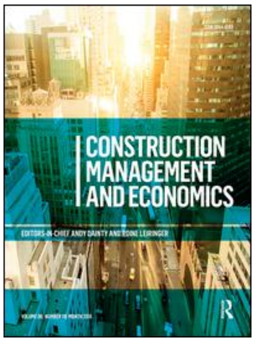

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Reorganizing construction logistics for improved performance

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ABSTRACT

Previous research indicates that logistics reorganizing can contribute to improved performance in the construction industry. In this paper, the opportunities for such reorganizing are investigated by focusing on the connection between logistics operations at the construction site and operations undertaken before building materials land at sites. The aims of the study are: (1) to empirically explore strategic actions to reorganize construction logistics by improving the connections between on-site and off-site logistics, and (2) to develop a theoretical framework for analysis of potential options for reorganizing. The empirical inquiry involves a case study of a logistics specialist's efforts to reorganize on-site logistics and the associated consequences for off-site operations. The study is based on 28 interviews with representatives of 13 organizations. The study provides two types of contributions. First, the theoretical framework, rooted in industrial network theory, enables analysis of reorganizing of activities, resources and actors to improve logistics performance. Second, the empirical study shows that a logistics specialist can improve on-site logistics substantially. However, such reorganizing requires adjustments of off-site logistics that may be resource demanding. Therefore, effective connecting of on-site and off-site operations calls for extended interaction between the actors in terms of joint planning and exchange of information.

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Logistics; site operations; off-site; performance improvements; network analysis

Introduction

The functioning and the effectiveness of the construction industry have been questioned by several researchers. For example, Vriejhof and Koskela (2000) identified a lagging productivity development. Love *et al.* (2004) concluded that inadequate organization and management practices contributed to unnecessary costs, time waste and increased errors. Owing to such features, many authors have claimed that the construction industry suffers from poor performance (e.g. Bankvall *et al.* 2010, Fellows and Liu 2012). For the improvement of these conditions, one common suggestion relates to better integration of business processes, following principles in accordance with supply chain management (e.g. Vrijhoef and Koskela 2000, Briscoe and Dainty 2005, Ekeskär and Rudberg 2016).

The logistics costs in supply chains represent a substantial share of the total costs in the construction industry. Wegelius-Lehtonen (2001) analysed these costs for eight supply chains for building materials delivered to a specific construction site. For seven of the supply chains, the logistics costs accounted for more than 10% of the purchase price. For one of these supply chains the figure exceeded 60% and for two others the share was between 25 and 30%. Another study found that enhanced efficiency in transportation and logistics was assumed to reduce total costs by 20% (SBI 2010). Similar expectations regarding potential benefits from advancement of the processes of supply and delivery of materials have been expressed by Agapiou *et al*. (1998), Jang *et al*. (2003) and Fadiya (2015).

These prospects for improvements stimulated firms in the industry to develop their supply and logistics processes (Browne 2015). Some organizations have been able to attain part of the potential advantages from logistics recovery (Sullivan *et al*. 2010). In general, however, supply chain management principles seem to be "neither widespread nor wholly adopted" in construction (Fernie and Tennant 2013, p. 1054). For example, Fadiya (2015) found that most companies have yet to realize the benefits that can be achieved. The authors claimed that one significant issue in the further development of these efforts regards the linkages between the processes of supply logistics and site logistics. Supply logistics involve operations related to specification, acquisition, transport and delivery of materials to the construction site, while site logistics is concerned with physical flow planning and materials handling on site. In a similar vein, Ying *et al*. (2014) pointed out that efficiency and effectiveness of a construction project is heavily dependent on the integration between on-site and

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off-site logistics. One reason for potential problems in this interface is "a lack of planning of material deliveries and unloading among subcontractors and their site workforce" (Ying *et al*. 2014, p. 269).

Opportunities for improved performance in construction logistics are contingent on two factors. The first step is to handle the logistics problems at the construction site, emphasized above by Ying *et al*. (2014). Previous research shows that substantial benefits can be attained through rearrangement of site logistics (e.g. Lindén and Josephson 2013, Ekeskär and Rudberg 2016). The second step regards improvements of supply logistics involving suppliers of building materials. In this area, research is scant and further studies of the linkages to suppliers and transport providers have been requested (Ekeskär and Rudberg 2016).

This paper explores the connections between on-site and off-site logistics by investigating both of the steps above, because improved interaction with the supply chain requires "improvements concerning logistics management at the construction site" (Ekeskär and Rudberg 2016, p. 188). The first aim of the paper is therefore to derive and analyse options for strategic actions to enhance construction logistics by improving the connection between operations at site and the logistics and manufacturing operations off-site. A literature review showed that such efforts would break with prevailing behaviour and structural arrangements in construction. The actions required for the modification of contemporary structures and processes are here identified as "reorganizing". These conditions generated a second aim: to develop a theoretical framework for analysis of potential options for reorganizing construction logistics. Previous research on supply chain management in this sector has requested "theory building to explain what change is possible, what such change may bring and the road to achieving such change" (Fernie and Tennant 2013, p. 1054).

During the course of the study, the framework and the empirical investigation evolved in parallel. What was found in practice affected the theoretical framing and vice versa. Both the framework and the empirical findings are thus important results of the study. These conditions caused particular problems regarding the structuring and presentation of the research findings. Even though theory building and empirics evolved together, one of them needs to be reported before the other. We found it most reasonable to present the framework first. The framework is to some extent outcome of the study, but the evolving framework also directed data collection and analysis. Moreover, the paper relies on the logic of the framework in the presentation and analysis of the empirics.

The paper is organized in the following way. The next section provides a brief overview of logistics issues in construction of significance for the connection between on-site and off-site operations. This is followed by the theoretical framework, offering a scheme for analysis of reorganizing options. The paper continues with an account for the handling of the methodological considerations in the empirical study. After that follows the empirics, involving a case study focusing on a service provider firm launching an approach for improvements of construction logistics. The paper concludes with discussion of the findings of the study in relation to previous research, as well as the contributions and implications of the study.

Logistics issues in construction

Lack of supply chain advances

While many industries have experienced performance improvements through supply chain management initiatives, the introduction showed that such benefits have not yet been realized to the same extent in construction. These conditions are explained by particular features of the industry. For example, Bankvall *et al*. (2010) argued that construction is a more complex industry than most others, due to the strong interdependencies between tasks, parts and firms. Mohamed and Anumba (2006) concluded that supply chain practice is problematic since construction work has become more complex technically, implying several challenging engineering and management problems at sites. Moreover, the fragmented structure of the industry makes coordination a challenging task (Fadiya 2015). Several authors have pointed out severe problems related to lack of trust and commitment among the actors involved in the processes. For example, Briscoe and Dainty (2005) brought up the consequences of adversarial contractual relationships. Gadde and Dubois (2010) discussed negative effects related to the short-term project focus and the competitive tendering culture.

Logistics problems at sites

Segerstedt and Olofsson (2010) concluded that the construction industry is lagging behind in terms of logistics practice and performance. Several authors have discussed these logistics problems at sites. Almohsen and Ruwanpara (2011, p. 1) argued that one of the most obvious causes of lost productivity in construction "is the poor management of materials, equipment and tools". Agapiou *et al*. (1998) brought up severe obstacles that impact negatively in this respect. Building materials require large storage capacity, which rarely is available at sites. The conditions for storage of materials often lead to damage from ingress of water, and movement of people and equipment. Materials that do not meet specifications may be delivered and then have to be returned, thus causing disturbances in assembly. Moreover, some materials may be purchased too late in the process, resulting in delays, while others are bought in large quantities that might lead to waste.

