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The Role of Intermediation in Business Networks

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ABSTRACT

Intermediation is a central phenomenon in the business landscape, addressed in numerous settings and contexts, for example, financial intermediation, innovation intermediation and internationalization through intermediation. Commonly, intermediation concerns how firms become connected through an intermediary that bridges the gap between the provider and the user of goods and services. Hence, the focus is on *who* connects firms in organizational arrangements of intermediation.

This study extends the view on intermediation by including *what* is being connected through intermediation in order to analyse the role of intermediation. What needs to be connected relates to 'what is done' and 'how it is accomplished', which generate connections, within firms and across firms' boundaries. These connections have become increasingly important since outsourcing, specialization, customization and network-like constellations have come to characterize the business reality. The thesis relies on industrial network theory to conceptualize intermediation, which allows the established focus on actor intermediation to be supplemented by intermediation of activities and intermediation of resources. The basic research issue analysed is how one intermediate element connects other elements, and the consequences of this interrelation. The analysis first captures activity intermediation, resource intermediation and actor intermediation separately, and compares the various empirical intermediation situations in the three network layers. Second, the analysis scrutinizes how the layers of activities, resources and actors are interrelated by examining the interplay among them.

Methodologically, the thesis is based on a qualitative case study of intermediation in the Swedish construction industry. It includes three subcases which each illustrate intermediation in one of the network layers. The case study includes 28 interviews in 10 firms, observations at construction sites and factories, and large amounts of secondary data and company records.

The thesis demonstrates that the broader scope of intermediation enabled by industrial network theory, contributes to an improved understanding of business settings. The interplay among intermediations in the three network layers is analysed in relation to operating efficiency, division of labour and control of resources. The thesis also addresses the dynamic nature of intermediation by identifying some principal modifications of intermediation. Finally, this research demonstrates that managing intermediation is a balancing act: balancing activity interdependencies, balancing resource interfaces, and balancing actor interactions stretching across firm boundaries. In addition, this balancing act is not a 'once and for all' task, but a continuous managerial issue to cope with the circumstances in the business reality.

Keywords: intermediation, business network, relationship, construction industry

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Göteborg, April 2014

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1 INTRODUCTION

This first chapter introduces and provides an overview of this thesis. The thesis deals with the role of intermediation in business networks, with a new perspective on intermediation. The established view on intermediation considers intermediation between firms and how a specific firm, an intermediary, connects other firms. This study extends this view by taking into account what goes on in the business landscape, which generates connections. Consequently, while previous studies on intermediation focus on who connects firms in intermediation arrangements; this thesis focuses on what is being connected through intermediation.

First, the established view on intermediation is described, and various studies of intermediation are discussed along with the various theoretical ways in which intermediation has been studied. Second, an extended view on intermediation is presented, focusing on what is being connected through intermediation. Third, an industrial network perspective on intermediation is introduced as the theoretical point of departure for this extended view on intermediation. Fourth, the aim of the thesis is defined based on this extended view on intermediation and the industrial network approach on which this exploration is based. Finally, the last section of Chapter 1 outlines the structure of the thesis and its 11 chapters.

1.1 THE ESTABLISHED VIEW ON INTERMEDIATION

Intermediation is a central phenomenon in the business landscape and has been discussed in various settings and contexts. For example, financial intermediation addresses how financial institutions (e.g. banks, insurance companies, investment firms) intermediate between depositors of funds and borrowers of money in the form of loans or mortgages (e.g. Shunk et al., 2007). Moreover, intermediation in relation to inter-organizational information systems that link firms and facilitate data exchange is covered in several studies (e.g. Colomo-Palacios et al., 2010). Innovation intermediation concerns how various types of intermediaries connect creators and users of new inventions in research fields such as technology transfer, innovation management, systems and networks of innovation, and service innovation (e.g. Howells, 2006). Internationalization though intermediation deals with how an exporter can sell goods to customers in foreign countries using third party intermediaries. These intermediaries provide sales contacts, hold inventories, process orders, supply market information, and provide advice, technical support and physical fulfilment services to facilitate imports and exports (e.g. Herbig and O'Hara, 1994; Balabanis, 2005). Thus, intermediation commonly concerns how firms become connected via specific functions carried out by various intermediaries.

Since intermediation is a profound business phenomenon, an enormous pool of research has been devoted to studies of intermediation in various contexts and settings. A search in the collection of databases included in ProQuest of scholarly journals, produced 10,037 articles on 'financial intermediation' and 7,939 articles on the 'the role of intermediaries' (excluding financial) (ProQuest, 2014). In studies of intermediation with regard to how firms become connected via the specific functions conducted by various intermediaries, research tends to take an institutional or functional point of departure. For example, work on marketing channels takes an institutional approach, analysing the various institutions that constitute these channels, with major attention to intermediaries (Alderson, 1957). Functional approaches consider the activities required 'to bridge the gap' between providers and users as the starting point for their analyses (ibid.). In the context of financial intermediation, Merton (1995) identifies a similar separation between a focus on the institutional structure of financial intermediaries and a functional perspective that includes the economic functions performed by financial intermediaries. Similarly, Howells (2006) highlights the different emphasis in various studies on the role of innovation intermediaries, and intermediation as a process focusing predominantly on two main functions: the information scanning and gathering function, and the communication function.

Studies of intermediation capture great variation in empirical settings. For example, Klerkx and Leeuwis (2008) explore intermediary organizations in the agricultural sector. Intermediation is also scrutinized in many studies of global fashion supply chains (see e.g. Christopher, 2000; Masson et al., 2007; Purvis et al., 2013). Sieg et al. (2010) study innovation intermediation in the chemical industry, while Wynne et al. (2001) focus on the role of intermediaries in the tourism industry. These studies are just a few examples of the existence of intermediation in various contexts.

Intermediation has been studied in several different ways by applying different theoretical perspectives. Peng and Ilinitch (1998) explore export intermediation from the perspective of transaction cost economics. Andersen (2005) combines marketing channels theory (Alderson, 1957) with transaction cost theory (Williamson, 1975) to create a framework for understanding the impact of digitalizing transactions on the organisation of export intermediation. In the development of 'the intermediation theory of the firm', Spulber (2003) combines economic approaches to strategy, such as the work of Porter (1980), with management approaches to strategy, such as the resource-based view (Wernerfeldt, 1984; Barney, 1991). Benston and Smith (1976) argue that a transaction cost approach to the theory of financial intermediation is more suitable than traditional macroeconomic analysis. Scholtens (1992) combines portfolio theory with a focus on market opportunities (e.g. Freedman, 1977), and eclectic theory on the strategic behaviour of firms (Dunning, 1981) to provide an analysis of international financial intermediation. Boyle et al., (2008) adopt an organizational theory perspective in their study of how e-intermediation can reduce supply chain environmental uncertainty. Supply chain studies claim also that, although an important element in many supply chains, the phenomenon intermediation is largely absent from existing literature in the field, which lacks a coherent explanation of intermediation (Popp, 2000; Purvis et al., 2013).

1.2 AN EXTENDED VIEW ON INTERMEDIATION

The established view on intermediation is interested in examining *who is involved* in intermediation, that is, which firms intermediate between other firms. Research on intermediation identifies 'intermediaries' as specific types of actors, different from 'providers' and 'users'. Consequently, the main emphasis is on identifying intermediaries as having specific characteristics as institutions. These classifications vary, and it is argued that as the business reality changes, new types of intermediaries emerge, and the roles of intermediaries change. This topic is important and worthy of attention. However, to achieve an extended understanding of the phenomenon intermediation, and to complement the established focus on 'who intermediates', a somewhat different perspective is needed.

Close at hand is to relate to a functional approach to intermediation. In this way focus is drawn to *what is done* in intermediation, and to acknowledge the activities undertaken by intermediaries. The established view on intermediation recognizes functions as important aspects of intermediation. For example, intermediaries in marketing channels are involved in buying and selling, risk-taking, transportation, storage, order processing and financing (Rosenbloom, 1995). In another example, Stern et al., (1996) distinguish between the functions performed by wholesalers for manufacturers in terms of functions of market coverage, sales contact, inventory holding and order processing and the functions performed for customers which include product availability, assortment convenience, bulk-breaking, provision of credit and finance, customer service, and advice and technical support. Thus, the literature couples certain tasks with the concept of intermediary; these tasks separate intermediaries from providers (manufacturers) and users (customers). Consequently, the business landscape provides a structure where functions or activities are allocated among various types of actors.

It is appropriate to define intermediation as perceived in the thesis. Intermediation refers to how one intermediate element connects other elements, resulting in these elements becoming interrelated, and denoting that no element can be adequately understood in itself other than in relation to the other elements. The established view of intermediation identifies these elements primarily as firms, although some acknowledge activities. However, in relation to activities, the established view on intermediation focuses on identifying the activities undertaken and who undertakes them. This is often described as 'intermediaries and their functions' or by the concept of 'division of labour', thus how functions or activities are distributed among the involved actors. Less attention has been paid to how these distributed activities are connected. In an extended view on intermediation these activities are recognized as one type of the elements that are interesting to examine with regard to how they are connected. This extended view also acknowledges the connections between activities within firms as important in the context of intermediation. Two main types of activities can be identified. One type is represented by 'physical activities', such as transportation, storing, materials handling and assembling. The second type includes 'organizational activities', such as coordination, planning and information exchange, which are crucial for the undertaking and connecting of physical activities.

Another important aspect of intermediation is how activities become connected and, thus, how the undertaking and connecting of activities is accomplished. Thus, an extended view of intermediation also involves the intricate issue of *what is needed* to achieve intermediation, and thus, the notions of resources and how they are connected are important. Numerous physical resources are involved in intermediation; for example, vehicles, machinery, plants, equipment and information systems. However, these resources would be useless in the absence of organizational resources such as personnel, and the knowledge, skills and capabilities of firms, to connect physical resources. The utilization of these physical and organizational resources enables the undertaking and coupling of the activities. As such, resources are also connected, and their interrelation contributes to the formation of the business landscape. Consequently, it is meaningful to perceive a resource also as an intermediate element that connects other resources.

Another notion related to intermediation is that the established view of intermediation focuses on the elements, for example, the various types of intermediaries. However, since intermediation refers to how one intermediate element connects other elements, *the connection*, hence, the content of what exists between the elements is crucial for intermediation. Some recent studies of intermediation call for such exploration: “much more research needs to be undertaken into the nature of the *relationships* that intermediaries exist in” (Howells, 2006, p. 725). Purvis et al. (2013) identify a need for more investigation of the complex interactions between different levels in the supply chain and the involvement of intermediaries. Several authors acknowledge the lack of evidence on the relationships between innovation intermediaries and their clients (Pittaway et al., 2004; Verona et al., 2006). However, in these calls for a focus on ‘what exists between’, it is only the connections among the intermediaries and the firms they connect that are acknowledged. In line with the above discussion of activities and resources as elements involved in intermediation, connections among activities and connections among resources deserve equal attention in an extended view on intermediation. The connections between activities, resources and firms are the means enabling what is accomplished through intermediation in the business landscape. Hence, intermediation is a vital phenomenon in the business landscape since it dictates how elements relate and connect to one another via one element residing ‘in the middle’.

Furthermore, corresponding to contemporary changes in the business reality, an increased understanding of how elements interrelate through intermediation is ever more important. Increasingly, business contexts are characterized by outsourcing, specialization, customization and network-like constellations. This is making ownership boundaries less central in the utilization of resources and coordination of activities. Instead, operations previously controlled within the ownership boundary of a firm are now to a great extent distributed across many firms, and individual firms are increasingly reliant on the resources controlled by others. Consequently, the integration and coordination of activities and resources across firm boundaries is highlighted, since specialization anywhere in the business context requires integration elsewhere in the same context (Håkansson et al., 2009). Thus, the specialized activities and dedicated resources on which companies are relying to a greater extent need to be synchronized, which is making intermediation of activities and resources across company borders increasingly important (Ford et al., 2003). Intermediation provides the means to connect activities and resources spread among various firms, which requires coordination skills to bridge firm ownership boundaries. In this context, it can be argued that it is not the ownership boundary per se that is most crucial for intermediation. Instead, current boundaries with regard to the interrelation among activities, resources and actors provide the means for what can be accomplished in intermediation (Gadde, 2013). Consequently, an extended view on intermediation includes how activities interrelate, how resources interrelate, and how firms interrelate in the business reality.

1.3 A NETWORK PERSPECTIVE TO INTERMEDIATION

Based on the issues outlined above regarding an extended view on intermediation, this study applies an industrial network perspective (e.g. Håkansson and Snehota, 1995; Håkansson et al., 2009) to intermediation. Inherent to this theoretical approach is the notion of ‘what goes on between’ as being central in the business landscape. Thus, an industrial network approach is aimed at analysis of how elements are connected. Since networks consist of connected relationships, the important interrelations among elements are acknowledged as crucial for intermediation. Thus, the nature and content of business relationships are spotlighted, which is in line with contemporary business contexts characterized by network-like structures. This theoretical foundation enables analysis of how one intermediate element connects other elements, and the interrelations among these elements, in line with the phenomenon of intermediation. The industrial network perspective has been applied to the analysis of intermediation, but with a main focus on intermediaries and how they interrelate with other actors (see e.g. Havila, 1996; Holma, 2009; Jensen, 2010). On the other hand, Rosenbröijer's (1998) study focuses on resources.

The industrial network approach includes the three layers of activities, resources and actors (e.g. Håkansson, 1987; Håkansson and Snehota, 1995; Håkansson et al., 2009). Hence, a network perspective provides three complementary views of the business reality. In an extended view of intermediation, the two dimensions of activities and resources can be examined together with the established view on intermediation focusing on firms as the actors. Ford et al., (2011) provide such an analysis where intermediation characteristics in the activity and resource layers are crucial determinants of the business performance of the intermediary and other actors. Sundquist and Gadde (2010) and Sundquist (2011) propose an initial framework for the analysis of intermediation in the three layers of activities, resource and actors.

An important notion in relation to actors emerges from application of an industrial network perspective to intermediation: all actors are intermediaries since all actors are involved in intermediation. Gadde and Ford (2008, p. 47) claim that "the diversity of relationships and interdependencies in a network mean that it is not possible to make a clear distinction between what apparently homogenous categories of firms…, irrespective of whether they are called manufactures, distributors, users etc.". Thus, it is not possible to generalize about what companies designated as manufacturers, distributors, middlemen and users actually do. Such assessments hamper understanding of what goes on in the contemporary business reality, and limit the ability to analyse these situations.

In today's business reality all firms are involved in intermediation through the many connections to business partners and their activities and resources. All firms in the business landscape are simultaneously a customer for some firms and a supplier to other firms; hence, all firms are involved in intermediation since they connect other firms located 'around' them. Thus, all the actors in the business landscape are intermediaries and all firms have to manage their relationships with other firms (Ford et al., 2011). From a network perspective, 'intermediary' is not a relevant theoretical construct in terms of separating the various types of actors (since all are intermediaries) for an exploration of intermediation regarding the interrelations among elements via an intermediate element (Sundquist, 2011).

Also important is the implication that there are indirect connections; they provide indirect means for intermediation. An industrial network perspective perceives firms as embedded in the business landscape: each firm has a number of connections to other firms, and these other firms in turn have other connections (Håkansson et al., 2009). The nature and content of one of these connections is interrelated to the other connections and their features (e.g. Anderson et al., 1994). Consider a situation where one intermediate element, X1, connects two other elements, X2 and X3. From a network perspective it follows that X2 and X3 also have connections that 'stretch out' in the network to other elements. These connections affect and are affected by the connections between X1-X2 and X1-X3. Accordingly, intermediation involves 'connections among the connections' in the business landscape. In other words, what resides on both sides of an element always interrelates to what resides on the two sides of the elements to which it is connected. The established view on intermediation tends to disregard these indirect connections. However, an extended view on intermediation studied through an industrial network lens, includes these indirect connections as important as direct connections whether the analytical focus is on activities, resource or actors.

Thus, while the established view on intermediation focuses on the intermediation among actors, the industrial network approach enables analysis also of the connections between various activities and various resources. In this sense, analysis of intermediation involves the interrelation among activities, interrelation among resources and interrelation among actors, through direct and indirect connections. These separate dimensions have been extensively scrutinized through studies focusing on either the activity layer, the resource layer or the actor layer in business networks. For example, Dubois (1998) analyses the intricate issue of obtaining efficiency in activity structures that involve several actors, using the activity based framework as a tool for identifying and analysing how activities are interrelated. The resource dimension of business networks has been addressed in studies analysing the interfaces between resources and the interactive element of resource development (Håkansson and Waluszewski, 2002). Work on the interrelations among actors acknowledges the strategic behaviour of firms as embedded and interdependent (Snehota, 1990) and note the evolution of relationships (e.g. Forsström, 2005). Although these works focus on one of the network layers, the other two layers are referred to implicitly in line with the business reality of layers of activities, resource and actors being closely intertwined. Thus, the research topic is reflected in the three layers, but most studies focus on one layer. This thesis study intends to investigate the interrelations between the layers and thus, the interplay between them.

1.4 AIM OF THE THESIS

The research issue analysed in this study is how one intermediate element connects other elements, and the implications of this interrelation. The industrial network perspective identifies three layers of business networks, identifying the elements as activities, resources or actors, all with specific characteristics and implications for the connections within each of the three network layers. Hence, the first step in this study is the separate investigation of activity intermediation, resource intermediation and actor intermediation. A 'snapshot' of the business reality at a particular point in time reveals one specific situation of intermediation. A snapshot at another point in time would reveal another situation. Thus, intermediation can be accomplished in various ways. Comparison of different intermediation situations provides an enhanced understanding of intermediation characteristics and the interrelations among elements.

For analytical reasons, it is useful to separate activities, resource and actors although, in reality, these three are closely intertwined. Thus, an intermediation situation in one network layer is related to all three network layers. Therefore, the second step in the study then follows, and examines intermediation in terms of the interplay among the network layers. These two steps of analysis enable scrutiny of intermediation with regard to the interrelations among elements - activities, resources and actors - through the direct and indirect connections via an intermediate element - one activity, one resource or one actor. The overall aim of this thesis is to provide an extended view on the role of intermediation in business networks with regard to activities and resources as connecting elements, to balance and contribute to the prevailing focus on actors as connecting elements.

1.5 STRUCTURE OF THE THESIS

This section describes the structure of the thesis as a guide for the reader. The introductory chapter sets the scene for the study by describing the phenomenon of intermediation including theoretical and practical notions. The choice of using an industrial network perspective is argued for, including what this theoretical lens provides. These discussions provide the general framing for the thesis. Chapter 2 presents the analytical framework with regard to business networks and the three layers of activities, resources and actors. The sections in this chapter identify concepts for analysis of activity intermediation, resource intermediation and actor intermediation, and identify the research issues. Chapter 3 describes some methodological considerations related to the study. Thus, this chapter discusses the research process, the research methodology and the quality of the study.

The empirical part of the thesis includes three examples from the Swedish construction industry. Each example is followed by an analysis of the intermediation in one of the three layers to which the respective part of the analytical framework is applied. Chapter 4 describes the supply of building materials to a building contractor, SweCon. This is analysed in Chapter 5 with regard to the three situations of activity intermediation, which are also compared. The subject of Chapter 6 is the second empirical example regarding materials handling and a firm, ConSite Logistics which specializes in these operations. The subsequent Chapter 7 analyses this example through the identification of two situations of resource intermediation and concludes by comparing them and identifying differences. Chapter 8 describes the third empirical example which illustrates the various approaches used by a building contractor in relation to its suppliers. Chapter 9 analyses this example with regard to actor intermediation in two situations, and ends with a comparison of these two situations.

To complement the analyses of the three respective network layers, Chapter 10 analyses the interplay among network layers. Three types of interplay are analysed in relation to the three empirical examples. This contributes to an enhanced understanding of the impact of intermediation in business networks. The thesis concludes in Chapter 11 which provides a discussion that includes three themes regarding the role of intermediation based on the analyses in the previous chapters. Chapter 11 finishes with final remarks about the study and suggestions for future research.

2 ANALYTICAL FRAMEWORK

This chapter presents the analytical framework, containing the specific concepts and models required to analyse and understand the research problem explored in this thesis. First, the industrial network approach, and primarily, the Activity-Resource-Actor (ARA) model is introduced. Second, the activity layer in business networks is presented to identify concepts for analysis of activity intermediation. This section ends with the research issues related to activity intermediation. Third, the resource layer in business networks is scrutinized to provide concepts relevant for an analysis of resource intermediation. Research issues in resource intermediation are identified. Finally, the focus moves to the actor layer of business networks. In line with the structure outlined in the activity and resource layers, this section presents concepts related to actor intermediation that lead to the research issues within this area.

2.1 THE INDUSTRIAL NETWORK APPROACH

The industrial network approach - and primarily the ARA-model - captures the three layers of activities, resources and actors and how they are connected (e.g. Håkansson, 1987) (Figure 2.1).

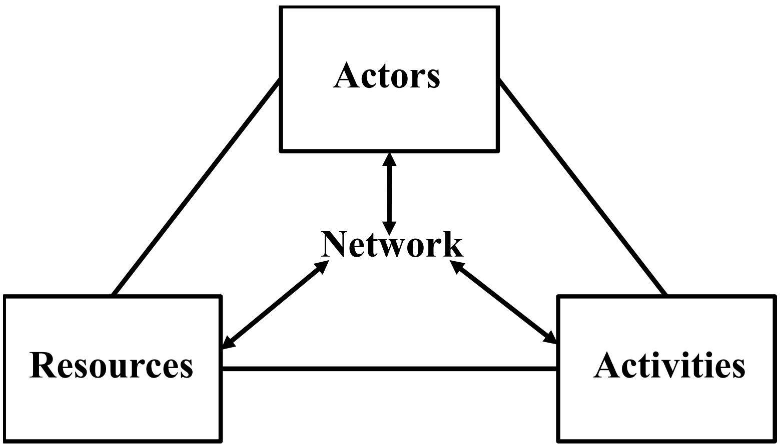


Figure 2.1 The ARA-model (Adapted from: Håkansson, 1987).

The three layers in the ARA-model capture the intricate connections between activities and resources, and their subsequent impact on the actor structure. Actors become connected through relationships based on their efforts to make adjustment between activities, and adapt resources in order to create effective processes. Thus, the content of a business relationship can be described in terms activity links, resource ties, and actor bonds. The functions of such a relationship are not limited to that specific relationship; functions must be considered for the individual firm, the relationship, and the network (several connected relationships). Also, the three layers of activities, resources and actors cannot be considered in isolation – they are connected.

