Taylor & Francis
Taylor & Francis Group

Production Planning & Control
The Management of Operations

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tppc20

# Effects of employing third-party logistics arrangements in construction projects

Mats Janné & Martin Rudberg

**To cite this article:** Mats Janné & Martin Rudberg (2020): Effects of employing third-party logistics arrangements in construction projects, Production Planning & Control, DOI: 10.1080/09537287.2020.1821925

**To link to this article:** https://doi.org/10.1080/09537287.2020.1821925



Published online: 16 Sep 2020.

PRODUCTION PLANNING & CONTROL
https://doi.org/10.1080/09537287.2020.1821925



# Effects of employing third-party logistics arrangements in construction projects

Mats Janné and Martin Rudberg

Department of Science and Technology, Linköping University, Norrköping, Sweden

**ABSTRACT**

Third-party logistics (TPL) arrangements are becoming a regular occurrence in urban construction projects. The industry is, however, still apprehensive regarding the effects that TPL arrangements bring. The purpose of this study is therefore to investigate the effects that can be realised when employing a logistics arrangement in construction, including possible benefits, concerns, and effects on cost elements. The purpose is fulfilled through a case study of a large construction project in Sweden that has employed a TPL arrangement. Results show that there are positive effects to achieve in terms of logistics performance and project performance, but that the main challenge to achieve these effects is to include all supply chain actors to reach a higher level of SCM maturity. This inclusion can be achieved through a better dialogue amongst supply chain actors to create an understanding for why TPL is employed and why policies and regulations needs to be followed.

**ARTICLE HISTORY**
Received 8 October 2018
Accepted 5 September 2020

**KEYWORDS**
Construction management; supply chain management; logistics; third-party logistics; case study

## 1. Introduction

Construction projects are temporary organisations that demand a multitude of materials and resources being delivered on-time, to the correct site and according to rules set by site management (Kim and Nguyen 2018). Where traditional manufacturing industries can achieve long-term relationships and economies of scale in stable environments, the construction industry is characterised by one-off projects, tendering and procuring contractors, sub-contractors and suppliers with every new project (Dubois and Gadde 2000; Seth et al. 2018). This leads to a situation where the projects are managed locally, and project management thus becomes disconnected from the company level (Dubois and Gadde 2002). This also affects how logistics within construction projects are managed, and the lack of efficient logistics in construction has been reported frequently in literature.

Lately, the interest in logistics management has gained momentum in the construction industry and the use of third-party logistics (TPL) has increased (Ekeskär and Rudberg 2016). The use of TPL is typically initiated either by an external party or internally (by the project or centrally at the main contractor). Irrespectively of how initiated, employing TPL often leads to logistics costs being made visible, whereas the benefits are hard to quantify. Thus, the use of TPL, or similar logistics arrangements, in construction is still met with some scepticism (Janné and Fredriksson 2019). TPL is a new phenomenon for both the clients and the contractors, but also for TPL providers traditionally not operating in the construction industry (Ekeskär and Rudberg 2016). Hence, there is a gap in researching this phenomenon and how it affects construction operations and project performance (Sobotka and Czarnigowska 2005).

The purpose is therefore to investigate the effects that can be realised when employing TPL arrangements in construction, including possible benefits, concerns and effects on cost elements. To fulfil the purpose, three research questions are addressed;

- RQ1: What realised benefits, issues, and challenges can be expected when employing a TPL arrangement in construction?
- RQ2: What cost elements are affected when using a TPL arrangement in construction?
- RQ3: How does the logistics maturity of supply chain actors affect the utilisation of TPL in construction?

The purpose and the research questions are analysed through a case study of a large construction project in Sweden that has implemented and used a TPL arrangement. The first question investigates the possible benefits a TPL arrangement can provide, but also the possible concerns and negative effects that may arise. The second question relates to the uncertainty regarding the costs of utilising TPL arrangements in construction projects. This is analysed by mapping the logistics process and cost elements of the TPL arrangement in the case study. The final question relates to both organisational and process related issues and that logistics maturity differs between the many actors in a construction project. Knowing the cost elements and benefits/concerns associated with a TPL arrangement is a first step towards logistics awareness, but it

CONTACT Mats Janné mats.janne@liu.se Department of Science and Technology, Linköping University, Norrköping, SE 601 74, Sweden
This article has been republished with minor changes. These changes do not impact the academic content of the article.

does not lead to supply chain orientation (SCO) as discussed by Mentzer et al. (2001). The final research question thus seeks to answer how the different levels of SCM maturity affects the utilisation of a TPL arrangement in construction and is answered by analysing the results of the case study through the lenses of a literature review.

After this introduction, the theoretical background for the study is presented, focussing on SCM and logistics in general and TPL arrangements in construction in particular. This is followed by the research design of this study. The case study is thereafter introduced by describing the development and application of the TPL arrangement investigated in this study. Thereafter the results of the case study are analysed using the theoretical constructs introduced in the theoretical background. From this, a discussion of the research questions and purpose are presented. Finally, conclusions are derived, and based on that areas for further research are suggested.

## 2. Supply chain management and logistics in construction

### 2.1. SCM

The thought behind SCM is that individual businesses no longer compete as autonomous entities, but rather as interlinked units with customers and suppliers, i.e. their supply chains (Mentzer et al. 2001). This has shifted companies' focus from keeping suppliers and customers at an arms-length distance, towards working in closer collaboration, leading to a major aspect of SCM being the relationship between supply chain actors (Kotzab et al. 2015). If these relationships are nurtured, improvements in long-term performance can be achieved (Kim and Nguyen 2018). However, realising SCM is difficult (Kotzab et al. 2015) and, as Mentzer et al. (2001) point out, the full potential of SCM can only be achieved if all participating supply chain actors strive towards a joint supply chain orientation (SCO), as visualised in Figure 1. To become SCO, the following issues needs to be addressed by all supply chain actors; *trust, commitment, interdependency, organisational compatibility, agreed SCM visions and key processes, top management support,* and *acceptance of taking a leading role in the supply chain* (Mentzer et al. 2001). If supply chain actors fail to address these issues there will be a lack of SCO, leading to the whole supply chain suffering and it will be difficult to reap the positive effects of SCM. The SCO issues presented by Mentzer et al. (2001) and highlighted by Kotzab et al. (2015) resembles many of the construction supply chain relationship factors identified by Kim and Nguyen (2018), indicating that the SCO issues also are valid in a construction setting.

### 2.2. SCM in construction

As discussed by Dubois and Gadde (2000), the construction industry is characterised with high levels of resource dependency and temporary network structures. The temporary networks means that different contractors, sub-contractors, consultants and builders' merchants are tendered and procured with every new construction project (Dubois and Gadde 2000; Seth et al. 2018). This means that with every new construction project, a new supply chain is created, focussing on the individual projects' success (Dubois and Gadde 2002). The coordination across businesses, that Mentzer et al. (2001) highlight as an important SCM aspect, is thus difficult to achieve in a construction setting. When new partners are procured every time, it is also difficult to achieve overall SCO, regardless of whether the different supply chain actors in themselves are SCO or not.

Gosling, Naim, and Towill (2013) find that the biggest barrier to integration between construction supply chain partners is giving up control and Zou and Couani (2012) add lack of information and lack of commitment as barriers to SCM in construction. To mitigate this, Zuo et al. (2009) highlight the importance of working with soft values such as stakeholder engagement, communication, and resource and risk management. Due to the temporary nature of construction supply chains, however, the overall joint goal and SCM vision needs to be re-established repeatedly (Dubois and Gadde 2002), leading to a situation where adversarial contracts and lowest price makes SCO difficult to achieve (Fernie and Tennant 2013; Behera, Mohanty, and Prakash 2015).