The economic consequences of these conditions are substantial. Strandberg and Josephson (2005) showed that construction workers spent 15% of their total working time on moving materials and equipment to assembly areas. Josephson and Saukkoriipi (2005) concluded that waste in the construction industry amounted to 30–35% of the production cost. They also observed a low level of utilization of the machinery at sites. None of these physical resources was used more than 50% of the potential working time. A lot of work at sites was undertaken manually, illustrated by the finding in one study that "transportation by hand" represented 43% of the logistics costs at sites (Wegelius-Lehtonen 2001). Vrijhoef and Koskela (2000) analysed the relationship between the price level of building materials and the logistics costs at site, and found that the lower the purchase price, the higher the extra costs for site logistics. "Traditional trading", based on lowest price, resulted in extra costs varying between 40 and 250% of the purchase price. In a similar vein, Agapiou *et al*. (1998) accused purchasing principles for problems caused by the chasing for lowest possible price, without careful consideration of the extra costs for handling and assembly at sites. Moreover, Ying *et al*. (2014) concluded that through the lack of formal and common procedures for purchasing, staff at sites had to deal with different formulas for ordering, handling and unloading of materials.

Ying *et al*. (2014) found insufficient planning to be a major reason for logistics problems. In the project they studied, the management of critical logistics resources was minimal. Sometimes, materials were delivered with as little as ten minutes of notice. As a consequence, site managers had to organize ad hoc teams to offload materials, which created scheduling conflicts and inefficient unloading. Moreover, materials delivered in this way often required additional handling to be transferred to assembly areas or work stations. In general, most building materials are first delivered to a storage area at the site and then to the specific assembly area. Fearne and Fowler (2006) showed how this double materials handling adds costs and increases the risk of damage. Thunberg and Persson (2014) confirmed the problem with delivery services by reporting that less than 40% of total supply to a site was delivered with the right volumes, at the right time and location, as damage free and appropriately documented. Behera *et al*. (2015, p. 1337) observed major problems caused by unsatisfactory interfaces between contractors and materials suppliers, in terms of "deliveries not in conformance with planning, wrong and defective deliveries, long storage periods, awkward packaging and large shipments". In a similar vein, Fadiya (2015, p. 260) concluded that although many construction firms have identified the importance of effective materials management, "today's practice and decisions still tend to be ad hoc and intuitive".

Improving logistics performance

Sobotka and Czarnigowska (2005) claimed that logistics performance can be enhanced through proper planning of delivery and storage, and better organization of materials handling and resource utilization. In such efforts "site materials management" (SMM) is recommended as a significant means (Thomas *et al*. 2005, Fadiya 2015). SMM is defined as "the allocation of delivery, storage and handling, spaces and resources, for the purposes of supporting the labor force and minimizing inefficiencies due to congestion and excess materials movement" (Thomas *et al*. 2005, p. 808). Sanad *et al*. (2008) showed that appropriate site layout is vital for ensuring the safety of the working environment and also impacts on productivity, costs and duration of construction projects. Mohamed and Anumba (2006) found SMM to be particularly important for enhanced performance in the daily handling of materials and equipment, as well as for maintaining and developing the skills of the workforce over time. Similarly, Cho *et al*. (2008) pointed out the significance of enhanced logistics capability for performance improvements in construction.

Attempts to improve the connections between on-site and off-site logistics have involved application of various information technology solutions, for example techniques for tracking and tracing building materials in the supply chain and at sites (Song *et al*. 2006). Although these technologies have improved the conditions, they have predominantly had a technical focus and paid less attention to managerial issues (Fadiya 2015). This is a problem since realization of potential improvements of new technologies at construction sites calls for changes in the organizational arrangements on-site and off-site. For example, Gadde and Dubois (2010) emphasized the need for increasing interaction in the relationships between firms involved at sites, as well as reduced authority for site managers in order to enable standardized operations across all the sites where the contractor is involved.

Another potential change of construction arrangements is to increasingly rely on specialized actors in the flow of materials – a solution recommended by several authors. Agapiou *et al*. (1998) suggested a new role for materials suppliers, based on overall responsibility for the flow of information. Similarly, Vidalikis *et al*. (2011) advocated a central role for distributors of building materials as main coordinators of the logistic activities. Lindén and Josephson (2013) recommended outsourcing to logistics service providers specializing in materials flow operations. Such organizations have substantially contributed to enhanced logistics and supply chain management in other industries (Haldorson and Skjoett-Larsen 2004, Maloni and Carter 2006, Gadde and Hulthén 2009).

Over time, contractors have increasingly come to rely on logistics service providers in order to emphasize supply chain management thinking in construction. Ekeskär *et al*. (2014) found that such organizational modifications represented a new phenomenon for both contractors and service providers, often unfamiliar with conditions in construction supply chains. On this basis, they concluded that "there is a need to explore how this new phenomenon affects the productivity of construction projects in general and the performance of the construction supply chain in particular" (Ekeskär *et al*. 2014, p. 2). This recommendation echoes the conclusion by Fang and Ng (2011) who found that few studies have analysed the consequences of outsourcing construction logistics to specialized firms. As described above some more recent studies (Ekeskär and Rudberg 2016, Lindén and Josephson 2013) have contributed to enhanced knowledge regarding on-site effects. This paper extends the scope to analysis of the connections between on-site and off-site logistics.

Theoretical framework

The basic approach

This section focuses on the second aim of the paper: to develop a framework for analysis of potential options for reorganizing, aiming at improving the connections between on-site and off-site logistics. There is a common agreement that the construction industry features severe complexity (e.g. Gidado 1996, Dubois and Gadde 2002a, Mohamed and Anumba 2006, Fellows and Liu 2012). A framework for analysis thus must be able to grasp this complexity. For research in such contexts, a network perspective on industry reality has been recommended by advocates of various theoretical schools of thought: e.g. transaction cost economies (Wathne and Heide 2004) and supply chain management (Christopher 2010).

The framework of this study takes the point of departure in industrial network theory, developed for holistic analysis of relationships between organizations embedded in larger network contexts (Håkansson and Snehota 1995, Håkansson *et al*. 2009). This framework distinguishes three significant layers of the business reality: activities, resources and actors. Actors (firms and individuals) are those undertaking activities, which require exploitation of resources, which, in turn, are controlled by actors. In practice, the three layers are completely intertwined, but from an analytical point of view, separation makes sense. As shown below, each layer applies specific diagnostic tools on a research phenomenon and together the three provide a holistic view of business reality, featuring the interplay between activities, resources and actors. Since the empirical study involves a firm engaged in third party logistics, representatives of this research field offer further support for the perspective applied. Two reviews of the features of the context in which such firms operate suggested industrial network theory as a relevant framing for further studies (Selviaridis and Spring 2007, Marasco 2008).

Changes of the features of networks through reorganizing can be initiated in any of the three layers. Moreover, attempts to modify the conditions in one of the layers will impact on the other two. Therefore, reorganizing will require, and lead to, reorientation in the entire network. Furthermore, reorganizing attempts of one actor affects, and are affected by, simultaneous reorganizing efforts of other actors. Regarding relevant aspects of reorganizing in the three network layers we rely on concepts from Gadde *et al*. (2010): reconfiguring of activities, recombining of resources and repositioning of actors.

Reconfiguring in the pattern of activities

In the activity layer, an actor may be able to reorganize in several ways. Firstly, activities can be taken over from another actor, or delegated to others, implying *changes in the division of labour*. Such changes are to a large extent contingent on the economies of scale on which activities are undertaken (Dubois 1998). Specialization is one way to improve the efficiency of activities, since this approach increases the scale of the operations. At the same time the conditions for learning and knowledge expansion are improved through the enhanced focus. Secondly, reorganizing can occur through *changes in activity configurations*. An activity configuration involves all the activities necessary for providing certain outcomes in terms of products or services. Such configurations are affected when activities are added, withdrawn or undertaken in new ways (Håkansson *et al*. 2009). An illustrative example would be when personal selling is substituted by various forms of e-business.