Within business networks, interaction is perceived to be the central coordination mechanism (Håkansson, 1982). According to Håkansson et al. (2009, p. 31) "interaction is a process that occurs between companies over time and gains all its content from the two parties, but which develops in a way that is not fully controlled by either of the two or, the two together". So, interaction affects what each firm contributes to and receives from others and also affects the firms themselves and their activities and resources. The content of a business relationship in terms of activity links, resource ties and actor bonds is the outcome of these interaction processes. The section on the actor layer explores interaction in more detail. However, the focus in the next section is on the activity layer of business networks.

2.2 THE ACTIVITY LAYER

The activity layer concerns what is done in business networks. Numerous activities are undertaken to produce goods, provide services, transport, procure and sell, and organize and coordinate operations. The activity layer is characterized by the interdependence of these activities which are never undertaken in isolation: activities are interdependent and, thus, the execution and outcome of one activity is dependent on other activities (Håkansson et al., 2009). These, activities affect each other because they are parts of intricate activity patterns stretching across the boundaries of firms in the business landscape.

Interdependencies evolve from firms' efforts to improve the performance of individual activities, and how these activities function together. The interrelation between their interdependencies and adjustments are the prerequisites for performance (Håkansson et al., 2009). These interdependencies arise from adjustments undertaken to improve the efficiency and effectiveness of activities (Dubois et al., 2004), and the adjustments between activities allow for the handling of interdependencies. By adjusting two activities in relation to each other, the joint performance of the two is improved. At the same time, this mutual adjustment increases the interdependencies among the activities, which must be handled. Also, while the adjustments might improve the joint functionality of the activities involved, this fine-tuning for a particular purpose can make one or both of the activities less useful in relation to other interrelated activities. Changing and adjusting interdependencies with regard to certain activities thus impact on other activities and their interrelation. In addition, a single activity and its interrelations with other activities are affected by what takes place at a particular point in time. However, these conditions have evolved from earlier activities; thus, a current situation characterized by interrelations among activities has a history that affects outcomes, and will affect what can be achieved in the future. Hence, a current situation entails particular characteristics of interdependencies and adjustments, but has its roots in previous situations and will affect future achievements.

Therefore, the efficient undertaking of an individual activity and the functionality among activities are dependent on the connections to other activities. The discussion above shows that these connections can be described as interdependencies. Hence, interdependencies and their features provide the 'glue' between activities and define the interrelation among activities. In what follows, various types of interdependencies are discussed.

2.2.1 INTERDEPENDENCIES AMONG ACTIVITIES

The mutual dependencies in relationships have been addressed in many studies of business networks (see e.g. Håkansson and Snehota, 1995). Håkansson et al. (2009) define three types of interdependence in business networks: serial interdependence, dyadic interdependence and joint interdependence (Figure 2.2). Each of these three types has its own particular influence on the configurations of activities.

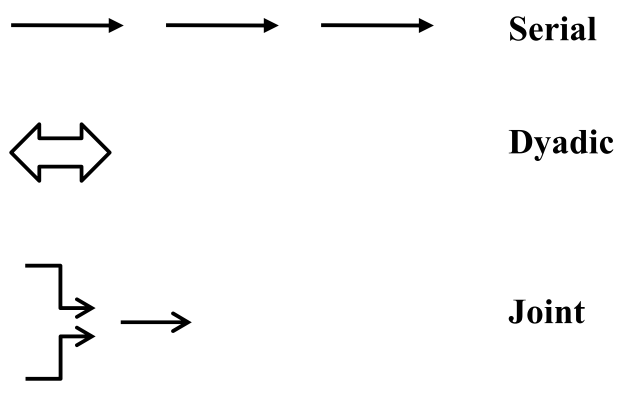


Figure 2.2 Types of interdependencies (Adapted from: Håkansson et al., 2009).

Serial interdependence implies that activities have to be undertaken in a predetermined order and in a step-wise manner. Thus, a specific activity is based on previous activities, and will lead to further activities. This serial relatedness extends across firms' boundaries. For instance, activities undertaken by one firm in terms of manufacturing are serially interdependent with the distribution activities of another firm, to provide what has been manufactured to customers. For example, in order to provide a customer with a new PC a number of activities have to be undertaken, in a particular order: component manufacturing – assembling – warehousing – transportation to customers – installation. Owing to the existence of serial interdependence, the activities need to be coordinated. Reliance on more or less standardized activities allows a degree of coordination of serial interdependence to be planned for.

Dyadic interdependence is present when two activities are specifically adjusted to each other, thus where "the output from one activity serves as the input for the other activity and vice versa" (Håkansson et al., 2009, p.106). The execution of these activities includes mutual adjustments that define their undertaking in a specific manner. Such adjustments require substantial interaction and information sharing in order to coordinate the activities. The individualization and customization of offerings in general are characterized by mutual adjustments of activities, which results in dyadic interdependence.

When the performance of one activity is dependent on another activity because both are related to a common third activity, joint interdependence is present. For instance, the activities of two firms that supply the assembly line of a car manufacturer are jointly interdependent, since both these activities are related to the car manufacturer's operations. If one of the suppliers experiences problems then both assembly line activities and the activities of the other supplier are affected. Joint interdependence can be handled through rules, routines and standards since standardization demands that an individual activity is carried out in a way that is consistent with how other activities are undertaken. When companies focus on one limited part in an activity pattern, i.e. there is enhanced specialization among firms, joint interdependence is further amplified. This disintegration of the activity pattern requires extensive coordination and integration to make the final activity arrangement function collectively. Thus, individual activities must be coordinated such that the configuration of activities leads to a valuable solution.

The three types of interdependencies, serial, dyadic and joint, are present simultaneously in patterns of activities. Each exerts its own particular influence on what can be accomplished in the activity layer of the business network. Accordingly, any activity is serially related to other activities since each single activity always comes between other activities. Dyadic interdependence is present owing to the adjustment of activities to each other. Similarly, joint interdependence is always present because a single activity influences other activities while at the same time being influenced by these other activities. When adjustments commence in order to improve the performance of activities, this simultaneously creates interdependencies of various kinds. This leads to the need for further adjustments to handle these interdependencies, and these adjustments in turn lead to a new situation of interdependence that needs to be handled. Consequently, over time activities become increasingly interconnected and fine-tuned in relation to other activities (Håkansson et al., 2009).

Adjustments undertaken to handle interdependencies and to improve current conditions, may also 'lock in' activities in a certain pattern. For example, adjustments of administrative routines for ordering, stock levels, planned production and other information can improve the functional economic performance of these activities. However, these adjustments require investment in a joint information exchange system among various firms. This investment is costly and can require the firms to 'stick to the system' for a long period of time to pay off the investment. Thus, activities involved in administrative routines must continue for a period of time and be compatible with the system. These activities become 'locked in' in an activity pattern that 'works' in combination with the system.

2.2.2 INTERMEDIATION AND INTERDEPENDENCE

The interdependencies among activities are crucial for intermediation. The various forms of interdependencies are based on different logics of intermediation with regard to how activities interrelate, and the outcome of this interrelation. Intermediation in the activity layer concerns *how* an intermediate activity connects other activities, directly and indirectly. Owing to serial interdependence among activities, the intermediate activity connects serially related activities carried out in a specific order. Accordingly, in Figure 2.3 intermediate activity D connects activity C and activity E in a direct manner. The way in which activity D is conducted affects the two other activities, at the same time as they affect activity D, since "the execution and outcome of any activity is dependent on other activities" (Håkansson et al., 2009, p. 96). Moreover, how activity D is undertaken and connects activities C and E will have indirect effects on activities A, B, F and G and vice versa. Also, owing to interdependence, activities A, B, F and G affect activity D and activities C and E.

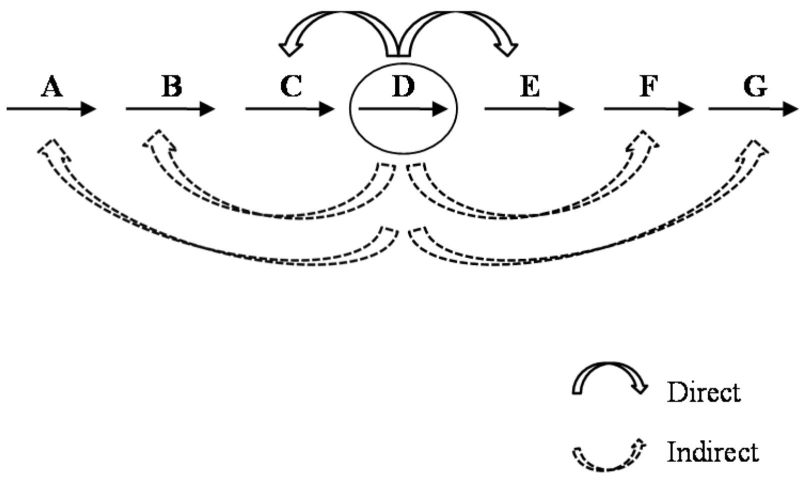


Figure 2.3 Intermediation among serially related activities.

Figure 2.3 depicts a particular activity configuration that involves activity A to activity G. An activity configuration comprises the activities involved in the creation of a particular product or service. Thus, a configuration is a subset of the overall activity pattern, and each configuration entails particular interrelations among the activities with regard to interdependencies. Thus, activities A to G are involved in the creation of a certain product or service. However, activities in a specific configuration do not exist as part of a one-dimensional chain or channel. Instead, each single activity is likely to be a junction intersecting a number of activity configurations. Hence, a single activity can be part of several activity configurations. For instance, in Figure 2.4 intermediate activity D connects activities C and E (parts of the activity configuration A-G) at the same time as activity D connects activities c and e (parts of the activity configuration a-g). Activity D is thus involved in the intermediation among several activity configurations, which, in theory, can be an infinite number from a_n to g_n (Figure 2.4). Together these activity configurations form a huge pattern of activities.

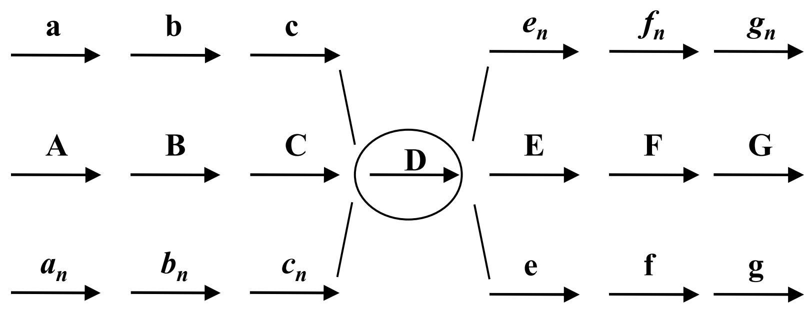


Figure 2.4 Intermediation of several activity configurations.

Accordingly, several configurations of activities become connected through the mutual sharing of an activity (activity D in Figure 2.4). Each configuration brings specific requirements to this activity in terms of how it should be performed. A single activity is thus involved in the interplay with numerous other interrelated activities, within and between various activity configurations. Thus, activities are interdependent. What is identified in an activity intermediation situation through a 'snapshot' of the business landscape involves numerous adjustments and interdependencies that impact on the performance of the involved activities.

Thus, interdependencies are crucial for activity intermediation. By considering the interdependencies among activities, the conditions for activity intermediation in terms of how one intermediate activity connects other activities are revealed. Particular types of interdependencies and a variety of adjustments, within and between configurations, affect the performance of individual activities and the overall function of activities. Therefore, activity intermediation involves complex interplay between operational performance, activity adjustments and interdependence among activities. Gadde et al. (2010) argue that performance enhancement of activities can be accomplished in two ways. First, the efficiency in the undertaking of single activities can be improved. Secondly, coordination of all the activities involved in an activity configuration can be enhanced. Both these efforts of performance enhancement have an impact on activity intermediation. The next section proposes concepts related to the analysis of activity intermediation with regard to activity performance.

2.2.3 CONCEPTS FOR ANALYSIS OF ACTIVITY INTERMEDIATION

Analysis of activity intermediation requires concepts that capture the interdependencies and adjustments among activities. Dubois (1998) and Dubois et al. (1999) draw on Richardson's (1972) work to analyse interdependencies among activities. Gadde et al. (2010) apply these conceptual tools in a framework used to analyse serial, dyadic and joint interdependence. Along these lines, similarity/diversity and complementarity/close complementarity are further explored.

Similarity and Diversity

Efficiency in the undertaking of a single activity is driven primarily by the ability to benefit from economies of scale. This type of efficiency is affected by the particular conditions of intermediation – in Figure 2.4, the characteristics of activity D and the connections will impact on the efficiency of activities C and E. The main influence of activity D concerns the opportunities to undertake activity D in the same way in activity configuration A-E and activity configuration a-e. Accordingly, efficiency in the undertaking of activity D is increased if D can be carried out in the same way in several activity configurations ranging from a_n to g_n in Figure 2.4. The concept that applies to this type of analysis is *similarity* (Richardson, 1972). Two activities (such as D in the two configurations in the example above) are similar if they require the same resources for their undertaking (Richardson, 1972). Similarity among activities applies to all types of resources, for example, assembling carried out in machineries, planning conducted by personnel organizational capabilities, and transportation in a vehicle.

Standardization enables similarity among activities. Through standardization enhanced similarity can be obtained, which makes it possible to gain from economies of scale in operations (Gadde et al., 2010). Standardization and similarity thus exploit joint interdependence among activities: the activities can be undertaken on a larger scale resulting in cost advantages from the increased similarity. However, the output of such activities is a standardized product. In other words, standardization and increased similarity among activities reduces the opportunities for customization.

Therefore, the call for increased similarity and economies of scale must be balanced against the advantages of customization and diversity (Håkansson et al., 2009). While joint interdependence is exploited through similarity among activities, *diversity* relates to dyadic interdependence, which can be handled through mutual adjustments among activities. Through these adjustments, diversity can be obtained in the activity configuration in order to cope with demands from counterparts regarding individual product features. However, diversity is costly since handling joint interdependence can be problematic, implying less opportunity to benefit from the exploitation of similarity in the undertaking of an activity.

A classic example of the clash between similarity and diversity is the 1920s mass production in the Ford factory. This arrangement was the outcome of efforts to exploit similarities in production to the highest extent. This limited diversity and Henry Ford claimed that: 'Any customer can have a car painted any colour that he wants so long as it is black'. The factory production activities could not cope with customization according to individual customers' desires. Similarity and diversity thus relate to the efficiency in undertaking a single activity. The analysis of efficient activity configurations also involves the integration of single activities in a total activity configuration, which is addressed next.

Complementarity and Close Complementarity

While similarity and diversity stem from how dyadic and joint interdependencies are handled, serial interdependence relates to the coordination of activities in a coherent configuration. Also, in this case, the particular intermediation of activities affects the outcome. In the exploration of serial relatedness and coordination, complementarity and close complementarity are useful conceptual tools (Richardson, 1972).

Activities that represent different steps in a process, and have to be undertaken in a specific order, are identified as *complementary* activities (Richardson, 1972). This serial interdependence puts specific constraints on the integration of separate activities into a total activity configuration. In addition, in some way or another, these activities need to be coordinated.

Serial interdependence is further strengthened if the relatedness of two activities implies that undertaking the first demands a specific succeeding activity. In this case, *close complementarity* is present, which relates to the undertaking of activities to provide customization (Richardson, 1972). Figure 2.5 depicts an example. Activities A-D result in a standardized product, while the undertaking of activity E provides a customized feature of the product. Thus, E and succeeding activities F and G, are directed towards a specific end-customer. Activities A-D are complementary, whereas activities E-G are not only complementary but are closely complementary. Consequently, once an activity leads to specific end-customer features, its output is useful only in relation to this end-customer. In this case, there is close complementarity among this specific activity and succeeding activities, since close complementarity implies that there is a need to "match not the aggregate output of a general-purpose input with the aggregate output for which it is needed but of particular activities" (Richardson, 1972, p. 889).

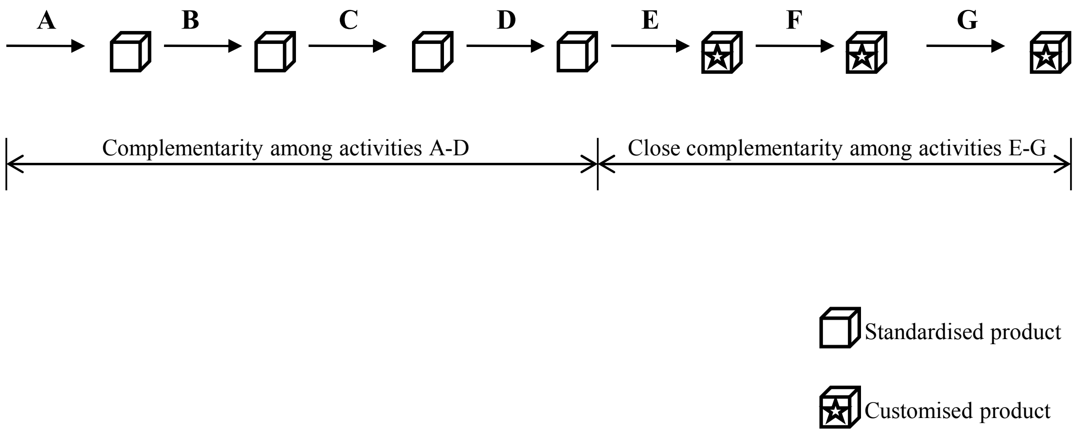


Figure 2.5 Complementarity and close complementarity among activities.

In the example in Figure 2.5 close complementary with regard to specific end-customer and product features go hand in hand. However, close complementarity with regard to a specific end-customer and to product features can also differ in an activity configuration. In this case, the two types of close complementarity, specific end-customer and product features, exist at various points in the activity configuration. For example, within an activity configuration, at one point a standardized product is transported to a specific end-customer. This implies that the transportation activity and succeeding activities are closely complementary with regard to this end-customer. However, this customer, through additional production activities, will provide the standardized product with adapted features to create a customized product. Thus, starting with these production activities, succeeding activities are closely complementary with regard to product features. Consequently, in this example, close complementarity with regard to the specific end-customer and with regard to specific product features occurs at different 'points' in the activity configuration.

Richardson (1972, p. 890) points out that "It is clear that complementary activities have to be coordinated both quantitatively and qualitatively". Thus, among activities, output volume as well as product characteristics must match. Activity configurations involving closely complementary activities need even more extensive coordination, since the activities are undertaken for a specific user. Coordination in this case involves either consolidation of activities within an organization, or close co-operation among "two or more independent organizations agree to match their related plans in advance" (Richardson, 1972, p. 890).

Hence, activity configurations are characterized by specific mixtures of similarity/diversity and complementarity/close complementarity. The location of the two points of close complementarity in an activity configuration is central for the efficiency of the configuration (Dubois, 1998). These two points require the matching of the particular activities and the specific outcome of these activities, to a particular end-customer. Thus, the efficiency with which these activities are undertaken relies on the combined effects of similarity and diversity, or standardization and customization (Håkansson et al., 2009). Speculation and postponement are two principles of activity configurations that can be identified in relation to the discussion of standardization and customization.

Postponement and Speculation

Postponement and speculation relate to activity configurations with different levels of complementarity. The principle of postponement was proposed by Alderson (1950) as a way to reduce marketing costs. The cost related to risk and uncertainty is tied to differentiation of goods; postponing changes to form and identity to the latest possible point in the marketing flow results in cost savings. Thus, the producer delays final completion of its offering to as close as possible to the time of purchase. The most extreme form of postponement occurs when the activities related to an offering are undertaken only when a specific order is received. Originally, the 'finished product' was taken as the point of departure in a discussion of various forms of postponement, which meant it was addressed mostly in terms of time and place (van Hoek, 2001). The offering had already obtained its final physical features.

Zinn and Bowersox (1988) proposed the notion of form postponement and the endowment with final features at various points along the process. In the case of postponement, there are no inventory buffers between the various activities, which increase the interdependencies among activities and require increased coordination (Ford et al., 2003). Accordingly, in such a configuration adjustments are made among the activities undertaken to cope with diversity, leading to close complementarity.

In contrast, the principle of speculation relies on expectation of demand and creation of standardized offerings. This allows the benefits of economies of scale in activity configurations. Speculation thus relies on a different logic for reducing various types of costs than postponement (Bucklin, 1965). Customers' choices are restricted, and inventories at various locations make the offerings available to customers (Ford et al., 2003). These inventories act as buffers to cope with fluctuations in demand, and are the result of exploiting similarities in activity configurations by undertaking standardized activities, while at the same time reducing opportunities for customization.

Hence, the principles of speculation and postponement feature diverse levels of complementarity in activity configurations. In addition, these approaches exploit similarity and diversity differently. Postponement favours customization through the exploitation of diversity while speculation implies advantages through standardization related to the utilization of similarities among activities. Combinations of postponement, speculation, customization and standardization provide numerous opportunities for activity intermediation (Lampel and Mintzberg, 1996; Håkansson et al., 2009). In other words, intermediation in terms of how an intermediate activity connects other activities, directly and indirectly, can be accomplished in various ways. In practice, intermediation in the activity layer, and in specific activity configurations, is also continuously changing.

2.2.4 RESEARCH ISSUES IN ACTIVITY INTERMEDIATION

The previous section provided concepts for analysing activity intermediation. Activity intermediation refers to how a specific intermediate activity connects other activities, directly and indirectly. A single activity affects other activities at the same time as it is affected by other activities since all activities are interdependent in various ways. The notion of interdependencies points to the importance of the connections among activities since it is these connections that enable and restrict what can be achieved in activity intermediation. The handling of these interdependencies is critical for the efficiency of single activities and overall functionality among activities. Interdependence is analysed by examining the conditions of complementarity, close complementarity, similarity, diversity, postponement and speculation among activities.

A snapshot of business reality identifies a specific intermediation situation. This snapshot reveals the specific interrelations among activities which dictate what can be accomplished with regard to the combined effects of similarity/diversity, complementarity/close complementarity and postponement/speculation. Moreover, at that point in time, the activity intermediation situation is characterized by a specific division of labour regarding how the activities are allocated among actors. In other words, by 'taking a snapshot', the features and consequences of a specific activity intermediation situation can be recognized including the conditions for individual activities, the functioning of the overall activity configuration, and the distribution of the activities among actors.

However, it is only through a snapshot intermediation reveals itself as being static. Activity configurations are continuously altered through the fine-tuning of and adjustments of activities. These modifications result in a new intermediation situation featuring new conditions with regard to similarity/diversity, complementarity/close complementarity and postponement/speculation. Comparison of these intermediation situations enhances understanding of the central characteristics of activity intermediation. Comparison of activity intermediation situations captures the consequences of various forms of activity intermediation.

An investigation of activity intermediation situations requires a mapping of activity configurations. Relevant comparisons require some characteristics of the situations to be constant. The concept of activity configuration is useful since it includes all the activities involved in the creation of a specific service or product. Following from the discussion above, modifications of intermediation situations result in new configurations with new characteristics; however, these alternative intermediation situations still result in the same specific service or product. Thus, comparison of intermediation situations entails investigation of the various interrelations among activities to provide a specific product or service. The first research issue related to the activity layer covers how to describe and visualize the intermediation situations.