A stepwise approach has been suggested to address SCM in construction. Ekeskär and Rudberg (2016) extend the work of Vrijhoef and Koskela (2000) and define five roles that logistics and SCM can play for construction, visualised in Figure 2: (1) focus on clarifying the interface between the supply chain and site activities, (2) focus on improving the supply chain, (3) focus on improving logistics at the construction site, (4) transferring activities from the site to the supply chain, and (5) manage the site and the supply chain as an integrated domain. The first four roles mainly concern logistics management, whereas the fifth role concerns SCM (according to the definition by, e.g. Mentzer et al. (2001)). To achieve the expected results of SCM, all actors must be SCO, regardless of which of the five roles is addressed. When evaluating a TPL arrangement in construction, the five roles can be seen as an operationalisation of SCM performance. Understanding how the TPL arrangement affects the construction supply chain means that performance issues can be

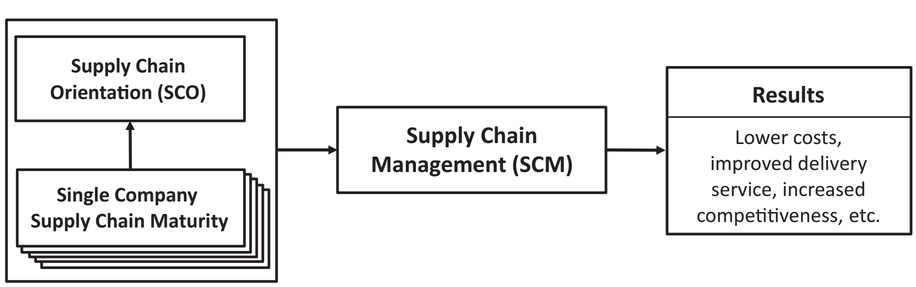


Figure 1. The results of SCM are dependent upon the supply chain orientation.

identified, but also how well the arrangement has been understood and accepted by the supply chain actors (Sundquist, Gadde, and Hulthén 2018). The latter addresses the impact of supply chain maturity and SCO (Mentzer et al. 2001).

### 2.3. Logistics in construction and third-party logistics

Logistics management is that part of SCM focussing on the operational management of the supply chain (Council of Supply Chain Management Professionals 2017). Seen in a construction context, logistics can be said to deal with supplying the right materials and machinery to the correct customer and construction site to meet the projects' requirements. As part of many SCM and logistics management initiatives in construction, logistics arrangements such as TPL, have been employed, especially when it comes to large construction projects in urban areas. Marasco (2008) defines TPL as 'an external organisation that performs all or part of a company's logistics function', and Selviaridis and Spring (2007) add to this that TPL is usually associated with the offering of multiple, bundled services, rather than just isolated transport or warehousing functions. TPL arrangements are also based on formal contractual relations, as opposed to spot purchases of logistics services (Lai, Cheng, and Yeung 2004; Stefansson 2006). TPL arrangements can thus be seen as formalised partnerships where a TPL service provider fulfils the needs of a client through tailored service offerings (Skjøtt-Larsen 2000).

The rationale for utilising TPL is that a firm can outsource parts, or all, of their logistics function to a specialised firm and instead focus on their core business (Bourlakis and Melewar 2011; Arnold 2000). Through this outsourcing process, benefits such as reduced capital tied up in facilities, equipment and manpower; increased flexibility and productivity; and new competencies can be obtained (Marasco 2008).

Currently, two main alternatives of construction TPL arrangements are common; terminal-based and checkpoint-based (Janné and Fredriksson 2019; Sundquist, Gadde, and Hulthén 2018). The two TPL arrangements share a common goal, to reduce the disturbances on site, but they differ in the way they achieve this goal. The terminal allows the TPL provider to consolidate goods to reduce the number of deliveries to site (Lundesjö 2015), but also to offer services such as e.g. kitting and short-term storage (Selviaridis and Spring 2007). The checkpoint focuses on timely deliveries from a just-in-time (JIT) perspective (Ekeskär and Rudberg 2016; Sundquist, Gadde, and Hulthén 2018). Thus, the number of deliveries might not be reduced, but the control of *when* deliveries arrive can be increased (Dubois, Hulthén, and Sundquist 2019; Ekeskär and Rudberg 2016). A common attribute for the two arrangements is that they are dependent on having joint planning systems to increase control of when and where deliveries arrive (Thunberg and Fredriksson 2018). TPL can help projects in streamlining logistics operations and a TPL provider can contribute with both knowledge and operational logistics, thereby helping contractors become more SCO (Kotzab et al. 2015; Mentzer et al. 2001).

Utilising TPL arrangements is still a new phenomenon in construction. Currently, most construction TPL arrangements are employed in urban areas (Janné and Fredriksson 2019), as these areas are often dense and limited through their available infrastructure (Dablanc 2007). Construction transports thus put additional strain on the transport system (Dablanc 2007), meaning that deliveries to and from construction sites need to be coordinated and managed in a way that reduces their impact on the transport system (Dubois, Hulthén, and Sundquist 2019). This has been a strong driver for employing TPL in construction (Janné and Fredriksson 2019). There are also indications from the industry that TPL arrangements will be the future norm for construction projects in urban areas (Janné and Fredriksson 2019). This means that construction companies are 'forced' to address coordination through TPL to ensure sustainable deliveries, thus opening up for more acceptance and

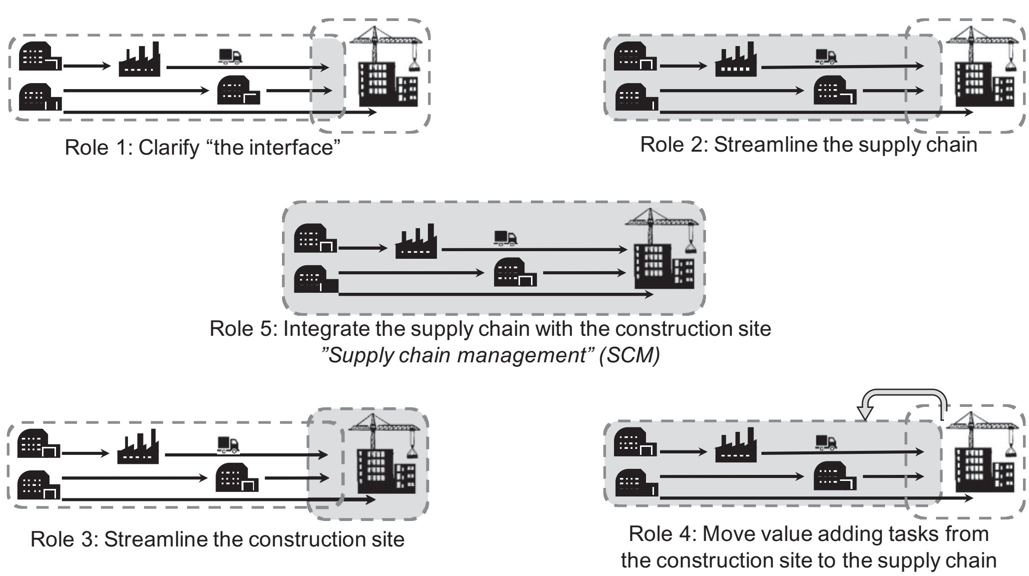


Figure 2. The five roles that logistics and SCM can play for construction (based on Ekeskär 2016; Vrijhoef and Koskela 2000).

understanding of logistics and SCM in construction (Fernie and Tennant 2013).

### 2.4. Evaluating logistics performance

Traditionally, construction projects have measured performance of construction activities focussing on time, quality, and cost (Jonsson and Rudberg 2017), i.e. the 'Iron Triangle' (Atkinson 1999; Chipulu et al. 2019). However, balancing project performance in the 'Iron Triangle' is dependent on well-functioning construction logistics that ensures that materials and resources are delivered to, and retrieved from, site when needed (Dubois, Hulthén, and Sundquist 2019; Ying, Tookey, and Seadon 2018). If materials and resources are *not* at site when needed, this will affect the progress of the construction project negatively and have further repercussions on subsequent construction activities (Dubois and Gadde 2002). If deliveries are delayed or poorly planned, or materials are missing or damaged during handling, the whole project can be delayed, leading to increased risks of cost overruns (Liu, Xu, and Zhang 2015; Dubois and Gadde 2002). As construction logistics performance has a direct impact on construction project performance, it is crucial to evaluate logistics operations (Thunberg and Persson 2014). Yet, Ying, Tookey, and Seadon (2018) found that few studies have focussed on construction logistics performance, and those that have focus either on costs or a specific construction logistics activity, e.g. transports.

