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# A model for visualizing cost shifts when introducing construction logistics setups



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## Abstract

**Purpose** – The purpose of this study is to identify how the responsibilities and costs of planning, controlling and executing the material, resource and waste flows are shifted between actors when introducing a construction logistics setup (CLS) as a product innovation in a construction project, compared to the traditional way of organizing these activities.

**Design/methodology/approach** – This study is an analytical conceptual research study which aims to bring new insights into a problem through logical relationship building. Empirical data are gathered in two cases where CLSs are used, through observations and interviews regarding how the activities within the order-to-delivery process are performed. The results have been discussed at workshops with suppliers, installation companies, contractor firms and trade unions.

**Findings** – The outcome of this study is a model for illustrating how costs and responsibilities are shifted in the construction project and supply chain when a CLS is introduced. The cost shift is dependent on the activity shift that accompanies the services included in the setup.

**Practical implications** – The practical contribution of this work is twofold. First, this study provides a methodology of how to evaluate the impact of logistics services on the actors in the construction project. Second, this study shows shifts in costs and responsibilities in logistics activities with the introduction of construction logistics services.

**Originality/value** – The theoretical contributions of the model and this study lie in the inclusion of a multi-actor perspective in total cost modelling in supply chains.

**Keywords** CLS, Supply chain costs, Total cost modelling

**Paper type** Research paper

## 1. Introduction

Because of the increasing interest in supply chain management (SCM) and logistics within the construction industry, existing actors and new actors – such as third-party logistics (TPL) providers – are now developing new service offerings for coordinating construction supply chains. These innovative products, services and businesses offered by new actors affect the dynamics of construction projects. New actors become innovation initiators and enterprises with traditional project control become passengers. A common product innovation offered in construction projects today is so-called construction logistics setups

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(CLS). A CLS is a product or service innovation (Stewart and Fenn, 2006), as it offers new or improved ways to organize logistics for one or more construction projects. CLSs are created as logistics services – such as planning, controlling and executing the flows of materials, resources and waste – which were previously performed by main contractors or subcontractors, are outsourced to TPL service providers (Janné and Fredriksson, 2019).

Outsourcing entails a transfer of activities, resources and decision-making from internal to external control and thereby a change in who carries out an activity (Fredriksson, 2011). For this reason, supply chain structures are created by how logistics activities are sourced (Fredriksson *et al.*, 2021) and how costs are shifted between organizations (Williamson, 1976). According to Halldórsson *et al.* (2015), key aspects of SCM include the design of a supply chain structure and the management of such a structure through inter-organizational relationships. As a result, understanding the dynamics of costs and responsibilities for activities when new innovations are introduced is an important part of SCM research in construction. It is thus important to understand how the introduction of new businesses, new actors and product/service innovations in the supply chain and in construction projects changes the dynamics of the project in terms of shifts in activity responsibilities and costs.

The adoption of product innovations such as CLSs is, however, challenging in construction projects because of the multi-firm complexity (Rose *et al.*, 2019) and common goal conflicts among actors in CLSs (Janné and Fredriksson, 2019). The introduction of a CLS requires a clarification of which activities will be carried out by the contractors and which activities are part of the services provided by a logistics service provider. This places the dependence between the project-oriented construction process and the flow-oriented supply chain at its apex. With services, such as on-site materials handling, the logistics service provider enters the construction site, as this activity was previously carried out by the contractor. Furthermore, activities previously carried out by the contractor, such as bundling materials or order planning, may be "lifted out" from the construction site to be performed by the logistics service provider off site. Stewart and Fenn (2006) argued as early as 2006 in favour of adopting innovations in construction SCM.

Janné and Fredriksson (2018) argue that CLSs create value for contractors if the site organization – in terms of logistics activities – has been relieved. Janné and Fredriksson (2018) show that introducing a terminal-based CLS adds several cost-driving activities that the traditional way of organizing logistics is not subjected to. They also demonstrate that the costs of the CLS range from 0.16% to 1.01% of the overall project cost. However, they were unable to show what savings have been achieved on site by introducing the CLS, although interviews reveal that the site management considers the project impossible to finish without the CLS. Thus, the hidden-cost situation still remains within SCM innovations in the construction industry (Thunberg *et al.*, 2019). This means that the effects on the different actors' costs are not captured. For total cost models to be a helpful tool for evaluating the introduction of CLS, better visualization of cost shifts and the inclusion of shifts in responsibility for activities are necessary.

Previous studies of CLS utilization have mainly been single case studies describing the different services that CLSs can include and implementation issues (Sundquist *et al.*, 2017; Janné and Fredriksson, 2019). However, few have studied how the introduction of CLSs as product innovations in construction projects affects the shifts of costs and activities among actors in a supply chain (Dekker and Van Goor, 2000; Firdausiyah *et al.*, 2019).

The purpose of this study is thus to identify how the responsibilities and costs of planning, controlling and executing the material, resource and, waste flows are shifted between actors when introducing a CLS as a product innovation in a construction project, compared to the traditional way of organizing these activities. This is done by developing a conceptual model for analysing and visualizing cost and responsibility shifts between actors. The unit of analysis is the order-to-delivery process and how the activities and costs within it shift between actors because of the introduction of the CLS.