In addition, the intermediation situations feature different conditions regarding interdependencies among activities. These conditions affect the performance of individual activities as well as the functioning of the overall activity configuration. In line with already identified analytical concepts for activity intermediation, the second research issue examines the features and consequences of activity intermediation with regard to similarity/diversity, complementarity/close complementarity, and postponement/speculation.

2.3 THE RESOURCE LAYER

The resource layer involves all resources that are needed to undertake activities. Thus, the resource layer covers how to achieve something in business networks through the combining of numerous resources: for example, materials, vehicles, financial resources, personnel and business partners. The main characteristic of the resource layer is that the value of a resource depends on its connections other resources (Håkansson et al., 2009). This follows from the assumption of resource heterogeneity: the value of a resource is not given, and a resource has economic value only when it is useful in combination with other resources. (ibid.). Penrose (1959) argued that the value of resources is dependent on the services they can render. Thus, the usefulness of a resource depends on how it is used in combination with other resources, within single contexts of firms, and between firms. What is central for a firm is how other firms perceive its resources and how they can be used and combined with these other firms' resources. In this way, it is important that resources in combination provide value and are recognized as useful. Any one resource exists in a number of combinations and contexts (Håkansson et al., 2009). Hence, the same resource must fit within various combinations in relation to specific counterparts. Each combination has its own logic, which can bring contradictory requirements of the resource shared between combinations.

These conditions emphasize the importance of the connections between resources. The form of connection between any two resources is identified as the 'interface' between them, and the value of each resource is dependent on its interfaces with other resources (Håkansson et al., 2009). Resources in combination entail numerous interfaces, and the performance of a single resource in relation to other specific resources can be improved by adapting resources to each other. At the same time, such adaptations may result in one or several resources fitting less well in other combinations. Hence, adaptations to suit certain combinations might restrict the usefulness of resources in other resource combinations.

The combining of resources implies that resources and their interfaces change over time owing to various combinations, thus, resources are continuously developed. Through their interfaces the resources have been adapted to fit particular constellations, but over time new combinations will require other features to be exploited via new interfaces and new interface characteristics. Hence, a resource is embedded in multiple contexts that evolve over time. The next section examines interfaces in more depth, including aspects of resource combining in multiple contexts.

2.3.1 Interfaces among resources

Resources take various forms. Håkansson and Snehota (1995) differentiate between tangible resources such as manufacturing plants, production lines, products and the people involved in operations, and intangible resources for example know-how, capabilities, skills and brands. Haythornthwaite (1996) acknowledges information, social support and influence as important intangible resources and technical facilities, manpower, financial resources and materials as tangible resources. A resource can be physical such as a factory, machinery or a product. Organizational resources include resources used for control, coordination and communication and a wide range of human resources, i.e. those resources required for the intricate and complex organizing of physical resources.

Several studies of resources (see e.g. Håkansson and Waluszewski, 2002; Gressetwold, 2004; Jahre et al., 2006) classify resources into physical and organizational resources. Both types are crucial for resource combining and resource utilization. From this perspective, physical resources are represented by plants, production machinery, vehicles, information systems, equipment and products. However, physical resource combinations do not develop automatically, they require organizational resources: “Resource combining and resource utilization call for organizational resources…, within and between firms. The knowledge and competence required for resource combining is generated and refined through these interaction processes and is thus embedded into the resource combination" (Gadde and Håkansson, 2008, p. 36). The reference to 'within and between firms' in this quote highlights organizational resources as being not only firms, firm units and individuals, but also the relationships among them. Hence, organizational resources encompass firms, parts of firms, and several firms together, in the resource combining efforts to utilize resources and obtain various combinations that create value. Thus, organizational resources include business relationships, which are crucial since resource combining efforts often cross the boundaries of firms. By connecting the resources of two or several firms, business relationships can improve organizational efficiency and contribute to innovation and development (Gadde and Håkansson, 2008).

Resources are connected via interfaces. Jahre et al. (2006) distinguish between three types of interfaces: interfaces between physical resources, interfaces between organizational resources, and 'mixed interfaces' between physical and organizational resources. Several studies apply the '4R-model' (Håkansson and Waluszewski, 2002) to scrutinize the interplay among interfaces for resource development. These studies emphasize 'mixed interfaces', that is the interfaces between physical resources (products and facilities) and organizational resources (business units and business relationships) (e.g. Baraldi, 2003; Wedin, 2001).

In addition, interfaces vary in their characteristics of being standardized or adapted. Standardized interfaces imply standardized utilization of resources, exploiting only standardized features in the combining of resources (Gadde et al., 2010). For example, a supplier can provide standardized products to a variety of customers. Through adaptation, some of the features of the single resource are modified, and these adaptations – technical, logistical or administrative – affect the content of the interfaces (Håkansson et al., 2009). Thus, adapted interfaces allow improvement to the joint performance of resources since their interfaces fit better. The important notion of standardized and adapted interfaces is developed further in the section on 'Resource utilization'.

Hence, interfaces arise out of various resource combining efforts in multiple contexts. The resource contexts of internal-external, and produce-use are explored next.

Combining Internal Resources with External Resources

A single firm can be interpreted as a resource entity consisting of numerous resources (e.g. Penrose, 1959). Thus, "the features of the firm in terms of its specialties and performance are explained by the ways it has been able to integrate and exploit its internal resource set-up for the provision of products and services" (Gadde et al., 2010, p. 61). Accordingly, every firm is unique in terms of its resource base, and these internal resources are controlled by the firm due to their location within the firm's ownership boundary. In most cases, this resource base has been built up over many years, and is continuously developing through attempts of combine resources in new ways. However, the integration of resources into a coherent product or service, and exploitation of the internal resource base, are not isolated and not confined within the firm. The interfaces of these resources with resources external to the firm may have formed the resources to a greater extent. Thus, external resources are as important as internal resources to a firm, and the interfaces between internal and external resources are crucial. Thus, it is important to consider a firm and its internal resources not as isolated entities but as parts of a larger resource constellation crossing the firm's borders (Håkansson and Snehota, 1995). Several studies show the importance of combining interfaces among various types of resources across firm boundaries in order to create positive economic outcomes (see e.g. Håkansson and Waluszewski, 2002 for a summary). Therefore, business relationships are crucial resources because they inherit the boundary crossing interfaces among firms.

In the combining of resources, utilization of internal resources is crucial, and includes the composition of internal resources and their development in comparison with what might be gained from the alternative use of external resources (Gadde et al., 2010). For instance, a firm can have the resources in house for its production operations, but under some conditions, the outsourcing of these operations to a supplier might be beneficial, i.e. it might be advantageous to exploit external resources rather than internal ones. Thus, in the combining internal and external resources, the division of labour among the parties is important, including how products and services are created through combinations of resources in these structures

Combining the Resource Use and Produce Contexts

In addition to interfaces in resource combining of internal and external contexts, resources have interfaces with their produce and use contexts (Håkansson et al, 2009; Gadde et al., 2010). All resources are 'double-faced' in nature (Håkansson and Waluszewski, 2002) since they originate from a produce context, but are for use in another context. Each of these contexts brings in its own requirements, and the resources need to function in both these environments and, therefore, a critical issue in relation to interfaces and resource combining is connecting the use and produce sides (Håkansson and Snehota, 1995; Harrison and Waluszewski, 2008). This is not unproblematic since "what is efficient and effective on the produce side is not always beneficial on the use side and vice versa" (Gadde et al., 2010, p. 64). For instance, large-scale operations are often beneficial for the produce side, but might constrain opportunities for individualization in relation to specific use contexts. In some situations the joint efforts of the two firms are not sufficient to connect the produce and use sides. For example, Skarp (2006) shows how other resources in the forms of organizations must be mobilised in the matching process involved in steel produced by one actor being adapted to the use context of a large customer. Thus, the organization mobilized provides the essential interfaces between the steel producer and the customer to provide the required adaptation. This leads to the connecting function of resources, that is, how one resource connects other resources in resource intermediation.

2.3.2 INTERMEDIATION AND INTERFACES

Intermediation in the resource layer concerns *how* an intermediate resource connects other resources, directly and indirectly. Figure 2.6 illustrates how the intermediate resource R1 connects other resources R2, R3, R4 and R5 (in theory, up to an infinite number, R_n).

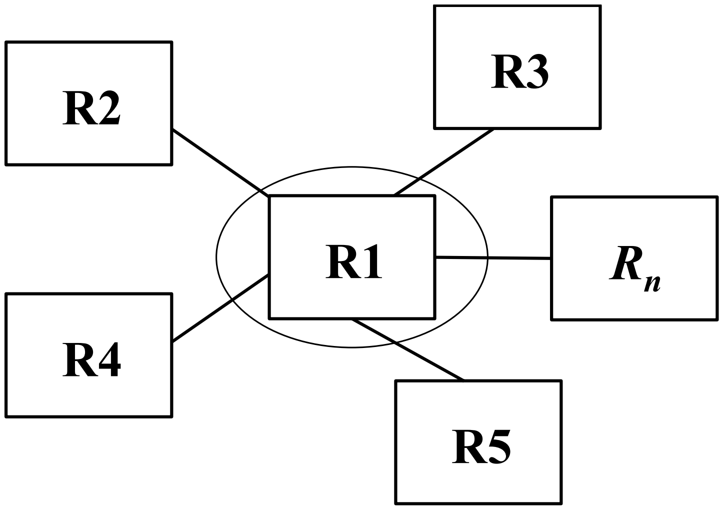


Figure 2.6 Intermediation among resources.

Resource intermediation is highly significant in the business reality since it affects how resource heterogeneity is exploited. The value of a resource is dependent on its interfaces with other resources (Håkansson et al., 2009). Hence, intermediation in relation to other resources determines the value of an individual resource and, also, how useful the combination of resources is in relation to a specific outcome of the combination.

Each single resource is likely to be a junction intersecting a number of resource combinations. Figure 2.6 shows only the direct interfaces between the intermediate resource R1 and the other resources. However, each resource, for example R2 in Figure 2.6 also has interfaces to other resources since it is part of other resource combinations. This is illustrated in Figure 2.7: R2's interfaces to those other resources affect resource intermediation with regard to R1 and its identified interfaces, while at the same time resource intermediation through R1 affects R2 and the other resources in that combination. This signifies the importance of indirect interfaces among resources, which affect what can be gained from specific combinations of directly connected resources.

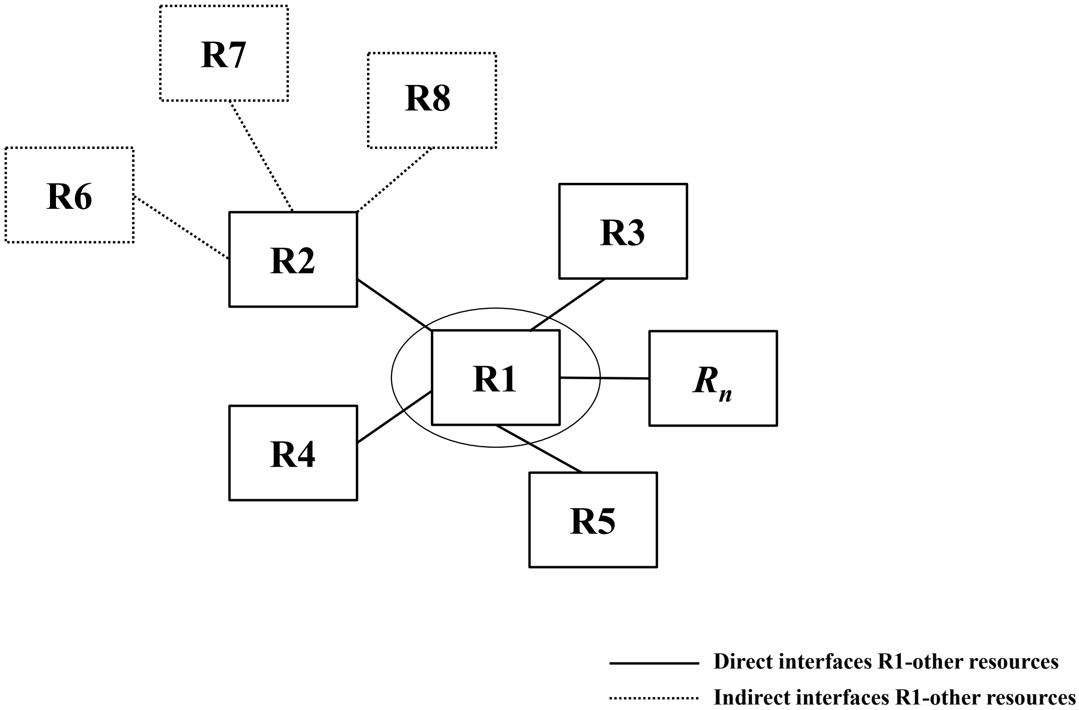


Figure 2.7 Resource intermediation: indirect interfaces.

Thus, the physical and functional aspects of the numerous resource interfaces have to function together. By adapting resources, the performance of a single resource in relation to other specific resources can be improved (Håkansson et al., 2009). Thus, adaptations improve the joint performance of two resources since their interfaces fit better. For example (Figure 2.7), the more R1 and R2 are adapted, the better they function in relation to each other, and the more the value of each is enhanced. However, through these adaptations, R1 may function less well in relation to R3, since the features of R1 have been adapted to R2, which does not correlate well with the interface between R1 and R3. In addition, R2 might function less well in relation to combinations with resources R6, R7 and R8. Therefore, the value of a resource is dependent on its direct interfaces to certain resources and on indirect interfaces to other resources.

A snapshot of the business reality identifies a specific resource intermediation situation, with certain characteristics of resource interfaces. Thus, the effects of previous combinations of resources are visible in specific resource features and resource interfaces. The features and interfaces strongly influence how each resource can be used. For instance, adaptations change some of the features of a single resource, and these adaptations – technical, logistical or administrative – change the content of the interfaces among the resources. This forms the usefulness of the specific resource combination, and enables and restricts future combinations of the involved resources. Thus, every resource and the way it is used is a product of its history (Håkansson et al., 2009), and the way resources are combined determines the evolvement over time of the features of the resources. Any modification of a resource will affect its value and have positive and negative effects. These effects have different impacts on various resource combinations and the economic outcomes of the various actors (Gadde et al., 2010).

Thus, the features of a particular resource and the features of a constellation of resources in a particular intermediation situation are determined through the interfaces. These resources have certain 'behaviours' and performance, based on their interrelation. Time and effort have been devoted to making these resources function together in that constellation. This functionality refers to the technical and physical aspects of products, components and machinery, as well as the capabilities, competence and knowledge of the people involved. Since there are so many interfaces to consider they can never be designed to form a 'perfect match', and there will always be reasons to develop them further. As soon as some interfaces are altered there will be effects on others. Changes in a single resource affect the multitude of the interfaces in the larger resource constellation. Hence, alteration that is perceived beneficial in some aspect may have negative impacts on other aspects. For example, a car door is designed with new hinges that improves the opening and closing mechanism of the door. However, the tools in the car production plant cannot be used for the new hinges which cause problems related to assembly. Accordingly, something 'new' is always introduced into an established context and resource constellations developed for certain purposes. While the 'new' might provide gains in some aspects, it may have positive or negative consequences for other resources.

Hence, resource intermediation is central to the business landscape since the features of a particular resource and the value of a resource are determined through the way it is combined with other resources. Adaptations can improve the joint performance of resources, but at the same time these adaptations might reduce the usefulness of the single resource in combination with other resources. The next section proposes concepts for the analysis of resource intermediation.

2.3.3 CONCEPTS FOR ANALYSIS OF RESOURCE INTERMEDIATION

Analysis of resource intermediation requires investigation of the many interfaces among resources which connect resources and affect resource utilization. Jahre et al., (2006) and Gadde et al. (2010) identify three types of interfaces depending on the types of resources being combined (Figure 2.8)

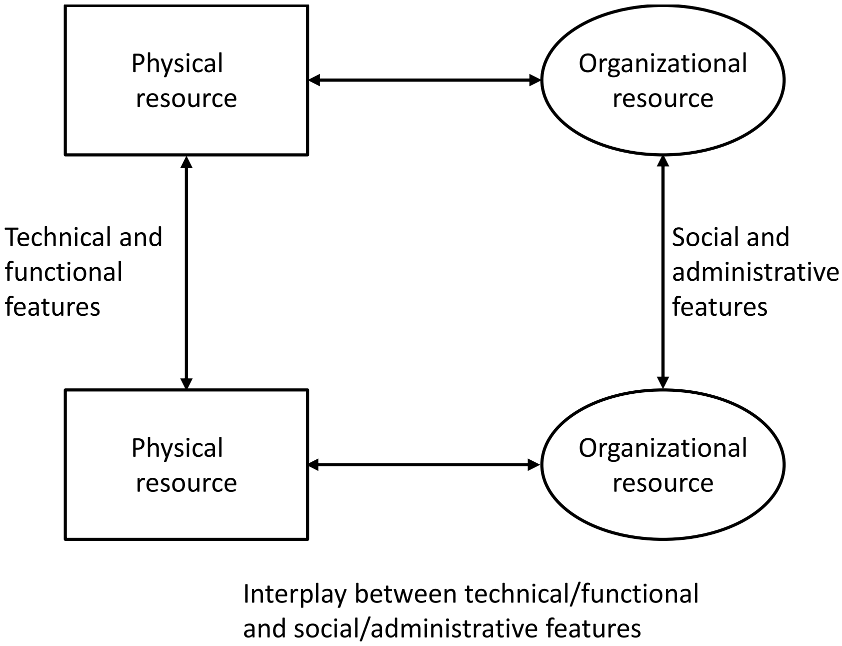


Figure 2.8 Interfaces between physical and organizational resources (Source: Gadde et al., 2010).

Interfaces between physical resources are characterized mainly by technical and functional features. These interfaces are important for the efficient utilization of resources, and impose constraints as well as providing opportunities for future resource development. While the interfaces between physical resources are mainly technical conditioned, interfaces between organizational resources are primarily characterized by social, organizational and administrative features. Thus, interfaces between organizational resources, among other things, capture how learning and competence within firms, and at different firms, are related.

Interfaces between physical resources do not develop automatically; organizational aspects are always involved in the combining of physical resources and their interfaces. Thus, 'mixed interfaces' between physical and organizational resources exist. 'Mixed interfaces' involve complex combinations of technical/functional features and social/administrative issues and tend to be more complex and more difficult to analyse (Jahre et al., 2006; Gadde and Håkansson, 2008). Indeed, "the investments made in physical resources would be useless if not supplemented by heavy investments in the resources required for the complex and intricate organizing of these physical resources" (Jahre et al., 2006, p. 214). These heavy investments in organizational resources capture the resources of single organizations and business relationships involving resources across firm boundaries in various resource constellations.

Regardless of the type of resource and how it is classified, all resources are affected by previous combinations. Thus, every resource exists as an outcome of previous combinations while also being the basis for future combining efforts (Gadde et al., 2010). In other words, organizational resources and physical resources evolve together and influence each other in numerous ways. Each resource interface has its own history and characteristics, which may constrain the possibilities to create other interfaces. Changes in the set of resources and interfaces tend to stem from mixed interfaces (i.e. those between organizational and physical resources) since they are crucial for economizing, i.e. the ability to achieve performance enhancement: "Each interface between physical and organizational resources has an economic content and these economic conditions are important determinants of interaction" (Jahre et al., 2006, p. 221). In many cases it is to change the economic content of an interface that is the main reason for a specific combining. Thus, efforts to combine resources within and between organizations are strongly determined by economic logic.

Resource Utilization

The various interfaces among resources affect the utilization of these resources. In investigating resource utilization, the assumption of heterogeneity of resources becomes central: the value of a resource is never a fixed parameter. Rather, the value of a resource is created through the combining with other resources (Håkansson et al., 2009). Thus, intermediation with regard to how an intermediate resource connects other resources determines the value of the individual resources. When the conditions for resource intermediation change, the value of the single resource may change as a result of new features, interfaces and combinations. There are always possibilities to utilize resources in different ways or in different settings.

Because resources are heterogeneous they can always be used in new combinations while exploiting their heterogeneity. In relation to resource utilization the scope and capacity of a physical resource are important issues. Each individual resource has a certain scope of abilities, i.e. the range across which it can be exploited. For instance, a milling cutter has a large scope of abilities because it can be used for numerous operations related to mechanical processing, whereas a specialized tool has a limited scope of abilities because it has been developed for one operation related to mechanical processing. The scope of abilities is related to the features of the resource at a given point in time; however, over time and in new combinations it may change.

Each physical resource has a certain capacity in terms of output quantity, for example, volume and speed. However, scope and capacity of resource utilization is determined by resource intermediation. The interfaces affect how heterogeneity is exploited and, thus, what is utilized with regard to scope of abilities and capacity. Standardized interfaces imply that a specific resource is utilized in a standardized way that enables combination only with resources that demand standardized 'value' at that point in time. The more standardized the utilization, the greater the economies of scale and the better the economic performance or, alternatively, the greater will be the similarity of the activities relying on the resource. However, standardized utilization of resources for a specific purpose in one context often requires adaptations for other contexts. Alternatively, exploiting resource heterogeneity through adaptations in regard to other specific resources means economies of scale are reduced, but considerable value is generated through differentiation. Thus, customization can be achieved by satisfying individual demands from various customers through adapted utilization of resources.

The form of intermediation affects the value of a resource which, in turn, affects the other resources it is combined with. These other resources will have certain prerequisites and restrictions regarding resource combining with this resource through their connections to other resources. Versatility refers to the ability of a resource to be utilized in different combinations with other resources (Holmen, 2001). The interfaces affect how versatility can be exploited, which, in turn, depends on the adaptations of resources. Accordingly, the exploitation of resource R1 in Figure 2.6 can be done without adaptations so that resources R2-R5 exploit R1 in a standardized way leading to low versatility in the exploitation of the resource. That is, resource utilization is carried out in a standardized way. Alternatively, the exploitation of resource R1 can involve adaptations to some of the resources R2-R5, or to all of them, leading to differentiated exploitation and, thus, increased versatility in resource utilization. The versatility of a resource relates to the exploitation of standardized or adapted interfaces with regard to utilization based on standardization or adaptation. In other words, intermediation in relation to how an intermediate resource combines other resources can be accomplished in various ways, with various conditions for resource utilization and opportunities for resource combining.

2.3.4 RESEARCH ISSUES IN RESOURCE INTERMEDIATION

Intermediation in the resource layer covers how a specific intermediate resource connects other resources. These resources interrelate through numerous interfaces in resource combinations within firms and across firms' ownership boundaries. Therefore, at one point in time, resources are distributed among various actors in a certain way. A snapshot of a particular resource intermediation situation identifies specific conditions for resource utilization with regard to various interfaces.