A third type of reorganizing comes about when actors *change the scale and scope of activities*. Economies of scale are affected when individual actors increase or decrease their capacity in production and logistics. Moreover, an actor can narrow the scope of its operations by focusing on a reduced number of activities, while another actor may broaden its scope by expanding the bundle of activities (Gadde *et al*. 2010). Fourth, and finally, reorganizing can be achieved through *changes in the coordination of activities*. Such modifications impact on the interdependence among activities, which is a significant feature of activity configurations (Bankvall *et al*. 2010). One type of interdependence regards the connections between serially related activities – i.e. when one activity must be finished before the next one can start. These conditions are typical in supply chains and can be analysed through the extent of "complementarity" between activities (Richardson 1972). Furthermore, two activities may be "closely complementary" through their mutual interdependencies. Close complementarity occurs when two activities are so highly adjusted in relation to each other to improve their joint performance that their output cannot easily be used in other configurations (Håkansson *et al*. 2009).

Reorganizing in the activity layer leads to network reorientation through reconfiguring of the established activity structure. Significant attributes of such reconfiguration concern changes in the division of labour, the economies of scale and scope, the forms of coordination, and the interdependencies among activities.

Recombining in the constellation of resources

In the resource layer, reorganizing may be based on *changes in the exploitation of resources*. Such exploitation is related to improvements of the economies of scale in the activity layer. For example, logistics resources such as airports and logistics hubs can be used more efficiently through expansion of the scale of the operations. In the analysis of the economies of such operations, another concept from Richardson (1972) is useful: similarity. Two activities are similar when they utilize one and the same resource. By increasing the similarity of activities, actors are able to economize on their resource utilization (Dubois 1998). Secondly, reorganizing may be rooted in improvements attained through new resources, which *changes the resource combining logic* in the network. Such resources may be physical, for example, new vehicles or materials handling equipment. They may also involve non-physical resources, such as planning systems and the skills and capabilities of people that improve the conditions for utilization of logistics resources (Håkansson *et al*. 2009).

Thirdly, one significant aspect of reorganizing in the resource layer regards the adaptations of resources. The joint effect of two resources can always be improved by adaptations, which *changes the interfaces between resources*. Such benefits are accompanied by disadvantages: the better two resources fit together, the more difficult it will be to use them effectively in relation to other resources (Gadde *et al*. 2010). Fourthly, the above conditions make resource combining and recombining central issues for reorganizing in the resource layer. In these efforts, an actor's *control of resources* is fundamental. Control can be achieved in two ways (Håkansson and Snehota 1995). Direct resource control is secured through ownership. Indirect control, on the other hand, is attained through access to the resources of other actors. Over time, indirect resource control has become increasingly important. The expansion of knowledge and technologies made it impossible for a single actor to rely on ownership control of all resources that are critical to its operations (Ford *et al*. 2011). Therefore, firms are increasingly engaged in relationships with other businesses in order to access their resources.

Hence, for the reorganizing in the resource layer, recombining of resources is critical. In these efforts, the access to other firms' resources is an important complement to the resources controlled through ownership. One significant aspect of recombining is concerned with changes in the adaptations and interfaces between resources. Another aspect relates to the benefits achieved from improved resource utilization through increasing similarity among activities.

Repositioning in the web of actors

Reconfiguring of activities and recombining of resources impact on the positioning in the actor layer. Firstly, reorganizing may occur through *replacement of actors* in order to contribute to enhanced performance in the activity and resource layers. Such improvements may result from increasing reliance on internal capabilities and skills, and/or through the linkages to the competences accessed through interaction with others (Håkansson *et al*. 2009). Secondly, reorganizing can be attained through *changing involvement with individual partners*. The level of involvement in a business relationship is determined by the extent of interaction and collaboration in terms of joint activity coordination and resource combining. The higher the involvement in a relationship is, the better the conditions for performance improvements. However, increasing involvement also leads to dependencies and more costly handling of relationships (Gadde and Snehota 2000).

Thirdly, a business relationship is embedded in a setting of other relationships in the network. This means that reorganizing can take place through *changes in the connections between relationships*. Therefore, an actor may initiate reorganizing by stimulating cooperation and joint actions through multiple interactions with its business partners, for example in relation to two suppliers. Finally, reorganizing may occur through changes in the *interaction patterns and the relationship atmosphere*. Interaction patterns are determined by the frequency and the depth of interaction (Håkansson *et al*. 2009). Significant aspects of the relationship atmosphere include issues related to confrontation, such as conflict and power, as well as more cooperative issues like trust and commitment (Håkansson and Snehota 1995).

All in all, for any repositioning in the actor layer, interaction in business relationships is central. An actor aiming at changing its position may find this task difficult owing to high involvement and strong bonds between other actors. On the other hand, the existing relationships of the actual change agent may be very useful in the reorganizing efforts. Moreover, repositioning will always be accompanied by changes of the network's relationships. These changes deal with both creation of new relationships and dissolution of existing ones, as well as modifications of the extent of involvement and the interaction patterns, which in turn are related to the relationship atmosphere. Finally, the outcome of the repositioning attempts of one actor will affect other actors, and simultaneously be affected by the efforts of these firms to reposition. Therefore, the analysis of the various options for repositioning need to consider potential actions and reactions of other firms.

The resulting theoretical framework

Figure 1 summarizes the above discussion. The theoretical framework provides a scheme for analysis of options for reorganizing in networks, thus representing the contribution to the second of the research aims. Previous frameworks for analysis of network dynamics tend to focus on one of the layers and the interplay within this layer. Figure 1 indicates that modifications of processes and structures can be achieved through various types of reorganizing in each of the three layers. The double-directed arrows in the figure indicate that changes in one network layer will impact on the other two. Moreover, reorganizing in the layers of a particular sub-network (e.g. construction logistics) will cause reorientation of the larger network. In a similar vein, reorientation in the larger network, triggered by various factors, such as technological development, will impact on the features of the embedded sub-network.

On the basis of the theoretical framework three overall research questions are formulated for the empirical investigation regarding potential improvements of construction logistics:

- What changes and effects can be achieved through reorganizing in the activity layer?
- What changes and effects can be achieved through reorganizing in the resource layer?
- What changes and effects can be achieved through reorganizing in the actor layer?

Research methodology

Research approach and research process

Through a research programme in the construction industry, we came across the firm ConSite Logistics (CSL henceforth). CSL was involved in reorganizing logistics at construction sites. Reorganizing of construction logistics was perceived an interesting topic as construction logistics is gaining more attention from both practice and academic research, and because actors in the form of logistics specialists have appeared in the industry. As indicated above, current arrangements in construction logistics tend to involve increasingly complex configurations. These conditions call for holistic framing of the research phenomenon, thus making the framework based on industrial network theory relevant. Construction features a multitude of activities, undertaken by numerous actors and relying on massive resources (Dubois and Gadde 2002a). Accordingly, reorganizing in this empirical setting involves reconfiguring of activities, recombining of resources and repositioning of actors.

