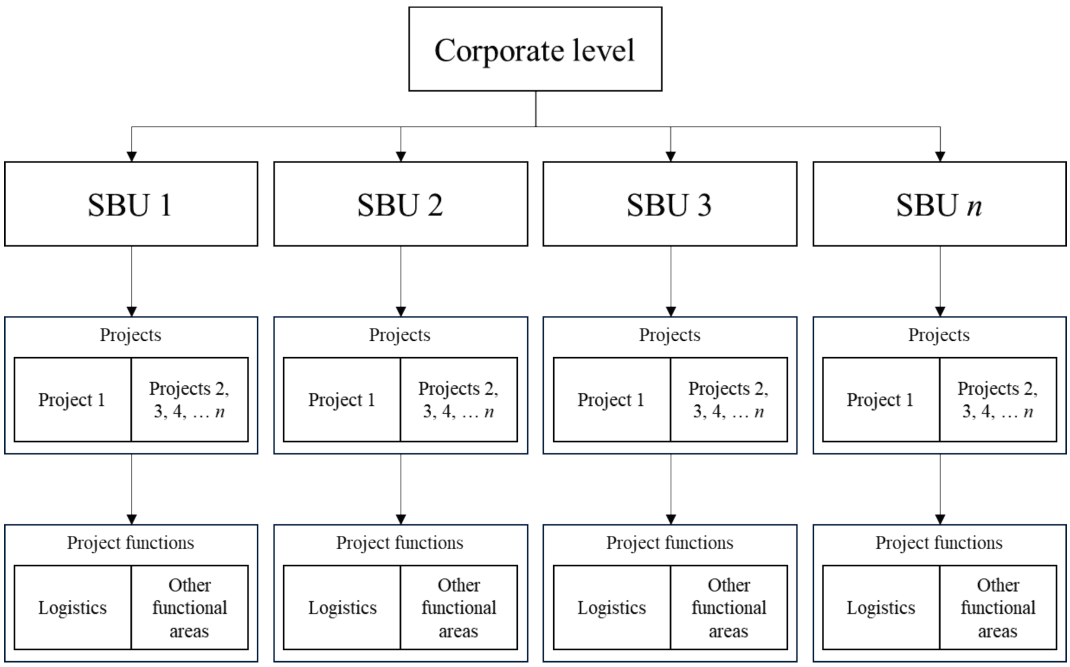

Figure 7 A project logistics function structure, generally referred to as "project structure".

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.

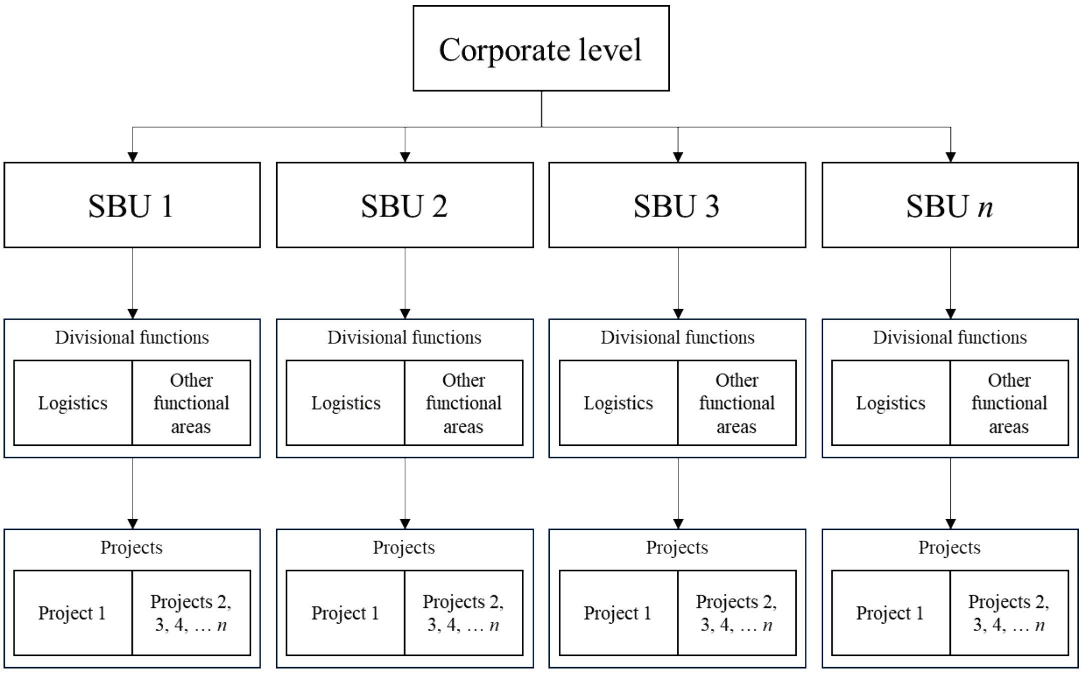

Figure 8 A divisionalized logistics function structure, generally referred to as "divisional structure".

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.

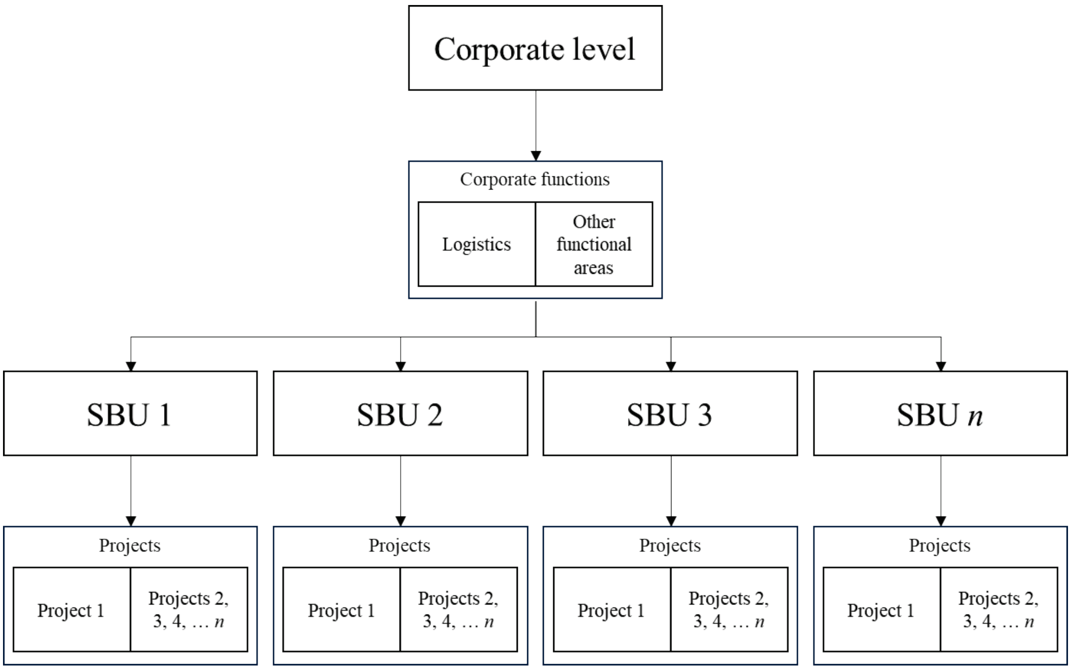

Figure 9 A corporate logistics function structure, generally referred to as "centralized functional structure" or "centralized support structure".

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).

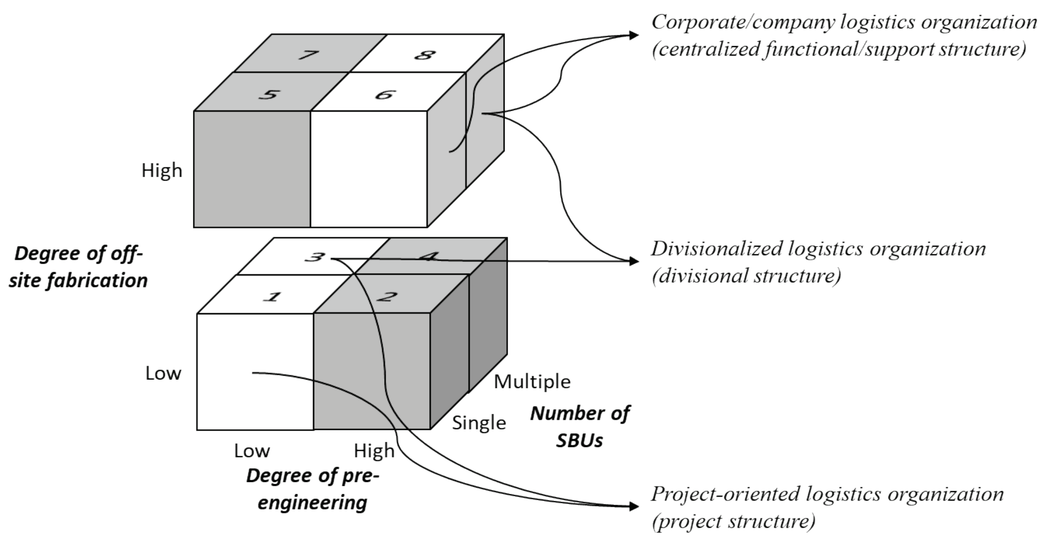

Figure 10 Logistics organization design configurations.

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 adaptions 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 adaptions 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 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 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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Paper 1

Organizing logistics to achieve strategic fit in building contractors: a configurations approach

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Organizing logistics to achieve strategic fit in building contractors: a configurations approach

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ABSTRACT
Previous research indicates that the success of logistics solutions in building projects depends on how they are organized in accordance with the logistics context, which is determined by building contractors' competitive priorities, product characteristics, and production process choices. Taking a configurations approach, the purpose of this paper is to describe the fit between the logistics context and the organizing of logistics at a strategic level. A conceptual research framework is derived from literature postulating an influence of the logistics context on the organizing of logistics. The framework is applied to four cases by the means of strategic profiling, which provides a snapshot of the fit in the cases' logistics configurations. The findings indicate that the type of production process influences the degree to which logistics decisions should be made centrally and that the degree of standardization and pre-engineering influence the degree to which logistics processes should be formalized. The main contributions are the identification of logistics configuration variables and the description of the fit between building contractors' logistics context and the organizing of logistics. For managerial practice, a logistics configuration profiling template was developed that can be used as a tool in the logistic strategy process.

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Introduction

While recent studies on the organizing of logistics in construction indicate that reorganizing logistics can reduce material-flow-related problems in projects and increase operational efficiency (c.f., Sundquist *et al.* 2018, Dubois *et al.* 2019), there are few papers that address logistics strategically at the company level. The contemporary construction logistics body of literature predominately focuses on operational logistics, but there is little known about the long-term strategic decisions that create the prerequisites for logistics management in building contractors' construction projects. In this context, a logistics strategy is a long-term plan that guides logistics activities at the operational level (Autry *et al.* 2008).

By neglecting the strategic level, construction logistics research does not often explicitly consider that some logistics solutions are invalid under certain circumstances. Contractors have begun using different logistics solutions, such as carry-in services to avoid disturbances to production tasks, terminals for inventory buffers, checkpoints to ensure timeliness of direct deliveries, and collaborative planning systems for materials deliveries (Janné and Rudberg 2022). However, the success of employing such logistics solutions depends on the way they are organized in accordance with product and process characteristics, which are typically determined in the logistics strategy (Chow *et al.* 1995). For example, a recent study by Sezer and Fredriksson (2021) reveals that the type of project and building method create different prerequisites for planning and controlling material flows to and from the construction site. Likewise, Ying *et al.* (2014) concluded that the planning and control methods used for order-driven materials are unfeasible for generic materials.

For planning and control of material flows, feasible methods are limited by the planning environment (i.e. demand, product, and production characteristics) (Jonsson and Mattsson 2003). Similarly, physical logistics tasks are limited by vehicle size, package size, and site constraints (Sezer and Fredriksson 2021). The organizing of administrative and physical logistics tasks is thus influenced by product and production process characteristics (Klaas and Delfmann 2005), which vary between traditional and industrialized housebuilders (Jonsson and Rudberg 2015). As such, production process choice and product characteristics

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create different conditions for logistics management in construction (Faniran *et al*. 1994). Industrialized housebuilders typically have off-site production facilities in which they produce standardized building modules with a stable organization that resembles more to that of a manufacturing company. On the other hand, general-purpose contractors can produce a variety of projects, typically by limiting investments in fixed resources to reduce overhead costs and maintain flexibility in the market (Simu and Lidelöw 2019). Although both types of contractors are within the same sub-industry, their preconditions for planning and executing logistics tasks differ. This indicates that a "one-size fits all" approach to logistics organizing is unfeasible (c.f., Pfohl and Zöllner 1997, Klaas and Delfmann 2005). As such, building contractors need to organize logistics to match their product characteristics and production process choice.

In logistics research, competitive priorities, product characteristics, and production process choices constitute typical elements of the logistics context (Chow *et al*. 1995, Klaas and Delfmann 2005). The organizing of logistics resources needs to match the logistics context to produce efficient (low resource utilization) and effective (strategically aligned) outcomes (Klaas and Delfmann 2005). This match between a building contractor's logistics organization and logistics context is described using the concept of "fit". Fit emanates from organization theory and denotes the alignment between the organization, its internal context which is typically reflected by its strategy, and its external context, which is characterized by market position, market structures, product lifecycles, etc. (Venkatraman and Camillus 1984). When applied to logistics, a fit between the logistics context and organizing of logistics tend to produce better outcomes in terms of cost, quality, delivery, and/or flexibility (Stock *et al*. 2000). However, the fit must not be mistaken for the correlation between two variables but can be achieved from different initial states and through many potential means and indicates a coherency between several strategies, structure, and process elements (Meyer *et al*. 1993). A common approach to determining the level of fit between context and organization is by the means of the configurations approach. It is a way of classifying typical organizational archetypes with similar characteristics in terms of their composition and fit between several contexts and organizational elements. Taking a configurational approach, the focus is on a broad set of commonly co-occurring organizational and/or strategic characteristics rather than the correlation between two organization variables (Meyer *et al*. 1993). Thus, a configuration approach to logistics accounts for a fit between several aspects of the logistics or supply chain context and the structure of supply chains or logistics systems (Klaas and Delfmann 2005).

In construction, the configurations approach has been used to study construction supply chain configurations (e.g. Voordijk *et al*. 2006, Hofman *et al*. 2009, Sabri *et al*. 2020), but there has been less emphasis on the fit between the logistics context and logistics organizing at the strategic company-level. At this level of analysis, the configurations approach determines whether the logistics organization structure and resources match with the type of production process and outputs (Pfohl and Zöllner 1997). This issue of organizing logistics has become increasingly important for building contractors over the past decade as they increase the use of logistics solutions in projects (Ekeskär and Rudberg 2016). Furthermore, building contractors have a central role in increasing awareness and the use of logistics solutions (Janné and Rudberg 2022). Thus, the configurations approach enables an analysis of logistics organizing at the company level to find ideal configurations (i.e. a high level of fit) of the logistics context and organizing of logistics of different types of building contractors. Therefore, in this paper, the configurations approach to logistics is adopted to examine the organizing of logistics in building contractors. The purpose is to describe the fit between the logistics context and the organizing of logistics at a strategic level. This includes the characteristics of ideal logistics configurations of building contractors regarding different competitive priorities, product characteristics, and production processes.

To address the purpose of this study, a conceptual research framework is developed based on literature within the fields of organization research, operations strategy, and construction logistics. The framework is then applied to four cases in a multiple case study approach to develop a logistics configuration profiling template (LCPT). Each case represents a building contractor, i.e. a company that undertakes residential and/or non-residential construction. The LCPT is used in two ways. Firstly, for within case analyses to describe the fit between the logistics context and logistics organization at the company level. Secondly, for a cross-case comparison to illustrate the differences between ideal configurations in different logistics contexts.

The scope is limited to two different sub-groups of building contractors: industrialized housebuilders that primarily pursue residential construction through standardized products and off-site construction, and general-purpose contractors that pursue both residential and non-residential construction by the means of customized building designs and primarily on-site production. The latter includes both construction of multi-family residences and non-residential construction, such as the construction of schools, elderly homes, hotels, etc. More complex construction projects, such as industrial and infrastructure construction, are not considered in this paper due to their higher complexity and typically longer project lead times compared to building construction.

This paper contributes to logistics in construction by addressing logistics at the strategic level by the means of the configurations approach. It adds to the contemporary construction logistics body of knowledge by identifying relevant logistics context and organizing variables, and by describing the strategic fit of building contractors' organizing of logistics. In practice, the LCPT contributes in terms of being a tool that can be used by strategists, logistics managers, and operations developers to initiate logistics improvement programmes at the strategic level.

Conceptual research framework

The conceptual research framework proposed is developed based on the configurations approach to the organizing of logistics (Klaas and Delfmann 2005), focussing on the fit between two parts: the logistics context and the organizing of logistics. The emphasis is on the consistency between logistics context variables and organization variables at the strategic level. Project-specific context and organization variables are therefore only considered at an aggregate company level. In the following, the two parts of the research framework are explained in more detail, starting with the logistics context followed by the organizing of logistics.

Logistics context

Sousa and Voss (2008) highlight the value of identifying a limited set of variables that best distinguish between different contexts. As such, we propose three broad context variables in this study, partly based on the works of Christopher (1986), Chow *et al.* (1995), and Klaas and Delfmann (2005): (1) competitive priorities, covering the external context, (2) production process choice, and (3) product characteristics, the latter two covering the internal context.

Competitive priorities in building contractor companies

Competitive priorities allow differentiating the building contractor's external contexts. The competitive priorities, e.g. cost, delivery, quality, and flexibility, are a part of a company's operations strategy (Slack and Lewis 2017). Two general types of operations strategies in housebuilding companies have emerged as a response to different contexts. The first type is the general-purpose contractor that undertakes a wide array of building projects and sets up specific organizations for each project, with responsibility typically residing within the middle management (e.g. project managers) (Simu and Lidelöw 2019). Competitive priorities for general-purpose contractors tend to be focussed on flexibility in the delivery of products and adjustment of the production process (Jonsson and Rudberg 2017). The second type of operations strategy is the industrialized housebuilder. They aim to reduce complexity and uncertainty in projects by standardizing products, thereby increasing repetition in production (Jansson *et al.* 2014). For them, projects are typically managed by a fixed organization that resides at the company level (Simu and Lidelöw 2019), and the competitive priorities for industrialized housebuilders tend to focus more on cost and lead time performance (Jonsson and Rudberg 2017). To support competitive priorities, a company must choose the appropriate production process for its products (Hill and Hill 2009). Hence, competitive priorities have a direct influence on the production process choice (L1 in Figure 1) and product characteristics (L2 in Figure 1), which is further described in the two following sections.

Production process choice: degree of off-site assembly

The choice of production process affects the degree of centralization of decision-making (L3 in Figure 1), the appropriate supply network configuration (L4 in Figure 1), and specialization of work (L5 in Figure 1) (Miltenburg 2005). In housebuilding, the choice of the production process can be summarized in four generic production processes, based on the degree of off-site assembly (Gibb 2001, Jonsson and Rudberg 2015), each with different requirements for the planning and execution of logistics tasks:

- *Component manufacture and sub-assembly (CM&SA)*: the traditional approach to housebuilding in which most production is carried out on-site.

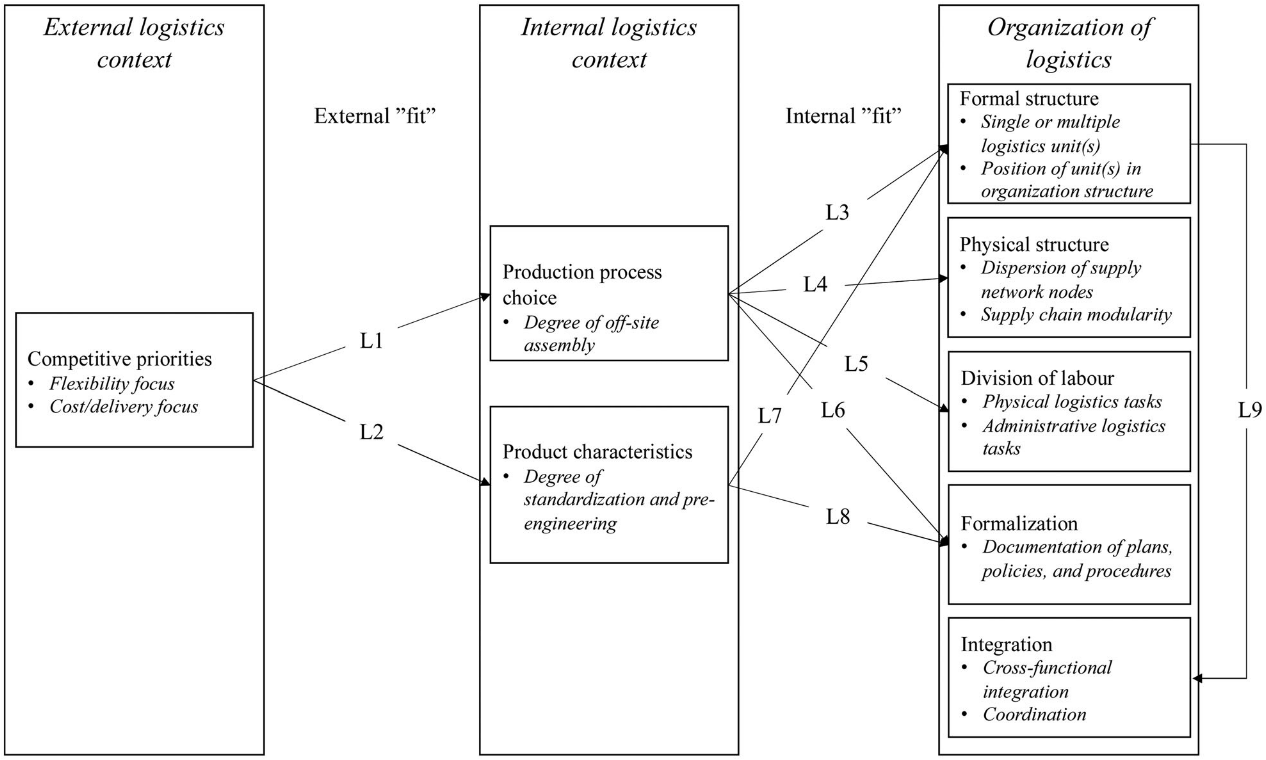

Figure 1. Conceptual research framework.

- *Pre-fabrication and sub-assembly (PF&SA):* components are prefabricated, and assembly works are performed on-site.
- *Pre-fabrication and pre-assembly (PF&PA)*: the degree of pre-fabrication is similar to *PF&SA* but has more pre-assembly (e.g. window assembly off-site).
- *Modular building (MB)*: volumetric modules are prefabricated in a factory and assembled on-site.

The production process choice influences the extent to which detailed plans can be developed before their execution, i.e. the degree of formalization (L6 in Figure 1) (Tenhiälä 2011). A configurations approach implies that the choice of production process determines the level of detail and the hierarchical level at which plans are developed and executed (Tenhiälä 2011). In this context, Bankvall *et al.* (2010) highlight the reciprocal interdependencies between planning levels and Thunberg and Fredriksson (2018) promote pre-construction planning at the company level (strategic and tactical) to reduce the many problems at the operational level.

CM&SA has the lowest degree of off-site assembly leading to low levels of standardization and repetition, which entails a higher degree of uncertainty in the production system. Thus, it needs to be supported by decentralized planning and control of on-site activities. MB has the highest degree of off-site assembly because it involves the prefabrication of volumetric modules in an off-site factory. MB is associated with standardization and repetition of activities, which entails a lower degree of uncertainty in the production system. MB processes thus allow for centralized planning approaches and systems.

Product characteristics: degree of product standardization and pre-engineering

Housebuilding typically involves highly customized products. However, differences exist within housebuilding, and Jonsson and Rudberg (2015) exemplify this using Lampel and Mintzberg (1996) five categories of product standardization: pure standardization, segmented standardization, customized standardization, tailored customization, and pure customization. Within this spectrum, general-purpose contractors tend to produce more customized products, while industrialized housebuilders tend to produce more standardized products (Jonsson and Rudberg 2014).

However, classifying building contractors based on product standardization alone only captures the actual product dimension but fails to recognize how the product was engineered. Housebuilding is engineer-to-order (ETO) production (Gosling *et al.* 2017) and the level of value-adding before the customer-order decoupling point (CODP) is thus low and so is the degree of product standardization. Therefore, product characteristics are heavily influenced by the degree of pre-engineering (Johnsson 2013).

Wikner and Rudberg (2005) suggest that ETO production is a special case of make-to-order (MTO) production, where design and engineering activities are driven by customer orders. To differentiate between ETO and MTO, they propose three subsets of ETO, which includes the product and engineering dimension. The engineering dimension denotes the "stock" of engineering work performed before the CODP in the same way stock of raw materials is held in the physical flow of goods (Gosling *et al*. 2017). The amount of value-adding through design and engineering activities carried out before the CODP is determined by the degree of pre-engineering, and is categorized into three main groups (Wikner and Rudberg 2005):

- *Design-to-order* (DTO): design is predetermined to a limited extent or not at all (typically combined with *pure customization*).
- *Adapt-to-order* (ATO): building components are pre-engineered and used to adapt the design to each project (typically combined with *segmented*, *customized*, and/or *tailored customization*).
- *Engineer-to-stock* (ETS): the entire building is pre-engineered before when a customer order is received (typically combined with *pure standardization*).

The degree of pre-engineering influences the extent to which the organization possesses information about the final product and its constitutive parts and assemblies through standardization. A high or medium degree of pre-engineering (ETS or ATO) facilitates a centralized supply and logistics organization (L7 in Figure 1) because the materials to be procured for a project are known before the production phase (Johnsson 2013). This primarily affects materials management of standard components and assemblies, which can be centralized (Moretto *et al*. 2022). Centralized supply and logistics are however also achievable for DTO but at the risk of invoking conflicts between the central organization and site management (Johnsson 2013). From a logistics perspective, product characteristics determine whether it is known before a customer order has been received which type of transportation is used, how the material is to be handled, storage requirements, packaging, the overall capacity for logistics tasks, and whether common logistics resources and capabilities can be used for these tasks (Pfohl and Zöllner 1997). Product characteristics, therefore, influence the degree of formalization (L8 in Figure 1).

Organizing of logistics

Bowersox and Daugherty (1987) were among the first to classify logistics organizations as companies. Their classification was based on clustering companies' logistics activities into three strategic orientations: process, market, and information. However, they concluded that a classification based on activities alone was inadequate since companies can pursue different activities regardless of their logistics organization structure. Thereby, they suggest researchers study the organizing of logistics using structural variables. The literature reveals five structural variables that typically are used to classify logistics organizations: (1) degree of centralization in the formal organization (Pfohl and Zöllner 1997), (2) physical structure of the supply chain (Klaas and Delfmann 2005), (3) division of labour in logistics tasks (Pfohl and Zöllner 1997), (4) the degree of formalization in logistics tasks (common set of rules, policies, procedures, strategy, etc.) (Daugherty *et al*. 2011), and (5) degree of cross-functional integration (Chow *et al*. 1995). These are explained in further detail in the following sub-sections.

Formal structure

The coordination mechanisms in the organizing of logistics typically include purchasing, production planning and control, order-to-delivery process, distribution planning, and post-delivery services (Jonsson and Mattsson 2016). The complexity and variability in these tasks determine to what extent logistics tasks, activities, and responsibilities can be aggregated into a centralized unit or group of specialists (Pfohl and Zöllner 1997). In housebuilding, Dubois *et al*. (2019) suggest that decentralizing administrative processes typically leads to low levels of coordination of inbound material flows to the construction site. On the other hand, centralized administrative processes, typically carried out by logistics specialists, facilitate increased coordination of material flows between the supply chain and the construction site. Hence, the formal organization structure determines if logistics is concentrated in a single unit or distributed in the organization, and also where in the organizational structure the logistics function is positioned (Chow *et al*. 1995, Klaas and Delfmann 2005).

Physical structure

Physical structure determines the structure of the supply chain, including the physical dispersion of warehouses, production sites, and distribution network nodes (Klaas and Delfmann 2005), which has also been denoted "supply chain modularity" (Voordijk *et al*. 2006). For instance, in *MB*, the factory and the construction site are decoupled in time and space. Material flows between the factory and the construction site consist mainly of building modules. Hence, high coordination requirements reside in the factory, and between the factory and the site, but are lower at the construction site due to the fewer value-adding activities at the site. In *CM&SA*, on the other hand, most production activities are carried out at the construction site leading to a lot of materials delivered to the construction site, and thus high coordination requirements on the many deliveries to the site. Therefore, the physical structure of the construction supply chain heavily impacts the requirements of logistics management.

Division of labour

The division of labour signifies the degree of specialization in physical logistics tasks (e.g. transportation, material handling, and goods reception) and administrative logistics tasks (e.g. order processing, delivery planning, and inventory management) (Klaas and Delfmann 2005). In housebuilding, physical logistics tasks are typically unspecialized and handled by construction workers that alternate between production activities and material handling. Outsourcing on-site logistics to a third-party logistics provider, or having dedicated materials handling workers on site, increasing specialization, and construction workers can focus on production activities (Lindén and Josephson 2013). A low degree of specialization in administrative logistics tasks typically means that planning and coordination are carried out by site management. Administrative logistics tasks are specialized when carried out by logistics specialists or outsourced to a third-party logistics provider that manages inventory levels, coordinate co-loading, and plans deliveries to the construction site (Dubois *et al*. 2019).