In line with the principle outlined with regard to activity intermediation, resource intermediation is in flux owing to modifications of existing resource constellations. Resource constellations are in continuous evolvement through resource combining efforts. The modifications result in new intermediation situations featuring new conditions with regard to resource utilization and interfaces. Comparison of these intermediation situations increases understanding of the central characteristics of resource intermediation. Comparison of resource intermediation situations captures the consequences of various forms of resource intermediation.

The exploration of resource intermediation situations requires mapping resource combinations. To enable comparison, some characteristics of these situations must be constant. It is useful to base the comparison on a specific resource involved in resource combining, with regard to the same context. Following from the discussion above, modification of intermediation situations results in new resource combinations with new features, however, these alternative intermediation situations still occur within the same context. Thus, comparison of intermediation situations entails exploration of the various interrelations among resources in relation to a specific resource in a specific context. This refers to the first research issue related to the resource layer: how to describe and visualize the intermediation situations.

The intermediation situations are characterized by different conditions regarding the interfaces among resources. These circumstances affect resource utilization. Consistent with the identified analytical concepts for resource intermediation, the second research issue is related to examination of the features and consequences of resource intermediation regarding: 1) physical and organizational resources and their interfaces; 2) resource utilization with regard to capacity, scope and versatility.

2.4 THE ACTOR LAYER

The actor layer covers whoever is involved in business networks. Actors control resources and undertake activities, and the coordination of activities and combining of resources require the involvement of actors. It is the actors that fuse these resources and activities into meaningful entities, within and across firms' boundaries. In this sense, actors bring life into business networks. Actors have intentions based on their knowledge of resources, activities and other actors, and how they perceive their evolvement over time and their location in the business network (Håkansson et al., 2009). Hence, the features of the actor layer determine what can be achieved in the other two layers of activities and resources.

The actor layer is multidimensional since an actor is defined by others: what is perceived to be the actor is determined by the specific situation. Thus, an actor can be an individual, a firm, a department or a firm function, a project group or even a constellation of firms. The notions of actor and actor identity are based on the perceptions of other actors. The multidimensional aspects of the actor layer have implications for how firms, as entities with ownership boundaries, interrelate, and how actors as individuals, people, come together. The notion of individuals introduces social behavioural aspects including the importance of inter-personal exchange and trust-building and commitment (e.g. Ford, 1980: Huemer, 1998).

A significant aspect of the actor layer is that no actor is isolated from any others (e.g. Håkansson and Snehota, 1995; Håkansson and Snehota, 2006): "Anything an actor does to accomplish something is based on direct contributions from others and, directly and indirectly, affects many other actors" (Gadde et al., 2010, p.106).

Consequently, the connections, the relationships, among firms are crucial. Through these relationships, actors identify opportunities for resource combining and activity coordination across firm boundaries (Håkansson et al., 2009). A key issue in relationships is interaction, which is a process that occurs between actors, and affects the involved resources and activities as well as the actors themselves (Håkansson et al., 2009). The nature of interaction has important consequences for the structure of the business landscape and the processes within it. Thus, a specific situation involves particular interactions between the involved actors, and the nature and content of the interactions and their evolvement over time affect what can be achieved in the business landscape (Ford et al., 2003). In addition, since business relationships among various actors are interrelated, features of interaction in one relationship between any two parties affect and are affected by interaction in other relationships. Exchange in one relationship is, thus, conditioned by exchange in another relationship (Johansson and Mattsson, 1992).

In this sense, the business landscape is an arena where actors are involved in interactions, and performance rests on these interaction processes. In other words, it is the interaction among actors that creates 'the action' in business networks. The next section further investigates interaction among actors.

2.4.1 INTERACTION AMONG ACTORS

Interaction can occur in a variety of forms. It can involve exchange of a standardized product that just happens once and requires very little involvement of the two business actors, or it can be related to very complex, joint efforts requiring extensive cooperation over many years between the parties.

Håkansson et al. (2009) conceptualize interaction with regard to how actors relate in space and time. Through market exchange products, services or money are exchanged between two actors without any significant intervention in the process. The actors are connected via the exchange mechanism, for the time of the exchange. This type of exchange is an isolated event. Although it may take place several times between the same two actors, the actors prefer to consider such exchanges as isolated events. Market exchange involving actor A and B is illustrated in Figure 2.9.

Figure 2.9 Market exchange (Source: Håkansson et al., 2009).

Other situations are characterized by more complex processes, which involve more than just the exchange and result in transformations. In such cases, the interaction process between the two actors extends over time and its content and direction are not fully controlled by any of the actors. The interaction affects what each actor contributes and receives from the other, and also affects the respective actors' activities and resources. Figure 2.10 illustrates this type of business interaction.

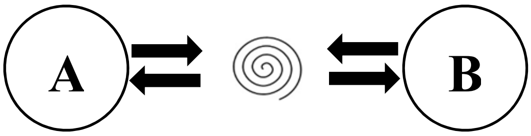


Figure 2.10 Business interaction (Source: Håkansson et al., 2009).

The spiral in Figure 2.10 represents interaction as a process over time that occurs between actor A and actor B; the arrows to A and B from the interaction spiral represent the outcomes for A and B of what emerges from the interaction. The arrows from A and B to the spiral represent the A's and B's approach to the interaction, which might follow a clear strategy or intent, or be unconsidered. These approaches can relate to a single episode of interaction with regard to products, services, deliveries, adaptations and payments as the result of the interaction.

Actors can choose to handle a current episode of interaction as isolated from past and future. In this case, the actors miss opportunities for learning stemming from investments in previous episodes. Thus, at a specific point in time, the interaction among two actors deals with a particular issue, and this episode of interaction follows its own logic. However, this interaction is not isolated in time: what has happened before and expectations regarding future interactions affect the current interaction. Over time, the effects of business interactions accumulate. Thus, interaction can be considered a process of investment, and time provides the conditions for learning, adaptation and developing the interaction further. Figure 2.11 depicts interaction and time.

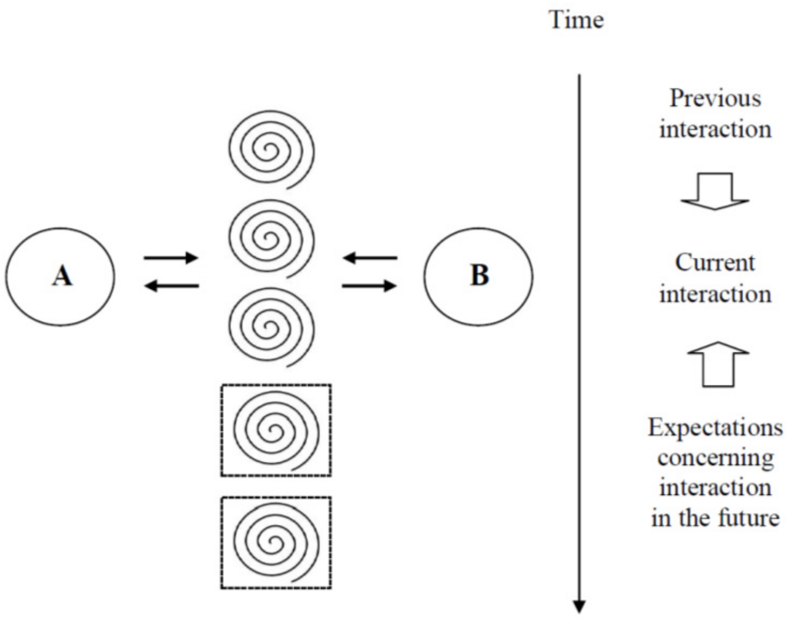


Figure 2.11 Interaction and time (Source: Håkansson et al., 2009).

The interaction episode is not isolated and the actors seldom interact with only one actor. Interaction takes place in several parallel processes continuous over time in which the two actors are involved. Interaction between any two actors hence interrelates with other interaction processes (Figure 2.12).

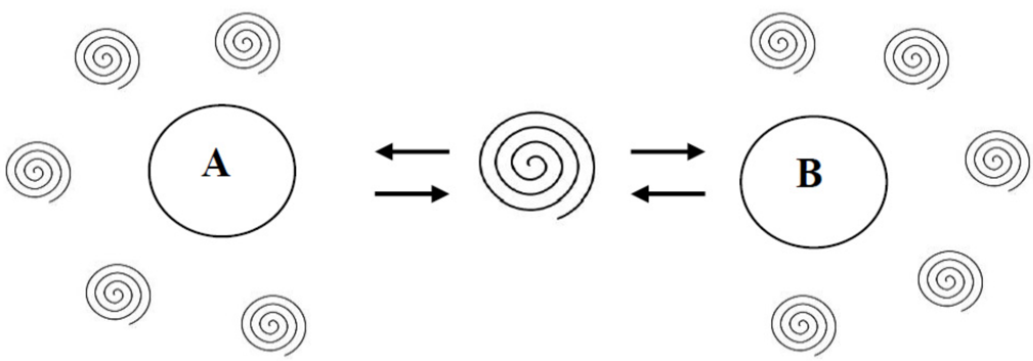


Figure 2.12 Interaction in space (Source: Håkansson et al., 2009).

Figure 2.12 shows that actors A and B are both involved in interaction processes in addition to the one between them. The interaction between them both affects and is affected by what occurs in these other interactions. The above discussion shows that single interaction episodes are related in time and space to other interaction episodes and other interactions.

Actors can choose to see an interaction episode as isolated; this choice affects the approach employed, and the outcome and benefit of the interaction. On the other hand, actors can see interaction as embedded in time and space: episodes are related and the various interactions affect each other. This affects other approaches to interaction and the outcomes of the interaction compared to if the interaction is perceived as isolated.

2.4.2 INTERMEDIATION AND INTERACTION

The interactions among actors are crucial for intermediation. Interactions provide for the coordination of activities and combining of resources among actors and, thus, how the various actors perceive and handle interaction has a profound impact on intermediation. Intermediation in the actor layer includes how an intermediate actor connects other actors, directly and indirectly. Figure 2.13 shows how the intermediate actor A1 connects other actors A2, A3, A4, A5 and A6 (up to an infinite number, A_n, in theory). In addition, all these actors are involved in interactions with other parties to which the intermediate actor A1 is indirectly connected (e.g. actors A7 and A8 in Figure 2.13).

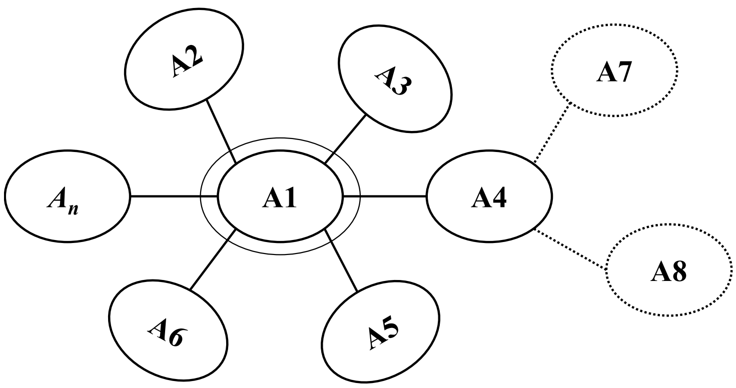


Figure 2.13 Intermediation among actors.

In line with the discussion above, actor A1 in Figure 2.13 is involved in simultaneously interactions with actors A2-A6, with the result that these interactions are interrelated. In addition, other interactions, represented by A4-A7 and A4-A8, affect and are affected by these interactions through the involvement of A1. Thus, at a specific point in time a particular intermediation situation can be identified, with certain characteristics related to who is involved and the interaction among the parties. This identification includes the nature and content of the interaction among the actors, including episodes in time with regard to previous interactions whose traces can be found in the current situation. In addition, expectations about the future are somehow mirrored in this intermediations situation since; they may or may not affect the various actors' intentions.

It is important to note that a particular actor intermediation situation can entail various features of interaction. The interaction between A1 and A2, for instance, can take place only one time showing the feature of isolated interaction, while the interaction between A1 and A3 might have a long history with continuous involvement of both parties showing features of joint efforts of development. Moreover, a snapshot of the situation at another point in time could reveal other interaction characteristics. There is enormous variation in interaction and actor intermediation.

Actor intermediation affects what can be achieved regarding the coordination of activities and the combining of resources. Thus, actors interact to achieve something in relation to activities and resources. The interaction takes place in relationships, which are crucial for these achievements because they facilitate the connecting of internal firm activities, resources and actors with the activities, resources and actors of other firms. Analysis of interaction in actor intermediation should consider three central issues. First, interaction features affect many aspects of the relationships. Actor intermediation that captures the interrelation among actors involves features of interaction that impact, in turn, on the characteristics of relationships. Features of interaction are related to both what is being exchanged and the type of exchange - isolated or continuous. Interaction is also featured by an atmosphere with various parameters related to collaboration and confrontation, and potential mutual orientation developed over time. Second, the level of involvement between business partners is important to conceptualize interaction with regard to actor intermediation. The various approaches applied by the actors are related to their involvement which, in turn, affects how activities are coordinated, resources are combined, and the interaction among individuals. Third, actor intermediation involves the organization of business arrangements. Actors have to organize internally and, in addition, organization arrangements need to provide for coordination of the internal and external, that is, the relationships in which the actor is involved. The next section examines concepts related to actor intermediation to analyse the features of interaction, relationship involvement and organizational arrangements.

2.4.3 CONCEPTS FOR ANALYSIS OF ACTOR INTERMEDIATION

In line with previous discussion three issues are identified as central for an analysis of activity intermediation: features of interaction, relationship involvement and, organizational arrangements. These concepts are discussed in more detail below.

Features of Interaction

Actor intermediation entails features of interaction in relation to *standardized or individualized type of exchanges*. Interaction is also characterized by the conditions of *type of exchange as isolated episodes or continuous interaction*. Together these features provide for various forms of actor intermediation. A standardized type of exchange that occurs as an isolated episode (i.e. it takes place only once, or is treated by the actors as isolated although some previous interactions might have occurred) entail features of 'market exchange' (Gadde et al., 2010). One example is tendering procedures where there is a strong focus on price. This type of exchange requires standardization since efficiency is achieved through price pressure and competition among the actors. In this sense, interaction involves 'shopping around' among many actors. However, standardized type exchange can also involve more continuous interaction. In this case, the interactions occur repeatedly, often in accordance with planned routines since regularity enables routines. The example of tendering procedures can also include these features if, for instance, previous performance is taken into account in the tender process. Consequently, although the content may be standardized in terms of what is being exchanged, the handling of the tenders may differ and taking account of continuous interaction in individual episodes.

Individualized exchange entail adaptations among the actors, and varying degrees of complexity. These adaptations might refer to deliveries at a specific time or, in the other end of the scale, interaction that extends over many years and involve many resources, activities, and individuals with different problem solving skills. Individualized exchanges can also involve a single interaction episode, for instance, procurement of a complex system or equipment with features that are adapted to a specific actor. Individualization can also take place over a long period of time through continuous interaction and mutual adaptations between the actors.

The *interaction atmosphere* in which interaction takes place is also important for the outcome of the interaction. Actor intermediation is associated with an atmosphere of collaboration including features such as trust and commitment on the one hand, and confrontation including features such as power and conflict on the other hand (Gadde et al., 2010). Through interaction, actors gain knowledge about each other, and knowledge based on experience in current and previous interactions is crucial for learning processes. Based on the outcomes of these experiences actors can develop trust. Trust includes integrity, reliability and confidence in one another's promises (Morgan and Hunt, 1994). Trust can develop into commitment if there is a willingness to commit, which in turn implies a desire to continue the interaction (Johanson and Vahlne, 2009). At the same time, it can be argued that, to be perceived as trustworthy, actors need to commit through investment in the relationship (Gadde et al., 2010). The collaborative features of trust and commitment are important for handling the tensions that can arise in relationships where actors have conflicting interests. There is potential for conflict in all interactions. The impact of this potential depends on how influencing ambitions are or are not implemented, which, in turn, relates to how power is applied.

Interaction in business relationships can over time lead to *mutual orientation* between the two actors (Ford et al., 2003). Actors become knowledgeable about the conditions on 'the other side' of the firm ownership boundary, and decision-making in cooperating firms may increasingly also considers the other side. Mutual orientation requires shared interest in the activity and resource aspects of the relationship (Håkansson and Snehota, 1995). In many cases actors tend to become more involved over time through intense interaction, formal development programmes, organizational adjustments and joint coordination of activities and combining of resources. This mutual orientation significantly affects long-term development of both parties.

Relationship Involvement

Features of interaction affect and are affected by relationship involvement. Thus, the level of involvement between business partners is important to conceptualize interaction with regard to actor intermediation. Involvement spans a continuum from close arrangements with extensive level of involvement to distant arrangements with limited level of involvement (Gadde et al., 2010). Gadde and Snehota (2000) distinguish among three dimensions of involvement that affect the outcome of relationships: coordination of activities, adaptation among resources, and interaction among individuals. Thus, the level of involvement is related to activity links, resource ties and actor bonds among firms. Activities can be more or less tightly coordinated, resources more or less specifically adapted, and individuals in the firms can interact more or less intensively (ibid.). These characteristics also interact: close interaction creates learning and knowledge about the other actor with effects on commitment and trust, and makes choices more interdependent. This affects coordination and adaptation. At the same time, there is large variation regarding links, ties and bonds, and some relationships ‘score’ high for all three dimensions of coordination, adaptation and interaction while others score high for only one or two dimensions. Related to the level of involvement is the number of actors involved in intermediation since extensive involvement is very resource demanding. Hence, the number of involved actors will affect the content of the interaction and the types of relationships that can be established between various actors.

Close arrangements and extensive levels of involvement in business relationships are identified as *high-involvement relationships* (Gadde and Snehota, 2000). These relationships are characterized by extensive activity links, resource ties or actor bonds. Actors typically are involved in business transactions over a long period of time; hence, these high-involvement relationships are characterized by longevity (Ford et al., 2003). The main reason for this longevity is the adaptations made by the parties to improve their joint performance (Anderson et al., 1994): “Adaptations are central for the efficient and effective combining of the resources on the two sides of the relationship, which in turn makes possible efficiency enhancements in the undertaking of activities within and between companies.” (Gadde and Dubois, 2010, p. 256). However, adaptations not only improve performance, they also induce interdependence. In fact, firms cannot escape interdependence when aiming for the potential advantage of high-involvement relationships, since it is through strong couplings that the firm is able to benefit from access to the resources of a specific counterpart (Håkansson et al., 2009).

The main rationale for high involvement is to achieve cost benefits in terms of reduced costs in production and materials flows, and improved service levels. It is possible also to take advantage of the other actors' skills and capabilities to improve the quality of internal products or services, which provides revenue benefits. However, high-involvement relationships are very costly. Reaping these benefits often requires non-standardized solutions with substantial coordination and adaptation among the parties. Hence, high-involvement relationships are associated with an investment logic.

Low-involvement relationships are characterized by weak activity links, minimized resource ties and limited actor bonds. These relationships are handled with limited coordination, adaptation and interaction costs. In general, the content of the relationship is standardized, which is a prerequisite for reaping the benefits of this type of approach, which requires that no actor becomes too dependent on another actor. One benefit is reduction in transaction uncertainty: reliance on several actors on arms-length distance allows switching among them if there is uncertainty regarding a transaction (Gadde et al., 2010). Also, actors avoid being locked into a specific relationship with regard to, for instance, a technology provided by a supplier. If an actor is too dependent on this technology, problems can arise if the supplier redevelops the technology in favour of another actor. An approach of low-involvement among actors encourages competition among actors, for instance, playing off suppliers with regard to price. In other words, low-involvement arms-length relationships help to reduce dependence on a particular actor or actors.

A low-involvement relationship is potentially cost effective and involves low relationship handling costs. It can also affect direct procurement costs positively by stimulating price competition. At the same time, splitting orders across multiple actors decreases the volume of each individual order and reduces the opportunity for volume discounts. However, although low involvement relationships may be perceived cost efficient there may be substantial hidden costs related to adapting internal resource or creating buffers to protect against potential delivery problems due to lack of close coordination (Gadde et al., 2010). In addition, since many relationships are aimed at securing availability and continuity handling costs increase.

In the context of level of involvement it should be noted that the approach is not selected only by one actor. The level of involvement is decided by the interaction between two or several actors based on their respective interests. Thus, one single actor cannot decide upon establishment of a high-involvement relationship. Assessing the merits of the two involvement approaches is not straightforward, and the economic consequences are difficult to trace and quantify (Gadde et al., 2010).

The number of business relationships with which an actor is connected has profound impacts on the features of interaction and level of involvement (Gadde et al, 2010). Resource adaptations and activity adjustments are resource demanding and call for extensive actor bonds, with the result that actors can handle a limited number of such relationships. As the number of relationships increases, an actor's limited time and resources have to be shared within more relationships; this might require the level of involvement to be decreased to enable the handling of multiple relationships.

Organizational Arrangements

It is the task of actors involved in intermediation to arrange for the handling of conditions with regard to interaction features and relationship involvement. Organizational arrangements refer to both the internal organizing of an actor and how to organize for the interrelations among internal and external with regard to activity coordination, resource combining, and interaction among actors across ownership boundaries. Internal organising thus involves what is located within the firm boundary in relation to all connections to other actors.

The formal organization of an actor can have a centralized or decentralized approach or a combination of both, for example, decentralized marketing function and a centralized purchasing function. Another option is to combine these approaches in one function, such as a centralized purchasing department and decentralized purchasing functions, with respective responsibilities. *Centralized organizational arrangements* provide for efficient utilization of internal resources, for instance skills and capability of specialist staff, and enable economies of scale in activities carried out with regard to organizing. Centralization allows the 'gathering' of tasks from various functions, divisions or projects that together can provide beneficial conditions with regard to joint efforts, for example, in price negotiations. Thus, centralized organizational arrangements bring benefits related to interaction among various entities, for example, various projects. *Decentralized organizational arrangements* imply that the individuals most closely involved in the carrying out a task should also be responsible for its organization. As a result, coordination of various entities, such as in the case of simultaneous ongoing projects, is not taken into consideration. In this view, centralization creates too much distance between those responsible for resource acquisition and those using the resources (Gadde et al., 2010). This approach reduces the opportunities for economies of scale that can be achieved through centralization.

Decentralization also means that the individuals involved in the organizing task are less specialized. Thus, a decentralized organizational approach will reduce opportunities to exploit the benefits of collaboration with a particular counterpart. At the same time, it may allow various entities, for instance a division or a project, more opportunity to fit their particular needs.