Analysing logistics costs, one must keep in mind that logistics is more than just transports and that all cost elements are made up of fixed and variable costs. Site storage for instance, can be comprised of receiving and unloading materials, moving them to on-site storage, registering the location of materials, the cost of storage, etc. (Fang and Ng 2011). The key to finding the actual composition of the different cost elements lies in identifying the cost drivers for each activity in the logistics flow, i.e. factors which cause a change in the costs of work performed in the process (Vasiliauskas and Jakubauskas 2007).

The actual effect on cost is however only one area of interest when analysing the effects of construction TPL arrangements. Hence, evaluating logistics performance includes different perspectives and, in this study, Selviaridis and Spring's (2007) division between strategy-, finance- and operations-related issues for evaluating the construction TPL arrangement is used. Utilising a TPL arrangement can reduce costs and add value, but this can be difficult to quantify (van Laarhoven, Berglund, and Peters 2000). Besides cost (finance-related issues) Selviaridis and Spring (2007) also argue for an evaluation from a strategic perspective, i.e. how the logistics arrangement can be a mean for reaching corporate objectives and business goals. At the heart of this lies evaluating whether or not the TPL arrangement has led to any benefits for the company's overall objectives, i.e. its ability to focus more on the core business (Marasco 2008; Selviaridis and Spring 2007). Selviaridis and Spring (2007) further suggest that TPL should be evaluated from an operational perspective, i.e. how the arrangement affects the day-to-day operations. Aspects to consider can be, e.g. inventory levels, lead-time performance, more efficient operations, improved delivery service, and better working environment (Ekeskär and Rudberg 2016; Selviaridis and Spring 2007).

## 3. Research design

To allow for an in-depth understanding of the mechanisms of a new phenomenon, Voss (2009) proposes that a single case study approach is followed. When selecting the case to study, different sampling and selection criteria can be employed (Voss 2009; Yin 2014). As TPL in construction is a fairly new occurrence (Ekeskär and Rudberg 2016), construction projects known through previous and on-going research projects where scanned to identify possible candidates for the study. The case selection was based on four criteria: (1) that it is a large-scale project, (2) that it utilises a construction logistics arrangement, (3) that it is located in a complex urban environment, and (4) that the project was willing to grant access to the researchers and share project and performance data. The set of available cases was few, and the case reported in this paper was finally chosen based on their willingness to participate and give full support from the client, the main contractor, and the TPL provider, a criteria highlighted as important by Voss (2009). The case study focuses on the logistics operations of a large construction project in Sweden, where a construction management (CM) company, acting as the main contractor, internally developed and implemented a TPL arrangement for a large office building project. Since the client is new to the use of TPL, they want the TPL arrangement to be externally evaluated, further facilitating access to the project, the site, and data.

The use of a single case study is motivated by the project being revelatory, providing in-depth information on a new phenomenon, and that it was possible to study the project over time, hence including longitudinal aspects (Yin 2014). As with all case studies, the generalizability is limited, and the results of a single case study must be treated with caution. However, for the purpose of exploring a new phenomenon and shed light on an area where not much research has been conducted, the single case study has an important role to play (Voss 2009). The research design builds upon three activities: *preparation*, *data collection,* and *analysing*. The research approach is iterative, revisiting each step over the course of the research project to get the best possible result.

### 3.1. Preparation

Planning for the study was performed in collaboration with the CM company, also ensuring that the research team had access to the right people and data sources. The case study was prepared through reviewing relevant literature regarding SCM, logistics, and the use of TPL in construction. Preparations regarding data collection was also undertaken and revisited throughout the research process. Each interview or site visit was prepared by discussing the purpose of the exercise.

Table 1. Data sources and collection.

| Data sources | Case area in focus | | | | | |
|---|---|---|---|---|---|---|
| | Background | Functionality | Impact on costs and productivity | Benefits, issues, and challenges | Performance | Communication and collaboration |
| Project documents | X | | | | X | |
| Interviews with TPL company | X | X | | X | X | X |
| Interviews with CM company | X | X | X | X | X | X |
| Group discussion with TPL company | X | X | | X | X | X |
| Group discussion with CM company | X | X | X | X | X | X |
| Group discussion with on-site material handlers | | X | | X | X | X |
| Group discussion with IT/Software/ planning company | X | X | | X | X | X |
| Site observations | X | X | | X | | X |
| Terminal observations | X | X | | X | | X |
| Student project | | | X | X | X | |
| Project planning tool | X | | X | X | X | |
| Supply chain planning system | | X | | X | X | X |
| Business Intelligence system | | | X | X | X | X |

### *3.2. Data collection*

Data has been collected through semi-structured interviews, group discussions, on-site visits at the construction site (twice) and the terminal (once), review of project documents, and through a students' project supervised by the researchers involved in the study. Furthermore, the CM company provided full access to a set of IT tools used in the project, including: the CM company's project planning tool, the cloud-based supply chain planning system used in the case project, and the business intelligence system supplied by the software provider. Table 1 presents the data sources and which case area each data source was used for. In Table 1 *background* and *functionality* provides information on the construction project and the TPL arrangement. *Impact on costs and productivity*, *benefits, issues, and challenges*, and *performance* collects data to analyse RQs 1 and 2. *Communication and collaboration* focus mainly on RQ3, which is also informed by the analyses of RQs1 and 2, as well as the background and functionality of the project and the TPL arrangement.

The semi-structured interviews were conducted with logistics representatives from the CM company, logistics coordinators on site, operators at the terminal, and managers at the CM company (logistics, purchasing, planning) and followed the structure presented in Appendix A. The interviews were used to get insights into the project background and rationale for the logistics arrangement, as well as understanding of how the arrangement had been perceived in terms of effects from different roles' perspectives in the project. The interviews also allowed for an understanding of how the supply chain had been affected by the arrangement by including questions specifically aimed at investigating how communication and collaboration had worked in the project in conjunction with the logistics arrangement (see the final two questions in Appendix A). In total, eight interviews a 2-h and seven group discussions a 1–2-h were conducted. Table 2 presents the respondents for the interviews and group discussions. The far right column denotes which group discussions the respondents participated in.

The site and the terminal visits aimed to observe operations and to interact with people involved and affected by the TPL arrangement. The software tools and systems were used to get access to quantitative data on the TPL arrangement and operations. The student project was used to go through, structure, and analyse a large set of documents and reports on operations and deviations filled out every day by the on-site materials handling team, which was then used as input in the case analysis.

### *3.3. Analysing*

The final phase of the research process is based on analytical and conceptual reasoning (Wacker 1998) grounded in the results from the literature review and the case study. In conceptual research approaches, analytical and empirical methodologies are typically combined to provide new insights into a phenomenon through logical reasoning (Meredith 1993; Wacker 1998). The case study findings are interpreted by contrasting the findings with the knowledge obtained from the literature review (Meredith 1993; Wacker 1998). By doing so, the study adds new insights into how construction projects can benefit from utilising TPL arrangements and how these arrangements can affect cost elements (Meredith 1993; Wacker 1998). Furthermore, the analysis aims at highlighting how TPL arrangements affect supply chain performance. In the analysis, the TPL arrangement is considered the unit of analysis. Hence, the analysis and the conclusions in this study are based on a perspective centred around the TPL arrangement. The interviews and the group discussions, combined with data on the project and TPL arrangement, the functionality and performance, are used as means to investigate the level of SCO, or supply chain maturity, for the different actors in this case study.