## 2. Literature review

### *2.1 Supply chain management*

The Council of SCM Professionals (CSCMP) defines logistics as "[. . .] that part of SCM that plans, implements and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption to meet customers' requirements" (Council of Supply Chain Management Professionals, 2013). This includes all the activities in both the physical flows and the information flows that are performed to supply the end customer with the required products. Different management tools exist for fulfilling this, such as just-in-time (JIT) deliveries. CSCMP also defines SCM as "[encompassing] the planning and management of all activities involved in sourcing and procurement, conversion and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers and customers." (Council of Supply Chain Management Professionals, 2013)

According to Ying *et al.* (2018), logistics and SCM has, from a construction perspective, traditionally been approached in an *ad hoc* manner by construction projects, focusing on logistics as a daily operation issue and solving the current logistics issues from day-to-day. Construction logistics has thus not been considered as a long-term challenge or opportunity (Ying *et al.*, 2018). With the increase in urbanization however, the problem of construction SCM becomes tangible as more projects take place within dense urban areas. One way to approach construction logistics and SCM is through the use of CLS (Dubois *et al.*, 2019). There is an increasing interest in construction logistics strategies and plans from municipal and developer perspectives (Transport for London, 2013).

CLSs can range from small-scale initiatives such as a change in working practices to ensure efficient logistics operations to and on site (Ghanem *et al.*, 2018), to using planning systems (Thunberg and Fredriksson, 2018) or introducing large-scale terminal setups (e.g. construction logistics centres) or JIT solutions (e.g. checkpoints) (Dubois *et al.*, 2019). However, these CLSs are still a rare phenomenon in the daily construction work (Ekeskär and Rudberg, 2016), especially when proposed as joint setups, and research has focus on finding acceptance (Hedborg Bengtsson *et al.*, 2018) for them as a concept and when to use them (Janné, 2020). This is in line with how Lambert and Cooper (2000) describe SCM as consisting of a set of management tools (described above). However, SCM also consists of business processes (such as sales, procurement and distribution) and design structure (which suppliers to involve and the location of production facilities) (Lambert and Cooper, 2000).

The description of SCM and logistics focuses on means for efficiently and effectively providing customers with requested products. The focus of research and practice, both in general and in construction, has often been on the physical flow of products and not the services offered (Datta and Roy, 2010). The flow of products in a supply chain is accomplished through different services offered by different actors. The logistics activities in a supply chain can often be described in terms of the order-to-delivery process (Forslund *et al.*, 2009), with one part consisting of the information flow and one part consisting of the physical flow. The information flow includes activities such as:

- the customer placing the order and the supplier;

- receiving; and
- managing the order.

The physical material flow consists of:

- packing the material;
- distribution and finally; and
- the customer receiving the materials.

*2.2 Allocating supply chain activity costs*

LaLonde and Pohlen (1996) and Dekker and Van Goor (2000) show that outsourcing logistics activities to a supply chain actor also results in the costs for these activities being shifted. However, according to Dekker and Van Goor (2000), modern accounting systems are not suitable for illustrating costs associated with logistics activities and therefore cannot illustrate the cost shifts when outsourcing logistics services. This results in transaction costs often becoming hidden when analysing the effects of outsourcing logistics activities. One way to allocate costs, however, is proposed by Grant *et al.* (2006). They argue that based on the order-to-delivery process, the cost of the logistics activities can be categorized into warehousing, inventory carrying, transportation order processing and information and lot quantity costs. This view is the basis for modelling costs of dispersed activities in a supply chain and has led to the development of total cost modelling.

*2.3 Total cost models*

Shen *et al.* (2011) describe total cost modelling as a tool and capability for a company to identify actual costs associated with purchasing, owning and disposing of materials. They also argue that total cost modelling helps companies to go “beyond” a lowest-price focus on purchasing and production and to look at all associated costs. As LaLonde and Pohlen (1996) illustrate, total cost modelling can be used as a tool in supply chains to identify and illustrate how costs are affected by a change in the setup of logistics activities and also for estimating the cost of outsourcing these activities to other actors in the supply chain. The level of these costs tells the outsourcing companies what the physical management and administration of outsourcing costs.

One important aspect of total cost modelling is understanding which activities drive costs and how much time is spent on these activities (Pohlen and La Londe, 1994). Everaert and Bruggeman (2008) looked at this aspect from a wholesaler perspective, focusing on physical products and concluded that total cost models need to incorporate time spent on activities to give a fair picture of the cost effect of outsourcing logistics activities. They argue that common tools for assessing activity costs often miss this time-driven aspect.