Thus, organizational arrangements refer to three levels: the organising of functions within the firm, organizing in relation to individual relationships, and organizing in relation to the whole network of relationships with which the actor has connections (Hessel and Gadde, 2013). Organizational arrangements to support internal and external interaction are crucial for actor intermediation. These arrangements are central to efforts to coordinate activities and combine resources since alternative forms of organizing provide specific opportunities in these respects. Organizing efforts can be directed to individual relationships or groups of relationships, such as a group of customers or a group of suppliers.

2.4.4 RESEARCH ISSUES IN ACTOR INTERMEDIATION

Intermediation in the actor layer refers to how one intermediate actor connects other actors. These actors relate to each other through interaction over time, which is a prerequisite for the fusion of activities and resources of various actors to create meaningful solutions. An individual actor is affected by the interaction that takes place, while at the same time this single actor affects other actors through interaction. The notion of interaction between firms highlights the importance of business relationships which facilitate interaction and enable the coordination of activities and the combining of resources. Accordingly, actor intermediation and interaction are analysed by examining the features of interaction, level of involvement and the organizational arrangements.

A snapshot of actor intermediation identifies a particular situation of actor intermediation. This intermediation situation involves how activities and resources are allocated among the actors, and the nature and content of the interaction among actors with regard to their interrelation. Actor intermediation is in continual flux owing to the dynamic content of interaction and the continuous modifications of actors to exploit current conditions. These modifications result in new intermediation situations featuring new conditions of interaction. In line with the principle outlined regarding activity intermediation and resource intermediation, comparison of these intermediation situations enhances understanding with regard to the central features of actor intermediation. Thus, comparison of actor intermediation situations highlights the outcome and consequences of various forms of actor intermediation.

Exploration of actor intermediation requires a mapping of the interrelation among actors. To enable relevant comparison, some characteristics of the situations have to be constant. It seems useful to centre a comparison on a specific actor that is involved in both situations. In addition, the 'outcome' - solution, product or service provided in a certain context in the situations – also needs to be somehow considered the same (although altered achievements provide this outcome). This allows comparison of how something is accomplished through various actor intermediations. Hence, comparison of intermediation situations involves an exploration of the various interrelations among actors within the same context. Consequently, the first research issue related to the actor layer deals with how to describe and visualize intermediation situations.

Intermediation situations are characterized by different conditions regarding the interaction among actors. These conditions affect the interrelation among actors and also how activities are coordinated and how resources are combined. In line with the identified analytical concepts related to actor intermediation, the second research issue refers to the content and consequences of actor intermediation regarding the features of interaction, the level of involvement, and the organizational arrangements.

3 METHODOLOGICAL CONSIDERATIONS

This chapter describes and discusses methodological considerations related to the research process. First, the research context is described. Second, the research process is reflected upon with regard to how the study evolves. Third, the research approach and implications of case studies including a description of systematic combining and casing are discussed. Fourth, the data collection is presented. Finally, the chapter concludes with discussion of the quality of the study

3.1 THE RESEARCH CONTEXT

Through interaction in business relationships, firms become connected, as do business relationships, since what happens in one relationship will affect and be affected by other relationships. Consequently, the business landscape is characterized by interdependence. The theoretical context of this study is grounded in the tradition of the Industrial Marketing and Purchasing (IMP) Group, which approaches marketing, purchasing, technological developments and management from the notion that multidimensional interaction and interdependence are basic features of the business landscape. The research for this thesis was conducted in the Division of Industrial Marketing at Chalmers University of Technology, whose researchers share this approach to business-to-business (B2B) research. The division uses a common conceptual language and shares central concepts and assumptions about the business reality. In addition, most of the conferences and workshops I attended are characterized by the research traditions of the IMP Group. Accordingly, my research was developed in a research context that has an interest in exploring interaction and interdependence.

Within the IMP Group tradition of working, empirically based studies of how firms are doing business and what is created through the interaction between firms and other organizations, are crucial. Empirical observations that did not fit the assumptions in mainstream economic theories provided the germ for the IMP approach. Thus, methodologically the research context to which I belong, takes great pride in conducting studies that generate empirical data that reflect the business reality. My methodological preferences are also in line with case study research, directed by the principles of systematic combining (Dubois and Gadde, 2002). Naturally, my preferences have been inspired by these traditions including assumptions about the business reality, theoretical perspective, and aspects of the methodology and research approach. I believe this is inevitable and natural – 'no man is an island'. In another context, other influences would have affected me and set me in – perhaps -another direction. The interplay between theory, empirical inquiry and research methodology is discussed later in the section on the 'Research approach'. The research process is described below.

3.2 RESEARCH PROCESS

The description of the research process starts with the first study that was presented in my licentiate thesis, and was conducted in the textile and clothing industry. The attention then shifts to the research process in the study of the Swedish construction industry, which is presented in this thesis.

3.2.1 THE FIRST STUDY AND FINDING THE PHENOMENON INTERMEDIATION

When I began the PhD process, I participated in a research project named "Efficiency and Value Creation in Logistics Networks" or LogNet. LogNet was a joint project between the Division of Logistics and Transportation and the Division of Industrial Marketing, to which I belong, at Chalmers University of Technology in Gothenburg.

Over time, I came to focus more and more on one of the firms involved in the LogNet project: the shirt manufacturer SM, and an issue raised by the CEO of SM particularly caught my interest: "Why cannot the suppliers be more flexible in dealing with our orders?" From the perspective of this CEO it would benefit SM if fabric suppliers were more flexible about due dates, quantities and variants, and could adjust more quickly adjust to changes required by SM to adapt to customers' fluctuating demands. These problems emerge because customers of SM demand extensive variations with regard to product types, models, fabrics, quality, colours and patterns, which are combined with short life-cycles and poor forecasting of demand for specific variants. The supply side, on the other hand, is characterized by large capital investments and traditional, batch-based production methods based on achievement of economies of scale, which create very long lead times for various processes such as fabric manufacture.

The LogNet project focus was networks and the connections among the firms in these networks, what these connections provided and what they constrained. Thus, my first PhD student experience thrust me into a research context whose starting point was 'what goes on between firms' rather than 'within individual firms'. Alongside my data collection, I took several courses that focused on inter-organizational issues from various theoretical perspectives and research disciplines: for example, 'Industrial network theory' and 'Business logistics and supply chain management'. These courses introduced me to concepts that I was able to apply to my data analysis, including conference papers written jointly with colleagues in the LogNet project. Here the ARA-model (Håkansson and Snehota, 1995) was brought in and I was able to show, for instance, the importance of the relationship between SM and one of its suppliers since it was through this supplier that SM was linked to the fabric suppliers. In addition, not only were SM and other actors, such as suppliers and customers connected, there were also important connections among their activities and resources. Hence, the actor layer, the activity layer and the resource layer all revealed different important aspects of the interaction.

The second theme I came to focus on was the differences, but also the similarities in the supply networks ending in SM: one vertically integrated, the other specialized firms. This brought me to the literature on different types of structures and the coordination mechanisms. This 'phase' was conducted in parallel with doctoral courses on topics such as the transaction cost approach (TCA) (e.g. Williamson, 1975), and supply chain management (e.g. Handfield and Nichols, 1999). However, by limiting the focus to single transactions or to a channel, I was not able to explain or provide answers to the empirical question posed by SM's CEO of why SM's suppliers could not be more flexible in dealing with SM's orders.

Instead, through focus on the resource dimension of business networks, I realized that 'the answer' to the question related to the joint utilization of resources (for instance, a loom) where the 'supply chains' of different actors became connected. A continuous process of matching theory and the empirical material provided insight into the empirically formulated issue. In addition, during this period, I was introduced to the work of Alderson (1954; 1957; 1965) during a doctoral course. Alderson's (1965, p. 200) thoughts about intermediation and the intermediaries needed to "bring together heterogeneous supply on the one hand and heterogeneous demand on the other", fitted well with the SM case study, and suggested that the phenomenon of intermediation might be interesting to explore further.

However, on reading the literature about intermediation and intermediaries, Alderson's holistic view of intermediation was obliterated; this literature captures only how an intermediary connects firms, thus focusing on how actors interrelate. In my case study, however, a resource such as a loom provided a crucial function for intermediation. I then began to focus on studies of distribution that applied an industrial network approach (see e.g. Gadde 2004; Hulthén and Gadde, 2007; Gadde and Ford 2008). On this basis, my study could contribute to the understanding of intermediation and intermediaries by creating a framework that included activities and resources as a complements to actors. This framework was applied in my licentiate thesis in the analysis of the shirt manufacturer case (Sundquist, 2011), by outlining the principle of 'one activity/resource/actor in the middle and how it connects other activities/resources/actors'. However, it was only in the resource layer that this principle was fully applied to analysis of resource utilization. In the case of activities, the study captures the interdependencies among the structures of activities and actor intermediation considered the actor positions. The main implication is the notion that, from a business network perspective, all actors are intermediaries since all actors are involved in the connections of all the other actors that surround them. The intermediate challenge for SM was clearly a matter of bringing together heterogeneous supply and heterogeneous demand; however, from the established perspective on intermediation and intermediaries this would not have been recognized.

Thus, the licentiate thesis was my first attempt to create a framework to analyse intermediation by applying a business network perspective. The framework was developed based on the notion of heterogeneity in the firm's supply and demand contexts. However, only activities and resources related to production were included in the study. Also, the framework for analysis of intermediation is not applied in a very systematic way, and recognizes intermediation only with regard to one specific situation, thus providing a static view of intermediation. Consequently, the outcome of the study in my progress towards a licentiate degree provided some insight into the phenomenon of intermediation, but left me with curiosity and interest in further research.

The above process has been described in terms of ‘I’ and ‘my’. However, it was by no means an introverted discussion involving me, myself and I. It involved interactions with numerous people, research contexts, empirical settings and theoretical foundations. These interactions took place within the research project LogNet, internal seminars at the Division of Industrial Marketing, at conferences and external seminaries, in doctoral courses with other PhD students and with senior researchers at Chalmers and other universities, during interviews with people in various functions at many firms, and in informal idea sharing settings. The written articles, which were co-authored with other researchers, and my licentiate thesis describe the outcomes of these interactions.

3.2.2 THE RESEARCH PROCESS IN THE STUDY OF THE CONSTRUCTION INDUSTRY

After completing my licentiate thesis I became involved in a research project funded by the Swedish Construction Federation (BI), ‘World class sustainable development in society’ (in Swedish: ‘Hållbart samhällsbyggande i världsklass’). The project’s objective was to examine the Swedish construction industry closely and thoroughly, to identify contemporary challenges, and opportunities and initiatives for improvement. Together with the project leader and researchers around Sweden, seven focus areas were identified, and research groups were formed to focus on these areas, one group for each area in relation to the research interest and previous research. It was hoped that this approach would enable analyses that would challenge common views of the industry as retrogressive. BI representatives also participated in the project which allowed them to contribute with their knowledge and experience in the industry.

I and my two supervisors from the Division of Industrial Marketing formed a research group focusing on ‘Efficient division of labour in the construction network’. Our project aimed to identify construction projects characterized by efficiency gains resulting from changes to division of labour and/or new forms of collaboration distinct from the competitive tendering procedures dominating the industry. One objective was to identify the effects of these changes with regard, for example, to reduce costs, increased performance and improved utilization of resources. The project aimed also to analyse the 'network consequences' of a particular change, that is, how a specific arrangement that results in improvements for one firm affects other firms. A general problem in this context is that improvements that stretch across firm ownership boundaries invariably have a positive impact for some firms but affect others negatively. It was felt that analysis of these 'network consequences' would provide increased understanding of the prerequisites for and barriers to positive effects, for the construction network as a whole rather than individual firms. The theoretical perspective of the industrial network approach identifies aspects of division of labour for to be what is done in terms of activities, who is involved, and what resources are needed to undertake the activities.

In an initial meeting together with the seven research groups the project leader suggested we explore an interesting case of changes to the division of labour. One of the major building contractors in Sweden, SweCon, had established its own factory for producing reinforcement profiles instead of, as previously, purchasing this construction material from the steel distributor, Steel Service. This initiative was also aimed at reducing cutting and bending operations to produce reinforcement profiles, which were taking place on construction sites. I and another researcher from our project group contacted SweCon and interviewed several members of central management at SweCon and at SweCon's reinforcement factory. The interviews and our tour of the factor revealed changes to the division of labour, from cutting and bending on sites and cutting and bending at Steel Service, to cutting and bending in the SweCon factory. It was interesting that, in essence, the cutting and bending process were the same at all three locations, only the scale was different. However, the location of the activity had several implications for other activities, such as transportation of the material to sites and installation of reinforcement on site. Based on these empirical observations and determining how this could be captured analytically, the study began to compare the situations. The cutting and bending was similar in all three situations, but we identified three situations of intermediation that placed these activities 'in the middle' in order to scrutinize the relation with other activities in the various situations. This idea was presented in a paper presented at an IMP conference for researchers interested in business networks, and at a meeting with the other research groups in the project.

Contributing to this re-direction was my focus on the change that resulted in the establishment of the reinforcement factory; I presented a paper on this at the Nordic Workshop of Inter-organizational Research. I took this change as the starting point for my exploration, and tried to map the consequences for the activity layer, the resource layer and the actor layer. However, my empirical material did not reveal those aspects and I did not have much data on ‘changing from something to something else’ as a process of change. Although interesting as a topic, it left me only with the notion that the material at this point in time did not reveal traces of this change that would allow systematic scrutiny. I discussed my dilemma during the conference with other researchers in the field of business networks. The change was there, and it was suggested I might see the change as the ‘background’ against which three situations could be identified, all with different characteristics whose study would be interesting and would show how they differed.

During the meeting with the project group where the case of supply of reinforcement was presented, a researcher from one of the other project groups gave us contact details for a firm that he thought might be of interest to us. The firm, ConSite Logistics, had become a specialist in materials handling operations conducted outside of regular working hours with the result that construction workers no longer had to be involved in these operations. Thus, this was also an example of changes to the division of labour, with elements of specialization. We contacted ConSite Logistics and conducted some initial interviews. During one of these interviews, the quality manager at ConSite Logistics said: “if you are interested in new ways of working in the construction industry and firms that are trying new approaches, you have to meet one of our customers”. This customer, BuildCon, and ConSite Logistics shared an interest in specialization and utilizing the capabilities of suppliers specialized in their fields, as a way to enable more efficient construction processes. A few weeks later, I was able to interview a project coordinator at BuildCon. This was the starting point for a study of alternative forms of collaboration since this firm, for some of its procurement categories, had started to work with dedicated suppliers rather than relying on competitive tendering procedures.

In parallel with the interviews, secondary data were collected to allow further exploration of the situations with regard to supply of reinforcement to SweCon sites, to understand the business of ConSite Logistics and the consequences of collaboration forms between BuildCon and its suppliers. Interviews were conducted with suppliers, at various construction sites, transportation firms, and many more. This process is described in more detail in the section on ‘Data collection’. During this process I began to see the study of ConSite Logistics as separate from the study of BuildCon and, together with the study of reinforcement, this provided me with three ‘sub-cases’ of intermediation in the construction industry. This is explained in more detail in the section on ‘Casing’.

The study of BuildCon and its suppliers was written as an example of ‘partnering’, a phenomenon that has attracted research attention and the attention of construction industry practitioners. However, while partnering mostly involves efforts directed towards the customer side, our study captures the supply side and collaboration between a contractor and suppliers. This investigation: a literature review of work on partnering in the construction industry, and our study of BuildCon resulted in a research report that was published as part of our participation in the project. This report and the reports of other research groups in the project were shared with the Swedish construction industry through the Swedish Construction Federation (BI). Also, as a result of us presenting the study at one of the research project meetings, I was invited to present it at BI’s annual general meeting since it was considered a very interesting study for practitioners in the industry. This presentation was filmed, and I was interviewed following the presentation. The study was later presented at the occasion of the prize-giving ceremony for ‘Best construction project of the year’ (‘Stora samhällsbyggnadspriset’) which is a prestigious award presented annually by the construction industry. I was also invited to present the study at the annual conference of ‘The Swedish Institute of Steel Construction’. All three presentations included discussions with an industry audience who commented and asked questions about the findings from our study.

Towards the end of the research project, the project leader made a compilation of the studies conducted, including our study of BuildCon, which was tailored to the industry and included some practical implications. Based on the BuildCon study, we also wrote a scientific paper that was presented at the IMP conference.

For several reasons, opportunities to present my research have been invaluable. They have made me learn to present to suit different audiences. At conferences and seminars with researchers, some share my theoretical foundation, but others have different perspectives and points of view. Other presentations involved audiences made up of construction industry practitioners with much greater knowledge about the empirical setting. I did my best to adapt to these different contexts in order to communicate my research. Both types of audiences provided important feedback which helped me to develop my understanding and advance my research, empirically and theoretically. In addition, as a PhD student presenting to very large audiences and participating in discussions 'on stage', necessarily improved my presentation skills significantly. They were great experiences!

In the many interactions with people in the construction industry I noticed their interest in my material and the empirical examples and results of analyses using the industrial network approach. This interest was apparent at all levels from 'the CEO to site construction workers. Although these people were not interested in intermediation as a phenomenon, they perceived their work as 'involving intermediation' and we had a common interest in 'how things interrelate', as in intermediation. These various discussions convinced me that intermediation is a central phenomenon in the business landscape.

3.3 RESEARCH APPROACH

This section describes the research approach. First, the choice of a case study approach is explained. All methodologies have links between theory, empirical phenomena and choice of method. The approach of systematic combining in this thesis is explained and justified in the second sub-section. Finally, casing is explained.

3.3.1 USING CASE STUDY

Dubois and Gibbert (2010) emphasize the links between theory, empirical phenomenon and research method. Thus, the choice of case method is linked to the empirical phenomenon, intermediation, and the theoretical field, the industrial network approach, applied in this study (Figure 3.1)

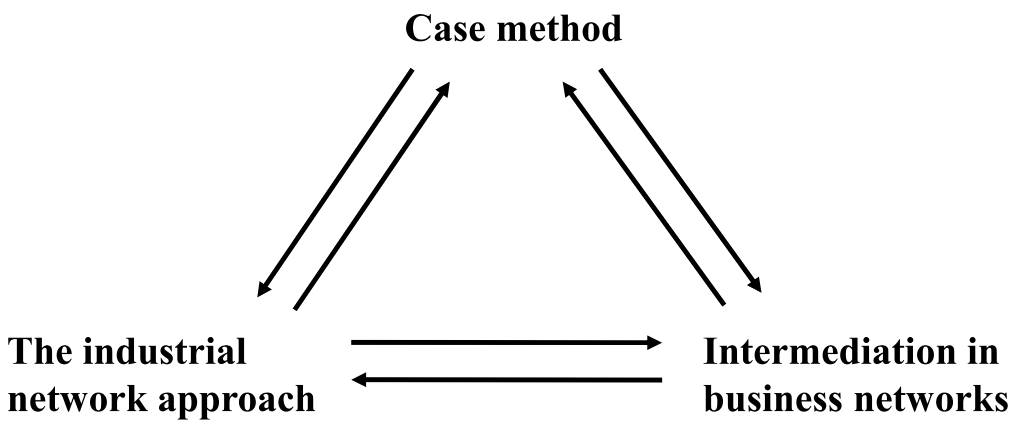


Figure 3.1 Dimensions in this study (Adapted from: Dubois and Gibbert, 2010).

A case study "investigates a contemporary phenomenon in its real-life context" (Yin, 1984, p. 25). This approach is recommended for studies of complex systems and events where broad conceptual frameworks are used (Normann, 1980; Dubois and Gadde, 2014). However, what is perceived to be a case or a case study, and the course of action for undertaking case research, vary among research disciplines, as Piekkari et al. (2010) argue. The main benefits of qualitative approaches are their ability to identify critical issues to address in deep-probing analysis (Knemeyer et al., 2002). Goffin et al., (2012, p. 805) demonstrate that "such approaches produce results that cannot be obtained through quantitative methods". For these reasons, qualitative case studies are frequently used for industrial network research (Dubois and Araujo, 2004).

According to Dubois and Gadde (2002, p. 554) "the interaction between a phenomenon and its context is best understood though in-depth case studies". Halinen and Törnroos (2005, p. 1286) also argue that a case strategy is considered to be the most appropriate method for studying business networks since "it allows the study of a contemporary phenomenon, which is difficult to separate from its context, but necessary to study within it to understand the dynamics involved in the setting". In line with this, Dubois and Gadde (2002, p. 555) state that: "case studies provide unique means of developing theory by utilizing in-depth insights of empirical phenomena and their contexts". Moreover, this method is suggested to be particularly useful when a holistic perspective is needed (Eisenhardt, 1989; Dubois and Araujo, 2007).

In particular, network studies present researchers with challenges since there are no natural, boundaries in a network. There are no guides for what should be included in the study, when the case study is finished, and its direction when 'completed'. However, case study provides opportunities since there are no pre-specified boundaries. Dubois and Araujo (2007, p. 178) state that: "one of the key strengths of the case study is the flexibility concerning the appropriate theoretical and unit of analysis (the case) to explain a particular set of findings. Cases evolve as patterned configurations in interaction with processes taking place in the empirical world and what happens to the researcher's theoretical notions and assumptions during the course of the research". Ragin and Becker (1992) refer to this process as 'casing', which involves making something into a case, and the notion that what the case is about will emerge gradually during the iterative process of theoretical and empirical choices, including reconsiderations of the focus of the case study. This allows the boundary to the study to remain relatively flexible throughout the investigation; boundaries are not fixed until the analysis is completed and written up. The 'casing' in this study is described further after discussion of systematic combining in the next section.

3.3.2 Systematic Combining

The research process is presented in 'story-telling format': the study started somewhere, has achieved certain progress, and concludes by presenting the results or outcome in the form of thesis chapters However, it should be noted that these story lines can only be told in retrospect. When the story begins, no page has yet been written, and progress in terms of content and focus is an ongoing process. I started out with an interest in exploring the phenomenon intermediation in more depth following what was revealed by the textile and clothing industry study. Also, the industrial network approach seemed to be a fruitful way to analyse intermediation, since its core acknowledges the nature and content of connections as crucial in the business landscape, including how various relationships are connected and interrelate. Thus, the industrial network approach was something of a 'given' when I set out on this study of the construction industry. The empirical context was not chosen by me with the aim of studying intermediation, but was an opportunity to do so through my participation in a research project on the industry. I was convinced that case study was my chosen research method, to enable the in-depth insights into intermediation that I was aiming for. In this sense, the 'boxes' of research method, theory and empirical phenomenon (Figure 3.1) were already 'established' when my research process to study the construction industry started. However, *the links* between these boxes were not given, nor were the results and outcomes of the study. What is presented in this thesis is the product, the outcome, of *the interplay* between these boxes along the process, involving continuous fine-tuning. They are thus a result of direction and redirection in iterations between theory and reality. Consequently, the research approach in this study relies on the principles of systematic combining (Dubois and Gadde, 2002).