Formalization

Formalization indicates the extent to which logistics processes, policies, procedures, and strategies are documented (Daugherty *et al*. 2011). A lack of formalization often results in the project and/or site management using different procedures for logistics activities. This can for instance lead to conflicts regarding delivery schedules, unplanned deliveries, poor goods reception, and inefficient vehicle loading (Ying *et al*. 2014). These effects are reduced by standardizing planning procedures for logistics but require that subcontractors and suppliers adhere to the planning procedures (Janné and Rudberg 2022).

Integration

Chow *et al*. (1995) define logistics integration as "the degree to which logistics task and activities within the firm and across the supply chain are managed in a coordinated fashion" (Chow *et al*. 1995, p. 291). They argue that the degree to which logistics is integrated with other functional areas is determined by the organizational structure (L9 in Figure 1), such as whether logistics is a separate function or part of a larger cross-functional department. Integration is most likely to occur when logistics tasks are specialized, formalized, and centralized (Abrahamsson *et al*. 2003). Hence, the degree of cross-functional integration is partly determined by the configuration of, and coordination with, the other logistics organizational variables.

Synthesis

Figure 1 presents the conceptual research framework, which is based on the configurations approach to logistics organizing. This approach suggests that logistics organizing is contingent upon its strategy and that a fit between context and organization will lead to better performance (Klaas and Delfmann 2005). As recommended by Moretto *et al*. (2022), both external and internal context variables are considered to account for the degree of the fit between the organizing of logistics and its market characteristics and operations strategy. The conceptual research framework is applied to four case studies in the following chapter.

Method

The research process was based on iterations between data collection and conceptual framework development, following the logic of abductive reasoning. A key concern in abductive reasoning is to identify deviations in the empirical material from prior theoretical knowledge to suggest hypotheses/propositions or to interpret existing phenomena through a new conceptual framework (Kovács and Spens 2005). The abductive research process in this study enabled the researchers to make meaningful interpretations of the empirical data from the case studies, while the

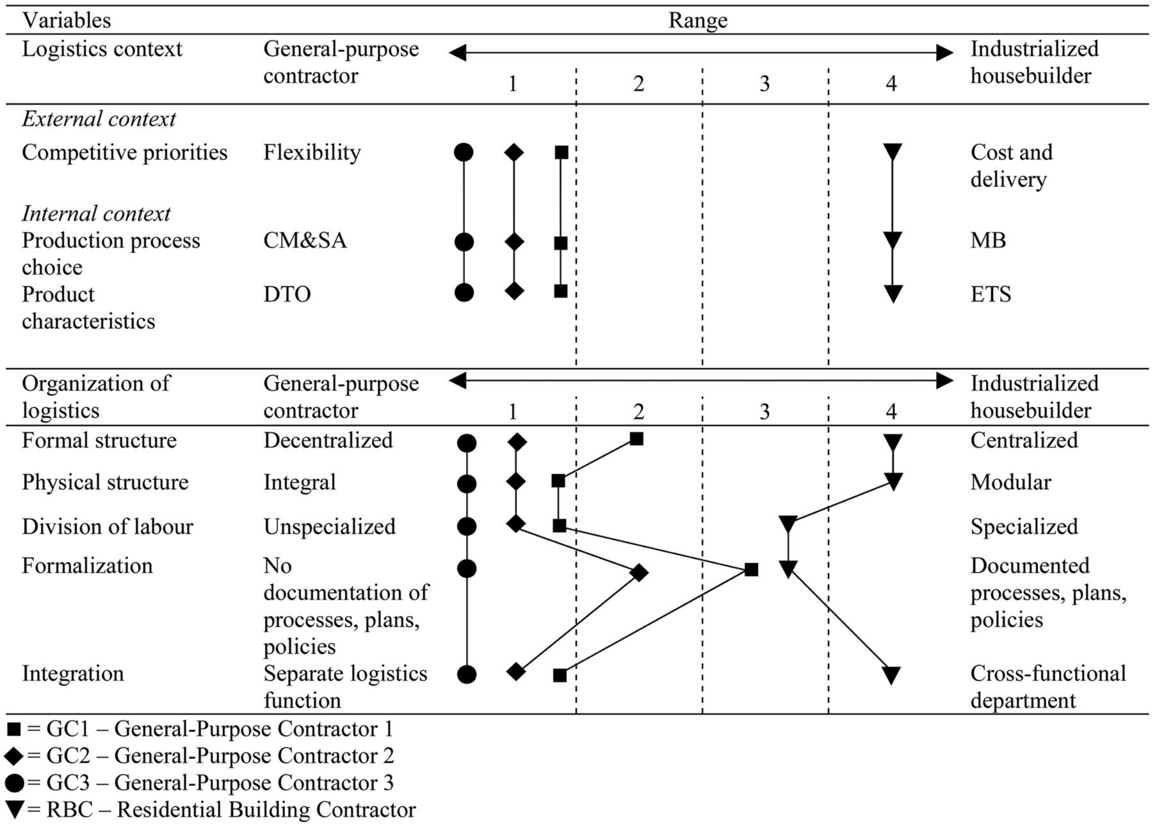

Figure 2. Logistics configuration profiles.

definitions and interpretations of the variables within the conceptual framework could be refined based on the case study findings. This process resulted in the LCPT (Figure 2), which was developed by combining the definitions of logistics context and organizing variables in the conceptual framework with the insights gained from the case studies.

The research process started with a review of the literature to identify logistics context and organization variables. A scoping review (Jesson *et al*. 2011) was conducted in this stage with a focus on identifying ways for classifying how building contractors organize logistics at the company level. The searches were conducted using Google Scholar and the university library's own database which includes Business Source Premier, Web of Science, and Scopus. The search words included *logistics organization and contingency*, *organizing logistics*, and *construction*. The identified articles were from both the logistics and the construction domains. The review of literature informed about potential logistics context and organization variables, which were used to develop a conceptual framework and structure early data collection.

A multiple case study approach was used to refine the conceptual framework and develop the LCPT. The conceptual framework only considered the definition of fit between the logistics context and organization of logistics, while the case studies could deviate from such theoretically "ideal" situations. The cases thus provided new insights into the current practices among building contractors. For instance, the case studies revealed that it is important to distinguish between operational and strategic tasks when determining the degree of centralization. A building contractor's organization of logistics can be considered decentralized despite having a central logistics department with responsibility for strategic logistics decisions if most operational logistics tasks are performed at the project level. Therefore, a low degree of off-site assembly does not imply that a building contractor should not centralize any logistics tasks, but that the contractor's degree of centralization is expected to be lower than in the case of a higher degree of off-site assembly. Thereby, given the abductive approach of the study, the case studies played an important role in altering the definitions of, and links between, logistics context and organization variables.

Case research is suitable for studying a phenomenon in its context and when the boundary between the phenomenon and context is blurred (Yin 2018), which is in line with the configurations approach used in this research. The organizing of logistics is expected to vary between building contractors with different competitive priorities, degrees of pre-engineering, and production process choices. The aim here was not to explain the use of the conceptual framework in a single case, but instead to investigate whether the conceptual framework assists in illustrating logistics context and logistics organizations in different subgroups of building contractors. Therefore, a multiple case study approach was chosen where the case selection was based on perceived similarities and differences in the logistics context.

When using multiple case studies in theory development, Eisenhardt (1989) argues that cases should be selected based on theoretical reasoning. In this study, the purpose is to describe the fit between the logistics context and logistics organizing at a strategic level which includes the characteristics of ideal logistics configurations of building contractors regarding different competitive priorities, product characteristics, and production processes. Considering these, two subgroups of building contractors are expected to vary significantly, general-purpose contractors and industrialized housebuilders. General-purpose contractors typically have a more project-oriented operations strategy than industrialized housebuilders (Simu and Lidelöw 2019). Therefore, theory suggests that general-purpose contractors have lower degrees of standardization, pre-engineering, and off-site assembly than industrialized housebuilders (Jonsson and Rudberg 2014).

Consequently, cases were selected based on their belonging to the theoretical category, i.e. general-purpose contractors or industrialized housebuilders. Three cases belong to the category of general-purpose contractors and one case belongs to the polar category of industrialized housebuilder (see Table 1, providing an overview of the companies and case participants). The two groups of cases were selected based on the grounds of theoretical replication to produce different results, but for expected reasons (Yin 2018). The two groups were expected to differ due to its differences in competitive priorities, degree of pre-engineering, and production process choice. The motivation for having three cases in the group of general-purpose contractors is that their practices typically vary that their operations strategies to a larger extent can be influenced by external factors, e.g. from suppliers and clients (Koch and Friis 2015). Industrialized housebuilders, on the other hand, typically have a narrow market focus, which means that their operations strategy will most likely not differ significantly across cases and that they typically have more control over its production system and supply chain (Lessing and Brege 2015). Therefore, the three general-purpose contractors were selected to account for potential differences due to the external influences on their operations strategy. The three cases included are also the three largest general-purpose contractors in Sweden and are therefore considered to represent large contractors in the general-purpose group. Only one industrialized housebuilder (RBC) is included in the study but is considered representative of its theoretical category since the group of industrialized housebuilders is smaller and more uniform than the group of general-purpose contractors.

Within the cases, data were collected with the use of different methods (semi-structured interviews, workshops, and secondary data), increasing construct validity by corroborating findings from different data sources (Yin 2018). Secondary data sources were mainly used for gathering additional information about the companies and included public information (websites, annual reports, newspapers, and trade magazines), and internal documents from the companies (presentations, checklists, and databases).

Data collection in the cases was initiated through four semi-structured interviews which were used to revise the set of logistics context and organization variables from the conceptual research framework. An interview guide was used, which was based on a case study protocol divided into three categories that were identified in the literature review: (1) questions used to gain an understanding of the companies' respective logistics context, which included the types of clients, competitive priorities, product characteristics, and production process choice; (2) questions to provide an understanding of the structure of their logistics organization and how logistics were managed in their projects; and (3) questions related to background

Table 1. Overview of case companies and participants.

Company	Type of company	Industry	Approximate turnover/employees (2020 Swedish market)	Profession of case participant	Years in role
GC1	Large general contractor	Construction and engineering	€3,2 billion (building division)/7200	Logistics specialist	13
GC2	Large general contractor	Construction and engineering	€1,3 billion (building division)/6500	Logistics developer	5
GC3	Large general contractor	Construction and engineering	€2 billion (building division)/3600	Logistics developer	3
RBC	Industrialised housebuilder	Residential housebuilding	€38 million/400 (2019 figures)	R&D manager	5

GC1: General-Purpose Contractor 1; GC2: General-Purpose Contractor 2; GC3: General-Purpose Contractor 3; RBC: Residential Building Contractor.

information about the case participants, a brief history about the company, and previous efforts within logistics. One representative from each company working directly with, or in proximity to, the logistics function was interviewed. The representatives from GC1, GC2, and RBC all have many years of experience in working with logistics in construction and the representative from GC3 has a Ph.D. in construction logistics and has been working 3 years as a logistics developer at the company. The interviews were conducted in online video meetings and recorded to facilitate transcription and analysis. Each interview lasted around 1.5–2 h. Interview questions were based on the three categories of case study questions. For the analysis, the authors listened to the recordings and used meeting notes to link interview data to the questions in the case protocol, followed by a cross-case comparison to identify similarities and differences between the cases.

Based on the input from the interviews, a new literature review was carried out with a narrowed focus on the configurations approach to logistics organization. Classifications are thereby based on a set of variables that are derived from logistics contingency research that has accumulated over time. This provided a more comprehensive view that may be of better practical use than only studying the dyadic relationship between two variables (Klaas and Delfmann 2005). Conceptual modelling (Mccutcheon and Meredith 1993) was used to categorize logistics context and design variables and to provide dimensions for classifying the variables. This resulted in the conceptual research framework, which provided the relevant variables used for classifying the case companies' logistics configurations. The cases were classified using the strategic profiling methodology, which is a suitable method for illustrating the degree of fit in a configuration involving four or more variables (Hill and Brown 2007). Each case was given its own logistics configuration profile based on the case findings. The profiling was done through an interpretative approach (Mccutcheon and Meredith 1993) by visualizing the case data using the LCPT derived from the review of the literature. This resulted in four visual profiles illustrating the degree of fit in the cases' logistics configurations.

The interviews provided data on the case companies' logistics context and organization variables but lacked insight into how to determine the level of fit between the two types of variables. Furthermore, since an interpretive approach was used to profile the cases, the researchers had to ensure content validity, i.e. that the variables were accurately measured (Mccutcheon and Meredith 1993). Thus, to address the purpose of describing fit, the researchers identified a need for further data collection. Dubois and Gadde (2002) refer to this process as "systematic combining" in abductive case research, which emphasizes the search for theoretical concepts or constructs that explain empirical phenomena and vice versa. As part of the matching process between the conceptual research framework, and data collection and analysis, the authors identified a need to refine the framework and decided to arrange three online workshops with the same case participants who were initially interviewed. Two workshops, lasting 2 h each, were conducted with the case participants from GC1, GC2, and GC3. A separate workshop was conducted with the participant from RBC, lasting 1 h, mainly due to problems with finding a suitable time for all four participants.

Having separate workshops created an opportunity to verify the applicability of the framework to the two different groups in more detail. Each workshop was recorded, and two researchers attended each workshop, where one was responsible for moderating the workshops and the other had a more passive role in listening to and commenting on the discussion. During the workshops, the case participants were first introduced to the notion of logistics configurations. Thereafter, they were given a task to classify their own companies using the LCPT and to discuss whether they agreed with the researchers' interpretation or not. The discussions revealed issues with how the logistics context and organization variables were related and what determined a fit between them. The workshop participants also discussed the possible applicability of the framework and the profiling in their organizations and whether they could be useful tools to initiate and guide logistics improvement programmes at a strategic level in their respective organizations. After the workshops, the authors compared the participants' profiles to the authors' profiles, listened to the recordings, and summarized the discussions before and after the participants had conducted the logistics profiling task. These steps served two purposes: (1) to verify the authors' profiling of the cases which had been done using an interpretative approach, and (2) to revise conceptual definitions since the workshops revealed some ambiguity about the organizing of logistics variables.

Results

Table 2 summarizes the key features of the case companies. The general-purpose contractors GC1, GC2,

Table 2. Summary of the cases' key characteristics.

Characteristic	GC1	GC2	GC3	RBC
Design and engineering	DTO, pure customization	DTO, pure customization	DTO, pure customization	ETS, segmented standardization
Production process choice	CM&SA	CM&SA	CM&SA	MB
Parent organization	Central logistics support function (10 people)	Central logistics support function (1 person)	Central logistics development (1 person)	Supply chain department
Regional divisions and projects	Project logisticians	Logistics developers (regional), project logisticians	Project logisticians	None
Documentation	Logistics plan template	Delivery calendar, checklists	Delivery schedules, site layout plans in information system	Policies and procedures for logistics planners
Coordination	Pre-construction, production phase	Experience feedback across divisions, pre-construction phase	Production phase	Product development, module production, and site assembly

and GC3 pursue extensive design and engineering activities in the pre-construction phase, which indicates that they have a DTO pre-engineering strategy. Furthermore, these building contractors perform most value-adding activities on the construction site, which resemble the traditional on-site construction process CM&SA. The residential building contractor, RBC, is an industrialized housebuilder that has established a product development unit in its supply chain department. Building designs are based on five pre-engineering building modules that are produced in their factory or sourced from one of their suppliers. The degree of value-adding activities in the factory is estimated to be 70–80%, which is a result of the use of the MB production process.

GC1, GC2, and GC3 have organized logistics tasks in similar ways; they have central logistics support functions and logistics developers in the parent organization. However, GC1 has more people (10) in their logistics function than GC2 and GC3 (1 respectively). Outside of the parent organization, the three have project logisticians, but only GC2 has logistics development at the regional level. In contrast, RBC has gathered its logistics expertise with product development, purchasing, and production in its supply chain department.

Regarding documentation, the cases indicate that formal documents are related to operational aspects of logistics. Coordination activities (i.e. at which point logistics is involved in the building process) are mainly carried out in the pre-construction phase in GC1, GC2, and GC3. In RBC, coordinating logistics with product development and production is considered a day-to-day activity. Each case is analyzed in further detail in the following section.

Within-case analysis

The challenge for GC1 is to involve the central logistics group in their projects. As of now, there are risks involved in using a centrally developed logistics plan with decentralized execution, especially since the logistics group is relatively small in comparison to the size of the company. The group currently provides support regarding logistics in large and complex projects but does not specify explicit logistics policies, procedures, and rules. In other words, the level of support from the logistics group differs between projects as it is up to site management to execute and update logistics plans. Projects that do not reach a certain threshold for contract value and technical complexity do not receive support from the logistics group, although these projects typically are DTO and utilize the CM&SA process.

GC2 prefers large and complex projects and competes primarily on its ability to handle variations between projects. Their challenge lies in coordination between regions to achieve economies of scale and to disseminate experiences from one region to the others. As of now, logistics development resides both within the parent organization and in the regional divisions. In the parent organization, they are working on a development project focussing on digitalizing the project purchasing process, which includes logistics, albeit to a low degree. Instead, regional divisions take the main responsibility for logistics development, and the intensity of such activities varies between divisions. Thus, some regions have come further than other regions in developing and implementing logistics tools, guidelines, policies, and procedures.

GC3's organizing of logistics is characterized by delegating logistics tasks to the projects, which suits their relatively low degree of production standardization, pre-engineering, and off-site assembly. Thus, project-specific logistics plans can be developed concurrently with design and engineering in the pre-construction phase but are typically not considered before the production phase. The logistics developer in the parent organization questions whether it is feasible to delegate all logistics tasks to the projects because the logistics tasks do not change drastically, regardless of the projects being unique and "one-off". Such distributed authority to site managers to make logistics-related decisions involves a risk of "reinventing the wheel" without learning from previous projects.

RBC's challenges lie with integrating a centralized logistics organization with the on-site assembly of volumetric modules. Although their logistics organization is centralized and specialized relative to the general-purpose contractors, the completion phase of their projects includes assembly works, on-site materials handling, and remaining works after module assembly resemble traditional on-site construction. Thus, because their production system has two parts, one off-site factory, and one on-site module assembly, their logistics planners need to consider both the industrial production process and traditional construction process logistics. This is of particular importance for RBC since they need to reduce production lead times as much as possible to compensate for the lower degree of flexibility in their production system and products.

Cross-case comparison

Figure 2 denotes the cases' logistics configuration profiles and is based on the framework in Figure 1 populated with data from the case study results. The upper part of Figure 2 shows the companies' logistics context profiles, whereas the lower part profile the organization of logistics. Both these areas are compared between the case companies in the following sub-sections. The cases are classified using ranges to enable a relative comparison of the different sub-groups of building contractors. The scale used in the LCPT ranges from 1 to 4, in which two cases that exhibit similar characteristics are classified in the same range. For instance, two cases that are classified as level 1 under "production process choice" indicates that they use CM&SA production processes. Levels 2 and 3 would indicate that they use either PF&SA or PF&PA, respectively, while level 4 corresponds to an MB production process.

Logistics context

Case GC1, GC2, and GC3 are identical in terms of competitive priorities, production process choice, and product characteristics. During the interviews in cases GC1 and GC2, it was explicitly stated that they prefer large and complex projects, and they viewed their sheer size as an advantage over smaller building contractors. The case participant from GC3 stated that they have a "react to the market" approach and prioritize flexibility in their projects and products to stay responsive to client requirements. Therefore, GC1, GC2, and GC3's competitive priorities are flexibility and innovativeness. Regarding their production process choice, most value-adding activities are performed on-site, and therefore, their degree of off-site assembly is CM&SA. They carry out design and engineering activities from scratch in the pre-construction phase, which indicates that their degree of product standardization and pre-engineering is DTO. RBC prioritizes cost and lead time and has the highest degree of off-site assembly due to their production process choice being MB, in which they produce volumetric modules that are assembled at the construction site. The modules are standardized and combined into complete buildings. Therefore, RBC has a high degree of pre-engineering (ETS).

Organizing of logistics

GC1, GC2, and GC3 have centralized logistics functions, but they are neither positioned near the upper hierarchical levels in the organization nor very large relative to the size of the companies. Most logistics decision-making takes place at the project level within these companies, which indicates that their logistics organization structures are decentralized. However, GC1's group of logistics specialists is larger than GC2 and GC3's. Therefore GC1's degree of centralization, with centralized logistics development and decentralized execution, corresponds to a configuration with PF&SA and ATO. Out of the four cases, RBC has the highest degree of centralization, which aligns with its high degree of product standardization, pre-engineering, and off-site assembly.

In GC1 and GC3, logistics tasks at the project level are primarily performed by unspecialized labour, while logistics development is performed at the company level. In GC2, although a logistics developer worked in the central organization, it is primarily the regional departments that carry out logistics development while the projects are responsible for execution. The degree of specialization (i.e. division of labour) therefore corresponds to their more product- and process-oriented operations strategy. In RBC, it is primarily administrative logistics tasks that are carried out by logistics specialists, but site management takes over when building modules leave the factory and are delivered to the construction site. The degree of specialization in RBC is, therefore, lower than expected for the MB process and ETS pre-engineering strategy.

In terms of formalization, GC1 and RBC have formalized logistics tasks (e.g. logistics plan template used in GC1) but have not formulated strategies at the company level. Instead, formalized policies and procedures were primarily intended for the project-level, which is why their degree of formalization is considered to be mainly product and process-oriented. Furthermore, GC2 utilizes logistics guidelines of other tools for delivery planning, but these are not as extensive as those of GC1 and RBC, which indicates their degree of formalization corresponds to a more project-oriented approach. GC3 has not formalized logistics activities, policies, procedures, or a strategy, indicating a low degree of formalization intended for a logistics context characterized by CM&SA and DTO, i.e. purely project-oriented.

GC1, GC2, and GC3's organizing of logistics entails that logistics is detached from design and engineering, implying a low degree of integration at the company level. Instead, GC1, GC2, and GC3 integrate logistics with design and engineering activities in the pre-construction or production phase due to the DTO pre-engineering strategy. Moreover, their respective logistics units are relatively small in relation to the size of the whole organization. In contrast, RBC's supply chain department accounts for approximately half of its organization, in which the logistics unit is in proximity to the product development and production unit. RBC's logistics organization, therefore, has the highest degree of integration, which is a result of the logistics function being concentrated in a single unit in the parent organization. By integrating logistics within a cross-functional department, RBC facilitates cross-functional coordination between logistics, production, and product development. A supply chain manager is responsible for logistics, production, and product development, which indicates that logistics is positioned in proximity to top management in RBC.

Discussion

Pfohl and Zöllner (1997) argue that the organizing of logistics is a response to market characteristics, product characteristics, and the type of production process. The conceptual framework in Figure 1 shows one external and two internal logistics context variables that influence building contractors' organizing of logistics. Building on this framework, the LCPT in Figure 2 illustrates the degree of fit in a building contractor's logistics configuration. A profiling template is a descriptive tool, which does not provide deeper explanations of the *whys* and *hows* but can be used to illustrate relative differences between configurations or changes in a configuration over time.

Based on the logistics configuration profiles of the four cases, two polar logistics configurations are identified in this study, corresponding to the distinction between general-purpose contractors and industrialized housebuilders (Simu and Lidelöw 2019). Similarly, Moretto *et al*. (2022) distinguish between project-oriented and product- and process-oriented contractors, which resemble general-purpose contractors and industrialized housebuilders, respectively. This indicates that there is no "one-size fits all" to organizing logistics for building contractors. In the following subsections, the relationships between context and organization variables are discussed as to what constitutes external and internal fit in a building contractor's logistics configuration.

External fit

In a building contractor organization, external fit signifies their attempt to adapt their product offering to the client's requirements (Jonsson and Rudberg 2014). Therefore, external fit does not directly relate to the organizing of logistics. However, competitive priorities influence the choice of the production process and product characteristics, which in turn influence the organizing of logistics. Thus, the fit between the external and internal context is necessary to account for the external fit in a logistics configuration.

The case studies indicate that the building contractors have a high level of fit between competitive priorities, production process choice (L1 in Figure 1), and product characteristics (L2 in Figure 1), which is represented in Figure 2 by the straight profiles under logistics context. The case findings align with the suggestions of Jonsson and Rudberg (2015) that industrialized housebuilders typically prioritize cost and delivery over flexibility. The industrialized housebuilder RBC utilizes a high degree of pre-engineering, product standardization, and off-site assembly, allowing them to reduce lead-time and costs. The general-purpose contractors are positioned at the other end of the spectrum with flexibility as their main competitive priority. Their low degree of pre-engineering, product standardization, and off-site assembly enable them to produce a variety of buildings without incurring added costs.

It is important to note however that the competitive priorities in the case studies are the case participants' interpretations of which their respective strengths and weaknesses. Whether or not their interpretations coincide with that of their clients is not revealed in the cases, which may hide potential external misfits between the building contractors' and their clients' competitive priorities (Maylor *et al*. 2015). A logistics configuration's level of external fit should therefore not only be considered from the contractor's point of view but by the degree to which the contractor's competitive priorities are reconciled with the priorities of their target market.

Furthermore, a building contractor's production process choice and product characteristics are seldom outlined in terms of explicit formulations of an operations strategy (Maylor *et al*. 2015). Production process choice and product characteristics are typically reactive rather than proactive responses to the external context. In general-purpose contractors, the operating strategy is a result of pursuing a flexibility-oriented operations strategy with a DTO pre-engineering strategy and a CM&SA process (Simu and Lidelöw 2019) rather than a deliberate commitment at the strategic level. This encourages project-specific design and engineering solutions, variations in production technology, and process layout, which lack coherence throughout the organization.

Internal fit

While the cases exhibited a high level of external fit, there were indications of misfits between the internal logistics context and the organizing of logistics. For instance, combining a single logistics unit with a low degree of off-site assembly (L3 in Figure 1) poses coordination challenges for logistics specialists. For the CM&SA process, the low degree of off-site assembly involves many components that are to be delivered to the construction site from different suppliers. A centralized logistics support function is thereby difficult to pursue due to the need for coordinating numerous suppliers, including the sub-contractors suppliers (Dubois *et al*. 2019). This is illustrated in case GC1 in which logistics specialists from the central logistics unit need to be consulted on projects. This suggests that the degree of off-site assembly influences the degree of centralization in the formal structure, i.e. the extent to which planning is carried out by a central logistics unit.

Furthermore, previous research indicates that product characteristics influence the degree of centralization (L7 in Figure 1). When products are standardized, logistics tasks may be predetermined correspondingly, which is typically carried out by a central logistics unit (Pfohl and Zöllner 1997). However, the construction supply chain poses coordination challenges due to the temporary production sites and supply chains. This is in line with the case findings, which suggest that operational logistics tasks need decentralized support. Both the general-purpose contractors' and the industrialized housebuilder's organizing of logistics must be able to handle variability in projects, albeit at different degrees, which implies decentralization of operational logistics tasks. Nonetheless, the case findings do not postulate it as being contradictory to having a central logistics unit focussing on logistics development and long-term issues. Thus, a distinction should be made between the organization of operational and strategic logistics. Operational logistics concerns making local adaptions while strategic logistics involves setting a frame of reference for logistics processes and how logistics is organized (Abrahamsson *et al*. 2003, Sandberg 2021). These two do not have to be organized in the same way, i.e. operational logistics can be decentrally managed while a central logistics unit sets the frame of reference for logistics processes. A central logistics unit can be assumed to be responsible for strategic logistics decisions, and its prerequisites are primarily set by the building contractor's operations strategy. On the other hand, projects must make local adjustments to account for the site location and its surroundings, local suppliers and sub-contractors, and the type of construction method used where it can differ between projects.

GC1 and GC2 have adopted this approach to some extent with standardized logistics plan templates and guidelines developed by logistics specialists in the central organization. The logistics specialists provide support in projects, but site management possesses the formal decision-making authority and control over day-to-day logistics activities. However, case findings indicate that site management has the main responsibility for both setting the frame of reference for logistics processes and making local adaptions to the project. These building contractors are considered as "heavy decentralized" since both operational and strategic logistics (to some extent) are the responsibility of site management. On the other hand, RBC can be considered as "lightly centralized" due to its combination of central planning and decentralized execution.

The distinction between strategic and operational logistics can be related to the degree of formalization. In line with Abrahamsson *et al*. (2003), the cases indicate that formalized logistics processes need not be centrally executed, but they have to be centrally designed and managed. The central entity thus set the frame of reference for logistics processes, which in turn are executed by logistics specialists at the project level. Daugherty *et al*. (2011) suggest that formalizing logistics processes, policies, and procedures signals a commitment to activities that are perceived as particularly important, even in a logistics context characterized by variability and complexity. As a result, both general-purpose contractors and industrialized housebuilders can benefit from formalizing logistics processes, policies, and procedures. However, a low degree of formalization is a common reaction to variability and complexity resulting from a low degree of product standardization (Chow *et al*. 1995), such as that of a general-purpose contractor. Therefore, the degree of standardization and pre-engineering is proposed to influence the degree of formalization (L8 in Figure 1).

Conclusions and implications

The purpose was to describe the fit between the logistics context and logistics organizing at a strategic level. To fulfill this purpose, relevant contextual and organizational variables were identified and used to create a conceptual research framework (Figure 1), which describes logistics configurations in building contractor companies. It summarizes the logistics context and organization variables identified in the literature, which were divided into three context variables and five organizational variables. To describe the fit between the logistics context and logistics organizing, the framework was applied to four cases by the means of the LCPT (Figure 2). Their degree of fit is illustrated using the LCPT. The findings from the case studies are consistent with the configurations approach in that there is no one best way to organize logistics in the context of a building contractor company, but rather that it is contingent upon the logistics context.