Another important aspect of total cost modelling is the multi-actor perspective, as incorporated by supply chains (Dekker and Van Goor, 2000). Despite including the time aspect, Everaert and Bruggeman (2008) model lacks this multi-actor aspect. The result of not having the multi-actor perspective is the inability to understand which proportion of the time and the activity is attributable to which organization. This risks all identified costs being allocated to one of the actors in the supply chain. One example of a model that includes a multi-actor perspective is presented by Dekker and Van Goor (2000) and illustrates how logistics activities and costs can be assessed for different actors in a supply chain. The model considers the network aspects and cost shifts between actors, but the drawback is that it only shows how the costs are affected not the responsibilities of activities. As the Incoterms so efficiently illustrate, the cost can be associated with one party, while risk and responsibility are associated with another. Firdausiyah *et al.* (2019) also include the multi-actor perspective modelling costs for using an urban city logistics centre. However, the drawback of their model is its sole focus on transports and utilization levels for the trucks. The other logistics activities involved in running the logistics centre are not modelled.

### *2.4 Previous research on cost modelling in construction*

Looking at previous research on cost modelling (and the related terms cost evaluation, cost assessment, cost forecasting) in a construction context three strands of research fields emerge. The first strand focuses on developing or assessing tools and/or methods for forecasting construction projects. One example of this is the construction-related costing concept of "target cost" developed in the 1950's (Burrows and Chenhall, 2012). Alwisy *et al.* (2020) have, based on the target cost process, developed a framework to improve cost estimates for construction projects based on the requirements of the client. Even though the framework is promising, it lacks the logistics services' needed to supply and handle materials and only includes cost associated with the physical material. Joukar and Nahmens (2015) also studied construction project costs from a target/forecasting perspective but focus on how the volatilities in material prices affect construction project costs.

The second strand of research in cost modelling in construction focus on assessing construction projects, especially large infrastructure projects, from a life cycle perspective. Moavenzadeh *et al.* (1974), e.g. developed a simulation model to illustrate time and cost distributions over the years based on geological data and construction time plans. In a similar vein, Mahalakshmi and Rajasekaran (2019) developed a model for estimating the cost of constructing a highway but also its future effect on traffic flows. Petrović *et al.* (2021) analysed the life cycle costs of single-family houses in a Swedish context, showing that the construction process accounts for 50% of the life cycle costs. Naneva *et al.* (2020) studied how building information modeling/model (BIM) models and software could be used for performing life cycle analysis of construction projects. Their work focuses on greenhouse gas emissions and not cost over the life cycle. They conclude, however, that "re-entering" data manually into the models are a cost driver for effective usage of BIM. Manual and repeating entering of the same data can also negatively affect digitalization as a means for doing life cycle analysis in general.

The third and final strand of research on cost modelling in construction includes studies focusing on new building materials and building methods and their associated costs. andKozlovská *et al.* (2015) studied how the increasing use of wood-based materials effected construction costs and developed a model for presenting the estimated price of the project for the client. Makul (2020) performed a cost and benefit analysis of using ready-mixed, high-performance recycled concrete in projects. Through a case study in Thailand, he modelled the cost and analysed the benefits with concrete type and suggested some improvements to lower the cost of using the concrete type. Marzouk *et al.* (2014) also analysed the effects of using sustainable building materials and develop a model for assessing the usage and estimation of project costs.

### *2.5 Synthesis*

To evaluate the effect of using a CLS, it is not only relevant to study the effects on a project level but also on a multi-actor level. As current methods for cost modelling in construction, like target cost, do not incorporate a multi-actor level, it is difficult to use it to motivate, for all actors, an implementation of CLS. As presented in Section 2.4, research on cost modelling in the construction context can be synthesized into three general strands of research:

(1) cost estimation of construction project (e.g. target cost);

(2) life cycle cost analysis of construction project; and

(3) cost modelling of new construction methods/building materials.



The emerging research area applying an SCM perspective on construction have not been included (Vrijhoef and Ridder, 2007; Dubois *et al.*, 2019; Sundquist *et al.*, 2017; Fredriksson *et al.*, 2021). It is also not possible to find support for modelling the shift of costs and responsibilities in the existing total cost models within general SCM research. The cost effects and drivers have not been studied earlier from a multi-actor perspective. This level is needed to be able to model how costs and responsibilities are shifted between the actors within the supply chain when a CLS is introduced in a project. Furthermore, Datta and Roy (2010) argue that time and multi-actor are often ignored in total cost modelling of supply chain services, as current accounting systems do not provide this kind of information. Based on the review of existing cost models within SCM (Section 2.2), we identify that the Grant *et al.* (2006) model can be used as a starting point for understanding which activities drive costs and how the costs are shifted between actors. Their model encompasses most of the activities in the order-to-delivery process from a goods buying company's perspective. Besides its benefits, the model has some drawbacks that need to be dealt with:

- It does not consider the uncertainties (opportunistic behaviour, oligopoly and lack of information) relating to costs associated with outsourcing to a supplier (Williamson, 1976).
- It does not propose how the costs should be calculated.
- It only illustrates "total" costs from the buying/outsourcing company's perspective and not how these costs are shifted between actors in a supply chain (LaLonde and Pohlen, 1996).
- Finally, the model only illustrates costs from a goods buying company's perspective and not a service buying company's perspective.