My research is based on an abductive logic, aimed at discovering new aspects of intermediation with regard to 'what is being connected'. The study aims to provide an extended view on intermediation to contribute to existing research and theories of the phenomenon. The research is not aimed at theory testing or generation of completely new theories. Since this study also entails interplay among the three network layers it should contribute to existing knowledge in industrial network theory that focuses mostly on these layers separately. This way of conducting research can best be described as systematic combining: "a continuous movement between an empirical world and a model world. During this process, the research issues and the analytical framework are successively reoriented when they are confronted with the empirical world" (Dubois and Gadde, 2002, p. 554). In the process of systematic combining, theoretical framework, empirical fieldwork and case analysis evolve simultaneously through continuous 'matching' between theory and reality and 'direction/redirection' of the study (Dubois and Gadde, 2002). For example, in my study this process involves development of a framework to analyse intermediation in the three layers of activities, resources and actors, where content shifts along the way with regard to concepts and models to use for the analysis. When I was focusing on the change 'from something to something else, the framework captured reconfiguring, recombining and repositioning as processes in business networks. When the focus was on 'what is being connected' and the implications of these connections, as this was what my material illustrated, the framework was developed with regard to connections in the three network layers, thus, interdependencies, interfaces and interaction. Consequently, my research aim shifted along with what I was studying in terms of boundaries to what was being studied. This is in line with systematic combining as a continuous matching between theory and reality, making the research aim, its boundaries, context and horizon, outcomes of the research process rather than something that could be decided in advance (Dubois and Araujo, 2007). The argument for systematic combining is that by moving between different research phases and alternating between empirical insight and theory development, the researcher "can expand the understanding of both theory and empirical phenomena" (Dubois and Gadde, 2002, p. 555).

For my licentiate study, the principles of systematic combing made sense: the phenomenon of interest – intermediation in contemporary business networks – was not a decision made beforehand to set the direction for the research process, but something 'discovered' along the way through continuous movement between theory and reality where the direction of the study changed over time. Hence, the evolvement with regard to the study for my licentiate thesis was directed to the phenomenon intermediation as described previously with regard to research process. Also, in the study of the construction industry, iteration between theory and reality revealed the nuances of intermediation in terms of what was being connected. With regard to the construction industry study, the 'matching between theory and reality' is explained later in relation to casing. Along these processes, my understanding of the inherent logic in the theoretical field of business networks in line with the IMP context and what can be revealed by perceiving the empirical world as business networks, also evolved.

3.3.3 CASING AND CASE ANALYSIS IN THIS STUDY

As a consequence of relying on the principle of systematic combining, the case has developed in parallel with the theoretical outline. Accordingly, what are presented in this thesis are the 'final' products of this iteration, both with regard to the case and the analytical framework. The case is, thus, central in case-oriented research (Ragin, 1992), and the case is both a tool and a product (Dubois and Gadde, 2002).

Throughout the research process, I have perceived my empirical material as one case illustrating intermediation in the construction industry. What I have studied is intermediation in the construction industry and, in line with what is presented in this thesis; I distinguish between three sub-cases within this case. As described in the research process, the collection of empirical material started with supply of reinforcement to SweCon. Later, the study of ConSite Logistics directed me to interviews with BuildCon. At first these studies were perceived as 'one study', but at some point in the process I separated them into two separate studies. This re-direction stems from the incentives of studying intermediation in the three dimensions of activities, resources and actors, and the collected data. By no means does my study capture only the firms mentioned above, on the contrary, connections to other firms are crucial for my exploration of intermediation. Thus, the study illustrates intermediation within and across firm ownership boundaries in all three sub-cases.

My three sub-cases are three empirical examples of intermediation, each of which illustrates and focuses on one of the three network layers of activities, resources and actors. All three layers are present in all three examples since, in reality, these layers are closely intertwined. However, the first empirical example of supply of reinforcement to SweCon is structured to illustrate by whom and where cutting and bending is carried out affects several other activities, their performance, how they are connected and, ultimately, their economic efficiency. Three situations are identified: cutting and bending undertaken: 1) on site, 2) at Steel Service, and 3) in SweCon's factory. Thus, in terms of 'what is connected through intermediation', the focus is on activities and entails analysis of how activity intermediation differs in the three situations.

The second empirical example covers materials handling, including ConSite Logistics. The data illustrate that materials handling can be carried out in a traditional way by construction workers or by hiring ConSite Logistics. However, the difference is not so much about what is being carried out in terms of activities; instead, these approaches differ significantly with regard to the resources utilized. Accordingly, this empirical example can be used to analyse resource intermediation, very much in line with my licentiate thesis. However, the study in this thesis analyses the differences regarding the connections between resources, the interfaces, and their impact on resource utilization, with regard also to indirect interfaces. Furthermore, in this example it was not easy to decide upon which resource to place in the middle, as the starting point for scrutinizing resource intermediation. I tried several alternatives; the construction worker, the site, the elevator. Finally, the tower crane seemed the most fruitful resource to place in the middle. Consequently, the analysis reveals different characteristics of resource intermediation depending on how resources are utilized.

The third example illustrates two situations that differ with regard to internal organizing of BuildCon and features of relationships with suppliers. Thus, the material was suitable for exploring actor intermediation. Any of the actors could have been placed in the middle as a starting point for analysis. However, when elaborating with difference choices, it seemed useful to place BuildCon in the middle as the situations where outlined based on their incentives for improvements where efforts on the supply side would, at least aim for, increased performance in building operations and, as a result, provide an attractive option for clients when competing for new projects.

My aim to analyse intermediation in the three network layers naturally directed my data search. However, the data could have been sorted in different ways. I believe that the three empirical examples capture important characteristics of intermediation in the network layers they illustrate and are used for the analysis. The identification of the various situations within each example is also important to increase understanding of the phenomenon and that intermediation can be accomplished in many ways.

My choice of these three empirical examples implies that some of the data collected, for instance, in the interviews with SweCon site managers, ended up in the ConSite Logistics example because they describe materials handling. Also, the tender procedures described by ConSite Logistics were important to include in the BuildCon example. As such, the three examples did not evolve as three parallel 'silos' throughout the study. My perception of the study being one case relies on the fact that in reality all the network layers are closely intertwined, that is, the examples do not only illustrate one layer as such, but focus on one of the layers. However, as sub-cases the empirical examples share the same context of the Swedish construction industry and all capture intermediation, thus, they are part of a case of intermediation in the Swedish construction industry. Nevertheless, it seems reasonable to separate them in order to focus on one of the layers, in line with what they mainly illustrate. I believe also that undertaking an analysis of all three layers in all three examples would not have contributed to an improved understanding of intermediation. Instead, the second step of analysis captures the interplay between the layers, in each example, by starting from the previously defined situations in one of the layers.

The idea outlined in the framework of my licentiate thesis of 'placing one activity/resource/actor in the middle and explore how it connects other activities/resources/actors' is, thus, applied fully in this study. In order to enable comparison it was essential to capture situations that had some constant features, which contributed also to why the situations were identified and illustrated in the way they end up in this thesis. The phenomenon, intermediation, as the notion of how one intermediate element in the middle connects other elements, provides a structure for the analysis by visualizing intermediation.

Another important issue with regard to case analysis is the 'level' of the elements that are included. For example, one transport activity can be divided into more detailed numerous activities, or can be lumped together with other activities to provide a 'higher' level of aggregation. These decisions in the three sub-cases are based on what they intend to illustrate, thus what needs to be explained, together with ability to analyse crucial features of each network layer. These notions also set the boundaries for what is finally presented in the sub-cases in this thesis, for the content of the framework and how the analyses contribute.

3.4 DATA COLLECTION

The case was studied from a network perspective and, since the phenomenon intermediation includes how various elements are connected and how they relate, data collection was directed towards several firms, with an interest in how they interact and are connected. Data collection was dominated by semi-structured interviews (Flick, 2006, Bryman and Bell, 2007). In order to allow for deep understanding of the phenomenon, interaction with people was considered crucial to capture the complex patterns of interaction and the content of the business relationships. Also, semi-structured interviews are necessary to discover unexpected data that can redirect the study. A very general interview guide with questions related to specific topics to be covered was used, but the interviewee was free on how to respond to the questions and in his or her own style. During the interview, additional issues arose which seemed interesting to follow up, which led to additional questions. Thus, in addition to the planned topics, both respondents and interviewers raised other topics. This seems reasonable since it is inevitable that reflections are made upon the data already at the time of the interview (Thompson, 2002). In addition, open questions allow respondents to speak freely which does not limit data collection to aspects of the phenomenon that are identified in advance (Dubois and Gadde, 2002). In this way, this approach generates 'active' data, which enhance research quality compared to 'passive' collection of data through predefined questions (ibid.). Table 3.1 lists the 28 interviews conducted in this study.

Table 3.1 Interviews made.

Organization	Function of interviewee	No. of interviews
SweCon	Central management	1
	Manager reinforcement factory	2
	Site mangers: house or infrastructure projects	4
	Construction workers: specialists reinforcement	2
	Manager pile factory (customer to SweCon factory)	1
	Project manager: house division	1
Steel Service	Manager: construction assortment	1
Transportation firm	Regional manager	1
ConSite Logistics	Quality manager, logistics analysis consultant	1
	Project manager	2
	Logistics manager construction site	1
	Materials handling manager	1
BuildCon	Project co-ordinator	3
	Logistics manager	1
	Site manager	1
The four dedicated suppliers to BuildCon	Manager/sales representative	4
Materials manufacturer	Regional sales manager	1

Interviews lasted between 1.5 hours and 5 hours (including observations, e.g. of production in the reinforcement factory, materials handling at a site). During these interviews, discussions sometimes focused on issues that brought the respondent to share secondary data in the form of presentations, requests for tenders, materials procurement statistics, and other information relevant to the topic. A large amount of secondary data was obtained which contributes significantly to the empirical examples in the case and understanding of the phenomenon in reality. In addition, during observations informal discussions took place with people working in production or transport of materials.

Extensive notes were taken during the interviews and, in some cases; pictures were constructed together with the respondent, to illustrate, for instance, ‘connections to other actors in the network’ or ‘transportation routes for the goods’. The interview information was transcribed directly after each interview. Some interviews involved two interviewers and in these cases their notes were compared during the process of transcribing the interviews. The transcripts became versions of data ‘straight from the written notes’. The interview data were also sorted and structured in another document according to areas of interest, for example, production, order generating, or planning of transportation routes. All the transcripts and these documents with ‘sorted’ notes were coded by the same researcher. However, it should be noted that these interview write ups are not copies or representations of some objective reality; the views and opinions of different respondents all contribute to an understanding of the phenomenon in question, and the researcher also interpret the data through the data collection process. Thus, transcripts are very much interpreted constructs which are useful tools for exploring the aims of our research (Kvale, 1997).

Follow-up interviews were conducted by telephone or email to resolve any confusions or misunderstandings. Some issues that seemed to interesting were followed up and explored further and became the starting point for additional data collection. Thus, the information led to further interviews with the same respondent or interviews with other respondents. In this way, the interview situations affected the direction of study in terms of next steps in the data collection.

Observations, for example, of the manufacturing processes, warehousing operations and outbound logistics, were very important for the study. They enabled visualization of activities and resources and, in particular, the connections between activities and resources, and how they varied among situations within the same empirical example. This enabled the content and impact of a transportation activity, for example, to be reflected. This is crucial for enhancing the central characteristics of intermediation. What is identified and labelled as , for instance, 'transportation activity' at several places in different situations in the analysis is accordingly not the same activities: they are particular versions of a transportation activity with specific substance that affects and is affected by its connections to other activities. As a result, the analysis also involved comparisons among these different 'transportation activities', including their connections to other activities.

This study benefited from good availability of industry data. This was related partly to the fact that the research project was initiated by the Swedish Construction Federation. This provided access to data and many occasions to discuss the empirical material in the study in the context of the industry, with people not directly involved in the study, but with experience in and insights into the Swedish construction industry. There was also a large amount of written information in the form of product brochures, sales presentations, product types, requests for tenders, tenders, drawings, internal documents, sales figures and cost calculations, the strategic plans of industry firms. Finally, there are other studies of some of the involved firms which could be drawn on. For example, in the case of ConSite Logistics several master theses provided costs calculations related to materials handling. These types of studies have added to understanding of the empirical context generally, but also generated issues that were discussed in the interviews.

3.5 QUALITY OF THE STUDY

It can be argued that the quality of a case study is based on whether the case together with the theoretical contribution are convincing to the reader (Dubois and Araujo, 2007). Dubois and Gibbert (2010, p. 134) identify two general characteristics of research quality: "(1) the strengths of the links between the empirical and the theoretical domains, and (2) the extent to which the description of how these links were created, as a result from the interplay between theoretical, empirical and methodological choices, convinces the reader". Hence, the presentation of my case study and the description of the process I went through regarding the case study and its theoretical contribution can be argued to be the most appropriate dimensions to measure the credibility of my study. In line with this, one way to evaluate quality of a study can be to analyse its trustworthiness, which Lincoln and Guba (1985, p. 290) describe as how well the researcher can "persuade his or her audiences (including self) that the findings of an inquiry are worth paying attention to, worth taking account of". Trustworthiness rests on four criteria: credibility, transferability, dependability and conformability, although it is argued that credibility is the most critical for judging the trustworthiness of the study (ibid.). The four criteria of credibility, transferability, dependability and conformability are addressed in turn below.

An important aspect of *credibility* is the amount of time spent in the empirical world "to be certain that the context is thoroughly appreciated and understood (Lincoln and Guba, 1985, p. 302). In my case, study of the construction industry continued for two-and-a-half years. During this period information from various interviews, secondary data in the form of documents, master theses, and observations combined to contribute a richness that allowed triangulation. However, this does not only apply to verification of accuracy of the collected data. In addition, sharing the data with people in the industry at conferences, seminars and meetings is another source of credibility as the study was presented and discussed. These audiences were mostly from other firms than the analysed firms included in my study. This 'sharing' was done along the way, thus, not only as 'final' outcomes, and these interactions contributed to how the study evolved. My understanding of the empirical context developed throughout the study. Had the data collection been confined to a very short period of time, with little interaction with people in the industry, this successive (re)directing of the study would not have been possible. The amount of time spent in the empirical world provides scope.

Analysis of the data was also continuous, and the results were shared with people in academia at seminars and conferences, which contributed to and affected the direction of the study. In that sense, the study was subject to 'debriefing' with regard to the empirical context and in academia: parts of it have been presented at international conferences such as the Nordic Workshop on Inter-organizational Research and at the IMP conference, in seminars in the Division of Industrial

Marketing at Chalmers, and in a number of PhD courses, at Chalmers and other universities. As a result of these various presentations and discussions, alternative steps and suggestions for future research emerged. Thus, both the case study and the theoretical framework were 'reviewed' on different occasions by different people. As the focus changed over time, different bits and pieces of data and theory were included, and other parts were left out, as described previously with regard to the research process. Thus, during this process some data have been excluded and I made choices regarding how the data would be presented. The case can therefore be seen as a product of the research process, as Dubois and Gadde (2002, p. 558) argue: "A selection must be made because, when the case is finally turned into a 'product', there should be no confusing pieces left". Some data are included because I believe that they add to the readers' understanding, but not all the presented data are addressed and used in the analysis. Nevertheless, when presenting the data, I have attempted to employ empirical language which allows readers to 'see' the data from a perspective not coloured by theoretical concepts.

In data collection I never attempted to secure an 'objective truth', all data are in some way interpretations (Silverman, 1993). However, during the process there were occasions when data were discussed with an informant to ensure an accurate understanding of his or her perspective. This was done in additional interviews and in formal meetings with members of the research project and people working at the firms, and via email and phone calls in order to straighten out questions after individual interviews.

Transferability refers to the extent to which something can be transferred to other contexts than it was originally developed for. Lincoln and Guba (1985, p. 316) refer to this as the importance of providing "only the thick description necessary to enable someone interested in making a transfer to reach a conclusion about whether transfer can be contemplated as a possibility", rather than the ability to specify external validity. This transfer does not only capture findings as results of a study. In my study, for instance, I would claim that the framework I formulated would be useful to study intermediation in other empirical settings. The framework was developed based on studies in the textile and clothing industry and the construction industry, which have particular characteristics. These characteristics affect how intermediation takes place, however, with regard to analysis of 'what is connected', the same concepts and models can be applied to various settings. In essence, the framework is based on the industrial network theory approach, entailing concepts that are generated from various empirical settings and analytical tools and models that are applicable to various settings. It is to be hoped that my description is 'thick enough' to convince the reader that transferability of the concepts for analysis of intermediation is possible to other context than the textile and clothing, and the construction industries.

Dependability relates to "examining the process of the inquiry" (Lincoln and Guba, p. 318). By outlining the research process including data collection, as was done earlier in this chapter, the reader hopefully has gained a sense of the underlying nature of this process. I have tried to explain issues that arose along the way, how they were handled and the basis for the decisions made during this process. This should create an understanding of how dependencies on informants, concepts and research context affected the study and its undertaking.

Finally, *confirmability* concerns evaluation of the product of the investigation and the extent to which the concepts used, the findings and the data are consistent. It is hoped that the analyses in Chapters 5, 7, 9 and 10, and the concepts suggested in the analytical framework in Chapter 2 of this thesis, match in a way that makes the findings in Chapter 11 reasonable. Analyses and framework should also match the respective empirical examples. The conclusions and findings outlined in the last chapter, which are based on the previous analyses, should make sense in a way that is consistent with the phenomenon and the aim of the thesis presented in Chapter 1. The successive process of going back and forth between the theoretical and empirical worlds contributes to this since it allows the boundaries of both worlds to shift as the study focus shifted. This process helped to achieve parsimony in the study, which implies "avoiding ending up with weak theory that is very complex and says very little about very much" (Dubois and Gadde, 2002, p. 559). At the same time, it is hoped that the process has avoided the problem of describing everything regarding the empirical world and "as a result describe nothing" (Dubois and Gadde, 2002, p. 559).

The criteria outlined by Lincoln and Guba (1985) referring to credibility, transferability, dependability and confirmability have been used to give an impression of the trustworthiness of this study. In combination with presentations of the research process and research method, it hopefully provides sufficient ground for an evaluation of the quality of this study.

4 SUPPLY OF REINFORCEMENT TO SWECON

This empirical chapter deals with the supply of reinforcement to SweCon construction projects. These projects consist of one or several constructions (houses, roads, bridges) each of which is unique in terms of type and amount of reinforcement tension devices in reinforced concrete. The steel is cut, or cut and bent, either on site or in an industrial indoor setting before the profiles are installed in the construction.

SweCon, a large construction company, used to obtain all its reinforcement from the wholesaler Steel Service. In addition to long steel bars and mesh, Steel Service produces 'prefabricated cut-and-bent reinforcement bars' (CAB) [1]. CAB is so-called 'ready-to-install-reinforcement', which is delivered to sites for installation. Thus, CAB requires no additional cutting and bending on site. SweCon came up with the idea of producing own CAB through its involvement in a large infrastructure project. Based on this successful experience SweCon decided to establish a factory to produce CAB to reduce costs by eliminating the need for supplies from Steel Service. This chapter first discusses the features and utilization of reinforcement. Thereafter the chapter describes Steel Service's business setting and SweCon's reinforcement factory, including supply of steel, production, transportation and customers. These sections highlight some implications of changing supply from Steel Service to SweCon's own factory.

4.1 REINFORCEMENT: FEATURES AND UTILIZATION

Reinforcement is fundamental to most construction projects whether house, road or bridge construction, or other types of civil engineering and infrastructure projects. During the building process, variously shaped reinforced parts are installed to form a 'skeleton' in casting concrete forms (Figure 4.1). In house building projects the dimensions are mostly 8mm, 10mm and 12mm diameter steel and larger dimensions of 16mm or more are more common in infrastructure projects, for example bridges.

[1] 'Prefabricated cut-and-bent reinforcement bars' (CAB), in Swedish 'inläggningsfärdig armering' (ILF).

Figure 4.1 Installed reinforcement in casting concrete forms.

In addition to standard carbon steel reinforcement, there is stainless steel and acid tolerant steel. These alternatives come in various shapes: bars, mesh, and CAB profiles. Standards are defined by stress tolerance in line with the function of a tension device in constructions. There are published charts displaying reinforcement shape codes in accordance with various standards. Figure 4.2 shows the Swedish standard of reinforcement profiles, ranging from A-Z in relation to size, measures, and numbers and types of curves.

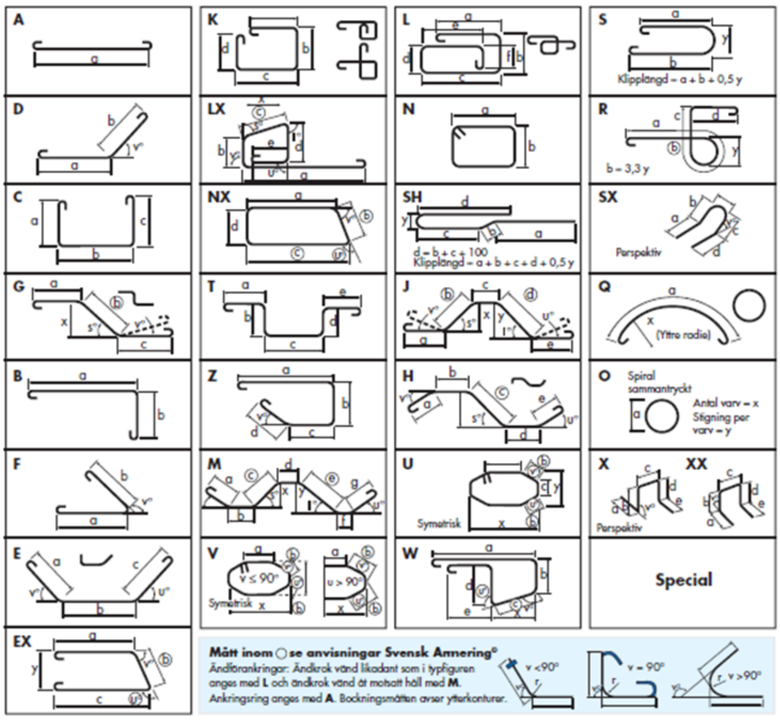


Figure 4.2 Swedish standards for reinforcement profiles.

The type and amount of reinforcement are specific to each construction. A construction engineer studies the project drawings and makes calculations to create a reinforcement drawing. Based on this drawing, a specification is generated of the exact amount and type of reinforcement needed for the whole construction. This is usually the responsibility of a reinforcement specifying consultant, but can also be done by a skilled construction engineer or site manager. The computer program Q-spec is often used to create these specifications, which then are 'translated' into production orders of the type and amount of reinforcement needed. Manually created specifications have to be manually converted to production orders. Based on the production orders, reinforcement of the appropriate dimensions is cut, or cut and bent to the measures and profiles specified. These profiles are then installed in the construction.

