# Logistics strategy, structure, and performance: A typology of logistics configurations in construction

Petter Haglund, petter.haglund@liu.se

*Linköping University, Sweden*

**Abstract**

Building contractors need to understand their operational context to manage logistics efficiently and effectively. However, we know little about the choices regarding organization of logistics in building contractors and its relationship to performance. Thus, the purpose of this paper is to develop a typology of ideal logistics configurations and to discuss the strengths and weaknesses of the fit as profile deviation perspective for logistics configuration studies in construction. The typology is based on a critical review of stand-alone contingency studies within the logistics and construction management research domains. Two logistics configurations positioned at the extremes of a spectrum are identified. The first is the product-process oriented configuration resembling to the way industrialized housebuilders organize and manage logistics. The second is the project-oriented configuration, which resemble to how logistics is managed when operations are characterized by a high degree of on-site construction and project-specific engineering designs. The product-process oriented configuration typically generates low total costs of material supply and short and reliable lead times, while the project-oriented configuration has a flexible material supply process to support the high degree of variability in on-site operations and in the supply chain. Thus, these two configurations will perform better within different performance categories (project lead time, cost, and flexibility). Furthermore, the fit as profile deviation perspective is a promising approach to empirically assess the two configurations. For managerial practice, the typology can guide building contractors and consultants in evaluating existing logistics configurations and how to maintain ideal configurations when new logistics roles emerge.

**Keywords**

Building Contractors, Configuration Research, Logistics Strategy

## 1 Introduction

During the last decade, new specialized logistics-related roles have emerged in construction companies. The new roles include logistics managers, coordinators, and specialists that are responsible for setting up the site layout, managing the material flow process, delivery planning, materials handling on-site, etc. (Dubois *et al.* 2019). Previous studies indicate that the organization of logistics, including these new roles, influence the performance of construction projects. For instance, on-site productivity is positively affected by specialization of logistics tasks (Sundquist *et al.* 2018) and companies can achieve economies of scale by using joint logistics resources across several projects (Dubois *et al.* 2019). Thus, the matter of how to organize logistics tasks has become increasingly important at the strategic level of building contractors.

Building contractors are a diverse group which consist of large general contractors, industrialized housebuilders, residential builders, etc. (Simu and Lidelöw 2019). Therefore, to manage logistics efficiently (i.e., achieve intended logistics outputs) and effectively (i.e., to achieve intended performance outcomes), contractors need to understand their type of operations and how it influences organization of logistics. The role of logistics differs across the spectrum of production systems, which in turn requires contractors to organize and manage logistics in a way that it supports their operations (Klaas and Delfmann 2005). Yet, so far, most research on organization of logistics in construction has focused on adapting logistics principles to construction with limited consideration of building contractors' operational characteristics.

Contingency theory is a common approach to organization of logistics, which contends that an alignment between the context and organization structure lead to better performance. However, logistics researchers have argued that contingency factors provide only a partial explanation to the strategy-structure-performance links (Klaas and Delfmann 2005). Configuration theory suggests an alternative approach and combines an array of contingency variables derived from stand-alone logistics contingency studies. This is a holistic approach that account for the strategy-structure-performance relationships more comprehensively than individual contingency studies do (Ketchen Jr *et al.* 1993). When applied to logistics, configuration theory suggests that a high degree of fit between several logistics context and organization structure variables should lead to certain performance outcomes (Klaas and Delfmann 2005; Pfohl and Zöllner 1997).

The challenge in studying logistics configurations comes from the plethora of analysis methods resulting from different perspectives to the fit of a sample configuration profile. Each perspective thus have different implications for how to approach, interpret, and empirically evaluate the effects of configurations on performance outcomes. Venkatraman (1989) proposes six different perspectives that form the basis for configuration studies that focus on the fit between constitutive elements: *fit as moderation*, *fit as mediation*, *fit as profile deviation*, *fit as gestalts*, *fit as covariation*, and *fit as matching*. Each of these perspectives differ in scope of and level of detail, which means that the perspective that is selected need to suit the phenomena being studied. The most common perspective for studying the effects of a configuration's fit on performance is from the perspective of fit as profile deviation. Here, fit indicates an adherence to a sample configuration of an ideal configuration. In other words, a deviation from the ideal profile is negatively related to performance, while exhibiting a high degree of fit to an ideal profile is positively related to performance. Thus, the purpose of this paper is to develop a typology of ideal logistics configurations in construction and discuss the strengths and weaknesses as to how fit as profile deviation can be used to study the relationship between logistics configurations and performance in construction.