The contribution of this paper is that the model presented provides solutions on how to deal with these drawbacks and adds a multi-actor SCM perspective to cost modelling in the construction context.

## 3. Methodology

The methodology section is written with Saunders's "research onion" in mind (Saunders *et al.*, 2019). The first sub-section covers the three first layers in the onion – philosophy, approach and strategy (here collectively named research design) – by describing how the underlying ontological perspectives have affected the selected approach and strategy. The second and third sub-sections covers the more hands-on layers in Saunders's research onion – method choices, time horizon (research process) and data collection and analysis.

### *3.1 Research design*

As presented in Section 2.5, we argue that cost modelling from a multi-actor perspective in construction when using a CLS is new. As research is scarce and little knowledge exists, it makes sense to take an interpretive approach in understanding how and why changes in logistics responsibilities affect the cost shifts and how it can be modelled. This approach is similar to what Yin (2009) calls a post-positivistic approach. With one foot rooted in a positivistic standpoint the paper strives to develop a normative model. However, with the other foot rooted in an interpretative standpoint, these normative suggestions are based on intrinsic knowledge of those actors affected by the change (i.e. the CLS introduction) in the system.

Regarding research strategy, Meredith (1998) claims that developing theory and understanding about a "phenomenon" is best done through an explorative study. This is supported by Eisenhardt (1989), Sousa and Voss (2001) and Voss *et al.* (2002) who all argue for an explorative approach towards constructing a theory and developing an understanding when the "phenomenon" is relatively under-investigated. Therefore, this study is of an analytical conceptual research study kind (Wacker, 1998). The study aims to bring new insights into a problem through logical relationship building based on exploration of the studied phenomenon conducting case studies as examples to illustrate conceptualizations (Wacker, 1998). The incorporation of tacit knowledge and experience into the development of conceptual models is key to their underpinning, credibility and usefulness (Jaakkola, 2020). Such tacit knowledge resides among the researchers, but also – to a great extent – among practitioners, wherefore a suitable research approach for exploration is a qualitatively inductive one (Voss *et al.*, 2002).

### *3.2 Research process*

Figure 1 depicts the research process. The research began with understanding the practical problems at hand and which theoretical areas could help to solve the practical problems. The strategy of building a conceptual model is based on carefully selecting complementing, existing models and forging them together, in a way that captures the essence of the phenomenon in focus (Jaakkola, 2020).

The conceptual model for analysing cost shifts in construction supply chains when introducing CLSs started with identifying existing models for cost modelling in supply chains in general. These models (Grant *et al.*, 2006; Dekker and Van Goor, 2000) were analysed in terms of advantages and drawbacks. The next step in the research process was to build the conceptual model by incorporating the advantages of previous models and overcoming their drawbacks. The conceptual modelling process is described in detail in Section 4. The conceptual model was in the next step applied in two different cases, selected

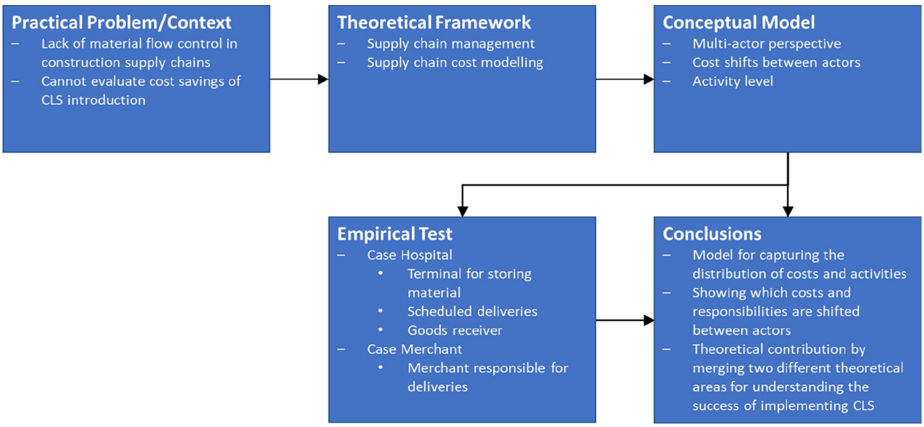


**Figure 1.**
Research process

to cover a large portion of the practical context studied. Sub-section 3.3 describes how these cases were selected and how data was gathered for testing the conceptual model. The final step in the process consisted of analysing the effects the CLS introductions had on the cost and responsibility shifts between actors and how suitable the model was to use in a practical context.

### *3.3 Case selection and data gathering*

Analysing process changes, costs and responsibilities within organizations and projects requires building up trust between the researcher and the observed organizations. Fortunately, the researchers had built up trust and long-term access to one builder's merchant and one logistics consultancy company, both offering CLSs for the construction industry. This offered the opportunity to study different types of CLSs in different parts of the practical context studied. Two illustrative cases of CLSs were selected for these two companies, as a multiple case study enables greater depth of undestanding. The two cases were selected based on the criteria that one should be client-driven and one supplier-driven, and one should be used in a complex setting and one in a smaller noncomplex setting. This is in line with the different contexts described in the literature for when CLSs are used. Table 1 below summarizes the demographics of the two cases identified to cover these criteria.