4.1.1 CUTTING AND BENDING OF REINFORCEMENT ON SITE

Cutting and bending of reinforcement can be undertaken at construction sites. In this case, steelworks produce steel bars with diameters of between 8mm and 32mm and in 8m, 12m, 15m and 18m lengths, with 12m length the most popular. Generally, a wholesaler purchases the bars from steelworks and stocks them for delivery to sites as required (Figure 4.3).

Figure 4.3 12m bars delivered to a site (Source: Caster, R. and Deuschl, G., 2007).

The machinery required for a reinforcement station has to be transported to the construction site. A reinforcement station consists of cutting and bending machinery, a ‘stair’ for storing the reinforcements, pallets and boxes for cut and bent profiles, and appropriate containers for waste material. Construction workers then produce the profiles as and when needed during the building process, mainly in the early phases of ground and pile work. Figure 4.4 shows a reinforcement station at a site.

Figure 4.4 Reinforcement station at a site (Source: Persson, M., 2011).

The reinforcement station occupies a large area in what is often an already crowded site. Often, the station has to be moved to other locations on the site as the project progresses. Cutting and bending carried out on site involves numerous operations: the steel has to be unloaded from the trailers and sorted and stored in the ‘stair’, then moved to the cutting machine for cutting and to the bending machine for bending. The cut and bent profiles have to be bundled and carefully labelled and then moved to a temporary storage area to be ready for installation. Movement of 12m bars and other heavy parts require a tower crane on site, while smaller parts stored on pallets or in boxes can be moved by a fork lift. In some cases light reinforcement parts can be moved by hand by the construction workers.

4.1.2 PREFABRICATED CUT-AND-BENT REINFORCEMENT BARS

An alternative way of supply of reinforcement to sites is delivery of prefabricated cut-and-bent reinforcement bars (CAB). In this case a wholesaler purchases long steel bars or so-called coils, which are large rolls of steel ‘thread’ 8-16mm in diameter, from the steelworks (Figure 4.5). Each coil consists of 3,000m of carbon steel, and is very heavy, with a weight from 1ton to several tons depending on the steel diameter. The straightening (coils have to be straightened before cut and bent) and cutting and bending take place at the wholesaler's steel service centre. Coils are used to the extent possible because they reduce waste. However, since coils only come in dimensions up to 16mm, larger profiles must be made out of long steel bars. When the profiles have been made, they are delivered to sites for installation.

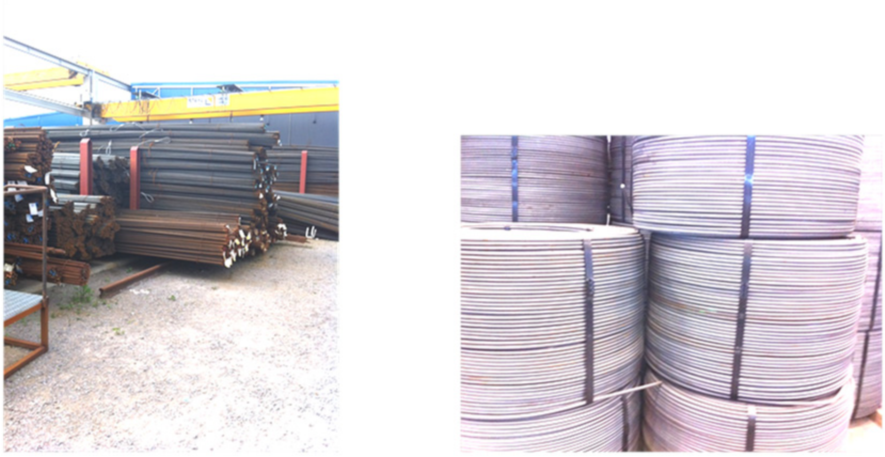


Figure 4.5 Long steel bars (left) and coils (right).

CAB requires no additional cutting and bending on sites, as well as reduces handling, storage and movement of materials on site. CAB is always produced to customer order to suite the unique shape of each construction. Accordingly, the lead time from placing an order to delivery to site is longer than for the supply of long standard length bars. Thus, communication between construction engineer, site and wholesaler regarding the type and amount of reinforcement and delivery is crucial. The moment in the competitive tendering phase for deciding who will build the construction and the project start time are typically very close, and project drawings are often not fully defined at this start time. This leaves little time for the reinforcement drawings and specification of the type and amount of reinforcement which often have to be produced progressively during the project. In some cases, there is not enough time to allow wholesaler produced CAB.

4.1.3 Reinforcement costs

The cost of the reinforcement represents a substantial proportion of the total cost of a construction project. A study by Sandberg and Hjort (1998) shows that the cost of reinforcement can be 15% for residential buildings, 25% for office buildings, and 18% for bridges. According to Löfgren and Gylltoft (2001), the cost for reinforcement accounts for 18% of the cost of building frameworks (55% for materials and 45% for labour). Also, reinforcement work is the most time consuming activity undertaken at constructions sites and accounts for over 20% of a project's total man hours (ibid.). CAB reduces the number of onsite man hours and provides ergonomic benefits for construction workers. This explains the increased use of CAB despite the higher per ton price compared to long bars for cutting and bending on site. CAB reduces the overall costs of reinforcement in projects.

The next section discusses the case of a Swedish wholesaler, Steel Service, which produces CAB and also supplies the construction industry with reinforcement bars, mesh and other steel products.

4.2 THE WHOLESALER STEEL SERVICE

Steel Service is a Swedish wholesaler that offers a wide range of steel products such as reinforcement, sheet metal and stainless steel. The construction industry mostly uses reinforcement in the form of bars, mesh, CAB, welded reinforcement, beams and rolled reinforcement, which account for around 85% of Steel Service's total sales. CAB has been produced by Steel Service since the beginning of the 1980s. Steel Service currently has two steel service centres that produce CAB. The largest capacity steel centre is in central Sweden and supplies construction sites in central and southern Sweden; the other steel centre is in northern Sweden and supplies sites in the north. Steel Service has a large central warehouse housing all of its types of products, and five warehouses across Sweden that store only reinforcement products.

4.2.1 SUPPLY OF STEEL TO STEEL SERVICE

Carbon steel is a standard product and numerous steelworks produce long bars, coils and mesh reinforcement. Steel Service purchases all of its reinforcement materials from steelworks in Europe, mainly Poland, Germany, Holland and Belarus. Over time, Steel Service's number of suppliers has increased as more suppliers become certified for supply to the Swedish market. Steel Services uses three or four main suppliers for the reinforcement categories of bars, coils and mesh. Each reinforcement product and dimension has a stock level limit below which a new order is generated. The steel price in SEK/ton and delivery time determine which supplier will be used for each transaction. Reinforcement must never go out of stock at the wholesaler or the customers will turn to another wholesaler or dealer.

The bars, coils and mesh are transported by boat or train from steelworks in Europe to ports in southern Sweden. A crane is required to handle the heavy cargo, for instance, unloading and loading. From the port, trains or trailers are used for transportation to the steel service centre in central Sweden. The largest trailers with platforms of 17m are required to transport the 18m bars. These trailers do not have cranes because they do not fit onto the trailer. Trailers with cranes can carry heavy cargo up to 25-30 tons, but since the platform is only 13-14m only steel bars of lengths up to 12m can be transported. To the extent possible railway is used for transportation since it is cheaper and more environmental friendly than road transport. One railway wagon can carry up to 55 tons of steel. Railway is always used for transportation to the steel service centre in the northern parts of Sweden owing to the long distances involved. But using the railway has some disadvantages: transportation can take from 2-4 days to 2 weeks based on availability of wagons and waiting time for access to marshalling yards to unload the cargo. Once the materials arrive at one of Steel Service's centres bars, mesh and coils are kept in storage until ordered by a customer. In some cases, long bars and mesh are transported direct to one of the five warehouses and then on to the customer, without any storage by Steel Service's two centres.

4.2.2 THE TWO STEEL SERVICE'S CENTRES PRODUCING CAB

In the two steel service centres CAB is made from steel bars and coils. The profiles are according to Swedish standards, types A to Z (Figure 4.2), with each profile made to a unique measurement. Extensive production planning is required to minimize waste of materials, and to avoid long times for setting up machinery. Coils are used as much as possible for dimensions up to 16mm, and 18m bars are used for dimensions of 20mm or more. Three or four orders are usually combined when cutting and bending the bars to maximize utilization of the steel bar. However, the larger the dimensions required, the more material is wasted. A just-in-time principle is used for the production and delivery of CAB, since the storage area with a travelling crane for outgoing deliveries is limited.

Reinforcement with special features, such as stainless or acid free must be cut and bent separately from standard carbon steel. Carbon steel filings can harm the surface of these special reinforcements and render them useless. Stainless steel is much less common than carbon steel for reinforcement, although its superior life span makes it popular with some contractors for some products. However, stainless steel costs ten times the price of standard reinforcement.

Steel Service uses straightforward pricing for CAB, of 'one price per cut' regardless of the dimension of the bar/coil, and 'one price per curve' regardless of the type of profile. However, the costs for producing profiles show great variation. A three-dimensional profile with many curves is very time consuming and, hence, expensive to produce, and especially in larger dimensions since it must be done manually by twisting and re-twisting the material. A two-dimensional profile with the same number of curves is less costly to produce. However, owing to the price list logic these profiles are sold at the same price.

4.2.3 STEEL SERVICE'S CUSTOMERS

Steel Service's customers are primarily major Swedish construction companies, and infrastructure projects account for the major part of reinforcement sales. CAB is often supplied to these projects. The volumes sold for house building tend to vary more. House building projects also undertake the cutting and bending on the sites rather than purchasing CAB. Thus, 12m bars are transported to the project sites. Steel Service also sells 6m bars to building materials distributors, local steel dealers, and large building materials retail chains.

The large construction companies contact Steel Service with details of the type of project and a preliminary estimate of the amounts of reinforcement required. Steel Service provides a tender based on experience of previous similar constructions, for instance, an average bridge of 1,500 tons reinforcement in total consists of 30% cut, 40% CAB and 30% long bars. Cost of transportation to the site is accounted separately. Thus, the preliminary cost of the total amount of reinforcement in the project can be estimated in the tender. Customers normally request tenders from two or three wholesalers in order to compare prices, typically the wholesaler with the lowest price is selected.

If Steel Service is selected, the first week of delivery sets the direction for the pattern of who undertakes the specification, and what type and how much reinforcement is needed. Large projects involve start-up meetings between Steel Service, the site manager and the person who is responsible for the specification. A plan for the casting operations is always obtained from the customer as guidance for when to deliver to the site. In most cases the customers choose Steel Service's own consultant to prepare the specification owing to its excellent reputation. This consultant's extensive experience allows the consultant to suggest improvements that might reduce the amount of reinforcement or allow a change to a simpler profile, thus reducing costs. All changes must be approved by the construction engineer because they affect the construction. If the Steel Service consultant is fully booked the customer must find someone else who can do the specification, often a construction engineer or an appropriately skilled and experienced site manager, but this adds to their extensive work load.

There are challenges related to specifying and producing reinforcement which, in turn, affect the option of using CAB. Steel Service's customers tend to order their reinforcement quite late, usually only two or three weeks before first delivery. This causes problems since the specifications must be produced, which usually takes a week, and the lead time for producing CAB is three weeks. Consequently, there is often not sufficient time to supply CAB. In large projects, the specification is produced progressively, and orders are sometimes at very short notice. Thus, at the beginning of the project there is not a complete list of what will be needed, and when. Infrastructure projects tend to be better planned, while in house building orders often have very short lead times. Since CAB is prepared to individual specifications, it cannot be prepared in advance and stocked by Steel Service.

For reinforcement all prices are in SEK/kilo. This applies to purchases from the steelworks, cost of transportation, and the prices customers pay. Prices are adjusted monthly in line with procedures in the steel industry. Therefore, customers pay similar prices for material supplied by various wholesalers. Steel Service has one price in SEK/ton cut and a slightly higher price in SEK/ton for CAB, which also varies according to the dimension. In addition, if an order for CAB is less than 2.5

tons an extra fee is added, and if delivery time is less than ten days this also adds to the price per ton.

Steel Service tries to encourage customers to purchase CAB rather than undertaking cutting and bending on site. Although the price of CAB is higher since Steel Service charges for its cutting and bending operations, the final cost of the reinforcement is lower since cutting and bending on site is very costly and absorbs many man-hours. Also, Steel Service can produce CAB on a larger scale owing to its machinery capacity. In order to persuade the customers, Steel Service provides calculation examples including workers' wages, steel prices and cutting and bending operations and average 12% waste for operations on site. Figure 4.6 provides an example showing that all the reinforcement needs cutting, and 30% is bent. It shows a total cost saving of SEK 2,002/ton for CAB purchased compared to cutting and bending on site. The cost of establishing a reinforcement station at the site is not included in the example.

Prerequisites	
Wages:	370 SEK/hour
Steel price:	8000 SEK/ton
Cut:	100 %
Bent:	30 %

		On the site		**ILF**		**Savings**
		Hours/ton	SEK/ton	SEK/ton/piece	SEK tot.	SEK/ton
Steel			8000	8000	8000	0
Cutting		2,9	1073	650	650	423
Bending		9,9	1099	1250	375	724
Waste	12%		960			960
Extra*	7			15	105	-105
TOTAL			**11132**		**9130**	**2002**

* Extra for each variant on the reinforcement specification, in this example 7 variants.

Figure 4.6 Cost comparisons: CAB versus cutting and bending on the site.

4.2.4 TRANSPORTATION: FROM STEEL CENTRES TO WAREHOUSES & CUSTOMERS

Reinforcement is a standard product, and the cutting and bending operations are not difficult to undertake. However, transportation is problematic - especially in crowded inner-city areas - due to the weight of reinforcement and the length of the bars.

Reinforcement is transported to sites from the Steel Service centres in central and northern Sweden using open trailers able to carry up to 25 tons, which are fitted with a crane - an important feature demanded by customers. In the big cities of Stockholm, Göteborg and Malmö the cargo often has to be reloaded onto smaller trailers to comply with environmental zones and space restrictions. Previously, Steel Service had its own trailers, but nowadays all transportation services are purchased from road haulage contractors. Different road carriers are used for different parts of Sweden, but Steel Service tries to use the same group of road carriers. Since reinforcement cargo is heavy and trailers required to transport 12m bars are long, driver experiences is a very valuable asset.

Maximizing the load on each trailer is crucial for the economics of transportation. Transport price is based on SEK/ton, and Steel Service charges one price for 0-10 tons, and a slightly lower price/ton for over 10 tons. A full trailer of 20-25 tons is priced even lower. Mesh, especially in small dimensions, is problematic and expensive to transport. Mesh occupies a lot of space on the trailers and also involves transportation of a lot of ‘air’, and other products cannot be placed on top of mesh.

There is a daily route from the Steel Service centre in central Sweden to a geographically proximate warehouse. From this warehouse there are planned routes with daily deliveries to customers. Reinforcement is co-loaded with other steel products, e.g. road railings, to maximize the load and space. This reduces the number of journeys to customers, and customers benefit from a lower price/ton when larger volumes are transported in one trailer. From the central warehouse there are also planned routes to Steel Service’s other warehouses in Sweden. From the warehouses out to the sites co-loading of reinforcement, steel and beams occurs. Transportation requires careful planning: there is a trade-off between co-loading and too much reloading which take time and add to the cost of transportation.

A specific date is usually set for deliveries to the sites. If the trailer is full and the whole cargo is for one destination then a firm delivery time can be given. In large projects almost all trailers are completely filled. If the customer wants the delivery at a specific time and it consists of small orders Steel Service will arrange that, but the customer has to pay the costs of the whole trailer since it cannot be used for multiple loads to various destinations.

Competition within the steel business is increasing in Sweden. Foreign competitors have contributed to reduced prices for CAB. However, although the price/ton for CAB may have gone down, transportation costs are high. Foreign trailers are always covered and, in order to unload them, the cover must be removed. However, the frame remains attached to the trailer and in windy conditions the cargo can become entangled in the cover frame. Also, Swedish regulation mandates that bundles of reinforcement, including CAB, delivered to sites cannot be heavier than 1 ton. Reinforcement delivered to Sweden by foreign companies are always in heavier loads which requires their unloading, splitting up, rebundling and reloading onto a trailer for transport to the sites. Also, in Europe, road carriers can load a maximum of 24-25 tons; in Sweden one trailer, depending on its size, can carry up to 25-35 tons.

The next section discusses SweCon, a large Swedish construction firm. SweCon used to purchase all of its reinforcement requirements from Steel Service. However, after successfully producing CAB in a very large project, SweCon decided to establish a permanent reinforcement factory.

4.3 SWECON: ESTABLISHMENT OF A REINFORCEMENT FACTORY

SweCon is one of Sweden's largest construction companies, involved in residential buildings, offices, industrial facilities, roads, bridges and other infrastructure projects. Overall, SweCon uses 24,000 tons of reinforcement a year in such projects: 12,000 tons of bars, 7,500 tons of cut and bent, and 4,500 tons of mesh. For many years, Steel Service was SweCon's sole supplier of reinforcement according to an agreement between the parties. Amounts of reinforcement and delivery dates for individual projects were agreed between SweCon's sites and Steel Service's steel centres.

About a decade ago, SweCon won a large infrastructure project requiring 15,000 tons of reinforcement over a period of 18 months and decided to undertake its own CAB production. It is rare for a single project to involve such large quantities of reinforcement. SweCon estimated that producing CAB would increase efficiency in comparison with undertaking cutting and bending on the site. SweCon also expected savings on procurement since long bars, coils and mesh could be supplied directly from steelworks located across Europe, allowing advantages from international purchasing operations. Also, Steel Service's CAB costs were considered to be high and SweCon expected cost reductions by eliminating the wholesaler.

SweCon initially contacted a steelwork in Poland for the supply of carbon steel. A factory with a travelling crane was rented near the site and machineries for straightening coils, cutting and bending were purchased. Throughout the project this arrangement worked well, and the factory was able to deliver to geographically nearby SweCon sites. A total of 15 projects were supplied with reinforcement from this factory. It produced a 15% saving in costs compared to undertaking cutting and bending at each individual site, including approximately four months saving in man hours. Based on this successful experience, SweCon decided to establish a permanent reinforcement factory to supply all SweCon's projects with reinforcement.

The location of the permanent factory was decided based on access to the railway and a port to facilitate transportation of the long steel bars and coils from the steelworks. The factory was close to most of SweCon's projects and there was rail lines running to the factory area. In February 2008, construction of the factory started and in April 2008 the machinery was moved from the facilities in the large infrastructure project to the factory, supplementary machinery was purchased, and factory management was hired. In September 2008, the factory started operations and took on supply for some 500 on-going SweCon projects.

The factory's motto is that: 'We take care of the reinforcement'. All SweCon's reinforcement requirements are filled by the factory rather than Steel Service or some other wholesaler. SweCon formulated a careful strategy and worked intensively to get the cooperation and commitment of site managers. It is important to accumulate orders, to make the factory profitable. In September 2008 the factory had a 93% purchasing commitment from SweCon's projects. For Steel Service the establishment of SweCon's reinforcement factory resulted in a considerable loss in volumes of sold reinforcement. However, Steel Service's sales have recovered to previous levels owing to several new customers.

The next section describes SweCon's reinforcement factory and its supply of steel, production, transportation and customers. The section also discusses some future challenges for the factory.

4.4 SWECON'S REINFORCEMENT FACTORY

The objective of SweCon's reinforcement factory is to supply its projects with reinforcement, whether it be bars, CAB or mesh. Coils, bars and mesh in various dimensions are bought from steelworks and kept in stock, CAB is produced in the factory, and reinforcement in various shapes and forms is delivered to sites (Figure 4.7).

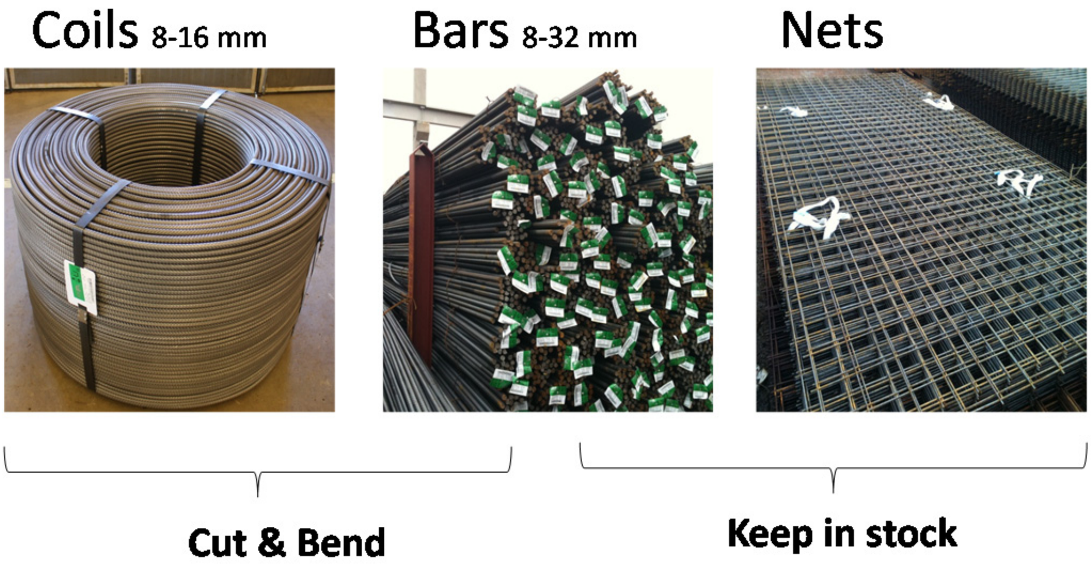


Figure 4.7 The reinforcement factory: coils, bars and mesh in various dimensions.

The factory is run by a manager and six people working on planning, coordination of processes and orders, logistics, administration, stock supply and production/quality issues. There are 11 workers who operate a shift system to produce CAB and handle orders for bars and mesh. The monthly volume of reinforcement sold varies depending on demand. However, production has risen from an average of 900 tons per month in autumn 2008 to 2,500 tons on average per month at the end of 2011. This has been accomplished by the same work force and the same machinery, thus, the increased efficiency is due to improvements in planning, production processes and logistics.

4.4.1 SUPPLY OF STEEL TO THE REINFORCEMENT FACTORY

The factory purchases carbon steel bars, coils and mesh from steelworks in Europe. Initially only one supplier in Poland was used. This was the same supplier as was involved in the large infrastructure project, which was the incentive for the permanent factory. This steelwork still supplies the factory, but supply is augmented by four other steelworks in Poland, Germany and Belgium. All are large business units, and the reinforcement factory for them is a rather small customer. For example, the factory's total annual demand accounts for one week's production for the original Polish supplier. SweCon's central purchasing function organizes the contracts with the five regular suppliers, and the factory chooses among them in individual transactions.