## 2 Logistics Configurations

Configuration theory postulates relationships between strategy, structure, and performance, which require consideration of multiple interrelated variables. Central to the configurations approach to logistics is the concept of fit between two groups of variables: the *logistics context* and the *organization of logistics* (Klaas and Delfmann 2005). Furthermore, it requires consideration of two elements: verbal statements (i.e., conceptual definitions) and operationalization of its constructs that enable empirical analysis (Venkatraman 1989). Both these two elements are necessary in theory building research using the configurations approach. The former ensures that the constituents of a particular configuration are rigorously defined, and the latter is the means needed to measure the constructs (Wacker 1998). Drawing on previous configuration studies and stand-alone contingency studies, the following sub-sections focus on defining conceptual definitions of logistics context and organization variables.

## 2.1 Logistics Context

Logistics literature provides a plethora of logistics context variables, such as strategy, environmental uncertainty and heterogeneity, importance of logistics, and information technology (Chow *et al.* 1995). However, Sousa and Voss (2008) argue that contingency based studies must identify a limited set of variables that best account for different contexts. Many logistics context variables proposed by logistics researchers have several resembling labels and conceptualizations and there are no general exact definitions. This partly stems from the broad range of fields in which they have been applied. Thus, it is necessary to define domain-specific logistics context variables for construction. As such, based on previous work on logistics-related contingency research in manufacturing (e.g., Chow *et al.* (1995), Pfohl and Zöllner (1997), Klaas and Delfmann (2005)) and construction (e.g., Jonsson and Rudberg (2015)), the logistics context of building contractors can be reduced to two variables. The first context variable is *the degree of pre-engineering* to account for the product-related contingency effects. The second is *the degree of off-site assembly* and addresses what typically is considered as process choice or technology in the manufacturing industry.

The reason for choosing the degree of pre-engineering is that it captures the product characteristics that differentiate between different housebuilders. In general, product characteristics is a broad concept that subsumes several other underlying concepts, such as product design, value density, product range, bill of materials (BOM) structure, etc. (Pfohl and Zöllner 1997). Housebuilding is engineer-to-order (ETO) production and thus, production is entirely order-driven with inventories consisting of only raw materials and components, if any (Johnsson 2013). As such, the degree of pre-engineering provides a useful distinction between different ETO situations and denotes to what extent the building specifications can be adapted according to client input (Schoenwitz *et al.* 2012). In other words, the degree of pre-engineering accounts for the extent to which design and engineering activities are performed prior to the customer-order decoupling point (CODP) (Wikner and Rudberg 2005). Table 1 describes the three groups of ETO products that represent different degrees of pre-engineering.

**Table 1.** Degrees of Pre-Engineering in Housebuilding (based on Wikner and Rudberg 2005; Jonsson and Rudberg 2015).

| Pre-engineering | Value adding prior to CODP | Product Standardization | Customizable BOM levels | Client input |
|---|---|---|---|---|
| Design-to-Order (DTO) | None | Pure customization | 6< | High choice of building design |
| Adapt-to-Order (ATO) | Standard parts, components, and sub-assemblies | Customized or tailored standardization | 3-6 | Limited choice of predetermined options |
| Engineer-to-Stock (ETS) | Standard buildings or building modules | Segmented or pure standardization | 0-2 | Limited/no choice of building design |

For process choice, the *degree of off-site assembly* represents different production processes in housebuilding. Process choice has been rigorously defined in operations strategy literature via the product-process matrix (Hayes and Wheelwright 1979). Jonsson and Rudberg (2015) proposes a product-process matrix for the housebuilding context comprising of two dimensions: the degree of product standardization and degree of off-site assembly. The degree of off-site assembly is used to denote to which extent a building is prefabricated in an off-site factory. Production is still driven by customer orders, but building components and modules are produce in a controlled environment and assembled on site. However, an off-site factory is typically feasible when is combined with relatively high degree of standardization to reach sufficiently high production volumes (Gibb and Isack 2003; Jonsson and Rudberg 2014). The feasible degree of off-site assembly thereby corresponds to the degree of pre-engineering; as customization increases, more production activities become feasible to perform at the construction site. Table 2 describes four generic production systems in housebuilding.