The data gathering was done to test the developed conceptual model to see if it could be used in the practical context and what benefits the model offered. In the hospital case, 26 interviews, five workshops and eight observations were conducted for testing the model, and hence, to understand the shifts of costs and responsibilities, the introduction of the CLS studied was generated. Interviews were carried out with different purchasers from different on-site contractors, client representatives and service provider representatives. The respondents – selected via purposive sampling (Morgan, 1997) – were either users of the CLS, suppliers of the services offered by the CLS or involved in designing and

| | Hospital | Merchant |
|---|---|---|
| **Construction project type(s)** | Renovation of a hospital | Renovation of buildings<br>New construction of buildings |
| **Service provider(s)** | Change management consultant<br>Haulage company<br>IT system developer | Builder's merchant |
| **Service user(s)** | Main contractor<br>Subcontractors<br>Material suppliers | Main contractor |
| **Service initiator** | Construction client (a county region in Sweden) | Main contractor |
| **Services included** | Storing and dispatching materials off-site at a terminal<br>Consolidating materials from several suppliers<br>Handling incoming deliveries and transferring materials to assembly location<br>Software for scheduling deliveries and waste collection<br>Transferring waste from production location to waste containers | Storing and dispatching materials off-site at a terminal<br>Consolidating materials from several suppliers<br>Handling incoming deliveries and transferring materials to assembly location<br>Planning and ordering material deliveries<br>Cleaning on site |

**Table 1.**
Case demographics

initiating the services. Respondents with practical knowledge of initiating and using the service were considered best suited for describing which logistics activities are affected and how. Observations of the different services were conducted to understand cost drivers and which activities were introduced or eliminated. Workshops were held with representatives from the construction industry to gain a broader understanding, what different activities included in the model should be named and what the benefits of using the model are.

In the merchant case, five interviews were conducted with the key account manager at the builder's merchant. The logistics manager and the environmental manager were also present at two of these interviews. One interview was carried out with the main contractor's site manager, evaluating the quality of the CLS and its importance to the success of the construction project. Finally, the construction site was visited to understand cost drivers and which activities were introduced or eliminated. In addition to the above meetings, the merchant and the main contractor were also asked to provide details of how much time, costs, etc. were saved for each actor (provider or user) for each different activity, and secondary documents were also provided. This resulted in a rough estimate of cost shifts and identification of shifts in responsibilities.

## 4. Conceptual model for identifying cost shifts

The introduction of a CLS will affect how costs and responsibilities are shifted between actors within the construction supply chain and the construction project. This section will introduce the reader to the developed conceptual model.

The developed conceptual model is presented in Tables 2 and 3. The model is used to analyse how costs are shifted with the introduction of a CLS for different actors. The model is based on both Grant *et al.* (2006) and Dekker and Van Goor (2000) work. As described in Section 2.5, four drawbacks exist with Grant *et al.* (2006)'s model (not considering uncertainty, not illustrating how to asses/measure, single-actor perspective and no service provider perspective). The first two columns of Tables 2 and 3 illustrate which costs are analysed (based on Grant *et al.* (2006)) and which activities these are associated with from a construction perspective. One of the drawbacks with Grant *et al.* (2006)'s model is the lack of showing how to assess/measure. The model introduced here tries to overcome this by translating [based on activity based costing (ABC) calculations] the cost elements into activities, which can be measured in terms of time and resource demand. In line with Dekker and Van Goor (2000) work, the following columns (three to eight) in Tables 2 and 3 illustrate which actors the various costs and responsibilities for an activity are attributable to. Here, we have included the following actors: merchants, subcontractors, main contractor, TPL provider and the client. However, this list is not exclusive and should also include the actors required for the specific project/CLS analysed. This multi actor perspective in the model overcomes Grant *et al.* (2006)'s drawback with only having a single actor perspective.

The aim of the model is to perform an analysis of how costs and responsibilities are shifted between actors when a CLS is introduced. Thus, both a baseline analysis of the current situation for a project or situation and a follow-up evaluation when the CLS is introduced need to be performed. How this is done will be illustrated through two different cases of CLS introductions. Altogether, the multi actor perspective, cost shifts, activity level, etc. make the model suitable to use in a project setting, such as construction. Because of the large amount of outsourcing, innovation often includes and affects several actors, wherefore it is important to use a cost model that analyses the innovation's effect on activity level for all actors (the fourth drawback with Grant *et al.* (2006)'s model).