The above features of the research phenomenon favoured a case-study approach that "investigates a contemporary phenomenon in its real-life context" (Yin 2003, p. 13). The focus of the study evolved progressively through data collection and the ambition to create a theoretical framework that could match the empirical world. Hence, the research process followed the logic

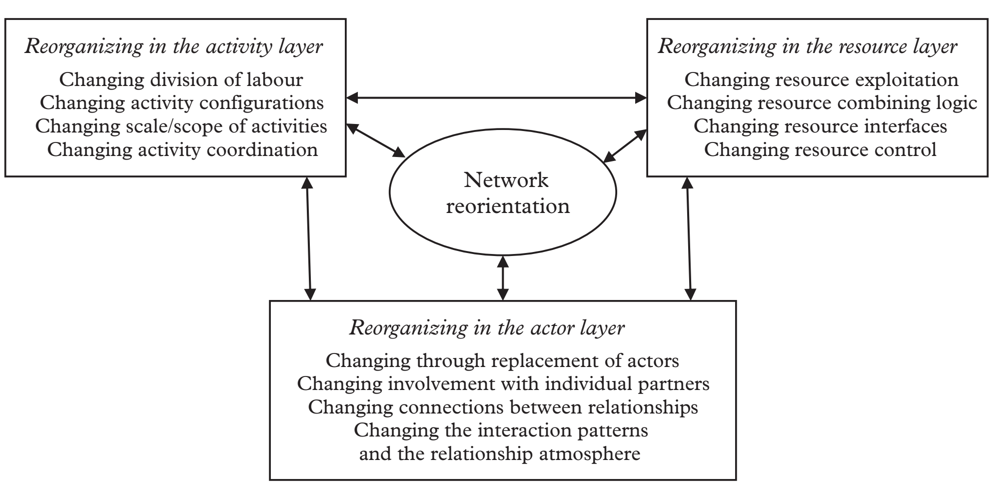

Figure 1. Central aspects of reorganizing in the three network layers.

of abductive reasoning where data is collected in parallel to theory building (Kovács and Spens 2005). In such creative iterative processes (Taylor *et al*. 2002), the case evolves through interaction with the business reality and confrontation with theory. Dubois and Gadde (2002b) presented "systematic combining" as a research approach for theory development through abductive case studies. In systematic combining, theoretical framework, empirical fieldwork and case analysis evolve simultaneously as researchers are "constantly going "back and forth" from one type of research activity to another and between empirical observations and theory" (Dubois and Gadde 2002b, p. 555). Systematic combining features two basic processes (Figure 2).

First, matching of empirics and theory is achieved by moving between research activities related to framework development, data sources and analysis, which directs the study and sometimes leads to redirection. Matching and direction/redirection are impacted by, and also affecting, the interplay between theory and empirical observations, as well as the evolving analytical framework and case description. The successively evolving case clarifies the need for supplementary data collection and directs the anchoring in theoretical concepts. These characteristics of systematic combining explain why the theoretical framework in Figure 1 is both prerequisite for, and outcome of, the empirical study.

The study of CSL went through three main phases. Each phase had its specific focus directing the research to various empirical phenomena that, in turn, required a certain focus on theory, useful for the development of a matching framework. Table 1 illustrates the three phases with regard to the phenomenon in focus, central features of this phenomenon, and what network layers were most significant.

To begin with, the study focused on how the logistics operations were carried out by CSL and how that affected the efficiency of on-site operations. In the case analysis, the collected data was sorted in two main categories: (1) "logistics operations by CSL", and (2) "consequences for efficiency on-site". Efficiency was analysed by applying concepts in relation to the activity and resource dimensions, focusing on efficiency as an outcome of how activities are configured and resources combined in new ways. When CSL is involved at a site, the conditions for contractors and subcontractors change, compared with their regular operations. Therefore, the effects for these firms when a logistics specialist is engaged became an intricate issue to explore further. The phenomenon thus switched to organizational issues on-site with features related to specialization and division of labour, with a special interest in what changes the use of CSL would bring about. In this second phase, consequences for the involved actors, their interaction and positioning in the network became central. The activity layer and actor layer were the main focus, and the framework evolved to cope with change in terms of reorganizing in these two layers. The case analysis progressed through data categories related to "logistics operations by CSL"

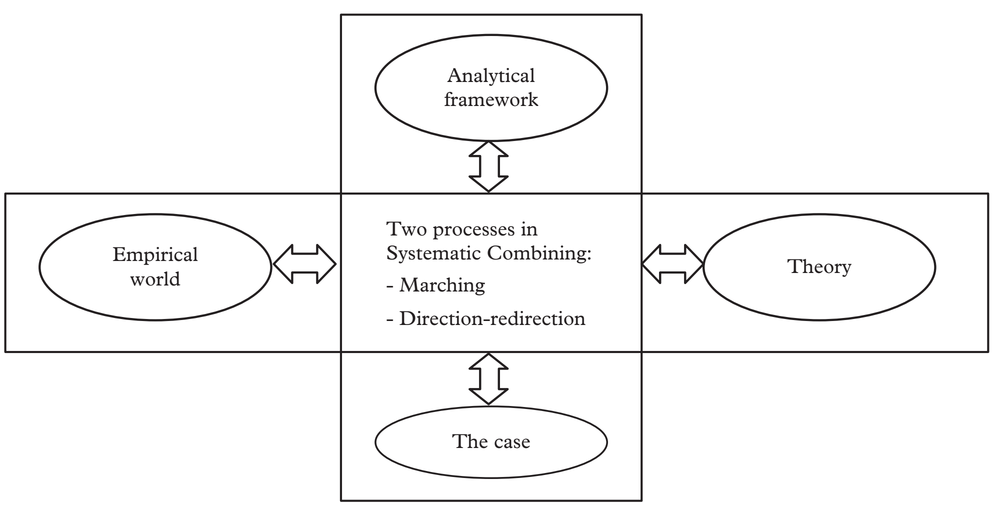

Figure 2. Systematic combining in abductive case studies.
Source: Dubois and Gadde (2002b).

Table 1. The three phases of the empirical study.

Phase	Phenomenon in focus	Central features	Network layer
Phase 1	On-site operations involving a logistics specialist	Efficiency	Activity layer and resource layer
Phase 2	Collaboration among firms involved on-site	Specialization and division of labour	Activity layer and actor layer
Phase 3	Connection between on-site and off-site operations	Network reorganizing	All three layers and the interplay among them

and "consequences for the involved actors". In this phase, the reorganizing among the actors and their interaction patterns pointed out the significance of including off-site actors.

Consequently, in the third phase, data collection was expanded to reveal the effects for off-site activities when division of labour in terms of "who undertakes logistics operations on-site" changes. CSL's on-site logistics approach impacted substantially on the operations of manufacturers and distributors, thus making the interface between them a crucial issue. The focus thus shifted towards analysis of the connections between on-site and off-site activities, with network reorganizing as the significant feature. This analysis involved the activity layer, the resource layer and the actor layer, as well as the interplay between the three. In the case analysis, data was now sorted in the categories: "the focal actor" (CSL), and "the on-site and off-site consequences" in the respective layer of the network. Accordingly, the framework was developed to capture aspects related to reconfiguring of activities, recombining of resources and repositioning of actors.

Data collection

The research framing based on industrial network theory directed methodology and data collection. According to Halinen and Törnroos (2005) a case study approach is suitable for studies relying on industrial network theory. They claim that this methodology allows for deep probing analysis of a research phenomenon, which is hard to separate from its context. The authors identified some key issues that need to be handled in order to secure the quality of case study research in networks. Below we discuss how this study has been conducted with regard to these issues.

Firstly, *delimiting the case network* was done by first focusing on one firm, CSL, and their on-site activities. From this setting, the "off-site consequences" were derived by tracing the consequences related to the novel on-site organizing of construction logistics. Hence, this search identified a variety of on-site effects and off-site consequences, in the three network layers and for various types of actors (such as distributors, transportation firms, contractors and materials manufacturers).