**Table 2.** Process Choices in Housebuilding (based on Gibb and Isack 2003; Jonsson and Rudberg 2015).

| Process Choice | Prefabrication | Site Assembly |
|---|---|---|
| Component Manufacture & Sub-Assembly (CM&SA) | Raw materials/components | Entire building |
| Prefabrication & Sub-Assembly (PF&SA) | Panel elements | Windows, doors, façade, non-load carrying elements |
| Prefabrication & Pre-Assembly (PF&PA) | Panel elements with pre-assemblies | Non-load carrying elements |
| Modular Building (MB) | Volumetric modules | Volume module assembly |

## 2.2 Organization of Logistics

While logistics context variables lack consensus in literature, organizational variables are more consistent across domains. Nonetheless, there are some contingency variables that are unique to logistics, besides those commonly used in contingency studies, such as centralization and formalization (Meyer *et al.* 1993). Table 3 presents the five variables for organization of logistics identified in this study with their respective conceptual definition.

**Table 3.** Conceptual Definitions of Organization of Logistics Variables.

| Variable | Conceptual Definition | Key Authors |
|---|---|---|
| Formal Structure | The degree to which logistics decision-making is concentrated to a single unit and their proximity to top management. | Chow *et al.* (1995), Pfohl and Zöllner (1997), Moretto *et al.* (2020) |
| Integration | The degree to which logistics tasks are coordinated with other functional areas within the firm. | Chow *et al.* (1995) |
| Supply Chain Structure | Geographic dispersion of suppliers, distribution network, and construction sites.<br>Channel governance in terms of vertical integration and supplier relationships. | Klaas and Delfmann (2005), Voordijk *et al.* (2006), Hofman *et al.* (2009), Stock *et al.* (2000) |
| Division of Labour | The degree of specialization in physical (transportation, material handling, goods reception) and administrative (order processing, delivery planning, inventory management) logistics tasks. | Dubois *et al.* (2019), Klaas and Delfmann (2005), Lindén and Josephson (2013) |
| Formalization | The degree to which logistics processes, policies, procedures, and strategy are documented. | Chow *et al.* (1995) |

Formal structure indicates the degree to which logistics tasks are concentrated to a single unit and the proximity of this unit to top management within the organization (Chow *et al.* 1995). Typically, this is referred to as the degree of centralization in the (logistics) organization structure. As centralization in logistics tasks increases, it typically follows a reduction in its ability to handle variation at the operational (project) level (Pfohl and Zöllner 1997). Centralization reduces the organization's information processing capabilities and when paired with production task variability, it creates a misfit between the information processing requirement and capacity (Galbraith 1974; Luo and Donaldson 2013). For instance, when purchasing and material flow processes are aggregated at the company level which limits the ability to cope with rush orders and changes in production schedules (Moretto *et al.* 2020). Furthermore, a high degree of centralization in the formal structure tends to be followed by a high degree of integration between different functional departments (Chow *et al.* 1995).

The supply chain structure constitutes of two elements and denotes the physical arrangement and governance structure of supply chain members (Klaas and Delfmann 2005). The physical element specifies the geographical dispersion of production facilities, suppliers, and customers (Stock *et al.* 2000). The governance structure indicates the buyer-supplier relationship, which subsequently is characterized by two dimensions: 1) the degree of vertical integration and 2) the strength of relationships between supply chain members (Voordijk *et al.* 2006). Based on the two dimensions, the governance structure can vary from integrated hierarchical structures with close buyer-supplier relationships to disintegrated market structures with loose buyer-supplier relationships. Furthermore, a third mode of channel governance, the network structure, is positioned between markets and hierarchies. The network structure denotes vertically disintegrated organizations but with close buyer-supplier relationships (Stock *et al.* 2000). These buyer-supplier relationships can be either short-term (project) or a long-term (strategic supplier) depending on the type of building material supplier (Voordijk *et al.* 2006).

The division of labour denotes the specialization in administrative and physical logistics tasks (Klaas and Delfmann 2005). An example of specialization in administrative logistics tasks is the use of logistics specialists in projects that have taken over material flow-related tasks from site management (e.g., site layout planning, delivery planning, etc.) (Dubois *et al.* 2019). Physical task specialization is typically achieved by purchasing carry-in services from a third party (Lindén and Josephson 2013). Furthermore, formalization is typically coupled with specialized and indicates to what extent decisions, tasks, and supplier relationships are governed by formalized processes, rules, and operating procedures (Chow *et al.* 1995).