**Table 2.** Costs and responsibilities before and after the introduction of the CLS in the hospital case

| Cost elements | Costs/activities | Before CLS introduction *Installation company* | *Main contractor* | *TPL provider* | *Client* | After CLS introduction *Installation company* | *Main contractor* | *TPL provider* | *Client* |
|---|---|---|---|---|---|---|---|---|---|
| Inventory carrying | Cost of tied-up capital | X | X | | | x | x | | |
| | Risk costs | X | X | | | x | x | | |
| Order processing and information | Quantifying | X | X | | | x | x | | |
| | Stocktaking | x | x | | | | | X | |
| | Ordering | X | X | | | x | x | X | |
| | Call-offs | X | X | | | x | x | X | |
| | Invoice processing | X | X | | | X | X | | |
| Transportation | Planning | x | x | | | | | X | |
| | Receiving | x | x | | | | | X | |
| Warehousing and material handling | External warehouse | | | | | | | | X |
| | On-site inventory | X | X | | | | | | |
| Waste management | Planning of fractions | | X | | | | X | | |
| | Sorting costs | | X | | | | x | x | |
| | Collection | | X | | | | x | x | |

| Cost elements | Costs/activities | Before CLS introduction *Merchant* | Before CLS introduction *Main contractor* | After CLS introduction *Merchant* | After CLS introduction *Main contractor* |
|---|---|---|---|---|---|
| Inventory | Cost of tied-up capital | | X | x | x |
| carrying | Risk costs | x | x | X | x |
| Order-processing | Quantifying | | X | x | x |
| and information | Stocktaking | | x | x | |
| | Ordering | | X | | x |
| | Call-offs | | X | x | x |
| | Invoice processing | x | X | X | x |
| | Personal admin | | X | | x |
| Transportation | Planning | | x | x | |
| | Receiving | | X | x | |
| Warehousing | External warehouse | X | | x | |
| and material handling | On-site inventory | | X | x | |
| Waste | Planning of fractions | | X | | x |
| management | Sorting costs | | X | | x |
| | Collection | | x | x | |

**Table 3.** Costs and responsibilities before and after the introduction of the CLS in the merchant case

## 5. Case examples of cost and responsibility shifts when introducing a construction logistics setup

This section aims to illustrate how the model can be used to analyse cost and responsibility shifts after introducing a CLS in two cases. This section is structured as follows. First, a description of the case is presented together with a motivation for introducing the CLS. Second, the model is used to analyse how the introduction of the CLS affected costs and responsibilities for the different actors.

### *5.1 Hospital case*

This case concerns the reconstruction of a hospital in northern Sweden. It is an extensive project that will continue until 2023. The planned budget for the project is SEK 1bn per year. Three to five sub-projects are in progress at the same time and 300–500 people (work management, craftsmen and fitters) are involved in the projects. The many sub-projects and the fact that many contractors, subcontractors and fitters are active at the same time mean that the number of material deliveries is expected to be high. The many deliveries that arrive in the area every day will compete with regular deliveries to the hospital, which have to continue as usual. In addition, the space for storing materials in the area is limited, and the daily operations at the hospital must not be disrupted. Traffic around the only entrance to the goods reception area is heavy. Thus, the client (the county region) has taken on the role of coordinating the logistics, partly to ensure that its own operations are not disrupted, but also to keep to the timetable and cost plan, guarantee patient safety and minimize traffic disruption. To design and execute the coordination of logistics, a change management consultancy firm, a supplier of delivery planning systems and a TPL company have been commissioned to develop a CLS.

The order-to-delivery flow in the CLS starts with contractors placing orders with a supplier and adding the delivery date in the delivery planning system of the CLS. The supplier registers the order and, upon delivery, prints a CLS-specific package label. Material is then delivered to the TPL company's terminal outside the city, where it is stored awaiting a call-off from the contractor. Twice a day (morning and afternoon), called-off materials are collected and delivered from the TPL company's terminal to the site. Nonscheduled orders from suppliers using the same TPL company as the transporter are picked up by the truck. Another service provided is waste management. The craftsmen collect waste near the assembly location and call-off waste collection to the TPL provider's on-site personnel using the scheduling software. The TPL personnel collect the waste bins and sort the waste into the correct container near the goods reception area.

### *5.2 Merchant case*

In this case, a construction merchant acts as a CLS provider for a housebuilding project in the centre of a medium-sized city in Sweden. The main contractor and the merchant have worked together for a long time in several different projects. However, this is the first time that both have formalized their working relationship using a CLS. The CLS was initiated by the main contractor because of the very confined area of the construction site. The terminal based CLS includes several added logistics services such as materials flow planning, warehousing, transport, materials handling at the construction site, cleaning and waste management and kitting of materials.

This is the first time the merchant has offered a CLS in Sweden. However, the concept comes from its international parent company. As this is the first time the merchant has used a CLS, there is a sharp focus on learning and an emphasis on providing feedback to develop the CLS further. The goal is to offer this CLS to other contractors or projects. Thus, the CLS is based on an existing concept, but has been jointly adapted between the merchant and the main contractor. The merchant has appointed two contacts to work with the adaptions and improvements: a vendor responsible for the commercial agreement and a material flow planner responsible for the weekly planning of the material flow.