Research and managerial implications

The main contribution is to existing research on the organizing of logistics in construction through the identification of logistics context and organization variables relevant in the housebuilding context. In line with recent contingency studies in the field of logistics and supply chain management (e.g. Bals *et al*. 2018, Moretto *et al*. 2022), the findings suggest that a "one-size-fits-all" approach to the organizing of logistics in building contractors is unfeasible. In line with this, two research contributions are highlighted: (1) Production process choice influences the extent to which planning and logistics decision-making is centralized (i.e. the degree of centralization), and (2) in contrast to previous configuration studies within the logistics domain, formalization can provide benefits in a logistics context characterized by complexity and variability, such as those of general-purpose contractors. However, it is expected that general-purpose contractors have a lower degree of formalization compared to industrialized housebuilders.

The LCPT can be used as a managerial tool to reflect upon the level of fit between the logistics context and organizing of logistics, for example by investigating which degree of centralization and formalization is reasonable. Therefore, the main implication for construction logistics practice is that logistics should be organized to match the preconditions set by the degree of pre-engineering and the type of production system. By simultaneously addressing both product, process, and logistics aspects, it creates a composition of logistics resources and processes that are aligned with the type and characteristics of production tasks, which in turn lead to shorter project lead times, less disturbances, lower total costs of material supply, etc. However, the findings indicate that management should carefully consider centralizing decisions regarding strategic logistics issues and formalization of logistics processes, policies, and procedures. A centralized entity can be responsible for setting the frame of reference for logistics, while operational logistics tasks are executed by logisticians at the project level. General-purpose contractors will need to delegate operational control to the project level, but they could benefit from using standardized logistics tools and guidelines (e.g. logistics plan templates) and logistics specialists' support in the pre-construction phase. Additionally, none of the building contractors had a deliberate logistics strategy, which is recommended to signal commitment to logistics tasks in building projects. For developing a logistics strategy, the conceptual framework (Figure 1) and the LCPT (Figure 2) can be used by building contractors and consultants in the initiation phase of the strategy process for analysis and early development of logistics strategy contents.

Limitations and further research

One limitation of this research is that the proposed relationships between logistics context and organization variables require further empirical investigation. Thus, the authors recommend future studies employ large-scale surveys with profile deviation analysis to find ideal logistics configurations of high-performing building contractors. Furthermore, while the LCPT is useful for illustrating relative differences, it does not indicate how to create fit in a logistics configuration. The LCPT considers the perspective "content of fit" as opposed to "patterns of interactions" (see Venkatraman and Camillus 1984). Future research should consider which decisions that need to be made to create internal and external fit by addressing decision areas and the process of formulating and implementing a logistics strategy in a building contractor company. The authors recommend in-depth case studies to gain a better understanding of how to create fit in a building contractor organization.

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Paper 2

Revealing patterns of logistics organization design among residential building contractors in the Nordic countries

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Revealing Patterns of Logistics Organization Design among Residential Building Contractors in the Nordic Countries

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Abstract

Purpose: The purpose of this paper is to investigate the logistics organization design among residential building contractors. This includes the influence of three contextual factors on the logistics organization design: company size, product characteristics, and production process characteristics.
Design/methodology/approach: A questionnaire was sent to medium to large-sized building contractors in Sweden, Norway, Finland, and Denmark to capture their design of the logistics organization, and how it is influenced by contextual factors.
Findings: The study reveals that product and production process characteristics shape logistics organization design. Decentralization is associated with low pre-engineering and off-site fabrication, while centralization prevail with high pre-engineering and off-site fabrication. Company size shows no clear effect. Instead, the number of construction types is more clearly associated with the logistics organization design.
Originality: This study contributes by identifying current patterns among building contractors' logistics organization designs. The study adds to literature on the organization of logistics in construction, where the contemporary literature is based mainly on a few case studies. Furthermore, the findings challenge assumptions about the impact of company size and emphasizing the role of diverse construction operations.
Research limitations/implications: The research is confined to building contractors in Nordic countries and focuses on medium to large-sized firms, limiting generalizability. Future studies could explore smaller firms and extend the geographical scope.
Practical implications: Contractors should consider designing their logistics organization based on the number of heterogeneous construction types, product characteristics, and production process characteristics.

Keywords: Construction logistics, Logistics organization design, Building contractors, Questionnaire

1. Introduction

To successfully deliver projects on time and within budget, while ensuring efficient utilization of resources and the well-being of workers, building contractors must prioritize effective logistics management in the construction supply chain (Dubois *et al.*, 2019). Achieving this goal requires a logistics organization capable of effectively addressing the logistical challenges (Haglund *et al.*, 2022). Prior studies suggest that efficiency at the construction site, the supply chain, and across supply chains can be improved by separating logistics from traditional roles (e.g., site managers) in construction projects (Dubois *et al.*, 2019). This is typically done by outsourcing whole or parts of logistical tasks (Sundquist *et al.*, 2018) or by acquiring such resources to perform logistical tasks internally (Ekeskär and Rudberg, 2016).

The building contractor's internal logistics capabilities play a large role in developing logistics management practices, e.g., in the adoption of Building Information Modelling for managing material and information flows (Magill *et al.*, 2022, Zeng *et al.*, 2023) and for collaboration with supply chain partners (Chen *et al.*, 2020, Le *et al.*, 2020, Janné and Rudberg, 2022). However, there is little known about how building contractors should organize logistics in terms of the locus of decision-making and control, division of logistical tasks, use of formal rules and procedures, and integration within the organization and with supply chain partners. Therefore, there is a need to investigate how building contractors should design their logistics organization to achieve its intended performance outcomes. While previous studies point towards outsourcing as a benefit to the contractor in terms of increased specialization and reduced disturbances for site personnel (Ekeskär and Rudberg, 2016, Sundquist *et al.*, 2018, Janné and Fredriksson, 2022), internal logistics capabilities are still necessary to establish a strategic management of logistics across the contractor's projects (Spillane and Oyedele, 2017). Most studies focus on individual cases, or at most, a handful of cases of how building contractors organize logistics (Elfving, 2021, Ekeskär *et al.*, 2022, Haglund and Rudberg, 2023). As such, the existing literature on organizing logistics in construction offer in-depth insights into specific cases. However, there is a need for a broader perspective to identify common trends and patterns among building contractors' internal logistics organization.

Therefore, the purpose is to investigate the logistics organization design among residential building contractors. Building construction is a heterogeneous industry, with company sizes ranging from large multi-purpose contractors to small niche contractors (e.g., homebuilders). To cater different market segments within different types of building construction, main contractors pursue different production strategies to deliver either unique projects for a broad range of clients or cost and time efficient projects for a narrow range of clients (Simu and Lidelöw, 2019). Logistics organization design literature highlight the need to consider such differences in company size, product characteristics, and production process characteristics in the design of the logistics organization (Dröge and Germain, 1998, Nakano and Matsuyama, 2022). Therefore, in this study, three contextual factors and four logistics organization design elements (organizational structure, division of labour, formalization, and integration) are identified. To capture a broader perspective among different types of building contractors, the influence of each contextual factor on the logistics organization design constructs are examined through a questionnaire study of building contractors operating in Sweden, Norway, Finland, and Denmark.

2. Frame of reference

In this section, the four constructs (company size, product characteristics, production process characteristics, and logistics organization design) are defined. Furthermore, the constructs and their elements are present along with operationalizations of the elements.

2.1 Company Size

Company size is typically considered as a multi-dimensional concept comprising the number of employees, number of sites, the company's total assets, and annual turnover (Child, 1973). It is a central factor that determines the organization design, in which a larger company size is associated with more layers in the hierarchical structure and a greater span of control for executives (Dröge and Germain, 1998). This typically leads to a situation where the company becomes more decentralized due to the increasing number of employees that executives must oversee. The need for formalized working rules, policies, and procedures increases because informal mechanisms would have required more direct supervision, something which is difficult in larger organizations with many hierarchical layers.

In this paper, three measures for company size are used: the number of employees, the annual turnover, and the geographical market. The number of employees is a common measure of company size, typically referring to full time employees (part time employees are then measured as 0,5 full time employees). The annual turnover is the total income made by a contractor over a year, referring to the operating revenue, i.e., income before tax from the company's core business and excluding income from financial items. The geographical market refers to concentration of the contractor's projects (local/regional, national, or international).

2.2 Product Characteristics

Product characteristics refers to the level of customization, volumes, and product complexity (Persson, 1978, Jonsson and Rudberg, 2015). This constitutes an important link between the contractors offering and the marketplace. In response to the product characteristics, an appropriate production process needs to be used to produce the products in the most effective way.

There are some distinct features that differentiate construction from other types of production, such as highly customized, one-off products that are produced using site-based production (Hill and Hill, 2009). Hence, the product design is typically customized for each project, albeit to different degrees depending on the contractor's strategic objectives. For instance, product customization is typically limited among contractors that pursue a cost leadership strategy, while it is more common to offer a high degree of customization for differentiation strategies.

Since construction is an engineer-to-order type of operation, the contractor's product characteristics can be regarded as the "degree of pre-engineering". This term is used to denote the level of product customization, which for building contractors is related to how much of the end-product that is engineered "to stock" (i.e., before the client enters the construction process). This means that contractors that have a high degree of pre-engineering would have completed most design and engineering tasks speculatively, which only allows minor changes to the end-product for the client.

2.3 Production Process Choice

The production process choice in construction will always carry some form of site-based production, even in cases with a very high degree of off-site fabrication. To differentiate between different process designs in construction, the term "degree of off-site fabrication" is used. This can be regarded as a floating scale that can differ for certain building parts and components, but at an aggregated level there are four distinct categories of off-site fabrication (Jonsson and Rudberg, 2015):

- Component Manufacture and Sub-Assembly (CM&SA): Very little to no prefabrication.
- Prefabrication and Sub-Assembly (PF&SA): Some prefabrication, typically panelized elements, but still predominantly site-based production.
- Prefabrication and Pre-Assembly (PF&PA): Prefabrication with parts and assemblies made off-site. Can be either panelized elements or large components with assemblies already installed to them.

- Modular Building (MB): Prefabricated enclosed spaces (typically volumetric modules) with final assembly/installation on-site.

2.4 Logistics organization design

The logistics organization design refers to how logistics functions are arranged within an organization to ensure efficient flow of materials, information, and other resources in the supply chain. It is typically a decision area in the logistics strategy, which further includes customer service levels, channels of supply and distribution, facility locations, allocation of activities, inventories, transportation, information management, and the logistics organization (Rao *et al.*, 1994). As such, the logistics organization design is one of eight decision areas in the logistics strategy, and it is essential to creating a well-functioning logistics system.

The design of the logistics organization involves determining the organizational structure, division of labour, use of formal rules and procedures, and the logistics functions integration with other functional areas as well as external stakeholders (Persson, 1978, Pfohl and Zöllner, 1997). The four elements constitute the logistics organization design and should be aligned with the strategic objectives of the organization and with the product and production process characteristics to ensure efficient and effective management of inbound and internal flows (Christopher, 1986, Haglund *et al.*, 2022).

2.5 Synthesis and operationalization of the constructs

The contextual factors and logistics organization design elements described throughout section 2.1 to 2.5 can be used to reveal patterns among building contractors' logistics organizations. For instance, in a prior study of logistics organization designs among four building contractors (Haglund *et al.*, 2022), it was suggested that traditional contractors that pursue many types of construction tend to have a more project-based approach to logistics, where logistics solutions are developed for a single project. This is typically associated with a decentralized logistics organization, requiring lower levels of cross-functional integration. Formal logistics processes are rare among these types of contractors, who also tend to include logistics management roles in more traditional roles, such as site managers and supervisors. Industrialized housebuilders, on the other hand, tend to have a more long-term, company-level approach to logistics. Thus, they can be expected to have a more centralized logistics organization requiring higher levels of cross-functional integration and formalization. They also tend to sub-divide logistics task to a further extent and are thus expected to exhibit a higher division of labour.

Table 1 contains the four constructs identified in literature, their respective elements, and the operationalizations of the elements. The operationalizations are used as a basis for developing the measurement items in the questionnaire. The total number of elements that potentially can be aligned with each other amounts to twelve, which signals the complexity of aligning the logistics organization design with the contextual factors. The number of elements also indicate that there are an endless number of possible logistics organization design configurations. Building contractors' logistics configurations will therefore likely be a mix of the project-based and the long-term, company-level-based approach.

Table 1 Operationalization of the constructs.

Construct	*Element*	*Operationalization*
Company size	Number of employees	Number of full-time employees: • Small enterprises: Up to 49 • Medium enterprises: 50-249 • Large enterprises: 250 and above
	Annual turnover	Operating revenue[1]: • Small: Up to €10 million • Medium: €10-€50 million • Large: Above €50 million
	Geographical market	Location of the contractor's projects: • Local/regional (L/R) • National (N) • International (I)
Product characteristics	Degree of pre-engineering	The level of customization measured in volumes of each product variant and the number of variants offered.
Production process choice	Degree of off-site fabrication	The amount of value-adding performed in the off-site production in relation to the total amount of value-adding.
Logistics organization design	Organizational structure	The degree to which decision-making is concentrated to a single unit and the proximity of decision-making authority to top management.
	Division of labour	The degree to which tasks are sub-divided into specialized roles.
	Formalization	The presence of written rules that prescribe how tasks should be performed independently of personal traits.
	Integration	Coordination of activities across functional and organization boundaries.

3 Method

In this section, the overall research design and sample selection are described. This is followed by a description of how the questionnaire was developed, how the data was collected, and finally the analysis procedures used.

3.1 Research design and sample

Since prior studies on logistics organization design among building contractors only rely on a few cases, this study relied on a questionnaire study to get a broader perspective and to reveal general patterns. The questionnaire was sent to construction companies with NACE code 412, which denotes construction of residential and non-residential buildings, either on own account or on a contract basis. Many of the contacted building contractors pursue other types of construction, besides building construction, which were also included in the questionnaire. However, the focus remained on residential building contractors.

Data were collected using a web-based key-informant questionnaire that was mailed to a person with a logistics-related or top-management role at each construction company. The target respondents and their email addresses were identified through the companies' websites and LinkedIn pages. The questionnaire was aimed at managers working in a central department (i.e., not at the project level) because they were familiar with the

[1] 2023 figures.

company's logistics operations. The data were gathered from contractors in Sweden, Norway, Finland, and Denmark that were classified as medium and large-sized according to the EU recommendation 2003/361 for classifying SMEs. Hence, the questionnaire was sent out to construction companies with a turnover of at least €50 million per year and a staff headcount of at least 50 persons. In total, 365 questionnaires were sent by email, and 52 complete responses were returned, which resulted in a response rate of 14%. The distribution by country of the 52 responses were: 30 from Sweden, 6 from Finland, 14 from Norway, and 2 from Denmark. Among the 52 responses received, 37 were identified as residential building contractors, which was the main focus of the study. The remaining 15 companies predominantly pursued other forms of construction. As a result, most of the analysis focused on these 37 building contractors. Although the primary focus of the analysis centred on these residential building contractors, the complete sample of 52 contractors was employed to assess the impact of the number of types of construction on the logistics organization design.

In contrast to questionnaires targeting a broader population of companies, this questionnaire targeted a niche population. This explains the relatively low target population (N = 365) whereas the response rate of 14% was within an acceptable range for web-based questionnaires that typically lead to lower response rates than, e.g., telephone questionnaires (Forza, 2002). The final population was selected by filtering the companies based on the NACE code, the number of employees, and annual turnover, which enabled identification of a specific group of building contractors. However, the final sample size is relatively small, but considering the given criteria for size and geographical location, it is still representative for medium and large-sized contractors in Sweden, Norway, Finland, and Denmark.

3.2 Questionnaire development

The questionnaire contained five main parts: personal information about the respondent, information about the respondent's company, the products, the production processes, the logistics organization design, and operational performance. The respondents first entered information about themselves (e.g., about their educational and professional background to ensure that the respondent had relevant knowledge regarding logistics) followed by information about their company (e.g., the type of construction they engage in). Note that the respondents received the questions regarding the product and production processes for each type of construction that they selected. To avoid unnecessary questions and salience of the questionnaire, display logic was used so that the respondent only received questions related to the types of construction that they had selected.

For the questions regarding the company's product and production process characteristics, a five-point Likert scale was used with "Never" to "In all projects" as anchors. This was to obtain information about how often (i.e., in how many of their projects) they pursued a certain degree of pre-engineering and off-site fabrication. The questions regarding logistics organization design and operational performance used a five-point Likert scale with "Completely disagree" and "completely agree" as anchors.

The questionnaire was pre-tested with a panel of academics within construction to ensure the validity of questionnaire items and to identify ambiguous questions. The questionnaire was then piloted to practitioners within the construction industry with similar profiles to the target key informant to further ensure salience of the questionnaire items. The pre-testing and pilot questionnaire led to some questions being simplified and some replaced according to the suggestions of the panel of academics and pilot questionnaire respondents. As a final step, the questionnaire was translated into the respondents' mother tongues. The questionnaire was originally made in Swedish and was translated into Norwegian, Finnish, and Danish using Chat-GPT. To verify the translations, the translated versions were sent to academics with these three languages as their mother tongue, which resulted in minor corrections.

3.3 Analysis

The analysis began with categorizing the data based on company size, product characteristics and production process choice. For product and production process characteristics, the scale was reduced to a 4-point scale from a 5-point scale by removing those companies that reported that they never used a certain degree of pre-engineering and/or off-site fabrication (i.e., they were excluded from that product or process category). Following that, the data was normalized since the accumulated numbers for the degree of pre-engineering and off-site fabrication did not equal to 100% of their projects. Thereafter, to determine the degree of pre-engineering and off-site fabrication, a score was calculated for product characteristics and production process choice through the following equations:

Equation 1 (the degree of pre-engineering):
*Product score: (-2) * very low pre-engineering + (-1) low pre-engineering + 1 * high pre-engineering + 2 * very high pre-engineering*

Equation 2 (the degree of off-site fabrication):
*Production process score: (-2) * very low off-site fabrication + (-1) low off-site fabrication + 1 * high off-site fabrication + 2 * very high off-site fabrication*

A negative score in the case of the degree of pre-engineering thus indicated that the contractor mostly produced customized products, whereas a positive score meant that they produced standardized products. Similarly, a negative score for the degree of off-site fabrication meant that they primarily pursued on-site-based construction methods, whereas a positive score indicated that they used prefabrication to a higher extent. Based on these scores, the sample was grouped into four main product/process categories:

1. Those with low pre-engineering and high off-site fabrication.
2. Those with high pre-engineering and low off-site fabrication.
3. Those with high pre-engineering and high off-site fabrication.
4. Those with low pre-engineering and low off-site fabrication.

However, since some companies fell into multiple categories, four additional groups were added:

5. Those with no specific product (both high and low pre-engineering) and low off-site fabrication.
6. Those with no specific product and high off-site fabrication.
7. Those with low pre-engineering and no specific off-site fabrication.
8. Those with no specific degree of pre-engineering and no specific off-site fabrication.

The resulting eight categories that were derived from the data based on the degree of pre-engineering and off-site fabrication are illustrated in Figure 1. Due to the focus of the research being on building contractors, category 8 was excluded from the analysis, except for in the analysis of the number of operations, since this group only contained contractors pursuing other types of construction than building construction. Table 1 thus includes the 37 residential building contractors.

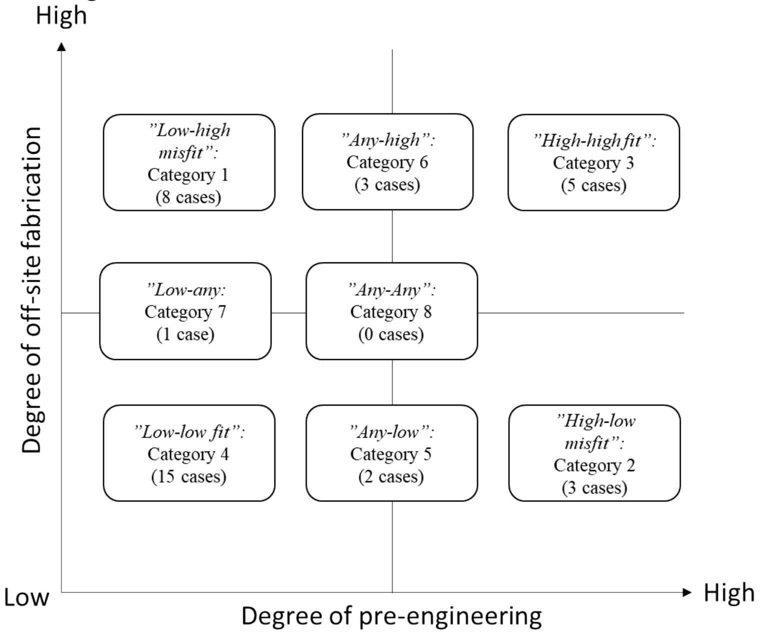

Figure 1 Categorization of the cases based on the degree of pre-engineering and off-site fabrication.

4 Results

4.1 Company size

Table 2 shows the means for the logistics organization design elements for medium and large sized residential building contractors (n=36). Company size is measured using both the annual turnover and the number of employees. Looking at the company size based on annual turnover, there is a tendency of medium-sized companies to pursue a slightly more centralized and formalized logistics organization design, with a higher division of labour than their large counterparts. The degree of integration within the logistics organization and with other functional areas is substantially higher for medium-sized companies than for large companies. These findings fall well in line with the expected results, in which larger companies tend to be more decentralized.

For the number of employees, one of the companies was removed since it employed less than 50 persons (but their annual turnover was over €10 million). Hence this sample consisted of 36 companies. Here, the number of employees indicate no noteworthy difference between medium and large-sized companies. The means for the logistics organization design are roughly equal across all four elements.

Table 2 Means for logistics organization design based on company size (standard deviation in parenthesis).

	Turnover (n= 37)		*Employees (n = 36)*	
Company size	Medium (€10-49 million)	Large (≥€50 million)	Medium (50-249)	Large (≥250)
Number of cases	n = 6	n = 31	n = 18	n = 18
Centralization	2,64 (1,21)	2,30 (1,33)	2,39 (1,39)	2,23 (1,06)
Formalization	3,05 (1,15)	2,88 (1,24)	2,85 (1,27)	2,87 (1,00)
Division of labour	2,54 (1,21)	2,41 (1,36)	2,31 (1,28)	2,42 (1,14)
Integration	3,57 (1,41)	2,77 (1,31)	3,06 (1,45)	3,02 (1,29)
*Logistics organization**	2,84 (1,23)	2,53 (1,29)	2,55 (1,34)	2,58 (1,13)

*1-5 (aggregated scores 1: project oriented, 5: company-level oriented).

Table 3 shows the number of cases in the product/process categories, including the means for the logistics organization across the three groups: local/regional, national, and international. Analysing the logistics organization, there is a clear pattern where local/regional companies have a more project-based approach to the logistics organization. A more long-term, company-level approach to the logistics organization is used in companies operating at the national level. This is even more apparent among companies operating internationally.

Table 3 Geographical market for the product/process categories.

*Geographical Market**	*L/R (n=17)*	*N (n=16)*	*I (n=4)*
Product: Pre-engineering			
High	4	2	2
Low	10	12	2
Process: Off-site fabrication			
High	5	8	3
Low	12	7	1
Product/Process category			
1 "Low-High misfit"	3	4	1
2 "High-Low misfit"	3		
3 "High-High fit"	1	2	2
4 "Low-Low fit"	7	7	1
5 "Any-Low"	2		
6 "Any-High"	1	2	
7 "Low-Any"		1	
*Logistics organization***	2.33	2.54	3.13

*L/R: local/regional, N: national, I: international
**1-5 (aggregated scores 1: project oriented, 5: company-level oriented).

4.2 Product, production process, and number of operations

Table 4 provides the results for the individual logistics organization design elements for the seven product/process categories. Among the 37 case companies, only 8 of them reported that they have a low degree of pre-engineering while 24 reported that their products use pre-engineering to some extent. 5 of the companies offer both a high and low degree of pre-engineering. When it comes to the degree of off-site fabrication, 20 of the companies (54%) reported a low degree of off-site fabrication while 16 reported that their processes use a high degree of off-site fabrication to some extent. Most of the companies fall into category 4 (n=15), followed by category 1 with 8 cases.

In overall, the mean for the logistics organization was 2.51 (indicating a slight favour of the project-based approach). Analysing the relation to the logistics organization, companies with a high degree of pre-engineering had a more long-term and company-level approach to the logistics organization. When it comes to the degree of off-site fabrication, there was large difference when it comes to the logistics organization, where companies with high degree of off-site fabrication also had a more company level approach. When it comes to the logistics organization, companies belonging to category 6 had the highest mean when it comes to the degree of centralization, formalization, specialization, and integration in the logistics organization (2.79), followed by category 3 (2.76) and category 1 (2.65).

In addition to the degree of pre-engineering and off-site fabrication, there were some notable patterns for the number of operations (i.e., the number of different types of construction) and the logistics organization design. Therefore, to investigate whether the number of different types of construction affect the logistics organization, the full sample of the 52 companies was included in this analysis. The companies pursuing one type of construction had the most centralized, formalized, integration, and the highest division of labour. When companies pursue two or more types of construction, the logistics organization design becomes less centralized, formalized, integration, and with a lower division of labour. There were some minor differences between pursuing two, three, or four or more types of construction, but the largest difference was seen between pursuing one or multiple types of construction. Table 4 provides the results of the analysis of the number of operations and logistics organization design elements.

Table 4 Results of the logistics organization design elements based on the product/process categories and number of operations.

Element	*Centralization*		*Formalization*		*Division of labour*		*Integration*	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Product: Pre-engineering								
High	2,33	1,04	2,88	1,04	2,40	1,04	3,00	0,87
Low	2,31	1,04	2,94	1,26	2,08	0,82	2,89	1,22
Process: Off-site fabrication								
High	2,48	1,14	3,00	1,26	2,22	0,98	3,46	0,69
Low	2,32	0,99	2,95	1,13	2,11	0,83	2,45	1,21
Product/process category								
1 "Low-High misfit"	2,25	0,99	3,08	1,31	2,09	0,79	3,54	0,80
2 "High-Low misfit"	1,89	0,51	2,78	1,07	2,53	0,76	2,22	0,69
3 "High-High fit"	2,6	1,23	2,93	1,14	2,32	1,25	3,47	0,61
4 "Low-Low fit"	2,42	1,08	2,98	1,24	2,14	0,84	2,62	1,30
5 "Any-Low"	2,17	1,18	3	0	1,23	0,04	1,50	0,71
6 "Any-High"	2,89	1,64	2,89	1,84	2,40	1,31	3,22	0,69
7 "Low-Any"	1,00	0	1,33	0	1,00	0	1,67	0
Number of operations								
1	2,82	1,30	3,44	1,44	2,49	1,10	3,33	0,92
2	2,26	0,84	2,79	1,16	2,13	0,66	3,03	1,00
3	2,19	0,73	3,00	0,88	1,91	0,89	2,92	1,33
4 or more	2,26	1,03	2,88	1,19	1,98	0,91	2,40	0,82

*SD: Standard deviation

4.3 Operational performance

Table 5 provides the results across the four performance categories: cost, quality, delivery, and flexibility. The results reveal some notable patterns for the four individual performance categories. Those excelling in cost performance belong to category 1, which are characterized by a low degree of pre-engineering and a high degree of off-site fabrication. The mean for the logistics organization is 2,65, indicating a slight company-level oriented approach. The worst performers are found in category 4, which combines a low degree of pre-engineering and off-site fabrication with an aggregated mean of 2,48 for the logistics organization. This suggests that cost performance is the lowest among contractors pursuing traditional site-based construction with little to no off-site fabrication.

Quality performance was the highest among cases in category 5 and was associated with no specific degree of pre-engineering and a low degree of off-site fabrication. The logistics organization were project oriented with a mean of 1,89 for the cases in category 5. The worst performers are found in category 1, which exhibit a low degree of pre-engineering and a high degree of off-site fabrication. The mean for their logistics organization is 2,65, suggesting a slight company-level oriented approach.

Regarding delivery performance, the best performers are found in category 6 (any degree of pre-engineering with a high degree of off-site fabrication). The mean for the logistics organization is 2,79, suggesting a slight company-level oriented approach.

Flexibility performance was the highest among the cases with a low degree of off-site fabrication and low or any degree of off-site fabrication (categories 2 and 5). The means for the logistics organizations also indicate a slight project-oriented approach. The lowest flexibility performance is found among cases with a high degree of pre-engineering and off-site fabrication (category 3). They also exhibit the most company-level oriented approach in their logistics organization out of the seven categories.

The results indicate that there is no clear pattern regarding the logistics organization design and whether a certain logistics organization design is superior to another. Moreover, they suggest that the logistics organization design *per se* is not associated with operational performance, but the fit between the degree of pre-engineering, the degree of off-site fabrication, and the logistics organization.

Table 5 Operational performance of the product/process categories.

Product/ Process category	*Logistics organization**	*Cost*	*Quality*	*Delivery*	*Flexibility*
1 "Low-High misfit"	2,65	4,19	3,94	4,19	3,79
2 "High-Low misfit"	2,38	3,83	4,33	3,83	4,11
3 "High-High fit"	2,76	3,60	4,20	4,30	2,33
4 "Low-Low fit"	2,48	3,53	3,91	3,93	3,56
5 "Any-Low"	1,89	4,00	4,50	4,25	4,17
6 "Any-High"	2,79	3,67	4,22	4,33	3,33
7 "Low-Any"	1,21	4,00	4,00	4,00	4,00

*1-5 (aggregated scores 1: project oriented, 5: company-level oriented).