## 3 Defining Fit - A Typology of Ideal Logistics Configurations

Fit is the common denominator that enables a distinction between different configurations. According to configuration theory, a fit between the individual variables correspond to a certain configuration where different compositions of variables form configurations with distinctive characteristics (Meyer *et al.* 1993; Venkatraman 1989). Configurations can be either conceptually or empirically derived, i.e., defined with typologies or taxonomies respectively. However, Meyer *et al.* (1993) view the dichotomy of typology and taxonomy-based configurations as artificial. Typologies are based on synthesis of stand-alone empirically driven contingency studies. On the other hand, all taxonomies are theoretically based since the forming of empirically driven configurations rely on organization theory. Thus, they should be viewed as complementary when describing configurations and it is instead the replicability of a configuration that is important (Miller 1996). Typology and taxonomy-based configurations do however require different methodological approaches. For instance, taxonomies can require cluster analysis to identify the configurations while typology-based configurations are identified through conceptual modelling (Venkatraman 1989).

Logistics configurations are typically typology-based, i.e., they synthesize stand-alone logistics contingency studies (Klaas and Delfmann 2005). This enables formation of configurations that represent a fit between a set of multiple interrelated logistics context and organization variables. In construction, two distinctive configurations have emerged via the distinction between *product-process oriented* firms and *project-oriented* firms (Lessing *et al.* 2015; Simu and Lidelöw 2019). Although these types of contractors are not the outcome of explicit configurations studies, their definitions closely resemble to that of the logistics context in logistics configuration research (c.f., Chow *et al.* 1995; Klaas and Delfmann 2005; Pfohl and Zöllner 1997). Therefore, two logistics configurations can be distinguished via their process choice and product characteristics. The product-process oriented configuration are typically industrialized housebuilders that produce highly standardized products via a high degree of off-site assembly. On the other hand, the project-oriented configuration tends to produce highly customized products via a low degree of off-site assembly (Jonsson and Rudberg 2015).

Based the contextual and structural differences between product-process and project-oriented configurations, they produce distinctive logistics outputs and subsequently produce different performance outcomes (Klaas and Delfmann 2005). Here, it is important to note that the strategy-structure-performance links in configurations studies differs from that of bivariate contingency studies. In configurational studies, it is the fit between multiple interrelated variables that relate to certain performance outcomes. Hence, the performance outcomes are a result of adhering to an ideal configuration profile rather than the features of individual constructs, such as centralization and formalization (Venkatraman 1989). This indicates that different compositions of multiple interrelated contextual and organizational variables will result in different logistics outputs. Figure 1 builds on the logic established by Vorhies and Morgan (2003) and illustrates the postulated relationships between logistics configuration profile fit, logistics outputs, and performance outcomes. For each ideal type of logistics configuration, there are certain logistics outputs that are specific for the type of configuration (Klaas and Delfmann 2005; Pfohl and Zöllner 1997).