Secondly, in order to *master network complexity*, Halinen and Törnroos (2005, p. 1290) claimed that "contacts to several informants that have good access to the studied issues and the case network, as well as close and direct relationships between researchers and practitioners, are needed". On this basis, we collected data from various types of actors in the network, all with their specific perspectives on the organizing of construction logistics. A total number of 28 interviews were conducted with representatives of 13 organizations (Table 2). In general, interviewees represented functions stationed at the site, workers and managers, as well as various supply chain functions. Interviews with CSL include both site staff and central management with responsibility for logistics planning and business development. Two construction projects were followed in more detail: the building of new residential units and the reconstruction of hospital facilities. In both these projects CSL was responsible for on-site logistics operations.

Interviews were semi-structured and lasted from 1 to 2 h. Nine interviews were recorded and 19 interviews non-recorded, in accordance with the respondents' preferences. All interviews were based on interview guides, with fairly specific topics to be covered in three main areas: planning and execution of logistics, how logistics relates to other operations, and the interaction among various firms and individuals. Table 3 is a condensed summary of the interview guides, illustrating the themes and key issues discussed in the interviews. The respondents were asked to reflect upon what they perceived specific in these projects in comparison with other projects, and particularly the consequences of using a logistics specialist vs. other logistics arrangements. The interview guide was adapted to the situation of the individual interviewee and in the interviews the informants also brought up additional topics. Certain meetings with informants evolved to interactive discussions rather than interviews, and some of them took directions that were not planned. The information supplied by each interviewee was transcribed directly after the interview. In situations where two interviewers were

Table 2. Interviews in the study.

Companies	Number of interviews and function of interviewee	
CSL – site staff	8	2 logistics managers, 2 logistics coordinators, 1 material delivery planner, 1 work manager, 1 arrival controller, 1 quality manager
CSL – central management	6	2 business developers, 2 logistics consultants, 2 materials handling managers
Four contractors	4	3 site managers, 1 work manager
Two subcontractors	2	2 work managers
Two distributors	3	1 logistics manager, 1 store manager, 1 sales manager
Transportation firm	2	1 transport leader, 1 chauffeur
Management consultancy firm	1	1 project manager
Materials manufacturer	1	1 sales manager
Project management firm	1	1 project manager

Table 3. Interview themes and key issues discussed.

Interview themes	Key issues discussed
1. General information about the respondent and the firm	Professional background of the respondent Role in the company and in a specific project if relevant General information about the firm that the respondent represents
2. Logistics operations	Characteristics of the organizing and coordination of logistics (on and off-site), actors involved in logistics (on and off-site), effects of the logistics organizing on actors (on and off-site), key challenges in relation to logistics, purchasing of materials and logistics services, cost and price aspects relating to logistics, the use of logistics specialists: experiences, opportunities and challenges, consequences for own operations
3. Information about the specific project	Type of project, duration of project, project size, key actors, organization, project challenges related to the specific context
4. The role of the firm in the specific project	How the firm was contracted in the project, why the firm was chosen among others, responsibilities and tasks in the project, how many people from the firm that are involved, similarities and differences compared to other projects that the firm is involved in, key challenges for the firm in the project
5. Interaction and business relationships	Key relationships, characteristics of relationships, historical relationships of importance, Connections among projects
6. Information exchange and communication	Key information flows, What is communicated, Key IT-tools for communication (e.g. BIM, Logistics planning tools)

present, their notes were compared before transcription. Any confusion in the data was followed up by additional contact via telephone or email.

Six site visits provided observations regarding unloading from vehicles, site transportation with pallets and elevators, as well as planning of delivery control and resource coordination. Furthermore, two visits were made to detect distributors' storage facilities, while another visit enabled observations of the materials manufacturer's production and storage facilities. In addition, secondary data was collected in terms of, for example, site disposition plans, requests for tenders, and resulting tenders. Other useful empirics included CSL's materials handling directives, and data from their delivery planning systems. The secondary data was crucial for understanding the complexity of logistics operations on-site, off-site and in particular, the connections between on-site and off-site logistics.

The third aspect discussed by Halinen and Törnroos (2005) regarded how to *tackle the dynamics of networks*. To handle this issue, we have followed the same firm (CSL) since 2010 in different projects and settings, one of which is still ongoing. This engagement, over more than six years, in various contexts, have contributed to enhanced understanding of CSL and its role in construction projects and construction networks.

Empirical study

The focal actor

The case study describes the reorganizing efforts of a firm engaged in construction logistics. This organization – CSL – specializes in on-site logistics with particular focus on materials handling. CSL contributes to site performance by delivering building materials directly to the assembly area. This approach differs from traditional logistic services where materials are transported to a storage area at the site. Moreover, CSL handles materials after regular working hours to avoid disturbances with the assembly activities undertaken during day time.

Typical projects for CSL are that they are hired by contractors for logistics organizing in house building and public building projects, or refurbishment of existing buildings. In some cases, CSL is instead hired by the client. The customer who hires CSL pays for logistics operations, including personnel and resources such as cranes and elevators on site. CSL's logistics services comprise: (1) planning of site layout with regard to cranes, elevators, transport routes and storage areas, (2) coordination of physical deliveries of vehicles to and from the site, and (3) materials handling operations. The logistics services are applied in various phases of the building process. In the initial phase, this organizing involves the shuttle traffic of demolition materials, transport of shaft and detonation bulk from the site, and filling materials to the site. The next phase involves organizing of the intense inbound deliveries of often fragile and weather sensitive materials to the many firms involved in site operations. To some extent, CSL is also engaged in logistics organizing during the third phase, when the construction operations have been completed, and elevators and cranes are removed from the site.

CSL's level of on-site logistics involvement differs among projects. Extensive logistics organizing is at hand in major construction projects, with challenging logistic conditions. This may occur at exceptionally crowded sites, in central city located projects or when the operations of a client have to continue, despite ongoing construction activities. Logistics analysis services may include resource- and materials flow analyses before the start of a project and/or "complete" logistic responsibility during the entire project. In the latter situation, CSL locates a team at the construction site. This team commonly consists of a logistics manager, a logistics coordinator, a delivery planner, a person responsible for arrival control, and one or several gate guards. Materials handling encompasses unloading from vehicles on arrival at the site, visual inspection of goods and internal transport to the specific assembly area. Contractors and subcontractors pay CSL a fee for materials handling, depending on the size and volume of goods, and whether the material arrives on pallets or are to be placed on trestles. The work force for materials handling includes a work manager and a number of staff corresponding to the size of the operations. CSL has developed a web-based delivery planning system and all contractors have to book their deliveries of materials to sites through the system five days in advance. The CSL delivery planner assigns appropriate resources, such as elevators and cranes, for the materials handling needed for these deliveries. CSL's involvement in a project thus varies from just materials handling operations in certain project phases to comprehensive logistics responsibility before and during a project.

Figure 3 illustrates a schematic network formation in accordance with CSL's operations. On sites, CSL provides logistics operations for the main contractor and subcontractors. Off site, suppliers in the form of materials manufacturers and distributors deliver various types of building materials to the site.

The following sections present the significant features of CSL's reorganizing of construction logistics in relation to the three network layers, as described in the framework in Figure 1. The new way of organizing on-site logistics is referred to as the "CSL approach". This set-up is discussed with regard to the "traditional approach" and the off-site consequences observed.

Reconfiguring of activities

Effects on-site

The CSL approach implies that all materials handling takes place after regular working hours by personnel hired by the hour by CSL. This results in an *activity configuration* different from the traditional approach where materials handling takes place during daytime. CSL's approach has several implications for construction operations. First, materials handling activities do not interfere with assembly work since the two operations are separated in time. Second, this reconfiguration enables construction workers to focus on assembly, which is appreciated because "when there are some problems with the materials, construction workers get really frustrated – in this project there are less problems" (subcontractor interview). Third, the physical resources at the site can be used solely for construction work during the day without breaks for materials handling activities, which is the normal condition in the traditional approach.