5 Discussion and further research

The purpose of this paper was to investigate the logistics organization design among residential building contractors. The findings supported the contingency argument for logistics organization design, emphasizing that one size does not fit all. The findings are discussed further in the following sub-sections, along with a discussion of the limitations of the study and suggestions for further research.

5.1 Company size

The results indicate that company size, does not seem to have a clear effect on logistics organization design. Contractors with more employees had a more centralized logistics organization, whereas the contractors with the highest turnover had a more decentralized logistics organization. There might be several reasons for this anomaly: 1) the use of sub-contractors among building contractors makes the number of employees a misleading measure, and 2) company size does not affect structure, but is rather a result of pursuing a certain organization design.

The use of sub-contractors is the norm in the construction industry, which enables smaller firms to specialize in a specific type of construction (Kristiansen *et al.*, 2005). Larger contractors rely on smaller contractors (or sub-contractors) to deliver project that are outside their expertise. Therefore, a building contractor with a few employees that use sub-contracting extensively can achieve a higher turnover than larger counterparts that do not rely as heavily on sub-contracting. The number of employees can thus be a misleading measure of company size as a contextual factor. This can potentially explain the contradiction in why the degree of centralization was higher for building contractors with a higher number of employees.

In the general organization design literature, the effect of company size on the organizational structure has been debated. Previous studies suggest that company size reduces the need for centralized control, which implies that that size determines structure (Pugh *et al.*, 1968, Pugh *et al.*, 1969). However, these studies only analyzed the correlation between company size and organizational structure but did not determine the cause-effect relationship between the two. Other studies have shown that it is mainly technology (which typically refers to product and production process characteristics for a producing company) that determine organizational structure (Woodward, 1958, Blau, 1970). This can potentially explain why product and production process characteristics more clearly affected the design of the logistics organization than the overall company size. Although the number of employees and the logistics organization structure can be expected to correlate with each other, the findings indicate that the former is not a direct cause of the latter. Instead, the authors suggest that the annual turnover is complemented by the contractor's total value of their project portfolio, which is retrieved by the sum of the contractor's project sums. This captures both the internal and external resources employed in projects (including sub-contractors) rather than solely the internal resources.

5.2 Product and production process characteristics

The findings reveal a notable pattern in the fit between product and production process characteristics among building contractors. One notable observation is the perceived lack of a conscious decision-making process in this regard. This is apparent among the cases within category 5 and 6 that appears to shift between a high and low degree of pre-engineering in their projects while their degree of off-site fabrication remains stable (see Figure 1). It suggests that some companies may not be making conscious strategic decisions in matching their degree of pre-engineering and off-site fabrication, but rather making decisions in a more reactive or implicit manner.

Regarding the decision related to the degree of off-site fabrication, the annual turnover of the company appears to have an influence. The findings indicate a positive relationship – as the turnover of a company increases, it tends to adopt higher degree of pre-engineering. In other words, larger companies exhibit a trend towards an increased use of prefabrication, implying that they are more likely to adopt industrialized and standardized methods in their operations. This could be explained by a need for larger organizations to streamline their processes to cope with their scale. Furthermore, larger companies may be able to take more risks and invest in off-site facilities than smaller companies due to higher production volumes to offset the initial investment and maintenance costs (Peltokorpi *et al.*, 2018).

Another noteworthy finding is the inverse relationship identified between company size and the offering of customized products. Contrary to the case of their production process characteristics, larger companies are reported to provide more customized products (i.e., a low degree of pre-engineering). This finding contradicts with the high degree of off-site fabrication, which typically means that they would opt for a high degree of pre-engineering. Instead, it suggests that larger building contractors might leverage their resources and capabilities to offer a broader spectrum of customized products.

Furthermore, the findings propose additional insights regarding larger companies. Besides the tendency for larger organizations to provide more customized products, they also tend to pursue multiple types of construction to a greater extent than their smaller counterparts. This diversification strategy aligns with the low degree of pre-engineering, allowing larger companies to cater to a wider range of client needs and project requirements. An increasing number of operations was also related to a more decentralized logistics organization, along with a lower degree of formalization integration, and division of labour. This can be explained by the need for autonomous logistics decision making when the company has multiple strategic business units that are operationally independent from each other, creating autonomous logistics decision areas (Persson, 1978). Hence, general-purpose contractors should be expected to be more decentralized in their logistics organization due to the heterogeneity in their markets, products, and production processes.

In summary, the findings suggest that larger companies favour a high degree of off-site fabrication but are at the same time offering more customized products across different types of construction. This introduces a question regarding how building contractors make strategic choices regarding their products and production processes. Several studies have pointed out that these types of decisions typically are made at the middle-level of the organization, rather than by a top management team (Koch *et al.*, 2015, Simu and Lidelöw, 2019, Elfving, 2021). It can therefore be expected that the degree of pre-engineering and off-site fabrication varies across different regional division and/or business areas, particularly among contractors operating in diverse industry segments. However, further research is needed to reveal the factors influencing the strategic decision-making in construction companies, with an emphasis on understanding how building contractors make product and production process-related decisions.

5.3 Logistics organization design

The findings support the contingency argument regarding logistics organization design, i.e., that one size does not fit all. The contractors with the highest degree of off-site fabrication (category 1, 3, and 6 in Figure 1) had the highest degree of centralization, formalization, integration, and a high division of labour. The influence of the degree of pre-engineering on the logistics organization design was not as apparent, where contractors that produced both standardized and customized products combined with a high degree of off-site fabrication were also highly centralized, formalized, integrated, and with a high division of labour.

The findings indicated that the degree of off-site fabrication affects the logistics organization design. As the degree of off-site fabrication increases, so does the degree of centralization, formalization, integration, and the division of labour in the logistics organization. This supports previous research on logistics organization design within manufacturing (Pfohl and Zöllner, 1997, Dröge and Germain, 1998, Nakano and Matsuyama, 2021, Nakano and Matsuyama, 2022). However, a main difference between the more repetitive types of manufacturing and construction is the project-based, engineer-to-order type of production. Furthermore, the final assembly, regardless of the degree of off-site fabrication, is performed at the construction site. This means that building contractors must also manage resource flows to and from the construction site although the degree of off-site fabrication is high. The results indicated that there was a marginal difference in the logistics organization design when comparing the companies that had a low and high degree of off-site fabrication. The need for on-site logistics capabilities remains even though most value-adding is performed in an off-site factory (Arashpour *et al.*, 2017). Such contractors should therefore be expected to combine centralized and decentralized logistics, although they might lean towards a more centralized logistics organization structure.

5.4 Operational performance

The results did not reveal any notable patterns of whether a certain logistics organization structure is superior, suggesting that the “ideal” design of logistics organization depends on product and production process characteristics. This can be related to the building contractors’ overall competitive priorities, in which prioritizing certain performance categories need to be reflected by selecting an appropriate configuration of products, production processes, and logistics organization. The findings support prior studies that suggest that product standardization and prefabrication are beneficial to increase cost performance, while a higher degree of customization and site production lead to higher flexibility (Jonsson and Rudberg, 2017). Besides confirming this prior research, the findings of this research suggest that the logistics organization design is expected to vary based on product and production process characteristics. The absence of a superior logistics organization design in terms of overall performance further supports this argument that different logistics organization designs are feasible under different conditions.

5.5 Limitations and further research

One potential limitation of this study lies in the potential bias introduced by respondents working within an SBU. Respondents may provide answers on behalf of the SBU, potentially overlooking nuances within different SBUs. This could lead to a generalization of practices that may not be representative of the entire organization.

Additionally, the relatively small sample size of 52 companies may introduce some uncertainty in the generalizability of the results. While efforts were made to select a representative sample from a targeted population of building contractors, the limited size may impact the robustness and applicability of the findings. It is important to acknowledge that individual variations among companies within the sample may not capture the full spectrum of diversity in the broader population of medium to large building contractors. Furthermore, the use of prefabrication might be more widespread in the Nordic countries than in other parts of the world. These limitations highlight the need for caution in generalizing the findings beyond Sweden, Norway, Finland, and Denmark and emphasize the potential for further research with larger and more diverse samples to validate and extend the findings.

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Paper 3

Flow design in site-based production using decoupling thinking: The case of industrialized housebuilding

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Flow Design in Site-Based Production Using Decoupling Thinking: The Case of Industrialized Housebuilding

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Abstract. Site-based production is typically used when the end-product is immovable once it has been assembled and/or due to weight and space constraints in the production and transportation system. It is primarily an engineer-to-order (ETO) type of production with a high level of customization and includes multiple value-adding locations that converge into a final assembly location with a higher or lower number of site-based activities. Most studies of operations with site-based production consider the separation between speculation-driven and customer order-driven activities and a few studies also consider customization activities. However, when it comes to planning and control methods and how to organize logistics, there has been little consideration of where the activities take place in site-based production. Hence, there is a need to make a combined assessment of the location of activities, customer order driven activities, and customization activities. The purpose of this paper is thus to develop a typology that provides a holistic view of operations including site-based production. A flow-based typology is therefore developed to assess combinations of three dimensions: flow driver (speculation/customer order), flow differentiation (standard/customized), and flow location (supply site/delivery site). The production flow is thereby divided into sub-flows by using decoupling thinking for flow driver, differentiator, and location. The typology is illustrated using two cases from the building construction industry, indicating that flow location must be considered when selecting appropriate planning and control methods and in the organization of logistics. Future studies should investigate how the typology can be applied to other types of construction and ETO industries. As such, the typology can be used to benchmark different industries with site-based production to address common challenges and identify best cases.

Keywords: construction industry, case study, decoupling point, logistics management

1. Introduction

Construction always carries some element of on-site production because the final product is too heavy and/or too large to move when it has been assembled (Ballard and Howell, 1998). It is therefore necessary to ensure that on-site activities can be performed as efficiently as possible. While on-site production typically is associated with construction, its underlying principles can be extended to other industries as well that face similar challenges related to site-based production. By learning from practices used in on-site production in construction, industries such as aerospace, shipbuilding, and energy can improve their production processes. Just as in construction, these sectors can perform the final assembly and installation on-site. Moreover, by the use of prefabrication, these industries can identify opportunities to enhance efficiency by performing certain activities upstream[1] of the final delivery site in the supply chain (Jonsson and Rudberg, 2014). Here the construction industry serves as an example of site-based production, and how it can be used for benchmarking site-based production to other industries.

In construction, the final assembly of the building is performed at the construction site, which is referred to as "on-site production" (Ballard and Howell, 1998). On-site production is usually, but not necessarily, organized as a fixed position layout, where production resources (materials, machines, and workers) are moved to the site where the final installation and assembly of the end-product are performed (Hill and Hill, 2009). Compared to "off-site production", which refers to the flow upstream of the final installation, typically in a factory, on-site production is characterized by higher complexity in terms of production planning and control, and in managing logistics.

In contrast to repetitive production using, for example, line flow layouts, on-site production activities in construction are characterized by reciprocal interdependencies (Bankvall *et al.*, 2010). Reciprocal interdependencies refers to a mutual reliance between various activities, where the execution of one activity is dependent upon and influences the execution of others, creating a tightly interconnected and interdependent flow (Thompson, 1967). Adding to this is the frequent use of sub-contractors in construction, which requires frequent and close coordination between on-site activities performed by different actors. Managing on-site production and logistics is thus more complex compared to repetitive production off-site.

The challenges involved in on-site production, coupled with the advantages offered by off-site production, have driven certain building contractors to adopt a hybrid approach that combines both on-site and off-site production methods. To address this challenge, the concepts of supply site(s) and delivery site are used in this paper to divide the flow into two parts based on the flow location, i.e., where the flow of activities is located. For instance, in construction, some activities can be performed more efficiently in a controlled factory environment, i.e., the supply site(s) located upstream in the value chain of the final assembly, which is performed at the delivery site. The supply site(s) resembles a traditional industrial production system in which the product is moved between fixed production resources, in contrast to the delivery site where resources are moved to the site and to the product at site. This type of hybrid production system creates significant differences in terms of activity interdependence between activities performed at the supply site(s) and a delivery site. This suggests that different production planning methods and approaches to logistics management are required within the production system.

A method to distinguish the supply site(s) from the delivery site is decoupling thinking. In a production environment, the notion of decoupling thinking involves separating the production flow into sub-flows based on their different characteristics (Wikner, 2014). The most common use of decoupling thinking is the separation of the

[1] "Upstream" and the related term "downstream" refer to the separation of material flow into the flow towards and away from an organization, production network node, or similar. The assumption is that the flow is one-directional, but this is not necessarily the case in every situation (the customer can sometimes become the supplier, e.g., in circular supply chains or for reverse material flows). However, for the sake of simplicity, this paper only takes the one-directional material flow into consideration.

speculation driven and customer order driven part of the flow using the customer order decoupling point (Hoekstra and Romme, 1992, Wortmann *et al.*, 1997). A further development in the distinction between speculative and customer order driven segments in the flow is presented by Wikner and Bäckstrand (2018). They expand on the customer order driven flow by sub-dividing it into standardized and customized sub-flows.

Decoupling thinking is used in this paper to expand on the customer order driven and customized flow by differentiating the location of the flow between the supply site(s) and the delivery site. Construction suffers from poor resource utilization in off-site production (Arashpour *et al.*, 2018), long lead times in on-site production (Arashpour *et al.*, 2016), and extensive challenges related to managing the interface between off-site and on-site production (Pan *et al.*, 2023). By using decoupling thinking for flow design, it is possible to identify where in the flow certain planning and control methods should be used, and how to manage logistics given the unique circumstances of a particular flow design with respect to the flow location.

The purpose of this paper is to develop a typology that provides a holistic view of delivery site activities in relation to customer order driven and customization activities. The typology can be used for flow design within companies that have elements of site-based production. Furthermore, the typology can provide guidance for how to manage a combination of supply site and delivery site activities more efficiently by applying appropriate planning and control methods given the planning conditions at the two types of sites. Additionally, the typology can be used for assigning appropriate roles and responsibilities for logistics management in both supply site and delivery site logistics. The similarities between construction and other types of site-based production entails that the typology can be used for cross-industry benchmarking to facilitate learning across industries that face similar challenges. However, in this paper, the cases used to illustrate the typology are limited to the construction of buildings with a relatively high level of off-site production compared to contractors performing most activities at the construction site.

The paper is structured as follows. Next the method behind the study is presented, including how the typology was developed and how the cases were selected. In the following section, the dimensions of the typology are described, followed by a description of the full typology. The typology is then applied to two cases to illustrate is applicability on two building contractors. This is followed by discussion of the paper results and findings, and conclusions with suggestions for further research.

2. Method

The purpose is fulfilled through a combination of conceptual and empirical research. The conceptual part of the research includes a review of literature of two of the typology dimensions: flow driver (speculation/customer order driven part of the flow) and flow differentiation (standardized/customized part of the flow). The third typology dimension, flow location (off-site/on-site part of the flow) was developed through conceptual reasoning. Typologies, which comprise of two or more dimensions, are used when one dimension is insufficient to explain a phenomenon (Meredith, 1993). For this paper, the three-dimensional typology was developed by combining the three dimensions: flow driver, flow differentiator, and flow location. The empirical part featured case examples illustrating the typology applied to two industrialized building contractors. The purpose here was not to use the two cases to verify the typology. Instead, the case examples were used to demonstrate how the typology can be applied in practice in terms of selecting appropriate production planning and control methods and adopting suitable logistics organization configurations based on the specific characteristics of the flow.

2.1 Case Selection

The empirical part of the research contains two case examples. The cases have different characteristics within the three dimensions and were selected to explain the expected similarities (and to identify unforeseen differences) between building contractors' using the typology, i.e., on the basis of theoretical replication (Eisenhardt, 1989). To illustrate the typology, the case examples included in this study have a relatively high degree of off-site production to make a clear illustration of flow location.

The selected cases are companies within the building construction industry in which there are clear challenges related to combining supply site and delivery site activities. Furthermore, the study was limited to building construction to exemplify the typology rather than to draw conclusions based on the cases. The typology can be applied to other types of construction with little or no off-site fabrication and to other ETO industries with similar challenges related to site-based production. However, in this paper the focus was on building construction since this enabled a close comparison of the cases and how they could illuminate the typology. Other types of construction and ETO industries are left out for future studies.

Case company 1 is a residential housing developer with in-house land acquisition, design and engineering, factory production and site assembly. They deliver complete residential areas and takes responsibility for starting housing cooperations. Their building system comprises standardized modules that are configured into project-unique buildings by their design and engineering team. Their off-site factory, producing the volumetric modules, is in the southern part of Sweden and their projects are typically located in sub-urban or urban areas.

Case company 2 is an industrialized building contractor with primarily external clients. They build condominiums, student apartments, rental properties, senior housing, and hotels. The building system is flexible, and each volumetric module is project unique. The volumetric modules are limited only by the external dimensions due to load-bearing considerations, openings, and size constraints in the factory production and transportation. Their off-site factory, producing the volumetric modules, is in the northern part of Sweden, but they have projects in most parts of Sweden.

2.2 Data Collection and Analysis

The data from the case examples were collected through internal company documents, semi-structured interviews, site and factory visits, and publicly available information from the case companies' websites. The main data source was company documents that the researchers acquired from the companies. This included most of the information required to create time-phased work-breakdown structures (WBSs, see Figure 2 and Figure 4), such as activity times and the activities' characteristics (speculation/customer order driven, standardized/customized, and supply site/delivery site). However, additional data were collected to ensure the reliability of the data retrieved from the secondary data, which were mainly from the internal company documents. Semi-structured interviews were held with key persons in each case company.

For case company 1, one interview was held with the head of research and development to verify the time phased WBS. One interview was deemed enough since the researchers already possessed a substantial amount of data about this company. For case company 2, the researchers did not have as much information regarding product variants, activity lead times, and the production system. Therefore, one online interview was held with the digitalization manager (who also works with production and logistics-related development). This was followed by a visit at the company's off-site factory. The company visit began with a factory tour, which was followed by a group interview with the digitalization manager, logistics manager, purchasing manager, and the process owner for volumetric module production. The data collection, including the method and the type of data, is summarized in Table 1.

Table 1. Summary of the case data collection.

Data collection method	Data sources		Type of data
	Case 1	Case 2	
Company documents	5 Power Points files Architectural manual	1 Power Point file	Product variants and customization, organizational charts, project time plans, lead times, process, and activity descriptions.
Semi-structured interviews	2 online interviews	2 online interviews and 1 face-to-face	Verification of secondary data, including lead times and planning methods.
Factory visits	Past visits to the off-site factory, but not specifically for this study	1 visit in the off-site factory	Verification of secondary data, process and activity description, lead times.
Site visits	Past visits to project sites, but not specifically for this study	Past visits to project sites, but not specifically for this study	Verification of secondary data, process and activity description, lead times.
Publicly available information	Information on company website	Architectural manual Information on the company website	Product variants and customization.

The data was used to develop WBSs that represented a typical project for each case company. Some activities and work packages were excluded since this would result in an excessively complex WBS given the purpose of using the cases to illustrate the typology. Hence, the WBSs comprised of the main work packages, e.g., foundation work, volumetric module production, roofing works, and critical components purchased from suppliers.

When the WBSs were developed, the data regarding activity times and the activities' properties were used to create a time phased WBS for each case. This method involves adding information about activity times for each activity in the WBS. Typically, this method has been used for bill-of-materials (see, e.g., Bäckstrand and Wikner, 2013). The method involves illustrating the lead time for each activity by the length of the activity's arrow. The cumulative lead time of the activities in the longest branch in the time phased WBS is thus the supply lead time to deliver the project. The delivery lead time is the time the customer is willing to wait for the project. The remaining lead times to identify are then the adaption lead time and the delivery site lead time. These two lead times are determined by the activities' properties, i.e., whether they are standardized/customized and at the supply site(s)/delivery site.

3. A Typology for Flow Design

This section provides a description of the three dimensions for flow design: flow driver, flow differentiator, and flow location. The dimensions are based on lead time relations between several strategic lead times, namely the supply lead time (*S*), the delivery lead time (*D*), the adaption lead time (*A*), and the delivery site lead time (*L*). *S* is cumulative lead time for all engineering and production activities. However, due to the focus on flow location in this paper, the engineering part of the flow is omitted to focus on the production part of the flow. For the three remaining lead times, *D* is the delivery lead time required by the customer, *A* is the time required for customization activities according to customer's requirements, and *L* is the time for delivery site activities.

To make a combined assessment of decisions within the three dimensions, the three dimensions have been combined in Figure 1. The figure illustrates the relationship between the respective lead times. Furthermore, the figure implies that the lead time for customization (*A*) and delivery site (*L*) activities should typically not exceed the delivery lead time (*D*). Delivery site activities that are performed under speculation can involve a high risk, but can be used in some cases, e.g., contractors that pursue speculative housebuilding. Supply site activities are can, however, be performed on speculation, wherefore *L* is investigated in relation to *S*.

This typology can be used to outline recommendations concerning appropriate production methods, investments in off-site facilities, guidelines for design and engineering activities (e.g., what level of customization to offer clients), implement appropriate planning and control methods, design a suitable logistics organization, to name a few. The next sub-sections contain descriptions of each of the three dimensions in the typology, namely flow driver, flow differentiator, and flow location.

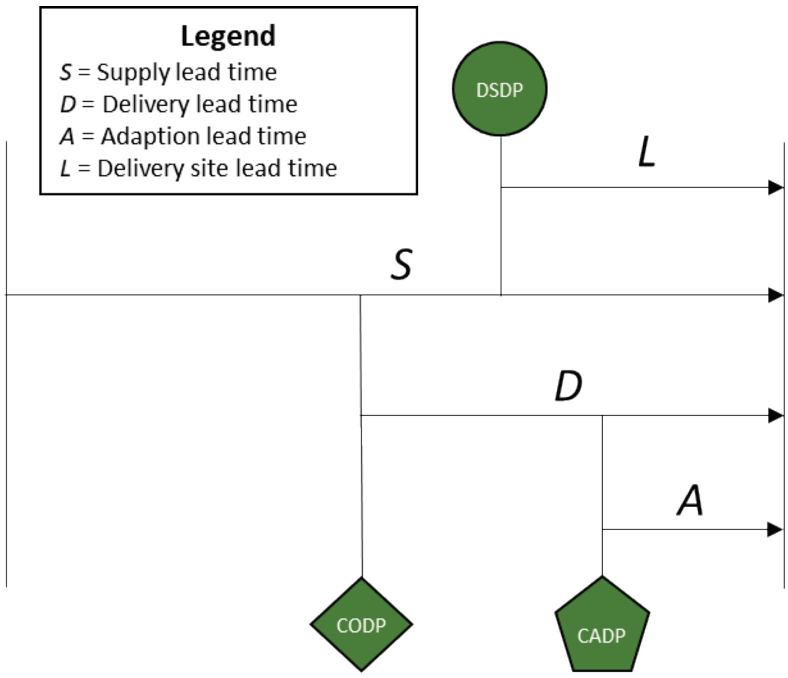

Figure 1. A typology for flow design based on decoupling thinking.

3.1 Flow Driver

The flow driver indicates whether activities are performed based on customer order or forecast. The Customer Order Decoupling Point (CODP) is an established term in operations management and denotes where in the flow that activities are driven by customer order by decoupling forecast driven and customer order driven activities (Hoekstra and Romme, 1992). The positioning of the CODP is determined by the relationship between the supply lead time (*S*) and the delivery lead time (*D*) (Bäckstrand and Wikner, 2013). When *S* is longer than *D*, some supply activities will need to be performed to forecast. If *S* is much longer than *D*, this will result in a make-to-stock or a assemble-to-order (depending on how much longer *S* is relative to *D*) situation since many, or all, activities need to be performed to forecast. When the *D* is equal to or longer than the *S*, all activities can be performed based on a customer order. Table 2 shows examples of the *D:S*-relation.

Table 2. *D:S*-relation.

D:S-relation	Example
$D << S$	Make-to-stock (MTS)
$D < S$	Assemble-to-Order (ATO)
$D \geq S$	Make-to-Order (MTO) or Engineer-to-Order (ETO) depending on whether engineering activities are included or not.

3.2 Flow Differentiator

The term flow differentiator denotes where in the production flow activities go from being market or customer generic (i.e., standardized) to customer order unique (i.e., customized). To separate these two sub-flows, the term Customer Adaptation Decoupling Point (CADP) is used. The positioning of the CADP is determined by the relationship between the adaption lead time (*A*) and the required delivery lead time (*D*) (Bäckstrand and Wikner, 2013). In other words, the relationship between *A* and *D* denotes how much of *D* that is customer order unique. A longer *A* than *D* should be avoided since it means that some forecast driven activities are also customized. On the other hand, most order driven activities can be standardized when *D* is much longer than *A*. Some order driven activities may also be standardized when *D* is slightly longer than *A*. When the two are equally long, the customer order driven activities are also customized.

It is also possible to consider *A* from a supply perspective, where *A* is compared with *S.* In contrast to the *A:D*-relation, which indicates how long the customer is willing to wait for making adaptions, the *A:S*-relation determines the part of the flow that can be customized (Bäckstrand and Wikner, 2013). Here, the possible activities that can involve adaptions are determined by *D*, where customer order unique adaptions are only possible after the CODP (Wikner, 2018). In this paper, however, only the *A:D*-relation is considered because the focus is on to what extent the flow is customer order unique rather than what is possible. Table 3 shows some examples of the *A*:*D*-relation.

Table 3. *A:D*-relation.

A:D-relation	Example
A << *D*	Almost all activities are standardized (customer generic).
A = *D*	Customer order driven activities are also customized.
A > *D*	Some forecast driven activities are customized (involves a high risk and should therefore be avoided).

3.3 Flow Location

Flow location is concerned with the location of activities that are either performed at the site, where the final delivery is made, or, at a facility that is positioned upstream of this delivery site, i.e., the supply site(s). The two sub-flows are separated by the Delivery Site Decoupling Point (DSDP), which denotes the relation between the lead time for delivery site activities (*L*) and the supply lead time (*S*). In site-based production (e.g., construction), *L* is longer than zero, while *L* is approximately equal to zero for pure distribution services with very little value-adding at the delivery site.

In ETO fixed position production, it is common that the product remains in one position and resources are moved to the product. This location is typically specified by the delivery site. The DSDP indicates where the flow goes from the supply site(s) to the delivery site. Hence, the DSDP denotes where in the flow activities are performed at the delivery site and at supply site(s), respectively. For instance, for a building contractor, the DSDP separates prefabrication from activities performed at the construction site. It thereby differs from related concepts in construction literature that are based on the degree of value adding that is performed off-site (Jonsson and Rudberg, 2015). The position of the DSDP is instead based on lead times to enable an assessment of whether order driven activities are performed at the delivery site (on-site) or at the supply site(s) (off-site).

A much longer *S* than *L* means that the final assembly at the delivery site is very short relative to the supply lead time. This is typically uncommon in building construction but can be the case for smaller buildings with a very low degree of value adding on-site, such as prefabricated single-family dwellings that are assembled in one or a few days. When *S* is longer than *L*, a larger share of the supply lead time takes place at the delivery site, although there still can be a considerable amount of the supply lead time that takes place at the supply site(s). When *S* is equal to *L*, all activities are performed at the delivery site. *L* should not be longer than *S* since this would mean that delivery site activities take longer than the cumulative lead time (*S*). In non-site-based production, *L* is approximately equal to zero. This means that the product is finished once it arrives at the delivery site where there are no finishing assembly works performed. Here there are no elements of site-based production, but it might include very short delivery site activities, e.g., replenishing goods on the customer's shelves. Table 4 shows some examples of the *L*:*S*-relation.

Table 4. *L:S*-relation.

L:S-relation	Example
$L << S$	Most of the flow is at the supply site with a very short assembly time at the delivery site.
$L < S$	The flow takes place both at the delivery site and supply site(s).
$L = S$	The entire flow is performed at the delivery site.
$L > S$	Not possible.
$L \approx 0$	The lead time at the delivery site is approximately equal to zero, which means that almost no activities (e.g., assembly) are performed at the delivery site.

4. Case Illustrations

In this section, the three-dimensional typology is applied to two case companies within building construction. Although one or two dimensions can be used to analyze one or two aspects of the flow, for the purpose of this paper, the focus is on the three-dimensional typology. Each case is analyzed by positioning the CADP, CODP, and DSDP in relation to each other in a time phased WBS of a typical project in the two case companies. Table 5 shows an overview of the cases' lead time relations reported as a percentage for flow driver (*D:S*-relation), flow differentiator (*A:D*-relation), and flow location (*L:S*-relation). The table presents approximate lead time relations because the lead times are retrieved from typical projects in the two case companies. As such, the lead times, and thus the lead time relations, can differ slightly between projects. Furthermore, the column containing the *L:S*-relation also show the approximate percentages of value-adding performed at the construction site in each case.

Both cases are considered ETO because design and engineering activities are performed after the customer order has entered the flow. However, since the focus of this paper is on supply and delivery site activities, design and engineering activities are not explicitly considered in the analysis. However, to calculate the *D:S*-relation and the *A:D*-relation, the lead time for design and engineering needs to be included *D*. This is done by adding 30 weeks (which is the estimated time required for design and engineering activities in both cases) to the supply lead time for each case. The two cases also have standardized and customized sub-flows, but to different extents. Finally, the share of delivery site activities in relation to the project lead time (*S*) is similar for both cases and they differ slightly in terms of the amount of value-adding performed at the delivery site.