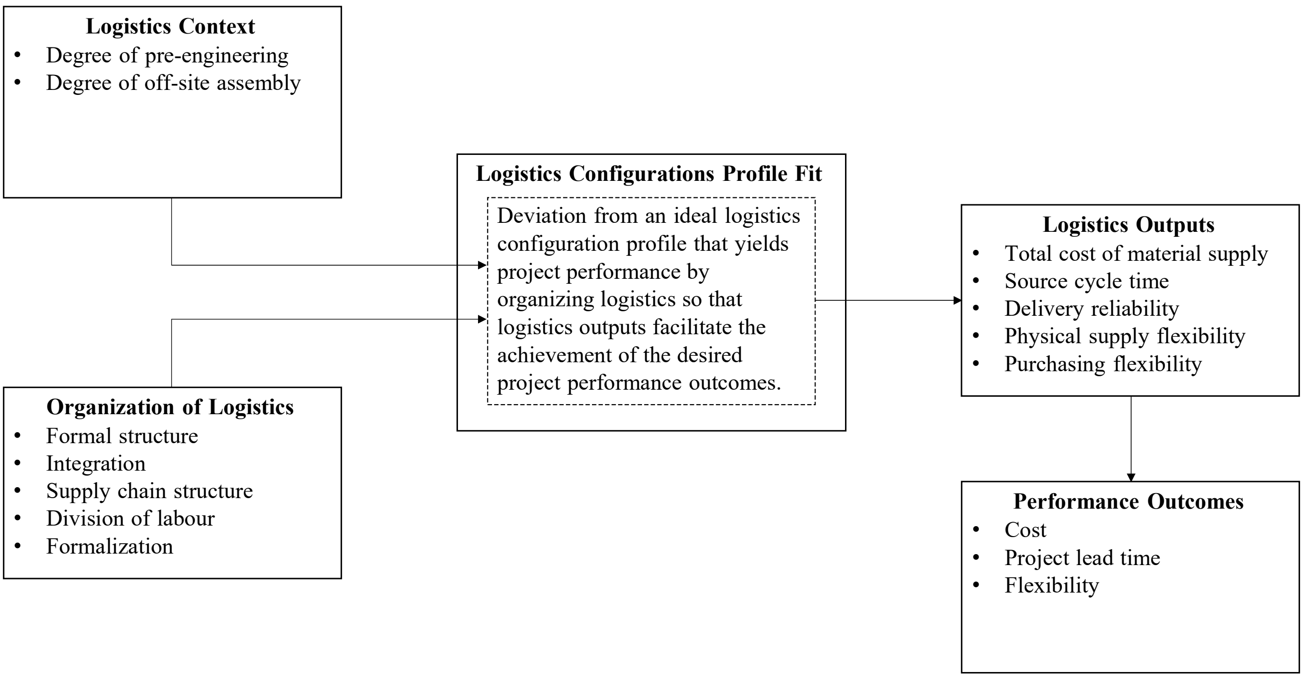


**Figure 1.** Logistics configuration profile fit, logistics outputs, and performance outcomes.

### 3.1 The Product-Process Oriented Configuration

Product-process oriented firms typically strive for low project costs and short project lead times combined with a high delivery precision by specializing in producing residential buildings for a narrow target market in an off-site factory (Jonsson and Rudberg 2015). The logistics context is thus characterized by a high degree of off-site assembly (MB) and a high degree of pre-engineering (ETS). This configuration's organization of logistics is characterized by centralization in logistics tasks. Centralized planning and control are typically feasible when there are only a few organizations' material and information flows that need to be coordinated (Rudberg and Olhager 2003). Product-process oriented firms can thus have formal operating procedures which are performed by a specialized planning function that coordinate material and information flows to and between multiple projects (Dubois *et al.* 2019). The supply chain structure that is characterized by geographical concentration, tight buyer-supplier relationships, and a high degree of vertical integration (Voordijk *et al.* 2006). Consequently, most value-adding is concentrated in an off-site factory with central inventories of finished volume modules and direct distribution to the construction site. This enables the product-process oriented firm to pursue a push-logic in inbound and production logistics in the off-site factory and thus optimization of both order-sizes of material components, production lot-sizes, and inventory of finished volume modules. However, final assembly still takes place at geographically dispersed locations. Hence, the material flows from the off-site factory to the construction site follow a pull-logic which needs to be synchronized with off-site factory takt time and volume module deliveries (Arashpour *et al.* 2017).

The logistics outputs of this configuration are mainly cost and lead time related. Centralized planning and control of material and information flows with formalized procedures enable contractors that adopt this configuration to exploit company-wide resources better than project-oriented configurations (Dubois *et al.* 2019). Furthermore, a centralized supply organization that engage in long-term relationships with material suppliers for standardized components facilitate short sourcing cycle times, high delivery reliability, and low administrative and physical distribution costs (Bildsten 2014).

### 3.2 The Project-Oriented Configuration

The project-oriented configuration can typically not match product-process oriented configuration's performance in terms of project lead time and cost level but strive to deliver a wider range of projects according to different customer requirements (Jonsson and Rudberg 2015). Due to the small production volumes of each product variant and variations in the production process, the formal structure of the logistics organization is typically decentralized with less formalization and specialization than the product-process oriented configuration (Klaas and Delfmann 2005). The project-oriented configuration's supply chain is highly dispersed since the suppliers differ from project to project and are typically procured locally. Logistic tasks are decentralized and instead there is a reliance on the project organization to coordinate material flows in individual project's supply chains (Simu and Lidelöw 2019). This gives rise to a high number of converging material flows to the construction site which leads to a temporary and geographically dispersed supply chain. As such, logistics integration is limited to activities and firms within the project, which restricts cross-functional integration at the company level.