Furthermore, the CSL approach changes the *division of labour* among actors. Construction workers become specialized and are no longer involved in materials handling since these activities have been transferred from the contractor to CSL. As a result, efficiency in assembly operations is improved since construction workers do not have to interrupt their work in order to collect materials or

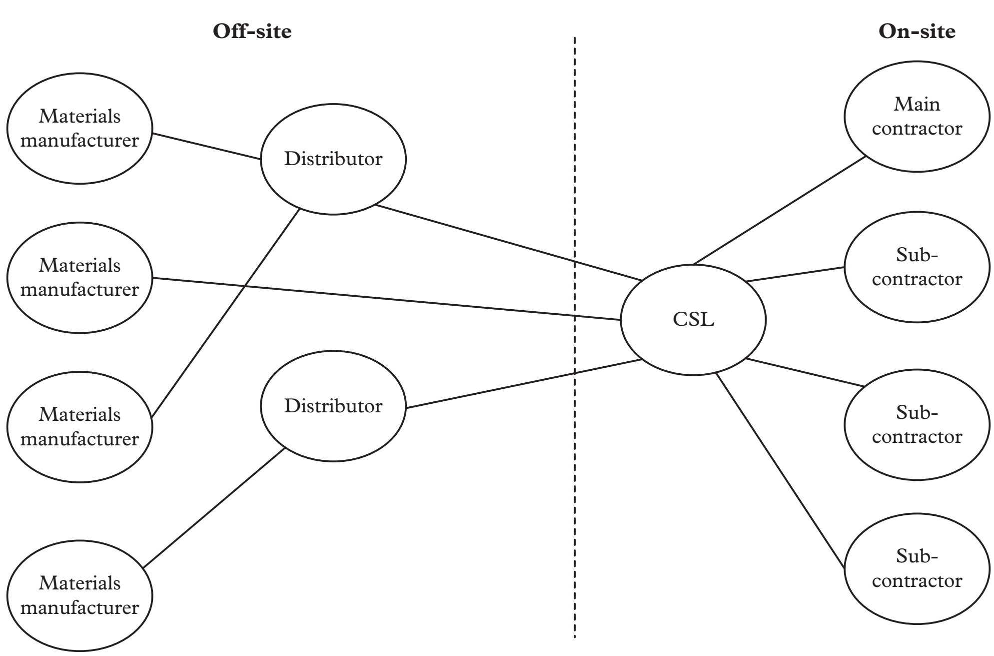

Figure 3. The network formation on-site and off-site.

to move materials from one storage location to another. Materials are now taken directly to the assembly area in the evening, implying that construction workers can start with assembly work immediately in the morning. One site manager expressed the new situation as follows: "To work in this way is a challenge for the construction workers as it is new to them. But they learn over time, and now appreciate that they can focus on their construction work".

Regarding *activity coordination,* the traditional approach to on-site operations features scattered activity structures. Construction workers constantly move between tasks in accordance with pre-planned work flows, with extensive adjustments required to upcoming conditions on site. As a result, materials handling activities are seldom undertaken in well-structured sequences. According to one respondent, "there is often no organizing of delivery planning and control of goods that arrive". This means that site managers spend a lot of time on ad hoc prioritizing among various tasks to cope with frequent deviations from plans. In the CSL approach, managers on site and CSL interact intensely regarding plans and updates of plans to ensure that adequate conditions for on-site logistics are at hand.

To facilitate coordination of deliveries, CSL developed the web portal in which time slots are booked for deliveries, including information about the sort of materials, type of vehicle, volume of goods, and equipment needed to handle the materials at sites. Since all logistic activities are managed by CSL, contractors and subcontractors are not allowed to bring in materials to the site. Instead they need to rely on CSL and pay for their services, something they are not entirely happy about since "it costs us to bring in materials, we pay per pallet, so we try to reduce the number of deliveries otherwise it would cost us too much" (subcontractor interview).

CSL's approach improves activity specialization at sites. These conditions reduce the *scope* of the activities of construction workers, thus enhancing the economies of *scale* of the operations. Both materials handling and installation benefit from increasing similarity which positively impact on the efficiency of on-site activities. The project manager of one subcontractor expressed the benefits by saying that "we have reduced the men hours at the site since construction workers are no longer involved in materials handling". In the traditional approach, activity similarity is substantially lower since construction workers are engaged in multi-task operations.

Off-site consequences

The changes of the on-site *activity configuration* have extensive off-site implications. Suppliers need to make adjustments to the handling conditions at sites. They must enable stacking on pallets for specialized lifts, and elevators have to be used. Moreover, building materials must be wrapped so they can be moved from the unloading area to the assembly area without being split and or damaged. The logistics manager of one main distributor concluded that "the prerequisites for efficient logistics on site are to a large extent due to adaptations made with regard to off-site logistics in terms of packaging and labelling of the materials".

These conditions also impact on *the division of labour* among the actors. Adjustments of materials to fit with site conditions were previously undertaken at sites, but are now relocated to building materials manufacturers and distributors. These firms have to change their packaging principles and routines, as well as alter the arrangements regarding delivery schedules to enable efficient transport, handling, co-loading and re-loading. Accordingly, while site operations gain from specialization, off-site actors have to increase customization which is costly. The experience of one distributor's logistics manager was that "it is challenging to make our customers pay for it".

The CSL approach relies on advanced planning and extensive *activity coordination* between on-site and off-site logistics to secure timely and appropriate delivery. Thus, the activity specialization on site needs to be supplemented with enhanced coordination with off-site activities, to ensure efficient materials handling and to avoid delays stemming from lack of materials. These modifications strengthen the integration between off-site transportation and on-site materials handling and installation. The CSL approach thus increases the complementarity among activities in comparison with the traditional approach.

The changes of the activity configuration and the division of labour impact on the *scale and scope* of off-site activities. Manufacturers of building materials have to increase the scope of their activities. This change reduces the similarity of their operations with accompanying negative effects regarding economies of scale.

Recombining of resources

Effects on-site

CSL's approach implies changes in the *resource exploitation* at sites. CSL is responsible for organizing logistics to enable efficient utilization of the various resources on site, such as cranes, elevators and the specialized skills of construction workers. They also bring in their own dedicated personnel, with knowledge and experience from logistics organizing in many projects. One representative of CSL expressed the significance of enhanced resource utilization in the following way: "for us it is key to exploit the resources: cranes, elevators, labor etc. in accordance with our standardized procedures". The conditions for resource exploitation on site are improved by the use of CSL's web portal as a planning device for efficient use of materials handling equipment. Through CSL's approach, elevators can be used exclusively for transport of construction workers during day time, while CSL exploits the elevators in the evening. Also, the utilization of the tower crane is improved compared to a traditional set-up, since it now can be used solely for construction operations.

The CSL approach affects the *resource interfaces* in the network. The traditional approach relies on deliveries of standardized materials, where interfaces are adapted to specific site conditions by contractors and subcontractors involved at the site. The modifications of packaging and deliveries to fit with the demands of CSL change the interfaces to pallet lifts and elevators. These adaptations, undertaken by manufacturers and/or distributors before delivery to the site, improve the performance of resources and enables CSL to organize on-site logistics in an efficient way. On the other hand, resource adaptations are costly and therefore it must be ensured that the benefits of improved interfaces are not outweighed by these costs. One subcontractor expressed his concerns as follows: "This way of working gives us less flexibility and requires more planning. To some extent more difficult, but it could not have been done in any other way since we are so many actors here at the same time with little space".