Table 5. Overview of the lead time relations in the two cases.

Case	*D:S*-relation	*A:D*-relation	*L:S*-relation
1	$D:S \geq 100\%$ (ETO)	$A:D \approx 35\%$ (Standardized and customized)	$L:S \approx 55\%$ (Value-adding during $L \approx 25\%$)
2	$D:S \geq 100\%$ (ETO)	$A:D \approx 40\%$ (Standardized and customized)	$L:S \approx 60\%$ (Value-adding during $L \approx 20\%$)

4.1 Case 1

Figure 2 illustrates a simplified WBS of a typical project in case company 1. The building system uses seven standardized volumetric modules that are combined into customized product variants. The volumetric modules are produced in the company's off-site factory and are completed with functional spaces that enclose bathroom, entrance, kitchen, and bedroom (see the S-branch in Figure 2). The volumetric modules are also installed with electrical fittings, plumbing, façade material, windows, doors, etc. However, earth- and foundation work is performed in parallel with the volumetric module production (see the V-branch in Figure 2). When the volumetric modules have been assembled in the factory, they are transported to the construction site for final assembly (activity W in Figure 2). Here the contractor supplies elevators, exterior corridors, and balconies that are delivered from the suppliers directly to the construction site (see activity J, K, and L in Figure 2). When the volumetric module assembly, roofing works, and the assembly of components purchased from suppliers are completed, the contractor performs internal and external finishing works comprising approximately 24 weeks (see the Z-branch in Figure 2). Since the company is a housing developer that deliver complete residential areas, the delivery site activities involve construction of common facilities, such as the inner courtyard, waste room, parking lots, etc., but that is not included in this example.

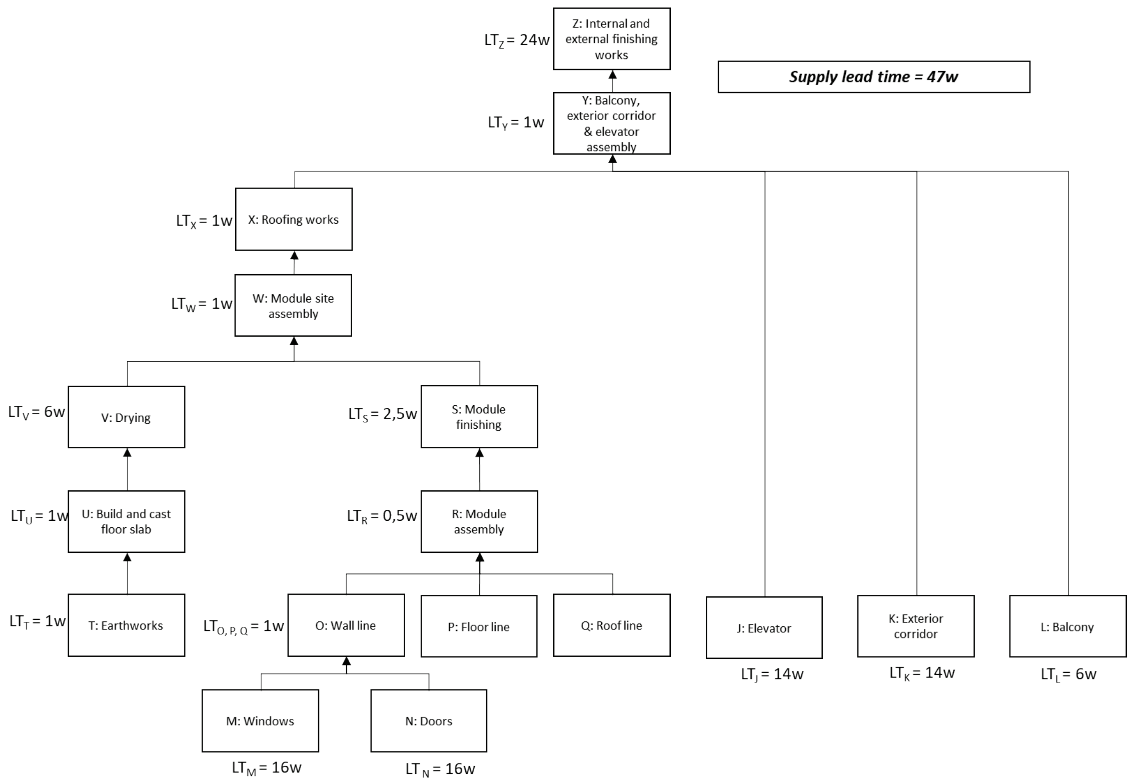

Figure 2. A simplified WBS of a typical project in case company 1.

S is 47 weeks, where most of the lead time is the internal and external finishing works at the construction site. The lead time for windows and doors from suppliers are 16 weeks, which further extends the supply lead time. Figure 3 depicts the time phased WBS of case company 1's typical project.

The entire flow is typically ETO from the contracting division in the company. Apart from conceptual designs, all engineering, and production activities are performed after the company's housing development division places an order for a new project (design and engineering are, for the purpose of the paper, omitted from the analysis). *D* is thus longer than *S*. However, a considerable part of the flow involves standardization activities. Customization activities do not take place until after the volumetric modules have been completed in the factory and shipped to the construction site. Here the final building is customized by configuring the standardized modules into project unique buildings. *A* (27 weeks) is thereby significantly shorter than *S*.

The lead times for delivery site activities differ between the different work packages in the WBS. Earth and foundation work (the V-branch in Figure 3) are performed at the delivery site (*L* = 8 weeks). For the volumetric modules (the S-branch in Figure 3), the DSDP coincide with the CADP. For the purchased material (activity J, K, and L in Figure 3), the supply site activities correspond to the suppliers' lead times and the delivery site lead times correspond to the final assembly at the construction site.

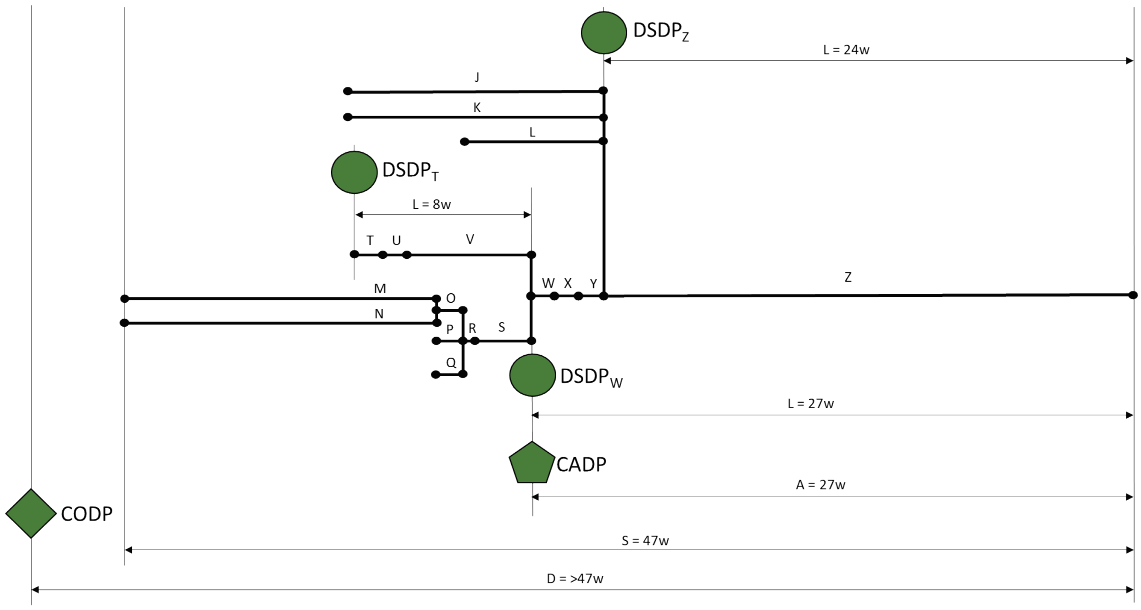

Figure 3. A simplified time phased WBS of a typical project in case company 1.

4.2 Case 2

Figure 4 illustrates a simplified WBS of a typical project in case company 2. In contrast to case company 1, case company 2 is a building contractor with external clients. The volumetric module fabrication is performed based on a customer order in an off-site factory (the Q-branch in Figure 4). Earth- and foundation works are performed in parallel with volumetric module production (see the T-branch in Figure 4). The volumetric modules are then assembled on-site (activity W in Figure 4). When the volumetric modules have been assembled, the roof is constructed and lifted on top of the volumetric modules (activity X in Figure 4). Thereafter, the façade and the elevator shaft are assembled (activity Y in Figure 4). The elevator and balconies are then transported to the site from the suppliers (see the U- and V-branches in Figure 4). The final step involve internal finishing works in the assembled building at the construction site by construction workers amounting to 22 weeks (activity Z in Figure 4).

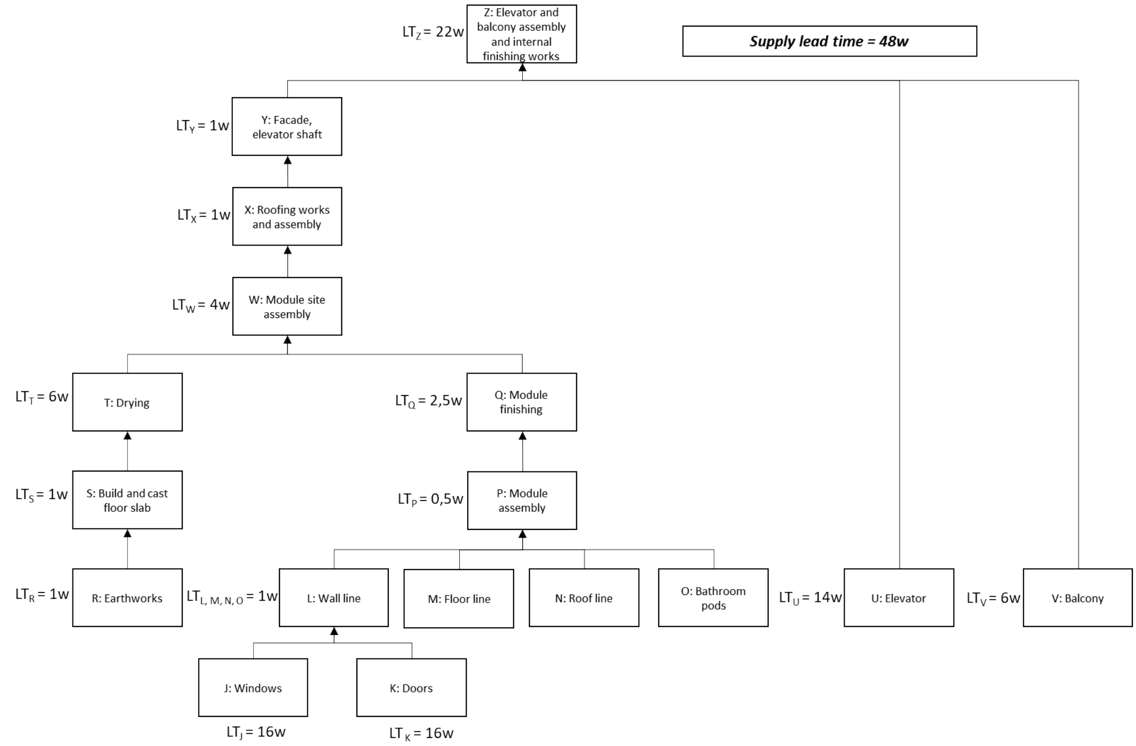

Figure 4. A simplified WBS of a typical project in case company 2.

S is 48 weeks, where most of the lead time is the internal finishing works. In similar vein to case company 1, the long lead times for windows and doors from suppliers prolong *S*. Figure 5 depicts the time phased WBS of case company 2's typical project.

The flow is ETO since the company operates as a traditional building contractor that performs design, engineering, and production activities after a client has placed an order for a project. As such, *D* typically exceeds *S* in their projects. The building contractor pursues a building system with a high level of flexibility. *A* is 32 weeks and comprises the volumetric modules, which are customized for each project. However, the volumetric modules are constrained in dimensions (maximum 9,6m x 3,7m) to accommodate the dimensions of the production line in the off-site factory and the trucks or boats for transportation. Other than the dimensions of the volumetric modules, architects and engineers have only minor constraints related to size of openings, shape of the volumetric modules, etc. When the volumetric modules have been delivered to the site, it takes approximately 28 weeks for the building to be completed.

As in case company 1, the lead times for delivery site activities differ between the branches. The earth and foundation work (see the T-branch in Figure 5) is performed entirely at the construction site and take approximately 8 weeks. The DSDP for volumetric modules (see the Q-branch in Figure 5) is positioned in between the module finishing (activity Q) and final assembly of the modules (activity W). The supply site activities for the purchased materials (the U-, V-branches in Figure 5) correspond to the suppliers' lead times. The delivery site lead time in the Z-branch include the assembly of the purchased materials, along with the internal finishing works.

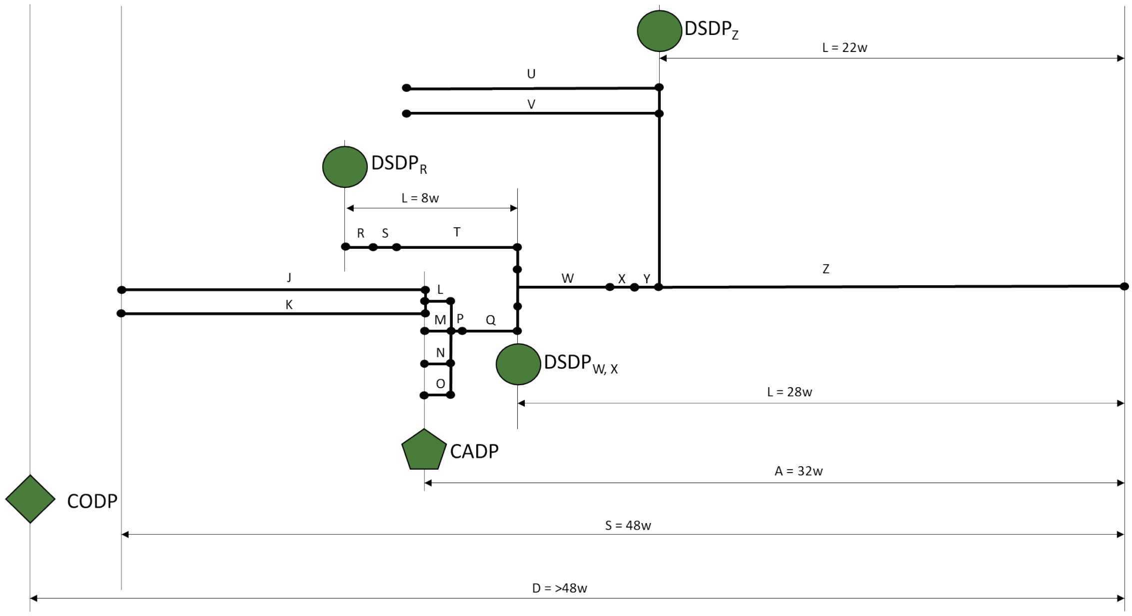

Figure 5. A simplified time phased WBS of a typical project in case company 2.

5. Analysis and Discussion

5.1 Cross-Case Analysis

The two cases exhibit similar patterns regarding their customer order driven, customization, and delivery site activities. In both cases, *S* was considered difficult to reduce, although there was some flexibility in being able to supply generic components and materials on speculation to reduce *D*. This approach was typically used during times of low interest rates because the inventory carrying costs were relatively low for generic components. However, activities related to project-specific materials, such as purchasing windows and doors, were never performed on speculation since it involved a high risk.

The main difference is the level of customization, where in case 2 the volumetric modules are customized for each project. This means that the building contractor in case 2 must handle more variation in the factory than in case 1, where the building contractor produces standardized volumetric modules. Furthermore, case company 2 has a lower degree of value-adding at the delivery site, despite that their *L*:*S*-relation is higher than in case 1. This is due to that case company 2 have additional activities related to the façade and elevator shaft. In case company 1, façade works are performed in the factory and the buildings do not typically have elevators (external corridors are typically used instead).

What the two cases have in common is that *L* is long relative to the amount of value-adding performed at the construction site. In case 1, *L* is 27 weeks ($L{:}S \approx 55\%$) and the amount of value adding at the construction site is approximately 25%. The corresponding figures in case 2 is 28 weeks ($L{:}S \approx 60\%$) and approximately 20%. A further analysis of case 1's delivery site activities reveal problems with project scheduling and planning of sub-contractor works and capacity. In terms of project scheduling, many activities are simply scheduled to take longer than they actually do. Several factors can contribute to this situation, but typically it is a measure to protect against unpredictable supply of materials and components, or to align scheduled activities with the availability of subcontractors. In case 1, it is rare for activities carried out by subcontractors to be completed in a continuous, uninterrupted manner from start to finish. This is in stark contrast to supply site activities in both case companies, where there was a clear focus on establishing flow between activities. For instance, case company 2 worked with line balancing in the volumetric module production, as well as materials and capacity planning to ensure a steady flow and high resource utilization in the off-site factory. This pattern was not noticeable in any of the two cases for delivery site activities.

The recurring pattern in the two cases is that the focus is mainly on managing the flow of activities and resources in supply site activities, while the flow of delivery site activities and resources is managed more reactively. The interview with the head of research and development at case company 1 revealed that their supply chain department, responsible for product development, purchasing, and production planning, had remained unchanged for many years. During this period, they had changed their product from completely standardized buildings with little value-adding at the construction site to the more flexible building system comprising the standardized modules, which required more value-adding at the construction site. Their supply chain department is also highly centralized, which could explain the problems related to project scheduling and materials and capacity planning. The change in their building system led to a more extensive use of sub-contractors and more materials and components that were delivered directly from suppliers to the site. As such, it became difficult to coordinate sub-contracting works and materials supply with the project schedule for delivery site activities.

In summary, the case illustrations highlight that the positioning of the CODP, CADP and DSDP in the flow can affect both long-term and short-term decision-making. In the long-term, such changes affect the type of planning approaches required for production planning, purchasing, and logistics. Furthermore, it requires a suitable organization design to perform these activities efficiently and effectively. In the short-term, the shop floor planning and sequencing at the supply site(s) are heavily dependent on downstream activities at the delivery site. For instance, the volumetric module production is performed in a sequence determined by the assembly sequence at the delivery site. The positioning of the DSDP in the flow illustrates the interface between the two sub-flows, which is a critical point in any type of production system with elements of site-based production. The next sub-section further elaborates on this issue with a discussion of production planning and logistics management in site-based production systems.

5.2 Discussion

The typology gives a detailed view of the flow, dividing it into sub-flows based on customer order driven, customization, and delivery site activities. Off-site construction faces challenges in coordinating on-site activities and the material and resource flows that converge to the construction site (da Rocha and Kemmer, 2018). The two cases illustrate that companies that pursue a relatively high degree of off-site fabrication face the same challenges as traditional contractors in delivery site activities, with the addition that they need to synchronize the two sub-flows (the supply site and the delivery site activities).

Research within off-site construction suggest that lean principles should be used for off-site processes where the contractor keeps a stock point of standardized components and materials, whereas agile principles should be used for on-site processes to respond to the inherent uncertainties with site production (Naim and Barlow, 2003, Mostafa *et al.*, 2016). However, this study shows that such uncertainties stemming from customization activities can take place both off-site and on-site, e.g., in case company 2. Furthermore, the three decoupling points (CODP, CADP, and DSDP) seldom coincide in the same point in the flow, suggesting that the position of the CODP in the flow is insufficient for determining when to use certain production planning and control methods. Typically, it is assumed that the position of the CODP in the flow corresponds to when customization and on-site activities take place. In the case illustrations, which are considered typical industrialized housebuilders, the CODP is positioned the furthest upstream out of the three decoupling points, while the CADP is positioned either right before or after the volumetric module fabrication. In both cases, the DSDP for the volumetric module flow is positioned after the volumetric module fabrication. However, in case 2 the CADP is positioned before the wall, floor, and roof line. Each of these properties of the flow have implications for both production planning and control methods and for how the contractors should organize logistics tasks.

The positioning of the CADP determines the last point in the flow where a lot-sizing inventory should exist (Wikner, 2014). For case 1, this means that the contractor could, in principle, produce volumetric modules on speculation (see Figure 3). In contrast, the contractor in case 2 produces project unique volumetric modules meaning that the last point in the flow where a lot-sizing inventory should exist is prior to the wall line, floor line, roof line, and bathroom pods (see Figure 5). The positioning of the DSDP separates supply site activities from delivery site activities. In both cases, the supply site activities are also customer order driven and customized. The only exception is the earth and foundation work, where the delivery site activities related to casting the foundation slab and a part of drying the concrete takes place before the CADP, but after the CODP.

In terms of production planning and control, batchwise modes are typically more suitable for supply site activities where there is a higher level of repetitiveness than in delivery site activities. The DSDP thus indicates the change in the level of repetitiveness in activities. This change in the level of repetitiveness indicates the point in the flow where the change of production planning and control modes is feasible (Wikner, 2018). Batchwise modes are preferred prior to the DSDP and onetime modes after the DSDP. This contrasts with prior research that suggest that the type of production planning and control mode should be determined by the position of the CODP (Naim and Barlow, 2003, Mostafa *et al.*, 2016, Wikner and Noroozi, 2016). Instead, the findings of this study suggest that the preferred planning and control mode is determined by considering flow driver, flow differentiator, and flow location holistically.

The main challenge, however, will be to combine different modes of planning and control when the production system consists of both supply site and delivery site activities. Incorrect sequencing and poor coordination from off-site production is common in building construction that combine off-site and on-site production (Pan *et al.*, 2023). To ensure both the efficiency and effectiveness in supply site and delivery site activities, onetime planning, and control modes (e.g., CPM and PERT), typically used in on-site production planning, will need to be coordinated with the batchwise production components and assemblies in the factory. The repetitive production oriented logic used in off-site production facilities and in transportation do not cater for the requirements for organizing shipments to the construction site according to assembly sequences (Bortolini *et al.*, 2019). The complexity in coordinating these activities is further increased if the contractor is not in control of the off-site production. This often occurs in construction, e.g., when the contractor buys windows that are supplied directly to the construction site from the supplier.

Regarding the organization of logistics, the typology provides a more detailed view of the flow, taking the flow location into consideration. The flow location constitutes a challenge for any type of production system with elements of site-based production. The delivery site (i.e., on-site) logistics is critical for the project to be delivered on time as any delay in the activities that lies on the critical path results in a delay of the entire project. At the same time, on-site logistics is perhaps the most challenging part in the flow, where site logistic personnel must ensure that deliveries arrive within narrow time frames to avoid disruptions in assembly activities, handle congestion at the site and its surroundings, and avoid accumulated inventory build-up at the delivery site due to space constraints. In addition, the delivery site activities in construction are characterized by reciprocal interdependencies, which require frequent coordination between delivery site activities, which can also affect upstream activities (Bankvall *et al.*, 2010). For example, uncertainty in delivery site activities affect transportation plans for the delivery of materials and components from the supply site(s) to the delivery site. This is critical as delivery plans must remain current with any changes to assembly plans. In summary, this suggests that industrialized housebuilders, like the ones in the two cases, must also ensure that they have the right capabilities to manage on-site logistics. Although this study was limited to two cases, both the housing developer's (case 1) and the building contractor's (case 2) logistics organization were centralized with most of the logistics personnel based in the off-site facility. The inherent high level of uncertainty in delivery site activities within ETO production (Hsu *et al.*, 2018) suggests that a combination of centralized logistics (overseeing the entire flow) and decentralized logistics (managing the supply site and delivery site, respectively) is preferrable.

Furthermore, the uncertainty in the delivery site activities affects supply site activities. Weather-, transport-, and resource-related disruptions are common in site production, which typically requires an inventory or lead time buffer to be positioned between the volumetric module production and the construction site when direct deliveries are not possible (Hsu *et al.*, 2018), i.e., at the DSDP. This buffer is not based on lot-sizing like the one that can be positioned at the CODP, or in some cases the CADP. Instead, it can be used for lead time hedging (i.e., as a time buffer) to cope with lead time variations at the supply site(s), ensuring that the volumetric modules can be delivered in a timely manner to the delivery site. Alternatively, from the delivery site side, an inbound lead time buffer can be used to absorb the variations in delivery site activities (Hedvall *et al.*, 2023), e.g., by using a terminal to cope for changes in the delivery site production schedule (Janné and Rudberg, 2022). Lead time hedging can be an effective method for handling uncertainty in supply and delivery site activities (Zhai *et al.*, 2017), but it requires that sites have sufficient storage capacity. It can also lead to a significant increase in capital tied-up if the inventory contains high-value goods, e.g., ready-to-ship modules. However, as seen in the two cases, generic components, can be kept at the CODP in the flow due to their relatively low inventory carrying costs.

The two cases illustrate companies having one supply site and one delivery site. However, the supply and delivery sites are, in practice, typically one of several supply and delivery sites. The material and components typically come from multiple supply sites and a contractor usually has several projects running simultaneously, meaning that there are multiple delivery sites. As such, there is a need to coordinate the flow between multiple supply and delivery sites. This constitutes a challenge in handling capacity constraints, both in production (machines, equipment, and personnel) and in logistics (material handling equipment, trucks, and warehouses).

6. Conclusions and further research

The purpose was to develop a typology that provides a holistic view of delivery site activities in relation to customer order driven and customization activities. Decoupling thinking was used to distinguish between different dimensions related to the flow driver, flow differentiation, and flow location. The three dimensions represent three important strategic decisions for companies that pursue site-based production to some extent. The typology illustrates the interdependence between the three dimensions which need to be considered holistically to select appropriate production planning and control methods and to adopt appropriate logistics organization configurations. The cases illustrate the importance of making a holistic assessment of the relative positions of the CODP, CADP, and DSDP. Furthermore, the typology can be used to position time and inventory buffers, to select appropriate planning and control methods and to promote efficient and effective logistics management.

Prior research is extended by concentrating on strategic decision areas that relate to challenges in flow design in site-based production systems. The focus has been on building contractors with moderate to high degrees of off-site fabrication, but the typology can be applied to other types of construction as well as to other types of site-based production. Within the context of building construction, further studies should investigate the feasibility of performing activities related to generic and project-specific materials and components based on the CODP, CADP, and DSDP. By using the generic terms "supply site" and "delivery site", the typology is developed with consideration of other types of site-based production systems. The authors also recommend further studies to put a greater emphasis on engineering activities since most site-based production is of the ETO type. Future studies can thus apply the typology to other industrial contexts to test its generalizability. Finally, the research only considers the customer's requirements from the perspective of the contractor. Future studies should investigate the supply perspective, and perhaps also the demand perspective, and include the flow that is external to the contractor, i.e., extend the system boundaries of the flow delimitation (see Wikner, 2014).

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Paper 4

A longitudinal study on logistics strategy: the case of a building contractor

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A longitudinal study on logistics strategy: the case of a building contractor

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Abstract

Purpose – Contingency studies within logistics and supply chain management have shown a need for longitudinal studies on fit. The purpose of this paper is to investigate the logistics strategy from a process of establishing fit perspective.

Design/methodology/approach – A large Swedish building contractor's logistics strategy process was analysed using a longitudinal single-case study for a period of 11 years (2008–2019).

Findings – The case study reveals three main constraints to logistics strategy implementation: a dominant purchasing organisation, a lack of incentives and diverging top-management priorities. This suggests that logistics strategy fit is not a conscious choice determined by contextual factors.

Research limitations/implications – Establishing fit is a continuous cycle of regaining fit between the logistics context and logistics strategy components. Fit can be achieved by a change to the logistics context or to logistics strategy components.

Practical implications – Logistics managers may need to opt for satisfactory fit in view of the costs incurred by changing strategy versus the benefits to be gained from a higher degree of fit.

Originality/value – This paper adopts a longitudinal case design to study the fit between the logistics context and strategy, adding to the body of knowledge on organisational design and strategy in logistics and supply chain management.

Keywords Construction logistics, Strategy process, Strategic fit, Organisational structure, Project-based organisations

Paper type Research paper

Introduction

This paper addresses the logistics strategy process in building contractor organisations. Building contractors are project-based organisations and are typically decentralised where projects are managed locally with little connection to the permanent organisation (Dubois and Gadde, 2002). Consequently, activities at the operational level seldom follow strategies formulated at the corporate level (Miterev *et al.*, 2017) and there is typically little connection between logistics plans at these levels (Elfving, 2021), which in turn causes material flow-related problems at the operational level (Thunberg and Fredriksson, 2018). However, a corporate/company-level logistics plan (i.e. a logistics strategy) can be a means of improving efficiency at the project level by reorganising logistics activities, leading to better resource

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utilisation and labour productivity (Dubois *et al.*, 2019). Addressing the issue of formulating and implementing a logistics strategy in a building contractor organisation can thus yield insights into how to establish the necessary prerequisites for managing logistics in building projects.