### *3.4. Research quality*

Utilising case study research is often criticised due to the specificity of each case, wherefore increasing research quality through transparency of validity and reliability is especially

Table 2. Interview respondents and group discussions.

| Company | Role | No. interviews | Part of group discussion(s) |
|---|---|---|---|
| TPL company | CEO | 2 | 1, 4, 7 |
| TPL company | Head of terminal | 1 | 1, 3, 4, 7 |
| TPL company | Terminal worker | 1 | 3 |
| CM company | Logistics and IT | 3 | 1, 2, 7 |
| CM company | Logistics project | 1 | 1, 7 |
| On-site materials handling company | On-site logistican 1 | 0 | 2 |
| On-site materials handling company | On-site logistican 2 | 0 | 2 |
| IT/Software/planning company | Business area manager | 0 | 5, 6 |
| IT/Software/planning company | Product manager | 0 | 5, 6 |

important (Yin 2014; Voss 2009). In this research, the following measures have been taken to ensure validity (Yin 2014):

- Multiple data collection methods have been used, i.e. interviews, observations, project documentation, audit reports, project management tools, and statistics. The data from these methods have been triangulated in the analysis.
- The study has followed an iterative process where literature has been reviewed prior to empirical data collection and revisited afterwards, to ensure that enough and correct data was collected as well as to facilitate the analysis. The findings from the case study have also been linked to the literature, to allow for analytical generalisation (Yin 2014).
- Interview protocols and notes from documentation reviews have been discussed with respondents and project officials to validate the understanding of documents and interview responses.
- Draft case study reports have been sent to key informants for review.
- Throughout all the phases of the study, the authors have collaborated closely and discussed any unclear aspects of data collection, data collected, statements in literature, or findings.
- As research findings are analysed with the aid of an international literature base, the case studies offer some directions for companies and municipalities in contexts similar to the Swedish one.

The following measures have been taken to ensure the reliability of this research (Yin 2014):

- Structured interview guides (see Appendix A) and research protocols have been used in all data collection phases of the case study.
- Drafts and notes from interviews and observations have been stored electronically and as hardcopies. This allows for case study material to be reviewed and controlled if necessary.

## 4. Case study

### 4.1. Background

The CM company focuses on inner-city construction projects, primarily hotels and office buildings. Building and refurbishing in such environments pose challenges for the logistics operations, as inner-city areas are often dense with limited space and shared infrastructure with commuters and other freight transports. This was the motivation for the CM company to start working more intensely with logistics management. Originally, the CM company bought services from a TPL provider that helped streamline their logistics operations by utilising a consolidation terminal. This alleviated some of the problems with getting the correct materials to site at the correct time, but logistics on site was still problematic. Each construction project tendered its own logistics arrangement from the TPL provider, leading to a non-standardised process. Eventually the CM company employed a logistician to work full-time in the projects, giving the CM company more of an insight into the logistics operations and challenges encountered. Based on the learnings from a handful of projects with the external TPL provider, the CM company decided to develop its own logistics arrangement, which was originally set up as an in-house standardised TPL arrangement that could be employed in the construction projects.

### 4.2. The logistics arrangement

The logistics arrangement was initially an in-house profit unit of the CM company, consisting of three employees. The profit unit was later turned into a TPL company, owned by the CM company. The newly established TPL company had the CM company as its main customer, but other construction companies also engaged the TPL company to varying degrees.

Since the CM company runs large inner-city construction projects, they decided that one of the key features of their logistics arrangement was to have a *terminal* to gain consolidation effects in the material flow. Besides the terminal, the main pillars of the logistics arrangement are an *on-site materials handling team* and a *planning system* with related *planning process*. The structure of the logistics arrangement, with the three main pillars (terminal, on-site materials handling, and planning system and process), is visualised in Figure 3.

The logic behind re-routeing material flows via the *terminal* is to reduce the number of deliveries to site by consolidating materials and to reduce materials handling related disruptions on-site. A haulier company is contracted to carry out the day-to-day terminal operations and transports between the terminal and the construction site. The haulier has four employees dedicated to working with the CM company's logistics at the terminal. The current terminal consists of approximately 2500 $m^2$ warehouse area divided over four terminal buildings and another 2000 $m^2$ outdoors. Due to

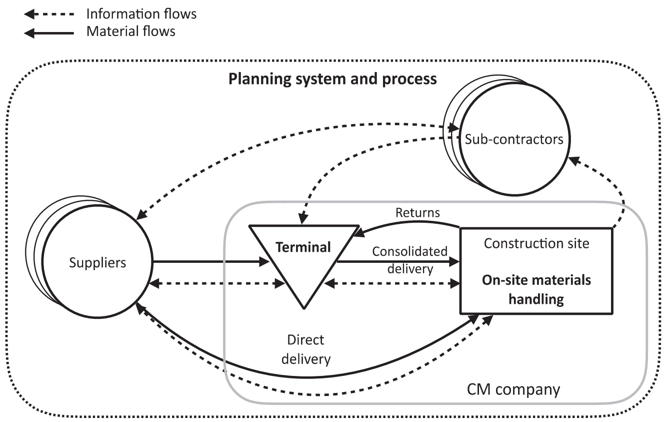


**Figure 3.** The studied logistics arrangement.

the design of the terminal, a lot of the available space is needed to manoeuvre trucks and material handling equipment.

The *on-site materials handling team*, supplied by another external TPL provider, should free up time for the craftsmen, allowing them to focus on their core competence, construction. The on-site materials handlers receive and record materials and move them to the correct materials zone on-site after hours, allowing for materials to be in place when needed.

Finally, the *planning system*, supported by a standardised process, is a commercial off-the-shelf, cloud-based system designed specifically for the construction industry. All material deliveries are planned and called-off in the system and all main actors have role-based access to the system. As such, it facilitates visibility in the logistics process and it is the main integrative tool between the CM company, the TPL arrangement, the sub-contractors, and the suppliers in the project organisation.

When a new construction project is initiated, a logistics start-up meeting is held with the sub-contractors and suppliers, highlighting the logic and the policies of the TPL arrangement. The sub-contractors are then tasked with setting up a delivery plan together with their suppliers, taking the TPL arrangement into account. All delivery plans are discussed with the CM company for approval. Once approved, the plans are fed into the planning system, detailing when materials are delivered to either the terminal or the construction site. Direct deliveries are allowed if a sub-contractor can motivate why they are needed. As far as possible, deliveries should, however, go via the terminal.

### 4.3. Employing the TPL arrangement in the construction project

Recently, the TPL arrangement was piloted at a large office project managed by the CM company. The project is located in a busy and dense urban area adjacent to other office buildings, a football stadium, a large supermall, residential housing, and a railway station.

The project consists of three house blocks varying from seven to fourteen stories with 90,000 $m^2$ floor space, a large garage, and an employee recreation centre. The office complex is set to house 4400 employees, 600 conference rooms, and space for temporary employees and visitors. The office complex is built as a design-build, turn-key contract with partnering and the total contract sum is M€170. Based on the logistical challenges of the area, the CM company decided that their TPL arrangement should be used and evaluated as a pilot, which was also accepted by the client. Addressing the client, the CEO of the TPL company, at the time also acting as the purchasing manager at the CM company, argued that 'it would be impossible to solve deliveries and materials handling at such a narrow site in such a dense area without a coordinated logistics arrangement'. He also argued that 'the only way to reduce the number of transports to site is by utilising a terminal and a common planning system'. Organisationally, the CM company is hierarchically situated below a property developer (the client) and employs sub-contractors to perform all trades. The logistics arrangement is contractually treated as a sub-contractor, with the terminal and transportation crew and the on-site material handlers as service suppliers to the TPL arrangement.

In the stipulated logistics process (Figure 3), the sub-contractors signal their suppliers and the terminal with regards to when materials are needed and how they are to be delivered; either directly, via the terminal for warehousing and call-off, or consolidation with other materials. The supplier acknowledges the delivery and notifies the terminal, or the construction site, of when materials leave the suppliers' site. The terminal receives goods and sends a notification of receipt to the supplier. When materials are called-off by a sub-contractor, the terminal crew notifies the construction site that delivery is forthcoming, and the terminal crew plans the delivery together with the on-site materials handling personnel. When materials arrive at the construction site, the on-site materials handlers receive the goods and delivers it to the stipulated delivery zone. Finally, material handlers notify both the terminal and the sub-contractor that the material is received. All planning and execution information is fed into/by the planning system. The material handlers also fill out delivery reports, indicating deviations from plans and other material delivery related problems that might occur.