The low degree of centralization, specialization, and formalization facilitates logistics flexibility, which is the ability of logistics system to manage both anticipated and unexpected in material supply that require rapid changes in the logistics system (Jafari 2015; Sandberg 2021; Zhang *et al.* 2005). Zhang *et al.* (2005) points out four elements of logistics flexibility, of which two are relevant to building contractors: 1) physical supply flexibility indicates that material deliveries and inbound supply resources can be adjusted in response to production requirements, and 2) purchasing flexibility denotes the ability to source different materials and components in different batch sizes on a short notice. A project-oriented configuration is thus characterized by a high degree of logistics flexibility, but it comes with precondition that flexibility does not entail a relatively large increase in total costs.

# 4 Findings and Discussion

The product-process and project-oriented configurations identified in this study represent the two extremes in the typology, and there is potential to identify further configurations that are positioned in between (see e.g., Jonsson and Rudberg 2015). Most configuration studies are however taxonomy-based and combine cluster analysis to derive ideal configurations empirically with profile deviation to compare the degree of fit in the sample to that of the ideal configuration (e.g., Kristensen and Nielsen 2020; Tomas *et al.* 2007; Vorhies and Morgan 2003). It is generally more difficult to define ideal profiles in typology-based configuration studies as the ideal configuration needs to be theoretically derived (Venkatraman 1989). On the other hand, Ketchen Jr *et al.* (1993) argue that taxonomy-based configurations provide little ground for studying the configuration – performance relationship and are better suited for describing configurations per se. The typology-based approach is however the more feasible alternative when the aim is to analyze the relationship between logistics configurations, their respective logistics outputs, and performance outcomes.

The typology and taxonomy-based approaches does however share the problem of being cross-sectional and only providing a static perspective to configurations. This is a potential issue for research on logistics configurations within construction since cross-sectional configuration studies can produce conflicting results (Venkatraman 1989). Logistics management in construction is still regarded as immature (Janné and Rudberg 2020) albeit the developments during the recent decade. A cross-sectional logistics configuration study in the construction domain may therefore risk of being overly conservative (particularly taxonomy-based studies) or idealistic (particularly typology-based studies). Additionally, the concept of fit is in its infancy in construction compared to manufacturing, which may indicate that fit is not a conscious choice among building contractors. For researchers, it is thus important to determine what constitutes fit in an ideal logistics configuration profile. This calls for both taxonomy and typology-based approaches as they are mutually reinforcing in the theory-building process (Ketchen Jr *et al.* 1993; Meyer *et al.* 1993; Venkatraman 1989).

Cross-sectional approaches are most likely the most feasible approach regardless of them being empirically or theoretically based. However, as new construction logistics practices, roles, actors, and organizations evolve, dynamic approaches will be needed to capture what is happening beyond the cross-sectional configuration samples (Venkatraman 1989). A potential venue for studies adopting the dynamic approach is to apply organizational information processing theory. Longitudinal studies can reveal how construction companies manage mismatches between organizational processing requirements and capacity over time (Galbraith 1974; Luo and Donaldson 2013). This has the potential to inform both theory and practice in terms of the process of arriving at fit.

# 5 Conclusions and Further Research

The purpose of this paper was to develop formal conceptual definitions of the constitutive elements of logistics configurations in building contractor firms and to define what characterizes ideal logistics configurations. The two logistics context variables and five organizational variables defined in this paper provided the basis for a typology of ideal logistics configurations in construction: the product-process oriented configuration and project-oriented configuration. This typology can be used to study determine the respective strengths and weaknesses of different logistics configurations in and their logistics outputs and performance outcomes. Fit as profile deviation is regarded a suitable analysis method to take in consideration both the configuration's profile deviation from that of an ideal configuration, and its effect on logistics outputs and subsequent performance outcomes. Taxonomy-based configurations are more suitable whenever there is uncertainty of what characterizes an ideal configuration and when the configuration – performance relationship is beyond the scope of the inquiry. This is due to the lower degree of generalizability among taxonomies, which limits them in comparing performance across different configurations. For managerial practice, the typology can guide building contractors and consultants in evaluating their existing logistics configurations and how to maintain ideal configurations when new logistics roles emerge.

The main limitation of this study is that it remains to empirically test the typology presented in this study. As such, empirical investigations can reveal the configurations positioned in between the two extremes to capture the entire spectrum of logistics configurations. Lastly, configurations can be studied at different points in time and levels of analyses. This study focused on the individual building contractor's configuration, but future studies can pursue longitudinal research designs and attempt to identify logistics configurations at the project/programme level through a multi-stakeholder perspective.

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