In comparison to production systems and supply chains in manufacturing, construction has more complex interdependencies between production and supply activities (Bankvall *et al.*, 2010). There is also a lack of adequate planning and control of materials and information flows; this leads to poor coordination between contractors and sub-contractors, which in turn gives rise to material flow issues (Thunberg *et al.*, 2017). Previous studies indicate that better planned material flows in construction projects can lead to reductions in total project costs by increasing efficiency in transportation, material handling and production tasks on site (e.g. Janné and Rudberg, 2022). However, logistics is rarely addressed holistically in projects and instead the main contractor and sub-contractors manage their own material flows (Dubois *et al.*, 2019). One effect of this is that planning methods are misaligned with material flow characteristics, leading to congestion on the site and poor resource utilisation (Sezer and Fredriksson, 2021). There is thus a need to consider contextual aspects that influence how logistics is organised, that is a contingency approach to logistics (Marchesini and Alcântara, 2016). The main contractor is typically highlighted to be in the position to address these planning-related issues, but it requires that logistics is addressed at a strategic level (Thunberg and Fredriksson, 2018).

Despite the existing research on logistics and supply chain strategy and structure (e.g. Sabri, 2019; Feizabadi *et al.*, 2021), the process of establishing the logistics strategy and structure is seldom addressed. A central concept within logistics and supply chain strategy is “fit”, which refers to aligning strategy and structure elements with internal and external contingencies, such as market and operations characteristics, respectively (Chow *et al.*, 1995). The concept of fit in logistics and supply chain research is typically considered from a content perspective (e.g. Nakano, 2015; Sabri, 2019; Feizabadi *et al.*, 2021), but this disregards how fit is established. Mintzberg (1979) argues that it is insufficient to describe fit based solely on strategic and structural elements because they do not represent the strategy as it is pursued. To understand how fit is established, one must look beyond strategic and structural elements to capture the process behind the realisation of the strategy.

Dynamic approaches to fit challenge the content of fit perspective (Venkatraman and Camillus, 1984) and suggest that fit is the outcome of an unpredictable process characterised by internal and external pressures that are involved in reshaping the organisation and its strategy (Child, 1972; Donaldson, 1987). For instance, in the case of construction, logistics practices are characterised by low maturity and the absence of a strategic approach to logistics (Janné and Rudberg, 2022), despite the emergence of new methods, tools and organisational forms for managing logistics in construction projects (Dubois *et al.*, 2019). This indicates that the development and deployment of logistics practices are not necessarily a conscious choice determined solely by their fit with the logistical context, which is postulated by the content of fit perspective. The literature on fit within logistics and supply chain management therefore needs to be expanded to encompass a more dynamic approach. The purpose of this paper is to investigate logistics strategy from a process of establishing fit perspective.

Dynamic approaches to fit deal with what triggers a change to strategy and/or structure with the aim to regain fit (Child, 1972; Donaldson, 1987). However, the logistics strategy and supply chain fit literature does not address this topic or explain what leads to fit. Hence, this paper poses the following research question:

RQ1. What factors influence the adjustment of a logistics strategy with the aim to regain fit in a building contractor organisation?

The content of fit perspective assumes that there is a natural drive within organisations to establish fit. However, the process of establishing fit perspective rejects this assumption and instead questions whether a theoretically ideal fit is feasible in all cases. For instance, adjusting the strategy to its context can be costly and the future benefits must exceed the costs of this adjustment (Luo and Donaldson, 2013; Gligor, 2017). Furthermore, bounded rationality, managerial discretion (or a lack thereof), institutional factors and the personal views and motives of decision makers can further influence the outcomes of the strategy process (Howard *et al.*, 2007). Therefore, this paper poses a second research question:

RQ2. What are the implications for a building contractor pursuing a satisfactory fit or a misfit in their logistics strategy?

The study is based on a longitudinal case study of a large contractor's logistics strategy process, which is examined through the lens of contingency theory. The case is, to the authors' knowledge, one of few deliberate logistics strategy processes in construction, where a wide range of strategy contents are addressed. In contrast, most logistics initiatives in construction are limited to one or a few logistics strategy components with an emphasis on the operational level. The longitudinal case design used in this study thereby provides unique insights into the process of establishing fit in a large building contractor organisation.

The paper contributes to research within organisational design and strategy in logistics and supply chain management. In particular, the study illustrates how fit is established in a large construction company. Project-based production is rarely considered in studies of functional strategies, such as logistics strategies. The paper also highlights managerial factors, and their potential influence on the strategy process, which must be considered in order to create necessary prerequisites for managing logistics in construction projects.

The paper is structured as follows: first a theoretical background to contingency theory in logistics and supply chain management is presented. Next, the research design and method are described. This is followed by a case description and analysis of the case. The paper ends with a discussion and conclusions, including the limitations of the study and suggestions for further research.

Contingency theory in logistics and supply chain management

The strategy–structure–performance paradigm

The leading stream within contingency theory has been the strategy–structure–performance paradigm (Chandler, 1962; Galunic and Eisenhardt, 1994). Early adoptions of the strategy–structure–performance paradigm in logistics research focused on intraorganisational issues, that is the fit between the firm's strategy, the organisation of logistics and the effects of fit on performance (Chow *et al.*, 1995). Later research has adopted the contingency theory lens to study fit at an interorganisational supply chain level of analysis (Nakano, 2015; Sabri, 2019; Feizabadi *et al.*, 2021).

These advancements have been valuable for logistics and supply chain management research in explaining which logistics organisation and supply chain structures are feasible under certain circumstances. Similarly, in the operations management domain, contingency theory has been successful in providing an understanding of which operations management practices are effective under certain conditions (Sousa and Voss, 2008). However, despite the valuable insights gained from using contingency theory as a theoretical lens in logistics and supply chain management research, there has been debate regarding the definition of fit within the logistics domain (Hallavo, 2015). Much of this debate stems from problems with contingency theory itself, that is, the tendency to apply reductionistic theoretical models that have provided inconclusive empirical results (Galunic and Eisenhardt, 1994; Van De Ven *et al.*, 2013; Turkulainen, 2022). To respond to this critique, major advancements in contingency theory have been made through the configurational view (CV) and the information processing view (IPV).

The configurational and information processing views on fit

The CV and IPV are complementary developments of contingency theory. The CV addresses the traditional reductionist approach and advocates a more holistic perspective with the use of multivariate studies of several contingency variables and organisation design elements (Meyer *et al.*, 1993; Van De Ven *et al.*, 2013). On the other hand, the IPV addresses the vague definition of fit by explicating fit as the match between information processing (IP) requirements and IP capacity (Galbraith, 1974). Both advancements in contingency theory have shown potential for logistics and supply chain management. The configurational view offers a more holistic picture of supply chains, which has been studied using multivariate analysis of contingency variables and structural variables (Feizabadi *et al.*, 2021). IPV has been useful for analysing fit at both an intraorganisational and an interorganisational (supply chain) level (Busse *et al.*, 2017; Aben *et al.*, 2021). Combined, the CV and IPV provide a solid lens for logistics and supply chain management researchers to determine under what conditions the different organisational configurations are feasible. However, to use these views in logistics and supply chain management research, the contingency variables need to be adapted to the specific empirical context (Koskela and Ballard, 2012; Turkulainen, 2022).

Dynamic approaches to fit

The strategy–structure–performance paradigm does not account for how strategy and structure changes (Galunic and Eisenhardt, 1994). Although the CV and the IPV are considered advancements on the reductionist approach in contingency theory, they also assume a static view on strategy and structure (Donaldson, 1987). Therefore, the static approaches within the contingency theory place less emphasis on what is happening within the structure and how strategies unfold and are realised (Mintzberg, 1979). This cross-sectional approach has been the main subject of criticism against the contingency theory, which is mainly related to its lack of relevance for dynamic environments where strategy and structure are prone to frequent change (Galunic and Eisenhardt, 1994). In response to this criticism, dynamic approaches to fit focuses on the sequence of events that reinforce an existing configuration, creates a new configuration, sustain an existing configuration or that removes old core elements of a configuration that have become obsolete (Siggelkow, 2002).

Two advancements in contingency theory addresses the issue of only considering fit at one point in time: strategic choice (Child, 1972) and the SARFIT (structural adaption to regain fit) model (Donaldson, 1987). There is considerable overlap between the two views, but they differ in that strategic choice places more emphasis on a dominant coalition (e.g. senior management) with a certain degree of discretion in strategic decisions. This implies that fit can be achieved by either responding to contingencies through organisational adaptation or by changing the contingencies *per se*, depending on the preferences of the dominant coalition or their degree of discretion (Montanari, 1978). SARFIT, on the other hand, emphasises performance (or a lack thereof) as the main trigger for organisational adaptation rather than the discretion and preferences of the dominant coalition (Donaldson, 1987).

Another stream that falls under the dynamic approaches is that of dialectics and paradoxes that emphasises the importance of internal tensions and contradictions as triggers for strategic renewal. Within this stream, internal misfits of an organization are means of strategic change, rather than temporary dysfunctional states of a configurations (Farjoun and Fiss, 2022). Misfits are thus a normal part of any organization and should be viewed as an opportunity to shift towards a different strategy configuration or to reinforce an existing one.

The majority of contingency research within logistics and supply chain management does however use cross-sectional research designs (Doering *et al.*, 2019; Danese *et al.*, 2020). Several researchers within logistics and supply chain management highlight the need for longitudinal studies (Sabri, 2019; Feizabadi *et al.*, 2021). Although they are rare, dynamic approaches to fit in logistics and supply chain management have been used, for example through the lens of strategic choice or SARFIT. For instance, Howard *et al.* (2007) draw on strategic choice combined with institutional theory to explain a failed implementation of supply practices at an engine plant. Another example is Silvestre *et al.* (2020) who use the SARFIT model to analyse the implementation of supply chain sustainability practices. Furthermore, dialectics and paradoxes are emphasized by Sandberg (2017) who suggests that these advancements in organizational research can benefit the logistics domain. Table 1 provides a synthesis of streams within contingency research.

A contingency approach to logistics strategy in building construction

While contingency theory is useful in the logistics and supply chain management domain, it is too generic in its original form to provide unique insights for researchers and practitioners (Koskela and Ballard, 2012). As such, the sources of IP requirements need to be adapted to the construction setting and viewed from a logistics perspective. In logistics research, uncertainty stems from the characteristics of material and information flows, which are determined by: demand characteristics, product characteristics, the design of production system, the supply chain structure and formalisation (c.f., Christopher, 1986; Chow *et al.*, 1995; Klaas and Delfmann, 2005). These are determinants of IP requirements. IP capacity is determined by the organisational structure and the need to match the level of IP requirements to achieve fit (Galbraith, 1974). The following paragraphs define the sources of IP requirements and capacity, starting with the contextual factors (demand characteristics, the degree of pre-engineering and the production system), to be followed by the logistics strategy content (structure and process components).

Demand characteristics relate to the heterogeneity among clients, determining what types of buildings to produce. The requirements of the target market(s) are typically described using competitive priorities (cost, quality, flexibility and delivery) (Maylor *et al.*, 2015).

The *degree of pre-engineering* refers to the degree of standardisation in the product offering, reflecting the demands of clients, and is operationalised by the contractor's competitive priorities (Jonsson and Rudberg, 2015). A flexible product offering typically entails an increase in bill-of-materials levels, which in turn increases the complexity for inventory management and delivery planning (Flynn and Flynn, 1999). In engineer-to-order situations, product standardisation is mainly determined by the amount of engineering work that is performed prior to customer order, which can be divided into three categories (Wikner and Rudberg, 2005):

(1) Engineer-to-stock (ETS): The product is designed prior to customer order.

(2) Adapt-to-order (ATO): An existing product design is modified according to customer order.

(3) Engineer-to-order (ETO): The product is engineered from scratch, offering broad customisability.

The *production system* characteristics determine how the product is to be produced, that is the type of production process and production technology that is to be used. For a building contractor, this entails choosing a suitable production system, which produces outcomes in congruence with competitive priorities (Jonsson and Rudberg, 2015). In general, the lower the degree of pre-engineering (e.g. ETO), the higher the coordination needs to handle the complexity from non-routine engineering tasks (Shurrab *et al.*, 2022). This influences both upstream and downstream processes in terms of their degree of task interdependency

Stream	Rationale	Conceptualization of fit	Representative paper(s)	Examples from logistics and supply chain management
Strategy–Structure–Performance	Rejects the "one size fits all" argument in favour of "contingency determinism", i.e. that strategy determines structure	Static: Strategy drives the development of suitable organizational structure and processes	Chandler (1962)	Nakano (2015), Gligor (2017)
Information Processing View	Addresses deficiencies in the conceptualization of fit. Explicates fit by portraying organizations as information processing systems	Static: Fit indicates that a firms information processing requirements (determined by contingency variables) are matched by its information processing capacity (determined by organizational structure and processes)	Galbraith (1974)	Busse *et al.* (2017), Luo and Yu (2016), Aben *et al.* (2021)
Configurational View	Addresses criticism of contingency theory for being reductionist and limited to bivariate studies	Static: Fit indicates a constellation of several commonly occurring variables of contextual factors and organizational structure	Meyer *et al.* (1993)	Sabri (2019), Feizabadi *et al.* (2021)
Strategic Choice	Rejects "contingency determinism", i.e. that contextual factors determine organizational structure. Strategic choices by a dominant coalition that influences fit	Dynamic: Dominant coalition (e.g. senior management) can make changes to contextual factors and/or organizational structure to establish fit based on personal preferences, performance, institutional factors etc.	Child (1972)	Howard *et al.* (2007)
SARFIT	Rejects "contingency determinism" and partially strategic choice in favour of performance as the main driver for a change of organizational structure to regain fit	Dynamic: Misfits lead to poorly functioning organizations, which in turn leads to poor performance. This puts pressure on reorganizing to regain fit to improve performance	Donaldson (1987)	Silvestre *et al.* (2020)
Dialectics and paradoxes	Rejects the assumption that misfits are always dysfunctional and criticise previous dynamic approaches for their lack of attention to how strategic change occurs. Misfits (or "contradictions" and "tensions" as they are called) are regarded as important drivers of strategic change	Dynamic: Organizations are everchanging and thus fit cannot be viewed as a state of equilibrium. Internal tensions always exist to some extent and these need to be deliberately managed and balanced	Farjoun and Fiss (2022)	Sandberg (2017)

Table 1.
Streams within contingency theory and their applications within logistics and supply chain management

(pooled, sequential and reciprocal), task predictability and problem analysability (Miles *et al.*, 1978; Cannas *et al.*, 2019). The degree of pre-engineering is thus associated with the choice of production system, which must accommodate for the type of product (Cannas *et al.*, 2019). Jonsson and Rudberg (2015) classify four different production systems in housebuilding:

(1) Component Manufacture and Sub-Assembly (CM&SA): Production activities are carried out on-site with a flexible sequence of operations and reciprocally interdependent activities, leading to a high level of process time and flow variability.

(2) Prefabrication and Sub-Assembly (PF&SA): Prefabricated panel elements that are assembled on site along with other sub-assemblies. Contains a flexible sequence of operations and reciprocally interdependent activities, leading to a high to medium level of process time and flow variability.

(3) Prefabrication and Pre-Assembly (PF&PA): Sub-assemblies are pre-assembled to prefabricated panel elements, leading to fewer materials to be delivered to the site and fewer operations. Contains a flexible sequence of operations and reciprocally interdependent activities, leading to a medium level of process time and flow variability.

(4) Modular building (MB): Volumetric modules are prefabricated in an off-site factory which has a production line or batch flow layout. Remaining assemblies on-site are reduced but still have a flexible sequence of operations and reciprocally interdependent activities.

Structural components include the logistics organisation structure and the supply chain structure. The logistics organisation structure determines the level of IP capacity, where centralisation is the degree to which logistics decision-making authority is concentrated to a single unit (Pfohl and Zöllner, 1997). Supply chain structure refers to the geographical dispersion and relationships with suppliers (Voordijk *et al.*, 2006). The supply chain structure has implications for the complexity of production and logistics tasks. In particular, the number and type of relationships with suppliers influence the degree of uncertainty in delivery reliability and quality (Flynn and Flynn, 1999). Construction logistics centres can be used to reduce the number of deliveries to the construction site or as short-term storage for just-in-time deliveries (Janné and Fredriksson, 2022). Moreover, the contractor can engage in long-term relationships with suppliers that enable better alignment between logistics solutions and on-site production (Bildsten, 2014).

Process components refers to the administrative and operational logistics processes (Klaas and Delfmann, 2005). Administrative logistics processes are associated with information processing, coordination, reporting and control (e.g. order processing) and operational logistics processes are associated with the execution of logistics tasks (e.g. transportation and material handling). IP requirements are reduced by formalising administrative and operational processes, that is when processes and procedures for performing logistics activities are explicitly formulated (Chow *et al.*, 1995).e.

Research design and method

Research design

To study logistics strategy from the perspective of the process of arriving at fit, the overall research approach needed to accommodate for temporal sequences between events and how they lead to strategy process outcomes. The research was based on a literature review and a longitudinal single-case study. The literature review focused on four literature areas: (1) cross-sectional contingency theory literature, (2) longitudinal/dynamic perspectives on fit,

(3) contingency theory applications to logistics and supply chain management and (4) construction logistics literature. These areas were chosen in line with recommendations by Voss *et al.* (2002) to establish a focus early in the research process, whereby the researchers can identify constructs and their presumed relationships. The empirical part of this study was a single-case study of a large Swedish construction company's logistics strategy process. The single-case design was selected to examine the company's logistics strategy process over a period of 11 years, thus making it possible to study the case over time as a longitudinal study (Yin, 2018). In 2008, the company initiated a project to develop a logistics strategy and tested the strategy through a total of eight pilot projects split into three phases. Phase 1 involved one project, phase 2 involved six projects and phase 3 involved one project. The project spanned over seven years and was discontinued in the middle of 2016, but the research study also includes the years 2016–2019 to cover potential outcomes of the project after its termination.

Case selection

The case selection is motivated by accessibility to the company and by the acquisition of information on an unusual case (Flyvbjerg, 2006). The authors had access to extensive documentation and key agents in the logistics strategy process. This contributed with rich information covering a long period, which enabled the longitudinal case design. Furthermore, while the building contractor was regarded as a typical large general contractor in Sweden, deliberate efforts to address logistics holistically at the corporate level among these types of contractors are uncommon. It is thus the logistics strategy process that makes the case unusual, and not the contractor's general characteristics. The case was however selected for theoretical reasons (Eisenhardt, 1989) based on the contractor's general characteristics in terms of size (large), target market (broad/local), production system (CM&SA) and degree of pre-engineering (ETO). Therefore, in line with recommendations by Ketokivi and Choi (2014), regarding using cases for theory elaboration, the case's characteristics and empirical data provided a basis for analytical generalisation. Finally, the phenomenon of the strategy process and the process of arriving at fit is favourably studied by analysing process data (Van De Ven, 1992; Langley, 1999). Therefore, the third reason behind the case selection was the opportunity to access process data that described decisions, activities and events that exemplify the unpredictable process of establishing fit.

Data collection

The data included both primary and secondary data (see Table 2). The primary data was of two types: participatory observation and semi-structured interviews. For participatory observation, one of the researchers participated in three pilot project kick-offs and performed three planned site visits at each pilot project. The interviews were held with key persons involved in the strategy process and were conducted in retrospect of the strategy process. A pilot interview was first conducted with the current logistics developer at the company, providing insights into the company's experience from the project. The insights from the pilot interview were used as input for the interview guide that was later used to interview the former logistics manager and the project manager, who were the key persons behind the company's logistics strategy and the pilot projects. The interviews were used to verify the researchers' analysis of the archival data, and a total of six interviews were held before the researchers' interpretation of the archival data had been verified. The secondary data comprised internal documentation containing summaries of the pilot projects, descriptions of the logistics strategy, records and presentations from strategy meetings, implementation plans and formal directives that were developed for central purchasing and logistics. This documentation was provided to one of the researchers who observed the strategy process

Data	Data collection method	Time period covered	Comments
6 interviews	Semi-structured interviews	2008–2019	• Logistics developer: 2 interviews in February and March 2021, respectively, 90 min each • Logistics manager: 3 interviews in March (60 min), April (90 min) and June (60 min) 2021 • Project manager: 1 interview in April 2021, 90 min
2 project time plans	Archival data from pilot project time plans	2009–2012	Details regarding pilot projects and implementation plans
9 project reports	Archival data with reports issued during the project	2008–2019	Reports continuously issued over 2008–2019
3 Annual reports	Publicly available annual reports from 2010 to 2012	2010–2012	Financial measures and comments from top management
10 planning and follow-up meetings	Archival data with presentations, agendas, and decision protocols	2008–2013	Details regarding logistics strategy content, pilot projects and implementation plans
7 instructional documents	Archival data with instructions for site managers, purchasing, delivery planners etc.	2010–2013	Descriptions of logistics processes aimed at different organizational members
2 pilot project kick-off/start up meetings	Researcher observation and notetaking	2011–2014	Observational participation during full day meetings with representation from all main participants for pilot project 2 and 3, respectively
3 site visits	Researcher observation, unstructured interviews and notetaking	2010–2016	Planned site visits at pilot project 1, 2 and 3, respectively. Unstructured interviews with site managers, foremen, project participants and site personnel. Walk around at site and full day observation of site activities
3 student theses	Master thesis projects/reports covering pilot project 1, 2 and 3, respectively	2010–2015	Containing information on pilot project 1, 2 and 3, with thesis 3 covering the full-scale implementation of the final logistics strategy outlined in the main project report in 2013

Table 2.
Data collection methods

from start to finish but did not take active part in formulating and implementing the strategy. The documentation covered the project from its initiation in 2008 to a final report issued in 2014. Besides internal documentation, publicly available information such as reports, trade magazines, annual reports and thesis works were used for background information to establish a sense of when and in what sequence certain activities in the strategy process took place. In total, the interviews, documentation and publicly available information covered decisions, activities and events from 2008 to 2019.

Analysis

This study adopted a two-step approach for the analysis. The first step concerned creation of the visual map (Figure 1), where activities, events and decisions that formed part of the logistics strategy process were structured in the form of an illustrative time plan representing the sequence and timing of events in the strategy process. In this first step, a tentative visual

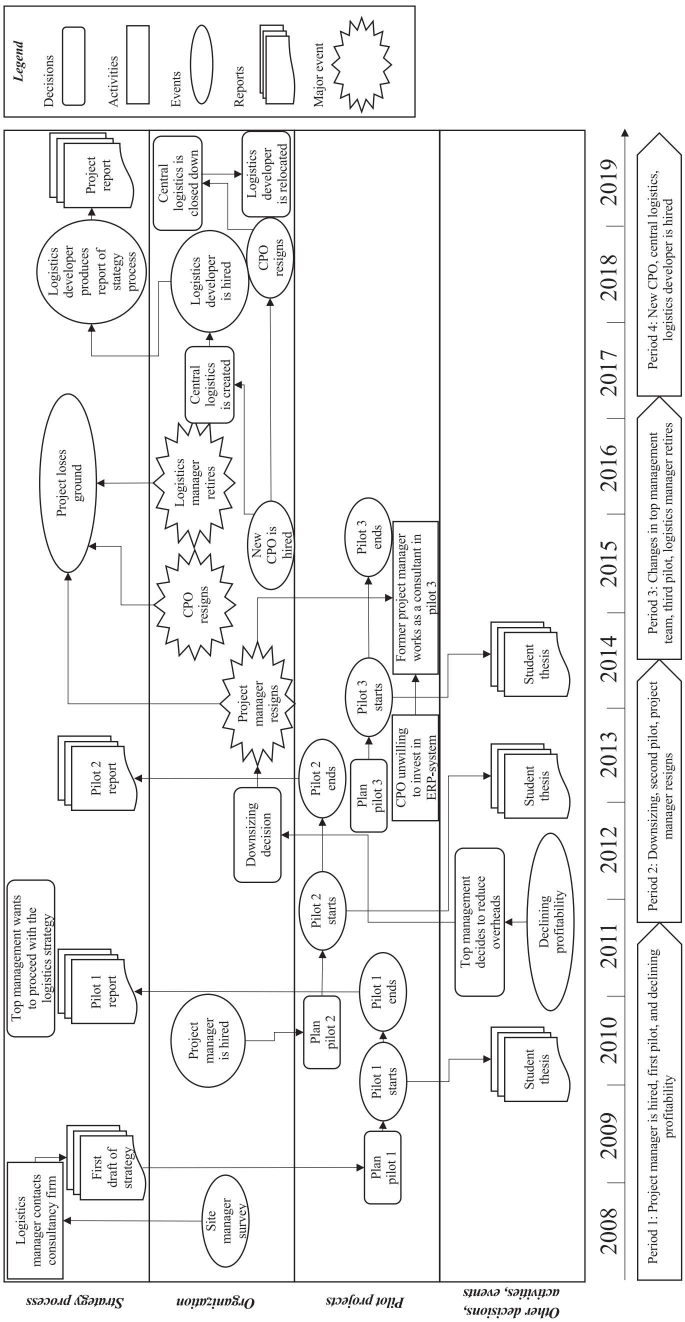

Figure 1.
Visual map of the logistics strategy process between 2008 and 2019

map was created based on analysis of the secondary data through a document analysis. The document analysis covered a total of 31 documents provided by the case company (see Table 2) and followed an iterative process of skimming, detailed examination and interpretation (Bowen, 2009). The result was a visual map of critical events that occurred between 2008 and 2019 (Figure 1). Langley (1999) recommends this approach for the "sense-making" part of process studies to overcome the extensiveness that characterises process data. The visual mapping approach is suitable as an intermediary analysis technique and enables researchers to retain strategy process data as a sequence of events. These events then provide grounds for explaining underlying causes for strategy process outcomes (Van De Ven, 1992). For instance, a particular decision by top management was related to the implementation phase, while the managers' predispositions were related to the strategy formulation. The visual map was thus used to describe the strategy process as it unfolded, including the decisions, activities and events that influenced strategic choice during strategy implementation.

The second step in the analysis concerned validating the tentative visual map and connecting decisions, activities and events to strategy process outcomes, which explained what influenced the logistics strategy implementation. This second step was based on the procedures for thematic analysis: open coding, axial coding and selective coding (Flick, 2018). The researchers used NVivo to generate codes and themes based on the interview transcripts and documentation. First, a total of 82 open codes were formed based on the interview transcripts and documentation. Second, the 82 open codes were reduced to 15 axial codes that represented identified constraints to strategy implementation (see right side of Table 3) that were linked to a specific logistics strategy component (see left side of Table 3). Third, three selective codes were identified based on the 15 axial codes: (1) a dominant purchasing organisation, (2) a lack of incentives and (3) diverging top management priorities. These three themes constituted the main constraints to implementation of the logistics strategy. Finally, the building contractor's initial state, expected outcomes and actual outcomes were compared, which enabled the researchers to infer the implications for fit of the realised outcomes (see Table 4).

Case study description

The company is a large contractor operating in the Nordic countries with a focus on the Swedish construction industry. The logistics strategy process is illustrated in Figure 1, and includes important decisions, activities, events and reports. The following paragraphs summarise the logistics strategy process in chronological order.

As a response to the low productivity levels and growth in the construction industry, the company's logistics manager sent out a survey to site managers in the beginning of 2008 to map how much time was spent on purchasing- and logistics-related tasks in projects. The survey indicated that the company had substantial potential to reduce waste in these areas. This convinced the logistics manager to develop a logistics strategy for the company. The logistics manager contacted a consultancy firm the same year which produced a first draft of the logistics strategy. In 2009, the logistics manager planned the first pilot project to further explore the potential benefits of a corporate-level logistics strategy. Towards the end of 2009, they initiated pilot 1, which had a narrow focus on transportation and material handling of make-to-order materials. Pilot 1 was completed in the end of 2010.