### 4.4. Results of the TPL arrangement

The 3.5-year office building project is finalised, and the CM company is currently evaluating the results of the pilot project with the TPL arrangement, with the aid of the researchers involved in this study. The total cost for the logistics arrangement throughout this project approximates 3% of the construction costs on site, and 1.4% of the total development and production cost for the whole project.

As for the *terminal*, the cost of operations has been higher than expected. This is partly due to that the terminal structure originally was designed as a train depot and not for warehouse operations. This has resulted in a lot of materials relocation to be able to facilitate storage and to be able to efficiently load delivery vehicles. Furthermore, the terminal seems to have been used more as a buffer, rather than as a consolidation point. Factors showing this is that there are approximately as many deliveries to the terminal as there are outgoing deliveries from the terminal, that the average number of parcels per delivery to site is four (indicating low fill rates of the outbound transportation from the terminal), and that the average storage time in the terminal was 14.7 days, to be compared with the initial target of around 5 days storage time in the terminal.

At the construction site the *on-site materials handlers* have tracked and reported all deliveries and highlighted any delivery deviations. In total there were 14,700 deliveries during the analysed period (averaging 25 deliveries per day) and they were distributed evenly between the five working days of the week. However, 75% of the deliveries were registered during daytime, contrary to the goal of having most deliveries after working hours. Hence, the on-site materials team had to work more during daytime operations, sharing the workspace and resources with the construction workers. As for the delivery reports, 223 delivery reports were filed over the period analysed. Of the reported work shifts, approximately 83% had one or more delivery deviations, and on average each delivery had 3.9 deviations. The five largest sources of deviations are errors in delivery quantity (256), communication and planning (162), delivery quality (102), administration (97), and equipment failure (90). This of course affects the total costs of the logistics arrangement negatively. Delivery quantity and quality relates to the performance of sub-contractors, communication & planning and administration relates to deviations related to the planning system and the planning process, whereas equipment failure relates to the resources on site provided by the materials-handling team themselves.

As for the *planning system*, it has, in general, worked satisfactory. Initially there were some issues as the planning system did not allow for the two delivery addresses needed (i.e. the terminal and the site) when routeing materials through a terminal. The same was the case with the double delivery dates needed. These issues were alleviated through a development dialogue with the systems provider. In total there were 73 suppliers and 71 sub-contractors registered as users in the planning system. The planning issues that have occurred, are more connected to the *planning process* that some sub-contractors and suppliers were unfamiliar with. For example, only just above 7000 out of the 14,700 recorded deliveries were entered into the system as a delivery plan and the rest had to be registered manually into the system. Changes to the delivery plans and the actual call-offs were stipulated to be done five days prior to delivery, but data shows that 23% of the deliveries were logged the same day as delivery, 24% one day ahead of delivery, 23% 2–4 days ahead of delivery, and only some 30% at the stipulated five days ahead of delivery.

## 5. Analysis

When analysing the case to answer the three research questions, Selviaridis and Spring (2007) division between operational (RQ1), financial (RQ2) and strategic issues (RQ3) of TPL will be used as a foundation. The logistics arrangement of the CM company is the unit of analysis, and as such the analysis is focussed on the three main pillars of the logistics arrangement; the use of a terminal, an on-site materials handling team, and the planning system and related planning process.

### 5.1. Realised effects

Table 3 summarises the key points regarding the realised effects of the logistics arrangement, addressing RQ1 and RQ2. For the operational effects (RQ1), both benefits and concerns (issues and challenges) are identified.

The use of a *terminal* as a construction consolidation centre has led to fewer deliveries to site and the temporary storage of materials has shifted from the site to the terminal. The terminal can be used as a buffer to cover for unplanned changes in the production schedule and to be able to call-off JIT-deliveries when needed. When it comes to effects on costs, a terminal is an extra node in the supply chain and the extra warehousing, handling, and personnel leads to extra costs. These are, however, to be offset by fewer, and more efficient, logistics operations on site. Then the terminal can be a lever to excel productivity at site. Fewer deliveries lead to reduced transportation costs and less disturbance, both for the ongoing construction operations and for third parties. However, the most common issues raised are that an extra node in the network adds to the administration and that the suppliers and sub-contractors are not used to working with a logistics arrangement and a consolidation terminal. This leads to some confusion on how to label, pack and deliver the materials. In this specific case, the poor layout of the terminal has also affected its efficiency, leading to negative effects on costs.

The *on-site materials handling team* is dedicated to their task, prepared when a delivery arrives and relieve work from the craftsmen, making on-site operations more efficient so that materials handling costs can be reduced. Limiting the amount of materials stored at site, and delivering materials after hours to designated materials zones, not only makes materials available for production when needed but also provides a more structured, clean and tidy production environment. This increases productivity, reduces accidents and subsequently also reduces the total cost of operations. The negative effects highlighted during the study often relates to that the sub-contractors and suppliers are not used to adhere to structured logistics arrangements, leading to increased planning and coordination, mistakes in labelling of goods and in the planning documents. This leads to extra work at site with unclear work instructions, missing materials, early deliveries with return flows, etc. All these issues lead to extra costs, which makes it hard to exploit the benefits and to offset the extra costs that comes with the terminal and the logistics arrangement. Add to this that there have been some issues with material handling equipment, delivery errors and that the materials-handling team is an extra cost,

Table 3. Benefits, issues and challenges (RQ1) and effects on cost elements (RQ2).

| | Terminal | On-site materials handling | Planning system and process |
|---|---|---|---|
| Benefits | • Some consolidation and coordination of deliveries<br>• Fewer third-party disturbances<br>• Less material on-site<br>• Material buffer to cope with production changes<br>• Option to call off JIT-deliveries | • Dedicated personnel for materials receiving<br>• Better utilisation of the construction site and equipment with materials handling off-hours.<br>• Time freed up for craftsmen<br>• Material available for craftsmen when needed<br>• Cleaner and more structured construction site<br>• Fewer work-related accidents<br>• Follow-up of deliveries and delivery deviations | • Standardised process<br>• Cloud-based system granting easy access for all parties<br>• Visibility of all planned deliveries<br>• Coordination of all materials stakeholders<br>• More proactive planning |
| Issues & challenges | • Terminal layout not suited for construction materials<br>• Added a node in the delivery network<br>• Unfamiliar concept in the construction context<br>• Non-standardised labelling | • Increased planning and coordination<br>• Unfamiliar concept in the construction context<br>• Non-standardised labelling<br>• Planning documentation not always correct<br>• Process and equipment related deviations add to workload for on-site materials handling team | • Unfamiliar process for sub-contractors<br>• Initial issues with functionality<br>• Process not adhered to by all, leading to issues on-site |
| Logistics cost effect | *Added:*<br>• Increased cost for materials relocation<br>• Cost for additional delivery node added to project budget<br>*Reduced:*<br>• Possible reduction in transport costs | *Added:*<br>• Difficult to offset costs for materials handling in sub-contractor agreements<br>• Planning documentation and labelling issues leads to extra work and added costs<br>*Reduced:*<br>• Possible reduction in materials handling costs<br>• Increased productivity reduces cost of operations | *Added:*<br>• Initial investment for planning system<br>• Administrative costs increase as process is dependent on updated delivery plans<br>*Reduced:*<br>• Reduces costs for tracking and tracing deliveries and materials |
| Performance indicators | • Only few percent consolidation effect<br>• 14.7 days average storage (goal 5 days) | • 14,700 total deliveries evenly distributed over the week (averaging 25 deliveries per day)<br>• 75 % of deliveries during daytime working hours (goal most deliveries after working hours)<br>• 83 % of deliveries had deviations<br>• Average 3.9 deviations/delivery | • 73 suppliers and 71 sub-contractors registered in the planning system<br>• Delivery plans only accounted for 50 % of the recorded deliveries (goal 100 %)<br>• 30 % of call-offs 5 days prior to delivery (goal 100 %) |

and one realises that the total cost equation might be tough to balance.