Regarding *resource control*, the traditional approach is based on direct contractor control of significant resources in terms of equipment and capabilities. Utilization of resources is planned by the contractor in interaction with materials suppliers for coordination of deliveries to the site. Potential benefits of resource specialization are difficult to attain because the equipment is needed simultaneously for materials handling and building operations. These multiple demands result in waste of resource capacity for moving around materials and for people swapping between various activities. In the CSL approach, contractors no longer have direct control of the logistics competence required. They rely on access to CSL's knowledge and routines, including the skills of people and the capacity of the web portal for delivery planning. CSL, in turn, exploits the available equipment at sites that is rented by the contractor. It would not be economically feasible for CSL to control these physical resources through ownership. Hence, CSL is dependent on access to these on-site resources provided by the contractor.

The traditional *resource combining logic* builds on standardized materials that need to be adapted at sites for resource combining to become effective. Decisions regarding this combining are to a great extent the outcome of the experience gained in previous projects by site managers and other personnel. Such knowledge represents a key capability in the combining of the numerous resources used in materials handling and construction activities. Since this capability resides in individuals, resource combining according to the traditional approach is conducted differently at various construction sites, implying unexploited learning effects across projects. One respondent concluded that "site managers decide, and they do it differently from project to project. On most sites, each actor handles its own logistics resulting in totally different processes". Therefore, the traditional approach to on-site resource combining implies low utilization of capacity. In the CSL approach, resource combining at construction sites is standardized. This logic allows for improved utilization of site resources since on-site logistics are undertaken after regular working-hours. Moreover, the resource combining logic of CSL relies on advanced planning, based on specialized staff and sophisticated systems for information handling and sharing.

Off-site consequences

The requirements for adapted deliveries of building materials in the CSL approach hamper efficient *resource exploitation* off-site. For manufacturers, these conditions cause extra work and thus additional costs. For example, window manufacturers normally bundle windows according to the logic of their production flows. The demands from CSL require windows to be packed in accordance with the logic of the materials handling activities at the site. These demands force window manufacturers to re-pack their products before delivery to a "CSL-site".

Regarding *resource interfaces*, materials manufacturers are affected negatively by the requirements for adaptations of materials packaging to the conditions on sites. These demands hence decrease the efficiency in the production context in comparison with standardized interfaces. In situations where manufacturers are unwilling to make these adaptations, they need to be undertaken in other ways. In one of the projects, a facility for intermediate storage had to be established off-site to enable repacking in accordance with CSL's principles. This intermediate storage was established on some distance from the construction site on the initiative by a distributor together with its transportation carrier. The contractors who used this intermediate storage paid a small amount for this extra service. For the distributor, however, the costs related to extensive storage, repackaging of goods and other adaptations exceeded by far the income from the contractors.

Instead of the normal process with direct transport from the distributor's central warehouse to the site, the transport was split into two activities: one delivery to the intermediate storage where repacking was undertaken, and one delivery from this facility to the site. Since several contractors were facing the same situation and used this distributor, the same set-up could be applied to a number of business partners. Therefore, the distributor was able to use its standard procedures for deliveries from the central warehouse to the intermediate storage. The "last-mile" delivery to the site was undertaken by the local carrier in accordance with the time slots booked in CSL's web portal. The intermediate storage facility represented adaptation of the distributor's normal logistics and transportation set-up and illustrates an off-site modification as a direct consequence of CSL's approach to on-site logistics organizing. The adaptations in the network's resource constellation improved the resource interfaces in relation to the logic of CSL's on-site approach, but created additional costs for suppliers, contractors and subcontractors.

With regard to *resource control*, increased interaction is needed between on-site contractors and off-site materials suppliers to provide access to the resources of business partners and secure the adaptations required for CSL's on-site activities. These adaptations of resources are critical for CSL to ensure that materials handling can be carried out in the same way at all sites where they are involved. This interaction between contractors and materials suppliers is directly dependent on the continuous interaction between the main contractor and CSL. The important role of information technology and openness in business relationships is pointed out by CSL's logistic coordinator in this way: "A key thing is the communication between contractors/subcontractors and their distributors and transportation firms".

Improved connection between on-site and off-site activities is the main feature of CSL's *resource combining logic*. This approach requires more extensive pre-planning of the utilization of resources across company borders, as well as adapted interfaces between on-site and off-site resources. The adaptation between the two types of resources is moved from construction sites to the factories of the manufacturers of materials.

Repositioning of actors

In this section, the effects in the actor layer are discussed, as well as the interplay between the three network layers. The two previous sections illuminate implications for the repositioning of actors. CSL's *replacement* of contractors in on-site logistics was enabled through the ability to provide enhanced performance in the activity and resource layers. The improvements in the activity layer were based on CSL's capabilities and skills built up over time through increasing experience of on-site logistics organizing, and the emphasis on standardized materials handling activities at many sites. Enhanced performance in assembly activities stemmed from the specialization of construction workers, which no longer have to alter between materials handling and assembly. By introducing new resources, such as specialized personnel, a delivery planning system, and exploiting existing resources, such as cranes and elevators, in more efficient ways, CSL was able to take over on-site logistics from contractors. The scope of activities performed by the various actors thus changed, as did the coordination of activities. In addition, the reorganizing also involved changing interfaces among resources through mutual adaptations.

The reorganizing in the actor layer affected the *involvement with business partners*. Some of these business relationships were introduced through the modifications in the network, but also existing relationships were affected, for example between contractors and materials manufacturers. For the coordination of on-site logistics, CSL is deeply involved in joint planning and frequent interaction with main contractors and subcontractors to synchronize logistics. One respondent claimed that "the main benefit is that the logistics specialist handles materials for all contractors and subcontractors". Regarding the interface to off-site logistics, CSL partly relies on the resources and services of distributors of building materials. Openness between the parties and effective exchange of relevant information are crucial issues for these joint actions in the entire network.

Furthermore, reorganizing in the actor layer required *changes in the connections between business relationships*. Contractors and subcontractors need to interact more closely with each other to secure effective on-site logistics. Moreover, they must be increasingly involved with materials suppliers to determine appropriate conditions for the interface between on-site and off-site logistics. As expressed by one respondent "more intense collaboration between the involved actors provides high quality, low project cost and short project time". Such extended interaction promotes knowledge transfer among project participants, which positively impacts on both assembly activities and the end product.

As illustrated in the analyses of the reconfiguring of activities and the recombining of resources, CSL's organizing principles cause both on-site and off-site effects. These organizing principles are perceived differently by the various actors in the network, since they affect *the interaction patterns and the relationship atmosphere*. Firms that have worked with CSL before tend to be more positive since they are aware of procedures and requirements, while others perceive them costly and too resource demanding regarding interaction. For example, small and less experienced actors "have not taken the costs for bringing materials into the site into account in the tender request, so they face unexpected costs" (logistics manager, CSL). Consequently, in some situations the demands of CSL create tensions and potential conflict in the relationships with subcontractors and their transportation partners, which have resulted in attempts of subcontractors to "smuggle in materials". In some situations, these conflicts can be solved constructively through communication and interaction within the frame of the relationship. However, sometimes this approach is not sufficient and in one project CSL needed to use additional control mechanisms to make subcontractors accept the logistics requirements. CSL had to apply its contractual control, stemming from the contract signed by the contractor and all subcontractors to follow the requirements set by CSL. However, using authoritative control may negatively impact on trust and commitment in the relationship atmosphere.