A project manager was hired in the autumn of 2010 and became responsible for planning and executing pilot 2. The pilot, which comprised seven projects, started in 2011 and was finished in 2013. The purpose of pilot 2 was more in line with the first draft of the logistics strategy developed by the consultancy firm, addressing how to supply multiple projects using the same logistics operations platform, how to organise logistics to achieve economies

Identified logistics strategy components	Expected outcomes	Realized outcome	Identified constraints towards strategy implementation (data source within parentheses: D = documentation, LM = logistics manager, PM = project manager, LD = logistics Developer)
Structure components			
Centralized logistics	Centralized development of logistics operations platform	Existed between 2016 and 2019	New purchasing manager left (started in 2016) (LM), Top management did not understand the strategy (PM), Logistics was part of the purchasing organization (D, LM, PM, LD)
Regional planning units	Aggregation of materials and distribution planning (MTS materials)	Not realized	Top management did not understand the strategy (PM), Regional managers were not committed to change current way of working (LM)
ERP-system	Connecting central/regional and project planning levels	Not realized	Central organization was reluctant to carry initial investment costs (LM, PM), Top management did not understand the strategy (PM)
Distribution terminals	Inventory buffers of MTS materials in each region to increase flexibility, minimize number of deliveries, achieve economies of scale	Not realized	Site managers only experienced the incurred cost of distribution terminals (PM), Central organization was reluctant to carry initial investment costs (LM, PM)
Process components			
Design and engineering	Routines to improve planning, supplier selection and accuracy of information	Not realized	Top management did not understand the strategy (PM), Low degree of standardization in design and engineering solutions (D, LM)
Site logistics	Site disposition plan, roles and responsibilities, delivery planning, goods reception	Not realized	Material handling on site was not considered logistics (PM), Purchasers were not aware of material flow problems on site (LM, PM)
Marking and labelling of goods	Ensure correct and informative packaging labels	Not realized	Site managers only experienced the purchasing cost but not the savings of labelling goods (PM), Lack of scale perceived by suppliers (PM)
Delivery planning and transports	Increased control of delivery times and reduce disturbances on production activities	Not realized	Logistics was part of the purchasing organization (D, LM, PM), transport costs were not visible to project purchasers (included in purchasing costs) (D, LM)
Supplier development policies	Continuous improvements to supply logistics	Not realized	Insufficient logistics capabilities within purchasing organization (D, LM, PM), Long-term supply agreements were not used by project purchasers (PM), Purchasing organization's incentives drove focus on purchasing costs over total costs (D, LM, PM), Logistics was part of the purchasing organization (D, LM, PM)

Table 3.
Influencing factors on the logistics strategy process outcomes

Table 4. Implications for logistics strategy fit

Contextual factors and logistics strategy components	Literature findings			Case study findings	
	Description	Implications for fit	Key references	Realized outcome	Implications for fit
Contextual factors					
Demand characteristics	Number, size, knowledge, behaviour and heterogeneity among clients	Determines suitable degree of product standardization and pre-engineering through competitive priorities	Shurrab *et al.* (2022), Maylor *et al.* (2015)	Remained unchanged. Projects were of local character with a high heterogeneity among clients	Products and productions system were adaptable to each client's requirements and the company mainly competes with smaller local actors
Degree of pre-engineering	No. product variants, BOM structure complexity (depth and breadth), and amount of engineering work performed prior to customer order impacting production and supply variability	IP requirements are generated from the late design changes	Cannas *et al.* (2019), Shurrab *et al.* (2022), Wikner and Rudberg (2005), Flynn and Flynn (1999), Christopher (1986)	Low use of standardized products and pre-engineered components. BOM structure changes from project to project	High level of IP requirements due to low amount of information possessed prior to task execution (DTO: low degree of pre-engineering)
Production system	Degree of off-site assembly (CM&SA, PF&SA, PF&PA or MB) impacting production and supply variability	IP requirements are generated from production variability (process time and flow variability)	Shurrab *et al.* (2022), Cannas *et al.* (2019), Jonsson and Rudberg (2015), Wikner and Rudberg (2005), Christopher (1986)	Mainly CM&SA production systems with high levels of production variability in projects	High level of IP requirements due to due to low amount of information possessed prior to task execution (high level of production variability)
Structure components					
Organizational structure	• Centralization: logistics tasks are either concentrated to a single unit or distributed in the organization • Division of labour: administrative and physical logistics tasks performed by general-purpose or specialized personnel	Determines level of IP capacity of logistics organization during task performance	Galbraith (1974), Klaas and Delfmann (2005), Flynn and Flynn (1999), Chow *et al.* (1995), Christopher (1986)	• Centralization: Site management had control over logistics tasks. No involvement from a central unit in projects • Division of labour: site management mainly administered purchasing, call-offs, deliveries, goods reception and invoicing. Material handling was mainly carried out by construction workers	High level of IP capacity generated from decentralized organizational structure. IP requirements reduced due to reduced division of labour

(continued)

Contextual factors and logistics strategy components	Literature findings			Case study findings	
	Description	Implications for fit	Key references	Realized outcome	Implications for fit
Supply chain structure	Number of suppliers and supplier relationships impacting delivery reliability and quality	IP requirements are generated from supply variability	Janné and Rudberg (2022), Bildsten (2014), Klaas and Delfmann (2005)	Mainly arms-length relationships with local suppliers of building materials. Direct deliveries to construction sites from materials suppliers	High level of IP requirements generated from short-term, market-based supplier relationships. Direct deliveries from many suppliers to construction sites
Process components					
Administrative processes	Formalized procedures for information processing, coordination and control activities, e.g.: demand management, inventory and order management, order processing, distribution and transportation planning	Determines level of IP requirements generated from level of formalization	Klaas and Delfmann (2005)	Formalized logistics processes were never implemented, and logistics tasks were handled in a problem-solving manner. Administrative processes were seldom considered by site management	High level of IP requirements due to low amount of information possessed prior to task execution (lack of administrative routines and information system)
Operational processes	Formalized procedures for physical activities, e.g.: on-site material handling, transportation, warehouse operations	Determines level of IP requirements generated from level of formalization	Klaas and Delfmann (2005)	Formalized logistics processes were never implemented, and logistics tasks were handled in a problem-solving manner. Construction workers and supervisor typically carried out goods reception and material handling	High level of IP requirements due to low amount of information possessed prior to task execution (absence of established material handling and goods reception procedures)

Table 4.

of scale and the potential benefits of increased standardisation and centralisation of logistics tasks. However, at this time the company experienced declining profitability in their housebuilding business unit. Consequently, top management decided that they would reduce overhead costs by downsizing the central organisation. So, as pilot 2 progressed as expected and finished with promising results, the project manager who had only been employed for two years was at risk of being dismissed, which led to him resigning voluntarily in the end of 2013.

Pilot 3 began in the autumn of 2013 with the former project manager now working as a consultant. Until this point in time, the strategy process seemed to be progressing well. However, the Chief Purchasing Officer (CPO) had been sceptical towards some of the investments proposed by the logistics manager and the now former project manager. For instance, the CPO and the logistics manager could not agree upon which ERP system to purchase, with the result that they did not purchase an ERP system at all. Instead, the former project manager had to manually make material requirements plans, delivery plans and produce packing, labelling and unloading instructions for suppliers and haulage contractors. Therefore, they could not use the learnings from the pilot in future projects. Furthermore, while pilot 3 was underway, the CPO resigned in the first half of 2015. The CPO had been an important spokesperson for the logistics strategy in the top management team, but his and the project manager's resignation meant that the strategy work was losing ground in the company. A new CPO was hired in the end of 2015, who was positive towards the logistics strategy. However, the CPO had not been involved and the logistics manager was now approaching retirement. The logistics strategy had already lost support throughout the organisation, and the process came to an end when the logistics manager retired in 2016.

In 2017, although the logistics manager and the project manager were no longer working at the company, the new CPO established a central logistics unit, which belonged to the central purchasing department. Despite there being no plan for developing a logistics strategy on the same scale as intended by the logistics manager, the new CPO hired several people to continue developing methods, tools and processes at a central level, one of them being the logistics developer. The logistics developer was hired in the beginning of 2018 and began gathering information on what had been done previously in terms of logistics development. In the beginning of 2019, the logistics developer produced a report summarising the logistics strategy process from 2008 onwards. Apart from a summary, the report included recommendations on which areas of logistics to focus on in the short and long term. However, central logistics was closed in 2019 when the CPO resigned. The logistics developer was then relocated to a support function focusing on technical support to projects.

Case study findings

Constraints to logistics strategy implementation

This section addresses RQ1: *"What factors influence the adjustment of a logistics strategy with the aim to regain fit in a building contractor organisation?"*. The interviews and the internal project documentation reveal constraining factors to the implementation of the logistics strategy. These constraints are detailed in Table 3. The identified constraints can be summarised as: (1) lack of a formal logistics organisation and thus formal authority of the logistics manager, (2) lack of incentives to change among internal stakeholders and (3) divergence in top management priorities.

Regarding the first issue, the logistics manager stated that *"the biggest problem was that we (logistics) belonged to purchasing"*. The central purchasing organisation lacked fundamental logistics expertise, for example of the total cost concept, lot sizing and transport planning. Consequently, site managers were reluctant to use framework agreements from central purchasing since they caused problems for transports and on-site logistics. The logistics manager added that purchasers were not aware of what was happening in projects, even though they had a company policy that required purchasing to evaluate supplier performance after project completion.

Besides purchasing, the interviewees indicated that site managers were not reluctant towards the strategy *per se*, but they lacked incentives to use centrally developed logistics solutions. For instance, the site managers' bonuses were based on project performance (i.e. time, budget and quality), which meant that they did not want to bear additional costs for material handling and marking and labelling of goods. Thus, there were no incentives for site managers to pay for distribution terminals and the ERP system because it was perceived as an additional risk to the project's budget. In addition, the project manager believed that they lacked an internal business model for how to allocate investment costs between the central organisation and projects. The project manager suggested that the central organisation should have taken the investments costs and that projects would pay a license fee, for example for using the ERP system.

Diverging top management priorities manifested themselves in several ways, but were most prominent between 2013 and 2016. Top management had in fact been positive towards the strategy in the first couple of years, but changes in the team's composition led to a more sceptical attitude. For instance, the CPO's resignation entailed that the logistics manager had to find a new way to gain top management support. After pilot 2 was completed in 2013, the CPO did little to gain support from the rest of the top management team, which the logistics and project manager perceived as originating from a lack of logistics expertise. For instance, the project manager stated: *"We always needed to go via purchasing . . . and when you have a CPO in the top management team that does not understand this (logistics), there will not be any change"*. The project manager also raised the need for a supply chain manager, or a supply chain department, with knowledge about what logistics means for operations and the ability to explain this to top executives.

Fit, satisfactory fit and misfit

This section addresses RQ2: *"What are the implications for a building contractor pursuing a satisfactory fit or a misfit in their logistics strategy?"*. The implications of strategic logistics decisions identified in the literature were compared with the case study findings to investigate what could explain the building contractor's lack of fit, despite their ambitious logistics strategy (Table 4). This comparison revealed that the logistics manager and project manager had not attempted to make significant changes that would lead to a change in the contractor's overall business strategy. However, there were attempts to increase the degree of pre-engineering and to move towards a PF&SA production system, but this remained unchanged. The predominant use of the CM&SA production system in projects thus entailed high IP requirements, which subsequently had to be matched with IP capacity to establish fit.

The analysis of the structural components reveals that the organisational structure generated high levels of IP capacity, since the central logistics department and regional planning units were unrealised. The contractor's logistics was thus managed in a decentralised organisational structure with low division of labour, thus generating a high level of IP capacity. This corresponds to the high degree of production and supply variability generated by the degree of pre-engineering, the production system and the supply chain. The high IP capacity generated from the organisational structure therefore matches the high IP requirements, which indicates a fit between the contextual factors and the structural components.

However, the analysis of the process components indicates that the company had an underfit logistics strategy (i.e. that IP requirements exceeded IP capacity). None of the logistics strategy process components were realised (Table 3), which was in favour of ad hoc problem solving by site management and construction workers without formalised administrative and operational logistics processes. The low degree of formalisation in the administrative and operational logistics processes thus generated high IP requirements in addition to what was generated from the degree of pre-engineering, the production system and the supply chain structure. In other words, the lack of formalised routines in the five process components (Table 3) generated uncertainty and complexity in addition to the low degree of pre-engineering, the CM&SA production system and the geographically dispersed supply chain structure. The low degree of formalisation is apparent in pilot 3, where the former project manager worked as a consultant to manually solve administrative logistics tasks.

Discussion

The case study findings reveal that fit is not necessarily determined by contextual factors as postulated by previous contingency studies within logistics and supply chain management (Sabri, 2019; Feizabadi *et al.*, 2021). Lacking performance and strategic choice both influence the pursued strategy, and thus, they mediate the fit between context and strategy. Howard *et al.* (2007) present similar findings in a case study of the implementation of supply practices at an engine plant, where the implementation plans received inadequate attention from top management and where unfortunate timing halted the process. Likewise, the case study findings here reveal that the downsizing decision at the building contractor unfortunately coincided with the intended implementation period starting in 2012. In a study of a similar building contractor, Elfving (2021) highlights timing as a critical determinant in the implementation of standardised logistics solutions. In this case, the financial crisis triggered a downsizing decision at the building contractor, which meant that only one logistics solution remained. Furthermore, Elfving (2021) discusses other aspects related to timing, such as the importance of the maturity of a company and ensuring that top management priorities align with the intended strategy process outcomes to enable implementation of the strategy.

In our case study, top management were initially supportive of the logistics strategy, but it lost ground when the CPO resigned. Although there is no concrete evidence in the case study findings regarding what triggered the downsizing decision, the reluctance to invest in an ERP system and to make changes to the organisational structure coincides timewise with the decision to cut overhead costs. However, this situation could have been avoided had the logistics manager, the project manager and the CPO been able to agree upon a satisfactory ERP system. Research on strategic consensus highlights this issue and indicates that shared reasoning and consistency in decision making over time are important parts of the strategy process (Mirzaei *et al.*, 2016). In the case study, the logistics manager had to negotiate with stakeholders at a variety of hierarchical levels, including top management, regional managers and site managers. Reaching strategic consensus between all these levels requires time, timing and consistency in decision-making (c.f. Ruffini *et al.*, 2000; Mirzaei *et al.*, 2016; Elfving, 2021), and may result in settling for a satisfactory fit.

The case study findings support two of the dynamic approaches to fit identified in the literature: strategic choice (Child, 1972) and SARFIT (Donaldson, 1987). For strategic choice, our findings reveal that managerial discretion was constrained by several factors, such as support among top management, incentives in the line organisation, the educational and professional background of internal stakeholders and company politics. This contrasts with cross-sectional studies of logistics strategy and supply chain fit which focus on outcomes over the process of establishing fit. The case study findings are more in line with the suggestions of Ruffini *et al.* (2000) that the building contractor's logistics strategy is codetermined by contextual factors and the level of discretion decision makers have to establish fit. The main thesis of this paper is that contextual factors do not directly determine the logistics strategy. The authors propose that strategic choice influences both contextual factors and logistics strategy content, where the antecedents to strategic choice are managerial discretion and the predisposition of managers. Since contextual factors (i.e. the degree of pre-engineering and the production system) are not static over time, there will be a process of regaining fit, where the outcome (fit/misfit) is dependent on strategic choice. This line of reasoning falls under the notion of dynamic fit put forward by Zajac *et al.* (2000) who treat fit as an ongoing process of regaining fit, either by making modifications to contextual factors, strategy or both. In other words, the logistics strategy process can be driven by a change in demand and production characteristics requiring an increase/reduction in the degree of pre-engineering and a change of production system (reduction/increase in IP requirements) and/or logistics driven by reconfiguring logistics strategy components (reduction/increase in IP capacity). The former is driven by the logistics strategy, where logistics is a source of competitive advantage. The logistics strategy triggers a change to product and/or process characteristics, which resembles the inside-out approach. In the latter, the logistics strategy is a means of pursuing the corporate/business strategy, which resembles the outside-in approach.

However, the competing model SARFIT was also supported by the case study findings. The main reason why the logistics strategy process was initiated at all was poor logistics performance stemming from a misfit between the logistics strategy and contextual factors. The logistics manager attempted to change the logistics strategy to accommodate the existing context and did not target the contextual factors alone. This highlights an important nuance between strategic choice and SARFIT. Strategic choice assumes managers can manipulate the context, the strategy or both. SARFIT, on the other hand, questions whether organisations will change their context without adjusting their strategy (Donaldson, 1987). Therefore, while strategic choice may involve making adjustments to contextual factors, it will not be without some changes to be made to the organisation’s strategy. However, it should be noted that neither of these two theoretical models alone can explain how fit is established. The application of each of these theoretical models as lenses to analyse the logistics strategy process yielded support from the case study findings, but the two contradict each other. Therefore, the two models can potentially be combined, although this is beyond the scope of this paper.

Besides the reason why strategic change occurs in the first place, studies focusing on the content of fit within logistics and supply chain management fail to explain why a misfit can endure over a longer period of time. Luo and Yu (2016) address this issue and contend that it is not simply a matter of differentiating between fit and misfit. For instance, they argue that misfit caused by an underfit (i.e. when IP requirements exceed IP capacity) has more detrimental performance implications than an overfit (i.e. when IP capacity exceeds IP requirements). It is thus preferable to pursue an overfit strategy, if for some reason fit is impossible to achieve. In essence, the decision to retain a misfit or adjust the strategy to regain fit comes down to the cost of incurring change vis-á-vis living with the misfit (Gligor, 2017). Although it is difficult to determine the costs incurred by the building contractor’s logistics strategy process, it is obvious that it ultimately did not pay off. In retrospect, a rational conclusion through the lens of contingency theory would be to not pursue the intended logistics strategy at all and live with the misfit if the pre-existing misfit was not too detrimental for performance.

From the perspective of the building contractor, the logistics strategy process cannot only be viewed as a means of changing the organisational structure to cope with uncertainty (lack of IP capacity) or establish formalised processes (reduce IP requirements). It needs to encompass the contextual factors, including demand characteristics (e.g. by changing project selection strategy), the degree of pre-engineering (i.e. moving the customer order decoupling point) and the choice of production system. This is in line with previous research on logistics strategy, which highlights the need to establish fit between product and process characteristics and the logistics strategy and structure. For instance, Christopher (1986) argues that different positions in the product/process matrix require different ways of organising logistics activities, and thus the product/process characteristics determine the feasibility of a particular logistics strategy. A configuration of logistics strategy structure and process components can therefore be integrated with Jonsson and Rudberg's (2015) version of the product/process matrix, which is adapted to the project-based production of housebuilding. Different positions in the matrix represent variations in product and process characteristics and each position has an ideal configuration of logistics strategy content. However, it is important to note that such ideal configurations are static over time. Building contractors need to continuously adapt their logistics strategy to its contextual factors, and vice versa. This is in line with the dialectical and paradox-based views on fit suggest that strategic change is not about achieving an optimal configuration, but about a continuous act of balance between tensions in the organisation (Sandberg, 2017).

Application of the strategic choice and SARFIT models, respectively, comes with different implications for building contractors. Strategic choice implies that there are three different routes towards establishing fit: (1) the logistics strategy can be adjusted to suit the contextual factors (demand characteristics, the degree of pre-engineering and the production system); (2) demand characteristics, the degree of pre-engineering and the production system can be adjusted to the logistics strategy and (3) a combination of (1) and (2). SARFIT, on the other hand, suggests that the logistics manager's discretion in adjusting any of the contextual factors (demand characteristics, the degree of pre-engineering and the production system) is limited, at least to the extent that changing the degree of pre-engineering and/or the production system will have any effect on strategic fit. Thus, SARFIT rules out the second option described previously in favour of options one and three.

Conclusions

The purpose of this paper was to investigate logistics strategy from a process of establishing fit perspective. The paper contributes to the body of knowledge on organisational design and strategy in logistics and supply chain management. The first research question is answered by identifying factors that constrain logistics strategy implementation (Table 3). In addition, the implications for fit are addressed through answering the second research question (Table 4). The study thus builds upon cross-sectional studies within this research area by elaborating on the process of establishing fit. The following sub-sections discuss the research implications, the limitations of the study and suggestions for further research.

Research implications

Previous research emphasises that fit creates superior performance, where fit is defined as the match between IP requirements and capacity. However, this would assume that a building contractor's contextual factors, logistics strategy and performance levels remain stable over time with limited need for strategic change, which is seldom the case even in industries with low clock speeds, such as construction. Add to this the fact that strategic decision makers do not always possess sufficient decision-making authority to pursue an ideal configuration, such as in the case of the building contractor's logistics manager. Contextual factors are thus important to consider, but they do not determine the logistics strategy. The contingency determinism argument should therefore be rejected. However, this is not to de-emphasise the importance of fit; different combinations of product and process characteristics have different theoretically ideal configurations of logistics strategy components.

Managerial implications

The findings indicate that managers may need to strive for satisfactory fit rather than attempting to establish an ideal form of fit. The factors constraining managerial discretion in this study (Table 3) can potentially be found in similar companies (project-based ETO companies). These can be used to map stakeholder demands and their willingness to compromise their demands to determine which structure and process components are possible to implement. Furthermore, the study distinguishes between logistics strategy structure and process components (Table 4). This distinction can be used to identify relevant logistics strategy components, but the components identified in the case study (Table 3) may look different for other building contractors and for companies in other ETO industries. Logistics and supply chain managers in other companies thus need to identify relevant structure and process components.

Limitations and further research

The contextual factors and logistics strategy components examined here are specific to construction and cannot be directly generalised to other industries. The peculiarities of construction, such as fixed position, temporary production systems and temporary project organising imply that the principles from other industries cannot be adopted without consideration of these peculiarities because the sources of uncertainty are different from manufacturing. However, future studies on logistics strategy implementation in other project-driven industries (e.g. ETO manufacturing) would be of interest for comparing with the results of this study. Large-scale surveys can preferably be employed to test which of the two models, strategic choice or SARFIT, can best explain the variance in firm performance. Furthermore, the authors suggest further conceptual studies to explore how the two models can be integrated into a single holistic framework.

The single-case design poses some limitations to generalisability. The logistics strategy components (Table 3) are specific to the building contractor in the case study. Further studies on other types of building contractors (e.g. industrialised housebuilders) and ETO contexts are needed to define generic logistics strategy components for ETO companies. In addition, the case study findings indicate that the middle management levels of building contractors may be overlooked in the construction logistics research domain. Regional and area managers have a high level of authority and oversee multiple projects simultaneously. The findings indicate that they were a constraining factor to logistics strategy implementation, but this needs to be investigated further.

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Paper 5

Organizing construction logistics outsourcing: a logistics strategy perspective

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Organizing construction logistics outsourcing: a logistics strategy perspective

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Abstract

Purpose – The construction industry shows an increased interest in how to manage logistics within construction projects. Often construction logistics is outsourced to a logistics service provider (LSP). However, construction logistics is normally approached either as a strategic decision or as an operational issue and rarely as a tactical concern. The purpose of this study is to explore how to organize the logistics outsourcing decision at strategic, tactical and operational levels.

Design/methodology/approach – This study is performed as a single-case study within a construction corporation, containing (amongst others) a building contractor (BC) and a construction equipment rental company (CERC) offering logistics services.

Findings – The study shows that to procure construction logistics service successfully, BCs need logistics capabilities at strategic and tactical levels to maintain an alignment between the use of logistics services and operational characteristics. Simultaneously, CERC's need to design their service offerings to correspond to the needs of the BC.

Research limitations/implications – This study builds on a single-case study of a Swedish construction corporation. Further research is needed to better understand current logistics outsourcing and development practices and how these can be improved to foster better logistics management at the project level.

Practical implications – BCs find suggestions of different logistics organization structures and suitable outsourcing arrangements. CERCs and LSPs can use the findings to understand their customers' needs and adapt service offerings.

Originality/value – To the best of the authors' knowledge, this study is one of the first studies of how two companies within a corporation can work together to develop construction logistics service offerings.

Keywords Construction logistics, Outsourcing, Building construction, Logistics services, Supply chain management, Construction management

Paper type Research paper

1. Introduction

Construction projects are characterized by an element of temporariness as production is carried out at the final place of consumption (Ekeskär and Rudberg, 2016), with new production sites in each new project. This differs from other industry contexts where the

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place of consumption is decoupled from the place of production and the production facilities are, to a greater extent, fixed in their location. These differences indicate that logistics in construction needs to be managed in a more dynamic way as the project conditions will dictate how logistics is carried out on-site (Spillane *et al.*, 2013; Spillane and Oyedele, 2017) as well as to and from sites (Ghanem *et al.*, 2018; Ying *et al.*, 2021). At the same time, construction is material intensive and according to Scholman (1997), 60%–80% of the gross work involves purchased materials and services and approximately 40% of the project cost is made up of logistics costs (Jang *et al.*, 2003). All in all, this suggests that logistics management should be a priority in the construction industry. However, as noted by Navon and Berkovich (2005), logistics management has traditionally been approached in an *ad hoc* manner by construction projects and not as an opportunity to improve the construction projects' performance. Instead, construction projects have solved their daily logistics activities on a day-to-day basis (Ying *et al.*, 2018). Lately, however, construction logistics has received more attention from the construction industry and research alike, and BCs are starting to see the benefits of managing logistics (Dubois *et al.*, 2019). In the construction industry, outsourcing is the norm and construction projects are typically dependent on a multitude of subcontractors and suppliers being procured for each new project (Dubois and Gadde, 2002). Outsourcing logistics activities is thus not farfetched, but rather keeping in line with the temporary structure of the industry (Fredriksson *et al.*, 2021).

While logistics outsourcing in construction can bring benefits in terms of specialization (Sundquist *et al.*, 2018) and better estimates of material handling costs (Lindén and Josephson, 2013), the benefits of logistics outsourcing do not always outweigh the cost of acquiring a logistics service provider (LSP). The outsourcing norm in the construction industry typically favour short-term arrangements with LSPs, despite that LSP alliances or even in-housing logistics can generate greater benefits under certain circumstances (Selviaridis and Spring, 2007). In general, when a firm is dependent upon an LSP, it is more likely to engage in a strategic alliance or in-house logistics functions to a greater extent (Hofer *et al.*, 2009). The main rationale why contractors decide to outsource logistics is thus primarily due to institutional factors rather than for efficiency and effectiveness reasons.

Previous research indicates that the logistics outsourcing decisions, regardless of the outcome in terms of in-housing or outsourcing, need to be rooted in the buying firm's logistics strategy (Selviaridis and Spring, 2007). Autry *et al.* (2008, p. 27) define logistics strategy as "strategic directives formulated at the corporate level [. . .] used to guide more efficient and effective logistics activities at the operational level of the organization". From the perspective of the BC, the logistics strategy thus plays a key role by guiding the decision-making at the project level as to whether to perform logistics in-house or to outsource it to an LSP. Previous studies on third-party logistics in construction suggest that logistics outsourcing can be a means of developing new capabilities that would not be possible with an internal logistics function (Sundquist *et al.*, 2018). On the other hand, by internalizing the logistics function, the main contractor can set up a logistics system that is aligned with the type of product, production process and supply chain characteristics (Haglund *et al.*, 2022).

Construction logistics literature has so far mostly focused on logistics outsourcing at the project level. Meanwhile, there are few examples of contractors with a formalized logistics strategy and an internal logistics function. Instead, construction logistics is seen as an operational issue to be managed within each construction project (Ekeskär and Rudberg, 2016). BCs typically struggle to achieve sufficient economies of scale in construction logistics and thus opt for the outsourcing option (Le *et al.*, 2021). This augments the temporary structure of the construction industry (Dubois and Gadde, 2002) and limits long-term strategic approaches to logistics management in construction. Furthermore, there is typically a missing link between strategic- and operational-level logistics among BCs (Thunberg *et al.*, 2017; Elfving, 2021). The missing tactical level of construction logistics should act as translating the operational needs of all projects into rough plans for the company's resources within the scope of the logistics strategy (Vollmann *et al.*, 2005). The missing tactical level means that there is a risk of procuring logistics services that are misaligned with the BC's operational characteristics. Therefore, the logistics outsourcing decision needs to be rooted in a company-level logistics strategy (Selviaridis and Spring, 2007), which guides decisions at the tactical and operational levels of the BC (Thunberg and Fredriksson, 2018). The purpose of this study is thus to explore how to organize the logistics outsourcing decision at strategic, tactical and operational levels.

The purpose is fulfilled through a case study of a large construction corporation's two sister companies: the BC and the construction equipment rental company (CERC). The BC has a history of different approaches to logistics development over the years, including an attempt to internalize logistics and more recently to outsource logistics. Recently, the CERC has acquired an LSP to offer third-party logistics services to its sister companies within the corporation.

2. Logistics outsourcing decision

2.1 Logistics outsourcing in construction

The decision to outsource logistics can be made for several reasons. A contractor can view an LSP as a substitute for investing in the resources and capabilities needed to manage logistics efficiently in construction projects (Ekeskär and Rudberg, 2016) or as an opportunity to learn from a specialized LSP that already possesses such resources and capabilities that facilitate economies of scale (Sundquist *et al.*, 2018). However, while lack of internal logistics capabilities can be in favour of outsourcing, another factor influencing the decision to outsource logistics is the logistical complexity of the project. Lindén and Josephson (2013) found that the lower complexity in repetitive projects (e.g. residential buildings and hotels) is in favour of logistics outsourcing. Therefore, there are two main dimensions that determine whether a contractor should outsource logistics to an LSP or keep the logistics as an internal function: the level of logistics capability of the contractor and the level of logistics complexity of the project.

Logistics complexity depends on several factors that influence the logistics outsourcing decision. The typical factors described in the literature are product, process and network characteristics (Wiengarten *et al.*, 2017). Product characteristics refer to the special considerations that need to be taken in transportation, storage and handling of materials (Rao and Young, 1994) and the product structure (Hofer and Knemeyer, 2009). Physical properties of goods mainly influence the ability of a client to control the quality of products, which can provide incentives to retain physical logistics tasks in-house. On the other hand, complex product structures demand high service levels to ensure timely replenishment of components and materials, which is in favour of logistics outsourcing (Bolumole, 2003).

Process characteristics comprise how critical timely deliveries are to the point of consumption (e.g. a production task) and the predictability of demand for materials and components (Rao and Young, 1994). The unsteady demand of materials and components in site production is in favour of small lot sizes and frequent replenishment (Schonsleben, 2000). As such, this requires a higher degree of coordination in the supply chain, which is in favour of outsourcing logistics for the client (Bolumole, 2003).

Supply network characteristics are defined as the geographical dispersion of suppliers and the type of business relationship (Hofer and Knemeyer, 2009). The geographical dispersion of suppliers determines the number and distance to nodes in the supply network. An LSP can be used in situations where network complexity is high, and the client does not possess the sufficient capital, capability and/or facilities to manage the wide dispersion of material flows (Rao and Young, 1994). For instance, a contractor can use a construction logistics company that channel deliveries through a terminal, thus reducing the number of deliveries to the site (Janné and Fredriksson, 2022). Besides the potential operations-related reasons for logistics outsourcing, experiences from previous business relationships with LSPs can determine whether a client favour outsourcing logistics or relying on in-house capabilities (Rao and Young, 1994). Construction projects are a typical example where contractors and sub-contractors have been unfamiliar with logistics service arrangements, which has led to scepticism in relying on LSPs (Ekeskär and Rudberg, 2016).