The *planning process* and the use of a cloud-based *planning system*, standardises the planning of material deliveries, introduces stipulated planning time fences, allocates resources to deliveries, and offers easy access for all project participants. As such, it creates visibility in the supply chain and all materials and deliveries can be coordinated more effectively, which in turn reduces costs for tracking and tracing and offers the possibility to plan operations more proactively. However, there were some issues regarding the functionality in the beginning of the project and as the sub-contractors and suppliers were not used to work in the system, the standardised process was not adhered to by all parties. This added some extra administrative costs and since the system was piloted in this project there were also costs regarding the initial investment of setting up the system to work with the stipulated process in the logistics arrangement.

### 5.2. Supply chain maturity and the level of SCO

According to Mentzer et al. (2001), all eight antecedents of SCO have to be addressed in a systemic and strategic way by all the participating companies in the supply chain to be truly supply chain oriented. As such, the level of SCO is hard to evaluate in this study, due to the narrow focus on the TPL arrangement and the CM company. Therefore, RQ3 will be analysed from the perspective of the CM company, the logistics arrangement, and the effects on operations at site.

Many of the negative effects relates to suppliers and sub-contractors not fully understanding or buying into the logistics concept. In fact, all three pillars of the arrangement were described as unfamiliar concepts for sub-contractors and suppliers, indicating that the projects supply chain lack in supply chain maturity and SCO. This can be due to that the CM company has not put enough effort into explaining how the concept is supposed to work and what is required from suppliers and sub-contractors, but also that the maturity of the suppliers and sub-contractors is not high enough.

Tangible examples are errors in when and how materials are packaged, labelled and delivered from suppliers, both to site and to the terminal. Furthermore, sub-contractors and suppliers neglect to enter necessary information, and sometimes also enters faulty information, in the planning system. Additionally, sometimes materials that have not been ordered, or have been ordered, but manually arrive to both the site and the terminal. When analysing how the suppliers, the sub-contractors, the terminal, the on-site team and the CM company work with the logistics arrangement, one can conclude that they all need to increase their level of understanding of logistics and SCM. As part of this they need to increase their level of maturity in terms of SCO. For this to happen, the CM Company would have to play a more active role in getting key suppliers and sub-contractors to address the issues making an organisation supply chain oriented (Mentzer et al. 2001; Ekeskär and Rudberg 2016). In this pilot project the CM company, the TPL provider, the terminal team, and the on-site team, all bought in to *a* vision of enhancing logistics operations, but not necessarily the *same* SCM vision. Also, the suppliers and sub-contractors were largely put aside when it comes to establishing SCO within the project. Hence, they did not understand the strategic intent of the CM company and often acted in a way that was counterproductive for the SCM vision that underpins the logistics arrangement employed.

## 6. Discussion

The construction logistics arrangement in this study is based on three pillars (Figure 3), addressing different parts of the supply chain. Using the five roles in Figure 2 (Ekeskär and Rudberg (2016)), it can be argued that the main focus of the terminal is to improve the supply chain operations (role 2), whereas the focus of the on-site material handling team is on improving site operations (role 3) and to some extent moving activities from site upstream in the supply chain (role 4). The stipulated planning process and planning system not only mainly focuses on establishing a clear interface between the site and the supply chain (role 1) but also provides the groundwork for possible supply chain integration (role 5). Hence, the construction logistics arrangement analysed in this research embraces all the identified roles that SCM can play for construction, yet it fails to deliver the results promised by SCM (see Figure 1).

As evidenced by that sub-contractors and suppliers are not used to working with a structured logistics arrangement (see Table 3), the CM company has not managed to communicate the working practices of this arrangement sufficiently. Hence, from a strategic perspective (Selviaridis and Spring 2007) the CM company fails to establish SCO amongst the key actors in the supply chain. This is in line with the findings of Kim and Nguyen (2018), where they found a strong relationship between managing construction supply chain relationships and project performance.

From a financial and operational perspective (Selviaridis and Spring 2007), the case analysis shows that by introducing a terminal, the on-site materials handling team, and a planning system, extra costs are added to the total construction cost (see Table 3). However, adding a TPL arrangement can streamline the logistics process for urban construction projects and offset the added extra costs (Selviaridis and Spring 2007). As such, it *should* have a positive impact on the project performance. As discussed by amongst others Liu, Xu, and Zhang (2015), a streamlined logistics process reduces the risk of delayed deliveries with subsequent delays to the whole project and increased risks of cost overruns. However, due to the lack of SCO, the positive impact has not necessarily materialised in this project. One of the goals in utilising a TPL arrangement in urban construction projects is to reduce delivery traffic to the construction site by consolidating smaller deliveries and, as discussed by Lundesjö (2015), a terminal-based arrangement can achieve this. Fewer transports to site reduces the transport costs *per se*, but also the cost for receiving, offloading and handling material at site. It also reduces the environmental impact. A terminal furthermore provides the possibility to reduce material stored at site, reducing the number of material related incidents and accidents.

The on-site material handling team means moving logistics and materials handlings activities from craftsmen to the TPL provider, meaning that the craftsmen can focus on their trades and thus increase the value-adding time in the project. This effect was also evidenced by a site manager claiming that 'We have never built at this pace before!'. Using skilled material handlings personnel with proper equipment, doing their work at times when the craftsmen are not around, should also increase the material handling efficiency. It also offers the possibility to utilise the construction site at times were the site is normally idle.

Taking the perspective of the CM company, who initiated the use of their TPL arrangement in this project, they have invested a lot of time and effort into designing and making the TPL arrangement operational. Nevertheless, even though the arrangement incorporates the necessary ingredients, the CM company falls through in getting the supply chain actors to use the full potential of the arrangement. This is mainly because the CM company failed in directing their efforts towards the SCO of their supply chain partners and making all supply chain partners collaborate towards a common goal in line with the teachings of Mentzer et al. (2001). A manager at the CM company verified this by stating that:

> We actually got positive effects for the few sub-contractors and suppliers that we worked closer with, but it was only isolated effects. Unfortunately, the rest of the sub-contractors and suppliers that did not adhere to the arrangement introduced a lot of disturbances in the system that caused problems for other actors. We should have worked harder to get all actors to buy in to the arrangement.

Poor performance due to lack of collaboration has also been noted in previous studies of construction supply chains (see e.g. Gosling et al. (2015) and Behera, Mohanty, and Prakash (2015)).

## 7. Conclusion and further research

This case study set out to investigate how a large office building project managed the logistics operations through an internally developed TPL arrangement, to add to the current knowledge of benefits, issues and costs that occur when utilising TPL in construction. Based on the case study, the key findings indicate that there are benefits to be realised, but that they come with a cost and they need to be based on supply chain maturity and an ability to offset costs against efficiency gains.

### 7.1. Theoretical contributions

The theoretical contributions of this study lie in the in-depth study of a TPL arrangement in construction. The study is one of the first that analyses the effect a TPL arrangement in construction has on the overall project performance.

Research question 1 addressed the possible benefits, issues, and challenges that can be realised when employing TPL in construction. The first two rows of Table 3 provide an answer to this based on the empirical findings in the case study, not only highlighting the benefits but also the experienced issues and challenges that came with the TPL arrangement. The major benefits are fewer disturbances (site, supply chain, third parties), less material on site, better site utilisation, increased productivity for the craftsmen, higher visibility in the supply chain and more proactive planning.

Research question 2 investigated what costs are affected by the TPL arrangement, and the empirical findings are displayed in the third row of Table 3. The affected costs are supplier-related (planning, picking, packing, labelling, handling, loading, announcing), terminal-related (warehousing, storage, receiving, registration, handling, relocation, planning, picking, packing, loading, announcing), site-related (planning, receiving, registration, handling, relocation, storage), and transport-related. However, empirical data in this study are not complete enough to be able to judge if the extra costs for the terminal, the transport company, the on-site materials handling team, and the planning system, were offset by the benefits incurred. Hence, the results on total costs are inconclusive and calls for further research and investigation.