Discussion

The empirical study confirms the claims raised by advocates of the site materials management approach (Thomas *et al*. 2005, Sanad *et al*. 2008). The CSL case illustrates that effective organizing of logistics activities and utilization of resources at sites are significant drivers of on-site logistics performance. These conditions contrast previous findings related to "poor management" (Almohsen and Ruwanpura 2011) and "insufficient planning" (Sobotka and Czarnigowska 2005, Ying *et al*. 2014). The CSL approach contributed to solving previously observed problems pointed out in relation to storage capacity (Agapiou *et al*. 1998), the moving of materials at sites (Strandberg and Josephson 2005, Fearne and Fowler 2006), limited utilization of the capacity of equipment (Josephson and Saukkoriipi 2005) and low delivery reliability (Thunberg and Persson 2014). The performance improvements realized by CSL in terms of benefits of specialization, exploitation of external logistical competence, and improved utilization of equipment, are similar to findings in other studies of logistics reorganizing at construction sites (e.g. Lindén and Josephson 2013, Ekeskär and Rudberg 2016).

The principles applied in the reorganizing of on-site logistics are in line with suggestions in previous research. The CSL approach exemplifies new types of organizational arrangements proposed by, for example, Vrijhoef and Koskela (2000), and Gadde and Dubois (2010). The standardized procedures and routines developed by CSL reduce the problem pointed out by Ying *et al*. (2014) that people at sites need to deal with different formulas for ordering, handling and unloading of materials. Moreover, CSL represents a new role as coordinator of on-site logistics, as suggested by Agapiou *et al*. (1998) and Vidalikis *et al*. (2011). In these coordinative efforts they rely on advanced information technology (for example the web portal), which follows recommendations by Song *et al*. (2006) and Fadiya (2015).

Regarding the connections to off-site activities, the study showed possible solutions for some of the problems caused by unsatisfactory interfaces between contractors and materials suppliers as pointed out by Behera *et al*. (2015). However, the main finding in relation to off-site logistics is that distributors and manufacturers of building materials are substantially affected by the on-site reorganizing. The benefits regarding on-site logistics were accompanied by disadvantages for the manufacturers' operations where standardized approaches had to be replaced by costly adjustments in packaging and forms of delivery. Unfortunately, no detailed information is available for more advanced evaluation, neither of the off-site consequences, nor of the total effects of the reorganizing. Moreover, there are no other studies to compare with since previous research is scant, primarily because firms have not prioritized the on-site/off-site connection and the linkages to distributors and suppliers. The need for taking these conditions into consideration through enhanced supply chain management thinking has been advocated for several decades. So far, however, these recommendations have been followed only to limited extent (Bankvall *et al*. 2010, Ying *et al*. 2014, Fadiya 2015).

Conclusions

This paper was initiated with the aim to investigate strategic actions to improve construction performance through enhanced connections between on-site and off-site logistics. A literature review indicated that such progress would require considerable reorganizing of the current approaches applied in construction. These conditions generated the second aim: to derive a theoretical framework for analysis of reorganizing in networks. This final section provides an account for the study's contributions in these two respects and some managerial implications based on the findings.

The contributions of the study

Previous research requested theoretical framings for analysis of modifications of established arrangements in construction (Fernie and Tennant 2013). This study offers a framework rooted in industrial network theory that is useful for examination of strategic options for reorganizing of construction logistics. This framework, illustrated in Figure 1, evolved through cross-fertilization of concepts from industrial network theory and findings in the empirical study of construction logistics. However, close examination of the features of the framework indicates that this framing also should be possible to apply for analysis of network reorganizing in other settings. This claim for generality is based on two arguments.

First, the framework was derived through the combining and integration of concepts from various conceptualizations of features related to all three network layers. In this way the framework represents a contribution in itself. Second, the reorganizing options identified in the three layers are formulated in a terminology relevant for network dynamics in general – no option is so specific that it would pertain only to modifications of construction logistics.

Exploration of the business reality with this framework and its three layers offers a multifaceted perspective on prerequisites and consequences related to reorganizing in networks. In this way it is well in line with the features of theory building requested by Fernie and Tennant (2013): to explain what change is possible, what such change may bring and the road to achieving such change. The framework provides academic researchers with a tool for analysis of reorganizing of business operations in networks. Practitioners can use the framework for evaluation of various opportunities to improve performance. For example, changing division of labour through outsourcing may be perceived an adequate action for enhancing economies of scale in the activity layer. However, such a change will also impact on the two other layers. It is most likely that effects may occur, or be required, regarding control in the resource layer and relationship involvement in the actor layer.

The specific contribution of the study regards the findings related to improvements of construction logistics through enhanced connection between on-site and off-site activities. Firstly, the empirical investigation shows that a logistics specialist was able to (1) advance on-site performance by improving the efficiency of site activities, (2) increase the utilization of site resources and (3) reduce the interference between materials handling and building activities. Ekeskär and Rudberg (2016) arrived at similar conclusions in their study of a TPL operator, where they witnessed the significant impact of external logistical competence. They claimed also that performance improvements need not necessarily require a new actor, since the same competence might be generated internally. Our opinion is different because materials handling and assembly activities rely on quite different capabilities. In our view, transferring on-site logistics to a specialized actor offers advantages in two ways. First, specialization provides opportunities for increasing economies of scale through enhanced similarity of activities. Second, the opportunities for extended learning will be greater for a specialized actor through the experiences gained from interaction with several types of contractors involved in a variety of construction contexts. The competence developed by an in-house logistics work force is limited to the conditions related to the own firm and its operations. Moreover, we base our argument on research by Lindén and Josephson (2013) who found that outsourcing of on-site logistics to an independent actor was more favourable than undertaking the activities in-house.

Secondly, the study shows that on-site reorganizing requires, and causes, substantial off-site effects. Suppliers of building materials need to adjust their activities and resources in relation to the changes undertaken on-site, owing to prevailing interdependencies among on-site and off-site activities. Therefore, off-site actors have to modify their packaging and delivery activities with accompanying negative consequences for resource utilization and costs. This finding implies that performance improvements owing to reorganizing of site logistics may be detrimental to off-site operations. Consequently, the total network effects may not be positive even though on-site logistics have been enhanced.

Thirdly, attempts to change the configuration of activities and the combining of resources in construction logistics cross the boundaries of firms. Joint actions in these terms require reorganizing in the actor layer in the form of mutual planning and exchange of information among business partners. Such modifications call for extended interaction and increasing involvement and may be difficult to achieve since business relationships in construction tend to be adversarial and governed by competitive tendering. Furthermore, successful joint actions between several actors require a fair distribution of the value generated through reorganizing. In business networks it is not uncommon that the outcomes for various actors do not reflect their actual contributions. Such conditions may substantially constrain reorganizing ambitions.

Managerial implications

The principles for reorganizing of logistics illustrated in this study break with established logic for efficient behaviour in construction, which tend to rely on competitive tendering and short-term perspectives. Extended interaction and increasing relationship involvement contrast prevailing recommendations to avoid dependence on individual business partners through arm's-length relationship. To obtain the potential improvements of on-site construction logistics described in the case study, contractors need to reconsider their perception of dependence. Dependence on business partners is a necessary condition for realizing potential benefits from reorganizing. This means that prevailing principles favouring competitive tendering and adversarial relationships have to be modified.

Reorganizing in terms of increasing activity coordination, resource combining and actor interaction always provide certain benefits. But these conditions are costly to create and maintain, which means that potential benefits in some situations may be outweighed by increasing costs. Therefore, it is crucial for those involved to analyse and evaluate potential effects of reorganizing before changes are introduced, and also measure realized effects once changes have been undertaken. This assessment is complex owing to the impact of both direct and indirect costs and benefits.

Finally, one particular aspect in this respect regards the interdependence between on-site and off-site logistics. This study shows that on-site benefits are gained on behalf of negative off-site effects. Therefore, further research is required for investigation of the total consequences of efforts to improve construction logistics. Moreover, further research in other contexts will show whether our claims for the generality of the theoretical framework are valid or not.

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