2.2 Logistics organizations designs

BCs are project-based organizations where functional areas typically do not exist or have a limited role. In general, the more variety there is between projects, the more project-oriented the organizational structure will be to handle this complexity and unpredictability generated from variety at the project level (Galbraith, 1971). Logistics organizations can be designed in several different ways that accommodate different contextual conditions in terms of logistics complexity and predictability (Persson, 1978). Kim (2007) identifies five generic logistics organization types: the non-supply chain management oriented, the functional, the matrix channel, the process staff and the integrated line:

- The non-supply chain management oriented is characterized by its absence of a logistics or supply chain department. Logistics activities are performed in the line organization within each functional area without the use of specialized logistics personnel.
- In the functional type, logistics is separated into its own functional area, i.e. it has the same status as production, marketing and sales.
- The matrix channel type is similar to the functional type, but rather than having the role as a functional area, it focuses on cross-functional coordination and takes a boundary-spanning role.
- In the process staff organization, the logistics department is a form of internal consultant, where logistics activities are executed by unspecialized line staff of each functional area, but with the support of logistics specialists.
- In the integrated line organization, the logistics department is positioned close to the strategic apex in the organizational hierarchy. In this type of logistics organization, the logistics manager possesses a senior management role and is typically part of the top management team, whereas day-to-day logistics tasks are performed in the line organization.

Because building construction is a project-based, engineer-to-order type of production, it is uncommon to find logistics departments at the central company-level or as a functional area within BC organizations (Haglund *et al.*, 2022). Many BCs' logistics organizations are therefore project-based versions of the non-supply chain management-oriented organizational type (Kim, 2007) where logistics is managed decentralized at the project level (Dubois *et al.*, 2019). This type of logistics organization design favours logistics outsourcing due to the lack of adequate internal logistics resources needed to achieve economies of scale (Daugherty and Dröge, 1997). Projects need to bear their own costs, and when the cost of logistics resources are allocated to the projects rather than to the logistics department at the central level, outsourcing becomes a means of increasing specialization and achieving economies of scale in the absence of internal logistics resources (Sundquist *et al.*, 2018).

2.3 Organizing construction logistics outsourcing

In the design of the logistics organization and the decision whether to outsource logistics or not, the latter is typically described as preceding to the former (Daugherty and Dröge, 1997). The outsourcing decision thereby precedes structure. Non-supply chain management-oriented and/or staff-oriented logistics organization structures are the result of a decision to outsource logistics. When logistics is outsourced, there is no need for the buying company to set up corresponding logistics capabilities in-house. Functional logistics organization types will however outsource logistics to a lower degree.

However, it is not possible to rule out the possibility that the structure does not follow the outsourcing decision because a change in structure may incur the need to change the decision. As such, rather than being unidirectional, the relationship between logistics organization design and logistics outsourcing is bidirectional, where an existing logistics organization structure may influence the decision to outsource logistics. The structure of the logistics organization in BCs is in turn influenced by other factors than logistics outsourcing decisions, for instance, the degree of logistics complexity and predictability generated by the number and variety of products, the production strategy (make-to-order/make-to-stock), interdependence between the logistics function and other functional areas (Persson, 1978; Haglund *et al.*, 2022). Such contextual conditions can therefore influence the logistics outsourcing decision via the logistics organization design and vice versa.

3. Research design and method

This study was based on a single-case study design (Yin, 2018), where the interaction between the BC's and the CERC's strategic, tactical and operational levels was the unit of analysis (see Figure 1). The focus of the empirical investigation was how the BC and CERC organized logistics outsourcing at the three levels. In line with the recommendation by Van de Ven (1992), the research is a combination of a retrospective perspective and real-time observation of the BC's approach to logistics outsourcing, which led to the CERC becoming

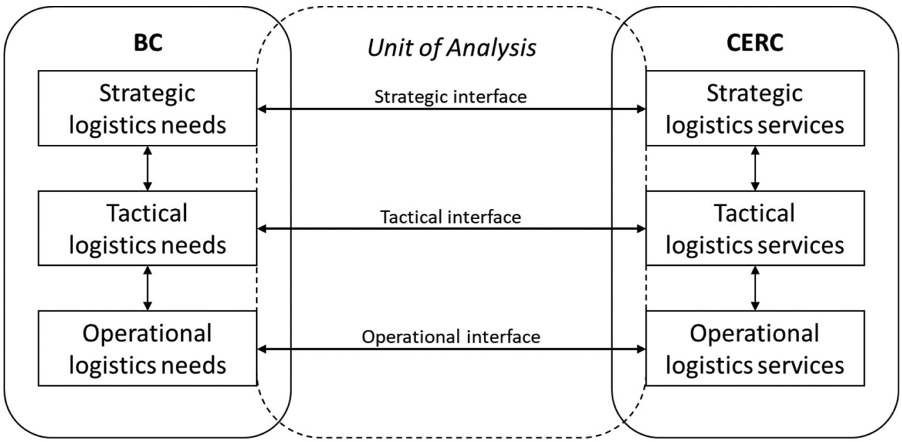

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Figure 1. Unit of analysis in the single-case study

an LSP. The longitudinal data was collected several years prior to the field studies that constitute the empirical foundation of this study. The longitudinal data was used to contextualize the current organization of logistics outsourcing between the BC and CERC by following the events that had led up to the present situation. Therefore, even though the study was not designed as a longitudinal study in a strict sense, it carried elements of longitudinal data while studying the organization of logistics outsourcing at different organizational levels in real time.

3.1 Data collection

Different methods were used to collect data, although in-depth interviews were the primary source of data. Table 1 summarizes the data collection methods used in the study and which organizational level the data was used for. For the interviews, they ranged from being unstructured interviews with key informants at an early stage of the research process to explore the case to semi-structured interviews in a later stage as the research problem became clearer. More importantly, the data collection strategy aimed to capture the perspective of the BC and the CERC, and the strategic, tactical and operational decision levels. As such, the researchers used a contact person at the BC (referred to as the logistics developer in Table 1) who referred the researchers to suitable persons to talk to in the BC or CERC. The logistics developer thereby assisted in finding suitable candidates to interview that met the researchers' sampling criteria (King *et al.*, 2018).

Other data sources used were documents and direct observations. The documentation was retrieved from the BC and the CERC and included information about the BC's past, current and planned (future) logistics organization, standard operating procedures and routines at the BC and descriptions of the CERC's logistics services. One site visit at an ongoing construction project recommended by the BC's logistics developer was conducted. In the project, the BC had one of their project logistics specialists working with site, production and delivery planning, while they also used the CERC's logistics services, e.g. the CERC's planning system and logistics specialists. The site visit provided valuable input on how the BC could use the CERC's logistics services.

3.2 Data analysis

The analysis procedures were partly deductive and partly inductive. Initially, the researchers formed tentative propositions regarding how construction equipment rental

Table 1. Data collection methods

Data collection method	#	Time	Perspective Strategic	Tactical	Operational
Interviews with logistics developer at BC	4	30 min to 2 h	X	X	
Interview with business developer at CERC	1	1.5 h	X		
Interview with operations manager at CERC	1	1 h	X	X	
Interview with project logistics specialist at BC	1	1 h			X
Interview with regional manager at CERC	1	2 h		X	X
Site visit at BC project	1	2 h			X
Documentation BC: strategy documentation, organizational charts, organizational procedures and routines	n.a.	n.a.	X		
Documentation CERC: logistics service descriptions	n.a.	n.a.	X		

Source: Authors' own creation

companies could become LSPs. During the process of collecting and analyzing the data, these propositions were revised. This iterative process is referred to as “explanation building” (Yin, 2018). For instance, in the case study, the study initially focused on the CERC’s new service development. However, the initial interviews with key informants at the CERC suggested that the BC played a large role in what services they developed. As such, the researchers partly abandoned the notion of new service development and instead shifted the focus towards the BC’s logistics organization and the CERC’s service offerings.

Furthermore, the initial screening of documentation suggested that the logistics outsourcing arrangement required attention on different organizational levels. Hence, the data analysis proceeded as thematic coding (Flick, 2018), in which short case descriptions were created for each interview. This description included a summary of what the interview dealt with and how it was related to the overall purpose of the study (i.e. whether the respondent worked at the BC or the CERC, and at which organizational level the respondent was involved). The result of this is outlined in the right part of Table 1 with the perspective of each data source. Finally, the case descriptions were compiled into the findings that covered the strategic, tactical and operational levels at the BC and the CERC.

4. Findings

The following sections present the case study based on the findings from the interviews, site visits and documentation. Furthermore, the relationship between the BC and the CERC is presented using information about two main components within the outsourcing relationship: the BC’s internal logistics organization and the CERC’s service offerings. Finally, the findings are synthesized by presenting the BC–CERC dyad.

4.1 Logistics development in the construction corporation

The BC and the CERC are part of a larger construction corporation. The BC is a general-purpose contractor that designs and builds multi-family residencies, industrial buildings, commercial buildings and public buildings (e.g. hospitals, schools and elderly homes). They have been working sporadically with logistics development projects since 2008, but it has never fully gained traction within the organization. They put in considerable effort between 2008 and 2015, but this lost ground when the logistics manager at the time retired. Instead, the purchasing manager at the time started up a central logistics function to drive the company’s logistics development. In 2018, a logistics developer was hired to pick up where the former logistics manager had left off. The logistics developer made a thorough analysis of the company’s previous undertakings and their current situation. In particular, the logistics developer investigated what types of material and resource flows the BC typically had in their projects, what supplier base they had, the existing internal logistics capabilities within the construction company’s subsidiaries and started working towards an understanding for what logistics services were needed in their typical projects to be able to find a supplier of said services. The logistics developer identified and categorized five vital flows, i.e. *site establishment resources*, *machine resources*, *project-specific materials*, *consumable materials* and *waste* (1 in Figure 2). In 2020, this resulted in a vision; all projects should at least consider how the five identified flows were to be managed as part of planning the construction projects. However, this could not be integrated into the contracting business area with its focus on traditional contracting services. Instead, the CERC was approached because they already offered all these services, except for logistics (2 in Figure 2).

The CERC is one of Scandinavia’s largest companies in construction equipment rental, crane rental and other construction-related services. They already had the ability to manage

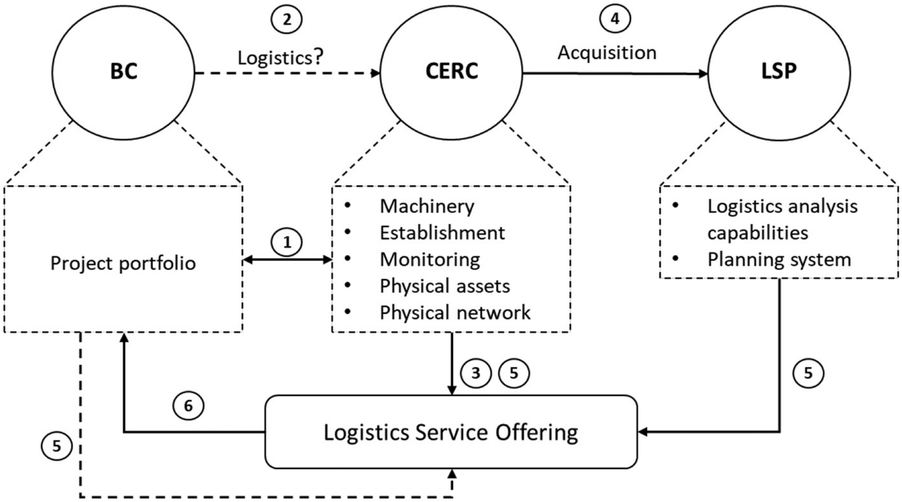


Figure 2. CERC's development of "new" logistics service offerings

Source: Authors' own creation

the machinery and establishment resource flows, and they also provided a solution for monitoring energy efficiency, etc. on site and added this as part of their logistics service offerings (3 in Figure 2). In addition, the CERC partnered with a supplier of a smart delivery container where consumable materials could be delivered using an app that unlocked the container from the outside, enabling the suppliers to deliver consumables contactless. The focus from the CERC was thus primarily on physical assets and providing these types of services once the projects were up and running.

However, even though logistics is a large part of the CERC's daily operations, they lacked more analytical and planning-based capabilities. As such, the CERC (in collaboration with the contractor's logistics developer) started investigating if there were any logistics planning systems that could be licensed and supplied to the construction projects through the CERC. They entered discussions with an LSP who had a well-developed planning system and found that the owner of the LSP company was planning to sell the company and retire. A decision was made, and the CERC acquired the LSP in 2021 (4 in Figure 2), thus gaining the planning system and logistics analysis capabilities needed. The logistics analysis capabilities alongside the planning system and the physical assets the CERC already possessed were presented as an initial logistics service offering to the contractor's logistics developer who gave input on what was needed in terms of logistics services in the projects (5 in Figure 2). These logistics services are now packaged as the logistics service offerings that the construction projects can choose to use (6 in Figure 2).

4.2 The building contractor's logistics organization

The BC's previous attempts with logistics development had set out to set up a logistics organization within the company, but this was never realized due to the failed implementation of the strategy and the previous logistics manager's retirement in 2015. As such, the BC had no one in the organization that owned and maintained logistics set-ups at a company level. Yet, the BC had a need for basic logistics services, such as delivery planning, site disposition planning and intermediate storage. In response to these requirements, the logistics developer at the company initiated the development of a logistics setups configurator. The configurator, which is inspired by product configurators in terms of handling constraints and combinations of modules, aims to maintain a certain degree of flexibility in designing project-unique logistics set-ups based on a set of predetermined services. For instance, in projects where the BC already has a project logistics specialist, this option is greyed out in the configurator. This flexibility in designing logistics setups is deemed important to the BC because their projects vary in size, complexity and availability of logistics resources.

Currently, the BC does not have a formal logistics department, but the organization constitutes the logistics developer working at the corporate level, and several logistics specialists working at the regional and the project levels. The logistics developer mainly works with the long-term, strategic, logistics development. The project logistics specialists work in projects from start to end as expert support for site management and as a hub for site management and the CERC's logistics specialists when these are used. In general, the BC lacks presence at strategic, tactical and operational levels due to the small number of logisticians relative to the company size. As such, the logisticians in the company's current logistics organization has limited influence on the overall organization. However, the absence of logisticians is most profound at the tactical level, which corresponds to the BC's regional divisions. Although there are routines and standard operating procedures across the company, the regional divisions operate autonomously to a great extent. A key point is that the BC's core business (i.e. contracting services) takes place at this level where traditional roles dominate, such as regional managers, project managers and site managers. The tactical level can be described briefly as a regional manager who is responsible for tendering procedures and decides whether to place a bid or not, a regional operations manager who is responsible for business development and sales and operations planning of the projects in their regional area and a project is assigned to a project manager who is responsible for master planning of the project in terms of costing, purchasing, scheduling and client relationships. The absence of logistics at a regional level has not gone unnoticed. The logistics developer is planning on strengthening the regional divisions across Sweden with regional logistics managers and project logisticians in the upcoming five years.

4.3 The construction equipment rental company's service offerings

The CERC has been offering logistics services since 2021 when they acquired an LSP. As the CERC is part of the construction company corporation, they had access to business area managers to get their input on what type of services are needed for the contractor's different project portfolios. During the service development, the CERC worked closely with the contractor's logistics developer, housing developers, business area managers and project managers to develop service packages. An issue that the CERC identified was that even though they are part of the same corporation, the construction industry's local character meant it was difficult to reach all the regions of the contractor to pitch their service offerings. This in turn meant that the CERC started to focus more locally from their different subsidiaries, using them as sales organizations.

The CERC took its departure from what they already knew and offered to their customers. The philosophy from the CERC's point of view was that "by paying a little more initially, we can reduce the total cost of operations for the construction projects". This philosophy has in the past led the CERC to develop solution-based service offerings related to site establishment and machinery resources, taking total ownership of the site establishment process. Example of this is that the CERC has equipped all their heaters with sensors and remote controlling to be able to keep temperatures constant during concrete drying processes or to lower the indoor temperature of buildings when craftsmen are not on site in evenings and weekends to reduce projects' total energy consumption. This not only creates value for the construction projects but also gives the CERC an overall control of their resources and assets. In addition, by taking the overall responsibility for delivering and retrieving machinery from sites based on the progression plan of the projects, the CERC has been able to reduce their tied-up capital and increase the occupancy rate of assets.

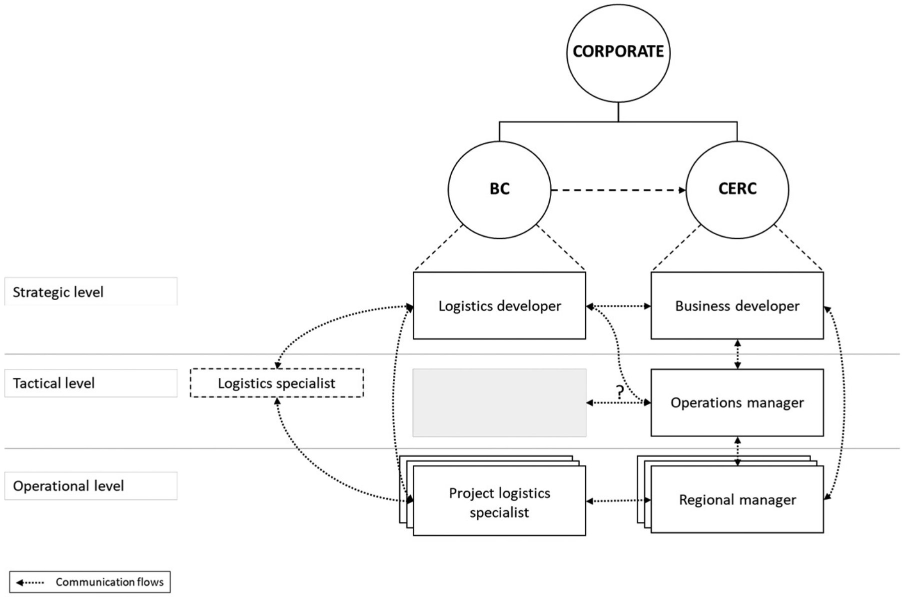
The CERC's preferred trajectory is to become a solutions supplier, providing logistics services that can manage the five flows defined by the contractors' logistics developer (*site establishment resources*, *machine resources*, *project-specific materials*, *consumable materials* and *waste*). As such, the CERC targets municipalities and large housing developers in their marketing efforts and prefers not to bid for procurement proposals unless they can be a solutions supplier. If, for instance, they are approached with a procurement proposal regarding on-site materials handlers, they prefer not to invest time in making an offer. However, the CERC is aware that not all construction projects have the need for all logistics services they offer. They thus work to develop service packages that can be of value in different project settings. An example of this is the logistics planning system that was acquired with the acquisition of the LSP company: the aim is to develop this system and to provide it in small, medium and enterprise versions to cater to different project sizes' needs.

With the acquisition of the LSP came some more hands-on construction logistics know-how in the form of LSP employees joining the CERC. This means that the CERC can offer logistics analysis as part of their service offerings. As mentioned previously, the CERC wants to be included early in the project planning process and by offering the analytical work, they can ensure that they can affect the construction projects positively from a logistics perspective. The analysis also includes offering recommendations on services and service providers that the CERC themselves cannot offer. As the construction projects progress, the CERC provides continued analytics to show the value that the construction logistics services has given the project. The goal of these analytics is twofold: to show the value created for the project, but more importantly, to increase the logistics awareness in the construction project managers and to drive home the point that well-functioning logistics is a necessity for a well-functioning construction project.

4.4 Building contractor–construction equipment rental company dyad

Figure 3 illustrates the BC–CERC dyad, including key persons in the BC and the CERC and their position in the organizational hierarchy. The CERC has a similar structure to the BC in terms of geographical divisions. At the strategic level, there is a business developer that focuses on developing the logistics service offerings. The business developer is supported by an operations manager, whose main responsibility is the delivery of logistics services for the CERC's logistics business unit. At the operational level, there are regional managers who work more closely with delivering services within a geographical region.

There are clear interfaces between the companies' strategic and operational levels. There is close collaboration at the strategic level, where the logistics developer and the business developer have put in joint efforts into designing the CERC's service offering in parallel with the BC's logistics configurator. At the operational level, the BC's project logistics specialists collaborate with an operations manager at the CERC. At the tactical level, the CERC's operations manager does not have a counterpart because this level does not really exist in the BC. The logistics specialist (positioned to the left in the figure in the dashed box) works in multiple projects in one regional division in Sweden, which could be regarded as the tactical level, but there is no communication between them and the CERC's tactical level.



Source: Authors' own creation

Figure 3. Logistics organizations and communication flows in the BC and CERC

Furthermore, most regional divisions in the BC do not have a corresponding role. Hence, the tactical level in the BC's logistics organization hierarchy is greyed out.

5. Discussion

The purpose of this study was to explore how to organize the logistics outsourcing decision at strategic, tactical and operational levels. The BC's use of the CERC as an LSP differs from transactional, arms-length relationships in that it is a systematic use of an LSP. As such, this use of an LSP goes beyond merely buying themselves free from managing logistics, where logistics is not considered as a cost only, but that it adds value to their operations (Tetik *et al.*, 2022). However, at a strategic level, there is still a mismatch between the BC's need for logistics and the logistics services offered by the CERC. The BC's logistics configurator is a means of developing customized logistics set-ups for each project, where some services can be excluded if they already possess corresponding capabilities in-house. On the other hand, even though the CERC recognizes that not all their services are required in every project, they clearly favour larger contracts with a wide variety of services that are bundled together. From a corporate perspective, this raises questions of what to prioritize because the two companies are part of the same corporation: profitability of the BC's projects or profitability of the CERC? Typically, standardized "package" solutions are preferred when they serve the main contractors' project portfolios while customized solutions are intended for unique, one-off projects (Fredriksson *et al.*, 2021). As such, the CERC should be able to offer package solutions of logistics services to the BC. The problem with this set-up is that the BC lacks organizational procedures and routines for logistics which, in the absence of logistics expertise at the BC's tactical level, results in that the BC only procures the CERC's logistics services on a project-to-project basis. In other words, there is no dialogue between the BC and CERC at a tactical level, which limits the sales volumes for the CERC's logistics services.

Tactical level planning in engineer-to-order contexts, such as construction, is characterized by a high degree of uncertainty (Shurrab *et al.*, 2020). However, preliminary production plans and rough capacity requirements estimates can be derived from previous projects with similar characteristics (Bhalla *et al.*, 2022). The BC thus needs to build up logistics organizations at tactical levels, corresponding to the BC's regional divisions, to increase the scale of logistics services purchased from the CERC. This enables the CERC to increase sales volumes of their logistics services and the use of standard logistics service package set-ups. There is a tendency among BCs to focus on either the strategic corporate level or the operational project level (Elfving, 2021). The tactical level is an important means of linking strategic plans of available resources within the company with project-level plans of required resources to carry out the projects (Thunberg and Fredriksson, 2018).

At the operational level, the question is whether the CERC should take a more comprehensive role in coordinating production with transportation, delivery and materials planning, whereas the BC's logistics specialists should work at higher planning levels. Currently, the BC's project logistics specialist coordinates project-level production plans with material deliveries. The CERC's logistics specialists are not involved in the site production but are involved in activities upstream of the construction site, such as planning of transports from suppliers to an intermediary storage or directly from suppliers to the construction site. Previous research indicates that logistics specialists that pursue multiple tasks that are interdependent (e.g. coordinating deliveries with production activities) can improve efficiency in the supply chain and at the construction site by reducing the number of transports while retaining service levels to the site production (Dubois *et al.*, 2019). Although this is a feasible option for projects where the BC does not have a project logistics specialist, the CERC's logistics specialist can be used as buffer resources during temporary periods of capacity constraints among the BC's project logistics specialists. As such, the CERC needs to ensure that they have sufficient capacity to provide buffer resources for BC's projects, whereas BC needs to carefully consider which projects they should allocate internal logistics resources to.

The findings from the case study suggest that both the BC and the CERC need to ensure that they have adequate logistics and service delivery capabilities, respectively, at all three organizational levels. At a minimum, the BC needs logistics capabilities at the strategic and tactical levels due to the company's geographical dispersion. There are several different organizational configurations that are possible when the BC uses the CERC's logistics services. Daugherty and Dröge (1997) identified two generic types that influence the degree to which logistics services should be outsourced: the "staff only" configuration and the "staff/line" configuration. These two configurations correspond to the functional type and the process staff type as defined by Kim (2007). In the process staff type, the BC would perform strategic and tactical logistics planning activities, whereas the CERC handles logistics activities at the operational project level. In the functional type, the BC would primarily use internal logistics personnel to perform logistics activities at the operational level or a combination of the BC's and CERC's logistics resources. In general, the process staff type typically corresponds to a higher degree of logistics outsourcing, whereas the functional type corresponds to a lower degree of logistics outsourcing (Daugherty and Dröge, 1997).

Even though the BC has a long history of trying to organize its construction logistics, the case study shows that there is still more work to do. Current efforts show the need for this work to be carried out in a structured way on the strategic, tactic as well as on the operational levels. However, as discussed by Sundquist *et al.* (2018), managing logistics in-house can be difficult if the in-house logistics capabilities do not cover all three levels. This can lead to a situation where one person tries to tackle all issues at once, which we can see in the case of the BC. One logistics developer tries to develop logistics management routines for an entire corporation. Traditionally, not possessing the “right” logistics capabilities has been a contributing factor to outsourcing logistics to a third-party logistics (TPL) provider (Selviaridis and Spring, 2007). Simultaneously, being overconfident in the in-house logistics capabilities can lead to a situation where a company does not know what to ask an LSP or TPL provider for (Janné and Fredriksson, 2022), and this is where it becomes important that the BC and (in this case) the CERC work together to develop both the BC’s in-house logistics capabilities and the CERC’s logistics offerings. However, once again, the case study shows the importance of addressing logistics capabilities on all three organizational levels also in the BC–CERC dyad. Logistics outsourcing should be a strategic decision that is not delegated entirely to the project level. However, on the strategic level, there is a mismatch between what the BC requests and what the CERC wants to achieve from their standpoint. The BC wants modularized service offerings, whereas the CERC wants to be a solutions supplier. On the tactical level, there is no real dialogue due to the BC’s logistics developer focusing primarily on the strategic and tactical levels, i.e. the CERC does not have a counterpart within the BC’s organization. This is in line with what Elfving (2021) found; the tactical level is often forgotten in strategy development. Yet, this is the translation from strategy to operational level and should not be forgotten. Thus, the minimum level of logistics capabilities needed in-house is at the strategic and tactical levels. This allows the BC a chance to maintain an alignment between the use of logistics services and the operational characteristics. Mid-term planning is needed here to ensure that logistics resources are available at certain times of a construction project and not left idle at other times of the project (Thunberg and Fredriksson, 2018).

The BC and CERC are both part of the same corporation, but from an organizational point of view, the respective logistics organizations are two small organizations within two large organizations within a large corporation. As such, the BC and the CERC must carry their own costs and deliver profits. Yet, there is an argument to be made for the BC and CERC collaborating to develop logistics capabilities within the two firms, as this can generate income for the CERC (Fredriksson *et al.*, 2021) and lower costs for the BC (Thunberg and Fredriksson, 2022). However, the corporation must be open to allow this collaboration in an area not seen as the respective firms’ core competence areas. If the BC and CERC are allowed to invest in developing collaborative construction logistics capabilities, the whole corporation can benefit from the collaboration.

6. Conclusions

The purpose of this study was to explore how to organize the logistics outsourcing decision at strategic, tactical and operational levels.

This study has shown that when organizing construction logistics services or set-ups, it is important to understand the connection between the strategic, tactical and operational levels within the organization, what logistics capabilities you possess within these levels and how these levels relate to one another. A suggestion is that the minimum level of logistics capabilities needed in-house is at the strategic and tactical levels to maintain alignment between the operational logistics characteristics of projects and the logistics services procured from an LSP. Understanding the in-house logistics capabilities will aid BCs in their outsourcing decision as it will help them realize what logistics capabilities they are lacking. Similarly, rental companies or LSPs need to understand what their customers

(BCs) are requesting and adapt their service offerings to cater to the missing logistics capabilities of BCs. Even if the drive is there to develop and offer full logistics service solutions, this may not be what BCs or developers are looking to procure. It is thus important that CERCs or LSPs consider their customers' in-house logistics capabilities as well and develop their service offerings in collaboration with BCs. To gain economies-of-scale in the construction logistics services offered, one suggestion is to develop modularized logistics services to allow BCs the chance to pick-and-choose the "correct" services from the project perspective.

Another important part of the outsourcing decision connected to the in-house logistics capabilities is to know what type of logistics organization aligns with the overall company logistics strategy. In this study, we suggest that BCs should aim for either a strategic/tactical process staff organization where operational construction logistics is outsourced to an external LSP or a functional type where BCs primarily use internal logistics personnel or a combination of internal and external personnel to perform logistics activities at the operational level.

There are inherent limitations to the single-case study approach in that a single case can only show the findings from that case. However, findings from this single-case study constitute a valuable starting point for further studies. To the best of the authors' knowledge, there are no similar cases where a rental company that has become an LSP and a BC are part of the same corporation. The CERC is thus semi-internalized in the BC. Future studies should use multi-case designs that pursue theoretical replication by comparing the findings from this study with cases where logistics is fully integrated within the contractor's organization and fully outsourced. Furthermore, this study has exemplified how the tactical level is overlooked amongst BCs. More research is needed to better understand the BC's current practices on the tactical level and how these practices can be improved to foster better logistics management at the project level. Finally, rental companies face challenges in becoming LSPs. Their traditional equipment and machinery rental businesses differ from that of an LSP. Future research should investigate potential synergies and/or contradictions between the rental and LSP trades.

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