As for research question 3, many of the issues encountered in this case study can be traced back to the lack of understanding of, and non-adherence to, the regulations and policies of the logistics arrangement and the use of the planning system and process. This lack of SCM maturity leads to deviations in e.g. delivery quantities and documentation. One structural issue here is that TPL is a rather un-utilised phenomenon in construction, and construction stakeholders are still asking themselves why they should pay for these services. In part, this is explained by the predominant temporary structure of the industry, where arms-length relationships are still the norm, as discussed by e.g. Fernie and Tennant (2013).

### 7.2. Managerial implications

Looking at other industries implementing TPL (van Laarhoven, Berglund, and Peters 2000), one can conclude that it does take some time to get TPL running the way it was planned to run, and that one needs to work long-term and purposefully with TPL to be able to reap the full potential of the concept. A TPL provider can in such a case contribute with both knowledge and operational logistics. They can also help contractors to become more aware of how logistics work and what benefits there may be, thus increasing logistics maturity in the industry. The managerial implications are thus that the main contractor, in this case, the CM company, needs to take a leading role, evaluate the current logistics arrangement and work hard to increase the logistics knowledge and the level of SCO for the suppliers and subcontractors that will be a part of the project. Otherwise, they stand the risk of adding costs to the project without being able to harvest the benefits and thereby being able to reduce the total costs of the projects (Kim and Nguyen 2018). This can be achieved through a better dialogue with sub-contractors and suppliers to ensure that these actors understand the purpose of the arrangement and why they have to adhere to the established policies and regulations.

### 7.3. Limitations and further research

This study is based on a Swedish case and as such it has some limitations. Even though the research has been analysed using an international literature base, being so contextually focussed on Sweden can have unforeseen implications on the applicability of the findings in other countries and regions. Furthermore, being a single-case study the findings may not be applicable to *all* project contexts. However, as the findings of this study have been contrasted against an international literature base, the analysis provides insights into *possible* effects of employing TPL arrangements in construction.

These limitations also open up for further research. A longitudinal study analysing TPL arrangements over a series of projects would be much needed. What can be learnt from other industries is that the renewal rate for TPL contracts is high (indicating that most companies are satisfied with the TPL arrangement) and that substantial cost reductions and service improvements could be attributed to the TPL partnership (van Laarhoven, Berglund, and Peters 2000). Yet, as in this study, also in other industries the participating companies found it hard to quantify the improvements and cost reductions of a TPL arrangement. Hence, it would be desirable to design a study that carefully measures the performance of a construction TPL arrangement and benchmark the operations with projects running without a TPL arrangement, considering both project and firm performance. Thus, it would be possible not only to find out the true cost of the construction TPL arrangement but also what is gained in terms of productivity improvement and waste reductions in the construction operations.

## Acknowledgments

The authors would like to extend their gratitude to the case companies' respondents for taking the time to participate in the study. The authors would further like to extend their gratitude to the anonymous reviewers, your comments helped in adding to the quality of this article.

## Disclosure statement

No financial interest or benefit has arisen from the direct applications of this research.

## Funding

This work was supported by the Development Fund of the Swedish Construction Industry, SBUF; under Grant [12902].

## Notes on contributors

*Mats Janné* is currently a PhD student in Construction Logistics at the Department of Science and Technology, at Linköping University in Sweden. He received his M. Sc. in Transport Systems Engineering from Linköping Institute of Technology, Sweden and his Lic. Eng. in Construction Logistics from Linköping University, Sweden. His main research interests include urban freight and supply chain management in the construction sector. Primarily his research is focussed on how third-party logistics in construction affects costs and productivity as well as how construction logistics can be utilized as a governance mechanism in large urban development projects.

*Martin Rudberg* is the L E Lundberg professor of Construction Management and Logistics at the Department of Science and Technology, at Linköping University in Sweden. He received his M. Sc. in Industrial Engineering and Management, and his PhD in Production Economics, both from Linköping Institute of Technology, Sweden. His main research interests include operations strategy and supply chain management in the construction sector, and he currently leads a large project on digitalization in the construction sector and how the establishment of a smart construction site will affect project performance.

## ORCID

Mats Janné http://orcid.org/0000-0003-0693-8537
Martin Rudberg http://orcid.org/0000-0003-1066-2094

## References

Arnold, Ulli. 2000. "New Dimensions of Outsourcing: A Combination of Transaction Cost Economics and the Core Competencies Concept." *European Journal of Purchasing & Supply Management* 6 (1): 23–29. doi:10.1016/S0969-7012(99)00028-3.

Atkinson, Roger. 1999. "Project Management: Cost, Time and Quality, Two Best Guesses and a Phenomenon, Its Time to Accept Other Success Criteria." *International Journal of Project Management* 17 (6): 337–342. doi:10.1016/S0263-7863(98)00069-6.

Behera, P., R. P. Mohanty, and A. Prakash. 2015. "Understanding Construction Supply Chain Management." *Production Planning & Control* 26 (16): 1332–1350. doi:10.1080/09537287.2015.1045953.

Bourlakis, Michael, and T. C. Melewar. 2011. "Marketing Perspectives of Logistics Service Providers: Present and Future Research Directions." *European Journal of Marketing* 45 (3): 300–310. doi:10.1108/03090561111107203.

Chipulu, Maxwell, Udechukwu Ojiako, Alasdair Marshall, Terry Williams, Umit Bititci, Caroline Mota, Yongyi Shou, et al. 2019. "A Dimensional Analysis of Stakeholder Assessment of Project Outcomes." *Production Planning & Control* 30 (13): 1072–1090. doi:10.1080/09537287.2019.1567859.

Council of Supply Chain Management Professionals. 2017. "CSCMP Supply Chain Management Definitions and Glossary." CSCMP. Accessed 27 May. www.cscmp.org.

Dablanc, Laetitia. 2007. "Goods Transport in Large European Cities: Difficult to Organize, Difficult to Modernize." *Transportation Research Part A: Policy and Practice* 41 (3): 280–285. doi:10.1016/j.tra.2006.05.005.

Dubois, Anna, Kajsa Hulthén, and Viktoria Sundquist. 2019. "Organising Logistics and Transport Activities in Construction." *The International Journal of Logistics Management* 30 (2): 620–640. doi:10.1108/IJLM-12-2017-0325.

Dubois, Anna, and Lars-Erik Gadde. 2000. "Supply Strategy and Network Effects – Purchasing Behaviour in the Construction Industry." *European Journal of Purchasing & Supply Management* 6 (3-4): 207–215. doi:10.1016/S0969-7012(00)00016-2.

Dubois, Anna, and Lars-Erik Gadde. 2002. "The Construction Industry as a Loosely Coupled System: Implications for Productivity and Innovation." *Construction Management and Economics* 20 (7): 621–631. doi:10.1080/01446190210163543.

Ekeskär, A. 2016. *Exploring Third-Party Logistics and Partnering in Construction: A Supply Chain Management Perspective*. Licentiate of Engineering Licentiate thesis, Linköping University.

Ekeskär, Andreas, and Martin Rudberg. 2016. "Third-Party Logistics in Construction: The Case of a Large Hospital Project." *Construction Management and Economics* 34 (3): 174–191. doi:10.1080/01446193.2016.1186809.

Fang, Yuan, and S. Thomas Ng. 2011. "Applying Activity-Based Costing Approach for Construction Logistics Cost Analysis." *Construction Innovation* 11 (3): 259–281. doi:10.1108/14714171111149007.

Fernie, Scott, and Stuart Tennant. 2013. "The Non-Adoption of Supply Chain Management." *Construction Management and Economics* 31 (10): 1038–1058. doi:10.1080/01446193.2013.830186.

Gosling, J., M. Naim, and D. Towill. 2013. "Identifying and Categorizing the Sources of Uncertainty in Construction Supply Chains." *Journal of Construction Engineering and Management* 139 (1): 102–110. doi:10.1061/(ASCE)CO.1943-7862.0000574.

Gosling, J., D. R. Towill, M. M. Naim, and A. R. J. Dainty. 2015. "Principles for the Design and Operation of Engineer-to-Order Supply Chains in the Construction Sector." *Production Planning & Control* 26 (3): 1–18. doi:10.1080/09537287.2014.880816.