## 6. Case analysis

### *6.1 Cost and responsibility shifts*

Traditionally, inventory carrying costs are measured using tied-up capital and risk costs. Even if it appears that no shift has occurred in the inventory carrying cost in both studied CLSs, the actual cost level should have decreased after the introduction of the CLS. This is because the risk associated with storing material on-site decreases, as it is now stored in a more secure place at the external terminal. Furthermore, the two cases feature differences. In the arrangement with the TPL in the hospital case, the contractors are still liable for the risks and the costs associated with the external terminal. However, in the merchant case, the cost and risks are borne by the merchant for its own materials, although not for other suppliers' materials that are also stored at the warehouse. The actual cost associated with risks and tied-up capital are not currently monitored by the contractors, which is why a proper cost analysis could not be carried out.

The order-processing and information cost element is also affected by the introduction of the CLS. Monitoring stock levels off-site is now performed by the TPL provider in both cases. One respondent, a strategic purchaser from an installation company in the hospital case, mentioned that the cost of searching for materials on-site and cost for loss of production time is significantly reduced with the CLS.

In the hospital case, ordering and call-offs are still performed by the contractors, but the TPL provider assists with this process. The time spent on ordering is slightly increased for the administrative personnel, but this time increment is less than the time saved by the shift in responsibility for receiving materials. However, the time spent on ordering and call-offs is not currently monitored, so no evaluation was possible. Quantity take-offs and invoice processing were not affected by the introduction of the CLS, even though the invoice processing task could be facilitated if the delivery status from the scheduling software was integrated with the invoice management software.

In the merchant case, the order processing and information have changed substantially compared to the traditional method. The planning is now shared between the site and the merchant. The material flow planner has operational contact with the merchant, and they meet once a week to plan deliveries and discuss potential improvements. The vendor only attends once a month to avoid sending improvement signals purely to sell more services. Deliveries are planned in two steps. First, the construction site's needs are broken down in relation to a production plan with a six-week horizon. Second, based on this, the merchant orders materials to its warehouse and call-offs to the site are planned with a one-week horizon. The main contractor and the merchant discovered together that the merchant could carry out some of the materials planning based on the contractor's plans without consulting the contractor. This saves time and phone calls and decreases the risk of mistakes because of information exchanges. Respondents from both the contractor and the merchant say in the interviews that improved planning through the CLS have resulted in less "express deliveries" and lower costs.

In both cases, one of the major changes because of the introduction of the CLS is seen in the *transportation cost*. Planning, and especially transport reception, is now entirely performed by the TPL provider/merchant (except for direct deliveries in the merchant case, which are planned by the contractors). The on-site staff from the TPL provider/merchant receive the material and move it to its destination on-site. In this way, the craftsmen can spend more time on value-adding activities. In the merchant case, transports are carried out by a local transport provider. As far as possible, the same driver is used to transport materials to the site, enabling learning. The same driver can use previous experiences to adapt how deliveries are carried out and to capture feedback from the operational point of view of on-site workers. Express transport and short time changes are offered an additional cost in both cases.

The other major change compared to the traditional on-site storage of materials is seen in the warehousing cost. In the hospital case, this additional cost – compared to the original situation – is covered by the client. The client's reasoning, according to the project manager from the county region in the hospital case, is that the cost of impeding ambulances because of materials being stored on-site is infinitely larger than the additional finite cost of the external warehouse. In the merchant case, the shift from traditional on-site storage to storing materials at the merchant's warehouse has involved significant changes for the merchant. The merchant now stores its own materials as well as other suppliers' materials at a warehouse on the outskirts of the city. Storing other suppliers' materials was a requirement in order for the main contractor to use the CLS, otherwise these materials would have been delivered directly to the site. Thus, the merchant is no longer operating logistics only in relation to its own products. To make warehousing handling as efficient as possible, the merchant has one dedicated person working with the main contractor's goods at the warehouse. This has been very important, as the merchant sees the process of acting as a terminal for other suppliers' goods as an internal learning process at the warehouse. JIT supplies to the site have also required adaptions in terms of using the warehouse's resources. Thus, handling has increased for the merchant while decreasing for the contractor.

The final cost element, waste management, has also been affected in both cases by the introduction of the CLS. Traditionally, waste management has been controlled by the main contractor, although subcontractors can also use the containers. Because the introduction of the CLS, the main contractor is still responsible for planning the different fractions (types of containers) necessary and paying to rent them. However, the TPL is responsible for collection and on-site sorting. Container collection is still paid for by the main contractor, but as the waste is correctly sorted, the penalty fees are less than normal.

Table 2 illustrates activity responsibilities and costs shifts in the hospital case, and Table 3 shows the same information for the merchant case. As the actual numbers of changes were difficult to ascertain, larger changes are illustrated with a capital X.

### *6.2 Cross-case analysis*

Studying Tables 2 and 3 reveals four interesting commonalities between the two CLSs.

First, looking at transportation and warehousing and material handling costs/activities shows that both setups involved the activities associated with warehousing and transportation going from being performed by several actors to being performed by only one actor. This meant that the costs and responsibility for performing these activities were fully shifted or consolidated to the TPL provider. In the hospital case, this meant that the TPL provider became responsible for transportation planning. In the merchant case, it became the merchant's responsibility. Even if the setups are different and suit different contexts, they both free up the main contractor from planning transports and most of the handling of incoming deliveries.