Janné, Mats, and Anna Fredriksson. 2019. "Construction Logistics Governing Guidelines in Urban Development Projects." *Construction Innovation* 19 (1): 89–109. doi:10.1108/CI-03-2018-0024.

Jonsson, Henric, and Martin Rudberg. 2017. "KPIs for Measuring Performance of Production Systems for Residential Building: A Production Strategy Perspective." *Construction Innovation* 17 (3): 381–403. doi:10.1108/CI-06-2016-0034.

Kim, Soo-Yong, and Viet Thanh Nguyen. 2018. "A Structural Model for the Impact of Supply Chain Relationship Traits on Project Performance in Construction." *Production Planning & Control* 29 (2): 170–183. doi:10.1080/09537287.2017.1398846.

Kotzab, Herbert, Christoph Teller, David B. Grant, and Anders Friis. 2015. "Supply Chain Management Resources, Capabilities and Execution." *Production Planning & Control* 26 (7): 525–542. doi:10.1080/09537287.2014.927932.

Lai, Kee-hung, Edwin T. C. Cheng, and Andy C. L. Yeung. 2004. "An Empirical Taxonomy for Logistics Service Providers." *Maritime Economics & Logistics* 6 (3): 199–219. doi:10.1057/palgrave.mel.9100109.

Liu, Q., J. Xu, and Z. Zhang. 2015. "Construction Supply Chain-Based Dynamic Optimisation for the Purchasing and Inventory in a Large Scale Construction Project." *European J. of Industrial Engineering* 9 (6): 839–865. doi:10.1504/EJIE.2015.074383.

Lundesjö, Greger. 2015. "Consolidation Centres in Construction Logistics." In *Supply Chain Management and Logistics in Construction: Delivering Tomorrow's Built Environment*, edited by Greger Lundesjö, 225–242. London, United Kingdom: Kogan Page.

Marasco, Alessandra. 2008. "Third-Party Logistics: A Literature Review." *International Journal of Production Economics* 113 (1): 127–147. doi:10.1016/j.ijpe.2007.05.017.
Mentzer, John T., William DeWitt, James S. Keebler, Soonhong Min, Nancy W. Nix, Carlo D. Smith, and Zach G. Zacharia. 2001. "Defining Supply Chain Management." *Journal of Business Logistics* 22 (2): 1–25. doi:10.1002/j.2158-1592.2001.tb00001.x.
Meredith, Jack. 1993. "Theory Building through Conceptual Methods." *International Journal of Operations & Production Management* 13 (5): 3–11. doi:10.1108/01443579310028120.
Selviaridis, Kostas, and Martin Spring. 2007. "Third Party Logistics: A Literature Review and Research Agenda." *The International Journal of Logistics Management* 18 (1): 125–150. doi:10.1108/09574090710748207.
Seth, Dinesh, V. S. R. Krishna Nemani, Shaligram Pokharel, and Abdulla Yaqoub Al Sayed. 2018. "Impact of Competitive Conditions on Supplier Evaluation: A Construction Supply Chain Case Study." *Production Planning & Control* 29 (3): 217–235. doi:10.1080/09537287.2017.1407971.
Skjøtt-Larsen, Tage 2000. "Third Party Logistics – From an Interorganizational Point of View." *International Journal of Physical Distribution & Logistics Management* 30 (2): 112–127. doi:10.1108/09600030010318838.
Sobotka, A., and A. Czarnigowska. 2005. "Analysis of Supply System Models for Planning Construction Project Logistics." *Journal of Civil Engineering and Management* 11 (1): 73–82. doi:10.3846/13923730.2005.9636335.
Stefansson, Gunnar. 2006. "Collaborative Logistics Management and the Role of Third-Party Service Providers." *International Journal of Physical Distribution & Logistics Management* 36 (2): 76–92. doi:10.1108/09600030610656413.
Sundquist, Viktoria, Lars-Erik Gadde, and Kajsa Hulthén. 2018. "Reorganizing Construction Logistics for Improved Performance." *Construction Management and Economics* 36 (1): 49–65. doi:10.1080/01446193.2017.1356931.
Thunberg, Micael, and Anna Fredriksson. 2018. "Bringing Planning Back into the Picture – How Can Supply Chain Planning Aid in Dealing with Supply Chain-Related Problems in Construction?" *Construction Management and Economics* 36 (8): 425–442. 1-18. doi:10.1080/01446193.2017.1394579.
Thunberg, M., and F. Persson. 2014. "Using the SCOR Models Performance Measurements to Improve Construction Logistics." *Production Planning & Control* 25 (13–14): 1065–1078. doi:10.1080/09537287.2013.808836.
van Laarhoven, Peter, Magnus Berglund, and Melvyn Peters. 2000. "Third-Party Logistics in Europe – Five Years Later." *International Journal of Physical Distribution & Logistics Management* 30 (5): 425–442. doi:10.1108/09600030010336216.
Vasiliauskas, Aidas Vasilis and Gražvydas Jakubauskas. 2007. "Principle and Benefits of Third Party Logistics Approach When Managing Logistics Supply Chain." *TRANSPORT* 22 (2): 68–72.. doi:10.1080/16484142.2007.9638101.
Voss, Chris. 2009. "Case Research in Operations Management." In *Researching Operations Management*, edited by Christer Karlsson, 162–195. New York, NY: Routledge.
Vrijhoef, Ruben, and Lauri Koskela. 2000. "The Four Roles of Supply Chain Management in Construction." *European Journal of Purchasing & Supply Management* 6 (3-4): 169–178. doi:10.1016/S0969-7012(00)00013-7.
Wacker, John G. 1998. "A Definition of Theory: research Guidelines for Different Theory-Building Research Methods in Operations Management." *Journal of Operations Management* 16 (4): 361–385. doi:10.1016/S0272-6963(98)00019-9.
Yin, Robert K. 2014. *Case Study Research: Design and Methods*. 5th ed. Thousand Oaks, California, USA: SAGE Publications, Inc.
Ying, Fei, John Tookey, and Jeff Seadon. 2018. "Measuring the Invisible: A Key Performance Indicator for Managing Construction Logistics Performance." *Benchmarking: An International Journal* 25 (6): 1921–1934. doi:10.1108/BIJ-11-2016-0176.
Zou, P. X. W., and P. Couani. 2012. "Managing Risks in Green Building Supply Chain." *Architectural Engineering and Design Management* 8 (2): 143–158. doi:10.1080/17452007.2012.659507.
Zuo, Kelvin, Regan Potangaroa, Suzanne Wilkinson, and James O. B. Rotimi. 2009. "A Project Management Prospective in Achieving a Sustainable Supply Chain for Timber Procurement in Banda Aceh, Indonesia." *International Journal of Managing Projects in Business* 2 (3): 386–400. doi:10.1108/17538370910971045.

## Appendix A. Interview guide

### *Context of the specific project*

Time frame
Client
Project size
Type of construction project (what is constructed?)
Location of the construction project
Is there something unique about the construction logistics due to:

- The location of the construction site?
- The method of construction?

### *Logistics arrangement*

How is the arrangement designed?

- Physical and non-physical assets
- Additional services
- Organisation
- Regulations

What is the goal of the arrangement?
How is communication carried out?

- Principles for information sharing

What common key resources (trucks, fork lifts, elevators, load carriers, cranes, IT-systems etc) are there?
How is resource utilisation planned and organized?
Are there some constraints regarding use of resources? (e.g. limited space for storage)
What problems have been encountered in the arrangement?

### *Material flows*

How much material enters the construction site and what types?
Are the different types managed differently?
From how many suppliers is materials ordered/delivered?
Where are the suppliers located? (distance)
What materials go through the logistics arrangement and why?
Do you use time windows for the transport? If yes, why? Which are the benefits?
How much time is there between ordering of material and expected delivery? Does this differ depending on type of material?

### *Collaboration/communication*

How is the collaboration/communication working?
What do you do to improve cooperation between parties?