A second important finding when analysing the two cases is that both setups split the waste management costs between the main contractor and service provider, having previously lain entirely with the main contractor. It is still up to the main contractor to plan which fractions are needed, but the activities associated with sorting and discarding are mostly handed over to the service provider, thereby saving the main contractor working time.

Third, neither setup had any effect on the risk of storing materials on-site. It is still the owner of the material (the installation company or the main contractor) who bears the risks and thus any costs involved with on-site storage. However, the merchant case showed that some of the risk is transferred from the main contractor to the merchant, as the ownership of the material is shifted to a later stage of the order-to-delivery process. This also means that potential risk costs are shifted.

Finally, the biggest changes with the two setups are seen in terms of order processing and information. For the merchant case, this meant that the merchant became fully responsible for the activities, and that efficiency gains were achieved because of having proper facilities for these activities. In the hospital case, the activities were also shifted but less time was spent in total.

## 7. Concluding remarks

The purpose of this study was to identify how the responsibilities and costs of planning, controlling and executing the material, resource and waste flows are shifted between actors when introducing a CLS as a product innovation in a construction project, compared to the traditional way of organizing these activities. This was done by developing a conceptual model for analysing and visualizing cost and responsibility shifts between actors, which was thereafter applied in two cases. The applied models are presented in Tables 2 and 3.

The theoretical contributions of the models and this study lie in the inclusion of a multi-actor perspective in total cost modelling within supply chains. The outsourcing of logistics activities is justified from the main contractor's perspective, as it increases a project's relative value-adding time by shifting non-value-adding activities to suppliers (Ying *et al.*, 2018). A few previous studies have succeeded in illustrating from a supply chain perspective how costs for logistics activities are shifted when outsourcing logistics activities. Dekker and Van Goor (2000) and Garfamy (2012) suggested including different supply chain actors but did not illustrate how costs are shifted between the actors. The contribution of this study is that we show how the costs and responsibilities are shifted between different supply chain actors, thus contributing important knowledge for future supply chain costing research. The cases also contribute to construction supply chain research on CLSs, e.g. and Sundquist *et al.* (2017) and Janné and Fredriksson (2019), adding a contemporary picture of how costs and responsibilities are shifted in construction projects. It is hoped that this knowledge will shape future research on CLS introductions, as it helps us to understand how different actors are affected. Finally, this study also contributes to the domain of innovation implementation research in construction. Previous research has shown that the introduction of a product innovation is dependent on supply chain integration and mutual understanding of the processes affected (Stewart and Fenn, 2006; Rose *et al.*, 2019; Hedborg Bengtsson *et al.*, 2018). We confirm this and show that innovation, supply chain integration and transaction costs cannot be studied in isolation in construction settings. This is also important from an SCM perspective. Lambert and Cooper (2000) describe how SCM consists of business processes among organizations, management activities and a supply chain structure. With the introduction of CLS, all three aspects are affected. Understanding the new management tools offered by new actors and how they affect shifts in costs and responsibilities brings insights into the possibilities offered by integrating and managing the supply chain. This is necessary (Stewart and Fenn, 2006; Rose *et al.*, 2019; Hedborg Bengtsson *et al.*, 2018) for building a mutual understanding of the process and needs and for the product innovation to be successful.

The practical implications of the developed model for cost and responsibility shift are:

- Logistics costs become visible.
- Easier contract writing, as costs and responsibilities are clear from the beginning.

The managerial implication of this study is thus that using the model enables the actors to visualize the costs of logistics activities and how they are shifted with the introduction of the CLS. However, one of the main reasons why it is has been hard to implement SCM in the construction industry is that logistics is not seen as a value-creating activity. From a practical point of view, the model contributes a better visualization and hence a clearer understanding of which logistics activities are part of the construction supply chain and of how the related costs and responsibilities shift between actors when introducing a product innovation such as a CLS. The logistics costs are thus no longer hidden, and the amount each actor spends on logistics activities also becomes visible. The cost level for each party is important when setting up the contract, as the introduction of a CLS might result in one actor being assigned a proportionately higher share of the costs when introducing the CLS. Visibility of how the responsibility for different activities is shifted between actors is also important when agreeing on the contract. Knowing who will be responsible for what reduces the risk of conflicts later on. The conceptual model presented in this study is thus far not aimed at a specific actor in a construction project or a construction supply chain. It is useful for all parties affected by the introduction. However, the question of who is most suitable to take responsibility is not investigated in this study nor is the matter of who should own the model and include it in their repertoire of innovation implementation tools. This is left for future studies.

Additional applications are necessary to improve the model and make it usable in more general settings. One limitation is the lack of numerical data, which made it impossible to test the cost part of the model. Future research should therefore strive to test the model and refine it, so that it can be used in a more structured way. Research should also focus on developing guidelines for using the model, i.e. going from a conceptual model to a conceptual framework, with guidelines for how to use it and anticipate the outcomes of introducing the CLS from the start.

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