The factory purchases bars of 12m, 15m and 18m. The 12m bars are not used for CAB since the amount of waste makes this economically infeasible. The 12m bars are kept in storage and transported to sites as needed. The 15m and 18m bars are bought to optimize production of CAB in thicker dimensions; but these longer bars cannot be transported to sites. Bars and coils are transported by rail from steelworks in Europe to the factory. Mesh used to be transported on trailers to the factory, but since May 2011 also they go by rail. Reinforcement with special features is purchased from Steel Service or some other wholesaler, and is delivered to the factory before being despatched to the site. Special reinforcement, i.e. acid free or stainless steel, accounts for a very small proportion of SweCon's total reinforcement used – around 200kg-500kg per month.

Reinforcement is characterized by price fluctuations based on demand and supply conditions. As a result, for the factory, supply becomes a 'poker game' of predicting when prices will rise or fall, and when to place orders, perhaps in larger volumes to 'secure' a lower price. For each item, i.e. bar/coil/mesh, and each dimension, there is predetermined minimum and maximum stock level at the factory. A system prompts when an order needs to be placed to maintain this minimum, and a request for tender is created and sent to all five suppliers. The factory then selects a supplier for the transaction based on price and logistic conditions, including freight 'due at factory'. If the supplier has the product in stock it can usually be delivered to the factory within a week. If it is out of stock, then another supplier is chosen at perhaps less favourable prices and logistic conditions. It is advantageous for the factory to place a large order for steel, say 1,500 tons which usually allows the factory to book capacity at the supplier that can guarantee delivery of the steel in say eight weeks on a specific day. For orders exceeding 3,000 tons, the factory gets a fixed price from the supplier, thus protecting the order from price fluctuations. Delivery can take place at several times in a period of six weeks according to a predetermined delivery plan.

The price/ton of coils used to be higher than the price for bars in the steel industry, but now these products are priced the same. Thus, for the sites, bars and CAB come at the same steel price and there is no advantage in selecting bars according to material price. Also, since 2004 steel prices have fluctuated monthly rather than quarterly. The factory would prefer to purchase larger volumes of steel when prices are low. However, the limited storage area for incoming materials severely restricts the volumes that the factory can stock.

4.4.2 PRODUCTION IN SWECON'S REINFORCEMENT FACTORY

Bars, coils and mesh are kept in the incoming material stock area outside the factory. For mesh and 12m bars there are no additional production operations before delivery to sites. Longer bars and coils are loaded onto wagons and transported into the factory for the production of CAB.

The factory has two production lines. Line 1 involves machinery for the straightening, cutting and bending of coils in smaller dimensions, thus mostly for housing and industry projects. Straightening of coils is a very precise operation, requiring rigorous testing to ensure the material is not deformed. This cannot be accomplished at sites. If smaller dimensions are required in lengths of over 10m the line 2 cutting machine is used, and the bending is done on line 1. Line 2 is always used for cutting and bending large dimension bars for reinforcement of roads and bridges. Figure 4.8 shows production of CAB in the reinforcement factory.

Figure 4.8 Production of CAB in the reinforcement factory.

Orders come to the factory by mail or phone. Previously all reinforcement specifications were in the form of Excel files and had to be converted manually into production orders. This work was time consuming and resulted in queues: it could take 4-5 days for an Excel specification to be translated into a production order. This manual operation also accounted for around 60% of all production mistakes in the factory. The factory has now installed a computer based system Q-spec which translates specifications into production orders. The factory wants all of its customers to use Q-spec, but some orders still arrive in the form of Excel files which demands manual operations to create production orders.

Production planning is an extensive operation, and orders from the various sites are combined to improve the utilization of machinery, reduce machine set up times, and minimize waste of material. Coils are used to the extent possible because of their superior production effects, enabling fast, automatic operations and very little wasted material. When using bars to produce CAB there is a waste target of less than 2,5% of the material, this is achieved by combining orders to maximize usage of lengths of material. In the factory, operations are fast and up to 10 pieces can be cut simultaneously. At the sites, waste accounts for around 15% of the material, and each cut and bent operation must be undertaken individually, involving large amounts of time.

In accordance with Swedish standards, CAB profiles range from A to Z (Figure 4.2). The factory prices are based on SEK/ton although production costs for various profiles differ substantially. For example, profile A is very simple and can be produced automatically, whereas profile X is very complicated and consists of five or six bends in three dimensions, requiring the steel to be removed from the machine, twisted and then bent in a different dimension, several times. These complex profiles are time consuming to produce and production has to start at least four days before delivery. Their production 'blocks' one of the machines for several days. Thus, complex profiles reduce the cost efficiencies in the production of CAB. The factory tries to convince customers to use a larger number of simpler bars rather than complex profiles for their constructions. The lead time for CAB is normally three weeks, i.e. three weeks from placing the order to delivery to the site. In large projects the site manager can pre-book capacity in the factory. This means that production capacity is booked, but the site manager can decide which profiles to produce at short notice, perhaps with only six or eight days warning.

When a production order has been completed the CAB are bundled and placed on a pallet or are boxed. Labelling is rigorous and includes details of project number and customer, delivery time and location, factory production unit, time of production, and so on (Figure 4.9). The system allows for traceability if there should be a mistake in production. Thereafter, bundles, pallets and boxes are moved to the area for outgoing reinforcements (Figure 4.10) and eventually loaded onto trailers for delivery to the sites.

Figure 4.9 Outgoing reinforcement is marked rigorously.

Figure 4.10 CAB ready for delivery to sites.

4.4.3 TRANSPORTATION FROM REINFORCEMENT FACTORY TO SITES

For customers, the price for transportation is set based on SEK/ton, regardless of the amount of reinforcement or the distance between factory and final destination. Central management at SweCon decided on these conditions for transportation. The site location should not be a reason for using a geographically closer wholesaler instead of the SweCon factory. Orders vary from e.g. 9kg to 35 tons which is a full trailer. For the factory, the target cost is SEK 360/ton; if this is exceeded it represents a loss on transportation. Thus, transportation requires extensive planning to maximize the fill rate of every trailer leaving the factory, and to reduce the frequency of transport to sites. The requirement for many small orders to multiple sites make this planning difficult; large orders or orders that can be combined for the same destination are more favourable for the factory.

On average, four trailers per day leave the factory with long bars, CAB and mesh for delivery to various sites. All trailers are open; some carry a crane, others do not depending on the customer's preference. Trailers with cranes are always used to sites in Stockholm and there is one trailer with crane that delivers within a 250km radius of the factory. When trailers without a crane are used, extensive coordination is needed with the sites since the building crane (or a truck if the load is boxes of small CAB) is needed to unload the trailers. The price for a trailer without a crane is SEK 360/ton, the price with a crane is SEK 400/ton.

The trailer drivers are given daily schedules for their routes. In the regions of the large cities Stockholm, Göteborg and Malmö customers prefer delivery at a certain time, but traffic conditions often render this impossible. For instance, if the reinforcement is required to be delivered at 07.00 in these zones the driver will need to arrive to the site long before 07.00 in order to beat rush hour traffic. Factory staff usually load the trailers using the travelling crane. If production of CAB is very intense and the storage area for outgoing reinforcement is full, products are loaded onto wagons outside the factory. The driver can then load the trailer. At sites, the drivers unload from trailers that are equipped with a crane; otherwise the site crane driver uses a tower crane to unload the trailer. Delivery security is very important, and mistakes related to destination are scarce. When they do occur, it is usually due to incorrect labelling of the products in the factory.

Different road carriers are used for different geographical site locations. The firm Cargo is a major supplier of transportation services for outgoing reinforcement. Cargo also transports products for Steel Service and other steel wholesalers. Steel Service’s transportation needs are some 20 times bigger than the SweCon factory’s requirements. Contracts between Cargo and its customers, such as the SweCon factory, cover a period of time and a certain geographical area, a total amount of reinforcement, and certain trailer availability.

Filling rates, combining orders on the same trailer, and splitting large orders between trailers and in time, are determined between customer and Cargo. Based on experience and established routes Cargo can suggest the best way to satisfy the customer. Communication occurs daily between Cargo’s traffic coordinator and customers over planning including changes and cancellation of transportation services. Close communication is required to obtain information on current conditions at the site, which have implications for the delivery. This is particularly important if the site crane is required for unloading since drivers do not want to have to wait for this operation. Waiting upsets the schedule for the other deliveries. In some cases, the liaison person at the customer does not know the conditions on and around the site. This can affect transportation and includes issues such as environmental zone regulations, turning radius for long trailers, axle loads for bridges, and electric wires. Sometimes a trailer arrives at a site where it cannot be unloaded and has to return to the factory to be unloaded and reloaded in a more suitable way.

The SweCon factory shares information with Cargo to improve transportation. Every Friday a preliminary delivery plan for the following week's production is sent to Cargo and Cargo uses this information to make a rough delivery plan. However, flexibility is crucial since the factory does not always stick to the production plan submitted. Late orders from customers require significant deviation from the weekly pre-plan.

4.4.4 THE REINFORCEMENT FACTORY'S CUSTOMERS

The reinforcement factory delivers to around 500-600 ongoing projects. While some projects require very small amounts of reinforcement others involve large quantities extending over several years. A large project might involve 6,000 tons of reinforcement to be delivered over a period of three years, but with huge variation across weeks from 12 tons to 500 tons, for example. Also, projects can involve numerous orders over their life span. An average order to the factory is 400kg of reinforcement. Single projects usually involve a mix of bars, CAB, and sometimes mesh, in various dimensions.

Delivery time for reinforcement that is kept in stock, that is 12m bars and mesh, is 2-3 days and for CAB 3 weeks. Many customers place their orders late but want it 'now'. This is a hangover from the days when Steel Service was the supplier and reinforcement could be delivered at very short notice. Based on the records from the large infrastructure project that was the motivation for the factory, and calculations based on production of CAB in the factory and how cut and bent profiles are produced on site, costs for supply of reinforcement in projects can be estimated. Accordingly, based on steel price in SEK/ton and production costs on site (based on man hours) the cost of CAB from the factory is 15% lower than if cutting and bending occurs on site. This is due to larger scale production, fewer man hours and less waste of materials. However, the price for CAB that appears on the tender is higher than for long bars to be cut and bent at the site, which makes many sites see CAB as too expensive. Also, CAB from Steel Service costs less in comparison with cutting and bending on site, although this alternative is on average 7%-8% more expensive than when CAB is supplied from the SweCon factory. Figure 4.11 shows the average costs to the customer of CAB from Steel Service and SweCon's factory compared with cutting and bending on site.

	Cutting and bending on site	CAB from Steel Service	CAB from SweCon factory
Cost supply of reinforcement (SEK/ton)	**X plus 15%**	**X plus 7%-8 %**	**X**

Figure 4.11 Costs: CAB versus cutting and bending on sites.

With better planning by customers the factory can provide advantages in purchasing, production and transportation of steel. However, many of SweCon customers do not like the long lead times required for orders of reinforcement and inflexibility to adjust to demand. If a customer places an order three weeks in advance the factory promises a price discount of between 2% and 4% based on favourable production and transportation conditions. If a single order consists of a filled trailer of 35 tons of reinforcement a discount of 7% is given. For example, in a large road project, orders were placed four months in advance, which allowed the factory to offer a 7% discount on the total quantity based on savings of 5% solely on transportation costs. Consequently, customers can always save at least 5% for orders placed well in advance of delivery because this allows for better conditions for SweCon regarding production and transportation. The price customers pay includes the purchase price of the steel plus the production costs for CAB and transportation costs; i.e. cost of a trailer with or without a crane plus the price/ton for transported reinforcement.

In addition to supplying SweCon's projects the factory delivers 6m bars and mesh to a large Swedish distributor of construction material. The factory also supplies some 35 small customers located within a small radius of the factory. These customers' orders correspond to about 500 tons a month, and it is cheaper for them to purchase from the factory than from wholesalers. The factory can offer a lower price owing to favourable production conditions since it is selling surplus. It is a win-win situation for the factory and these customers. The factory also produced loops made from reinforcement to the piles produced in SweCon's two large pile factories. The loops were previously bought from wholesalers, but delivery from the factory enabled a price reduction of 16%.

Around 40% of the reinforcement used in SweCon projects is to be cut and bent on sites. Since final drawings are often delayed it does not accommodate the three-week lead time for CAB orders. Sites traditionally see it is a time well spent to use construction workers for undertaking the cutting and bending operations ‘since they are already in place, and can do this when there is nothing else to do’.

Infrastructure projects, such as roads and bridges, order CAB to a greater extent than house building projects. Infrastructure projects require a lot of reinforcement in larger dimensions, but small dimension of 8mm are needed for casting forms. All dimensions come in different profiles, adding up to a huge assortment of reinforcement. Although most CAB is purchased, the most common dimensions of bars are kept in stock at sites, together with a small station for cutting and bending. This is necessary for the installation operations on the sites, and if some reinforcement is missing from a delivery or extra material is required. For example, in a project involving nine bridges requiring 1,100 tons of reinforcement, 3 tons each of 12mm, 16mm and 25mm bars are kept in stock at the site. Figure 4.12 shows the building of a bridge: this section alone consists of over 50 types of reinforcement.

Figure 4.12 Fifty types of reinforcement are used in this bridge section.

SweCon projects have experienced differences between ordering reinforcement from the factory and ordering from Steel Service. Although Steel Service’s stated lead time is three weeks for CAB Steel Service can often supply it more quickly. In addition, Steel Service has more precise delivery times. The sites have very good experience of Steel Service’s accuracy in the content of deliveries, and clear and correct marking of products. Although in most cases the contents of deliveries from the factory are correct, there can be mismatches regarding orders. This creates extra work for the site, since the delivery has to be checked manually to ensure the content is correct and each batch must be sorted. This cannot be done as part of the unloading operation because it delays the trailer and disrupts the driver's delivery schedule. Sometimes individual reinforcement types are poorly marked, creating even more work for the reinforcement workers as CAB is delivered and unloaded in large bundles of different lengths, dimensions and profiles. It involves extra time and physical effort to sort the CAB on site. Figure 4.13 shows a reinforcement worker having to bend to sort out 27 pieces for installation in four different areas of the site, from an unsorted bundle of CAB.

Figure 4.13 Sorting out certain pieces of delivered CAB on the site.

Steel Service also has a very experienced reinforcement consultant who formulates the reinforcement specifications and Steel Service creates delivery plans on that basis. When ordering from the factory, the site manager is responsible for this and has to do it himself or find an outside consultant to take on the job. The specifications must be converted into a delivery plan by the site manager or someone responsible for procurement. Sometimes the factory can help the site manager to find an appropriate consultant who can formulate the reinforcement specification, but this still needs to be converted into a delivery plan.

So some SweCon sites still uses Steel Service for their supplies of reinforcement. The factory can never refuse a SweCon site order. However, if the factory is unable to fill an order, it obtains the goods from some wholesaler such as Steel Service. The products are then delivered to the factory and from there on to customers, as if they had been produced by the factory. This is done to uphold the strategy of SweCon reinforcement being supplied by the factory, and to discourage sites from searching for alternative suppliers. Reinforcement with special features is supplied by Steel Service or another wholesaler and these products are also first delivered to the factory before being sent to the relevant sites. In addition, SweCon projects in the north of Sweden are supplied by Steel Service because the distances are too long to make it economically feasible to transport reinforcement from the factory to these sites. However, the majority of SweCon's projects are in the central and southern parts of the country and these projects are thus supplied by the factory.

4.4.5 CHALLENGES FOR THE REINFORCEMENT FACTORY

Central management of SweCon regard the reinforcement factory as a success. In just a few years production increased from 900 to 2,500 tons per month. Currently, almost all SweCon projects in central and southern Sweden are supplied with reinforcement from the factory. However, transportation and delivery from the factory needs to be improved. The factory also wants to supply sites located in northern Sweden, which would require establishing a warehouse in the north, using the railway for deliveries to the warehouse and keeping products in stock.

The existing factory needs to be enlarged, especially the storage area. Currently, the factory can store around 1,800 tons of incoming reinforcement; if that were to be extended to 5,000-7,000 tons there would be potential for improvements. With the wharf just a few metres from the factory, SweCon perceives that transportation from the steelworks by water would be more cost efficient than using rail. A larger storage capacity would enable speculative purchases of steel when prices were low. The factory management would also like to employ reinforcement consultants in order to offer a better service to its customers.

This chapter has discussed the supply of reinforcement to SweCon projects. In some cases, mostly house building projects, bars are transported to sites for cutting and bending. Reinforcement can also be delivered to sites as CAB, which previously came from Steel Service but now is mostly supplied by SweCon's own factory. Thus, there has been a change from Steel Service supply to using the factory to supply reinforcement. Chapter 5 analyses the supply of reinforcement to SweCon sites with regard to activity intermediation.

5 ANALYSIS OF ACTIVITY INTERMEDIATION: SUPPLY OF REINFORCEMENT

Chapter 5 provides an analysis of activity intermediation related to supply of reinforcement to SweCon construction sites. Steel is cut and bent, either on site or in an industrial indoor setting, to obtain customized reinforcement profiles. Initially, SweCon bought all its reinforcement from the wholesaler Steel Service, either in the form of long steel bars to be cut and bent on site, or as CAB. Eventually, SweCon made the decision to produce CAB in its own reinforcement factory, thus eliminating the need for supply of reinforcement from Steel Service. Three situations with diverse conditions of activity intermediation can be identified. Cutting and bending of reinforcement undertaken (1) at SweCon sites, (2) in Steel Service's centres, and (3) in SweCon's reinforcement factory. In line with the analytical framework employed in this thesis, cutting and bending is 'in the middle' - an intermediate element - of the analysis of activity intermediation. Thus, cutting and bending is considered a single activity. Other activities, such as steel production, transportation, storing and installation, interrelate with cutting and bending in different ways according to the situations identified above. It should be noted, that although transportation may be supplied by independent road carriers, here transportation is considered part of Steel Service or of SweCon's reinforcement factory since these parties arrange transportation to the sites.

Therefore, analysis of activity intermediation deals with how the intermediate element, cutting and bending, is transferred in the configurations of activities: from the sites, as in situation 1, and at Steel Service, as in situation 2, to SweCon's reinforcement factory, as in situation 3. Consequently, cutting and bending intermediates between other involved elements in situation 3 than in situation 1 and situation 2. In principle, the cutting and bending activities are the same in all three situations, varying only in scale. But, the different settings affect function and efficiency of the activity configurations and the analyses of situations 1, 2 and 3 focus on these aspects. The three intermediation situations are analysed separately, and then compared.

5.1 SITUATION 1: CUTTING AND BENDING AT SWECON SITES

In situation 1 cutting and bending of reinforcement takes place at SweCon sites by SweCon construction workers, to produce various reinforcement profiles. First, the serial relatedness among the activities is analysed, and then the efficiency of single activities is examined.

5.1.1 SERIAL RELATEDNESS IN SITUATION 1

Situation 1 entails production of long carbon steel bars and meshes, transportation and storing, transportation to sites, storing at sites and then cutting and bending and installation on site. These activities are serially interdependent and have to be undertaken in this specific order. Thus, they can be considered complementary activities (Figure 5.1).

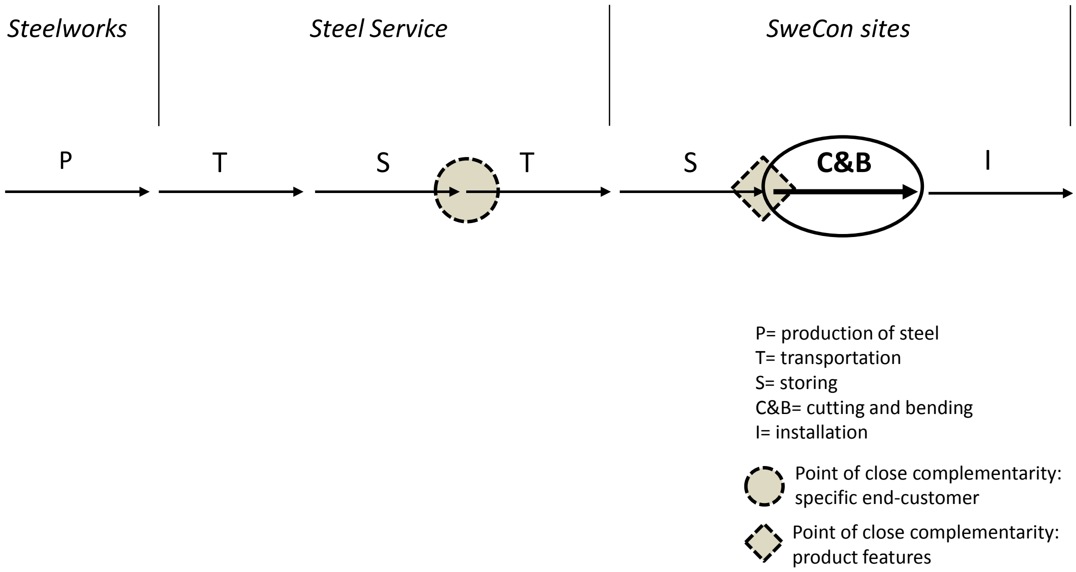


Figure 5.1 Serial relatedness among activities in situation 1.

The steelworks produce long steel bars, in various dimensions, based on speculation regarding future requirements of customers such as Steel Service. The bars are transported to one of two steel service centres, the central warehouse, or one of five other warehouses around Sweden for storing. Transportation and storing activities are also based on speculation, in this case, Steel Service's customers' future needs.

Figure 5.1 depicts the close complementarities with regard to a specific SweCon site, which is the end-customer, and the product features. The close complementarity in the activities performed related to individual SweCon sites occurs after the bars have been stored at Steel Service. The succeeding transportation activity directs the bars to SweCon's sites as required. This is indicative of the close complementarity among the activities following transportation, which are customized in relation to time and place of delivery to a specific site. Thus, transportation from Steel Service to the sites, and the activities that follow, are carried out based on postponement in time and place in relation to a single site. Following on site storing at the sites, cutting and bending creates the types of profiles and the volumes of reinforcement needed for installation. Thus, cutting and bending and installation are closely complementary activities and are decisive for the specific product features. These activities in relation to form are postponed to suit conditions present at individual sites.

The dimensions of meshes are set during their production at the steelworks. These meshes are standardized and suited to installation in constructions at numerous sites. Their close complementarity in relation to specific end-customer needs occurs after storing at Steel Service when subsequent transportation directs the meshes to the individual sites. The meshes are stored on site until installation; there is no cutting and bending involved in meshes.

It should be noted, in relation to situation 1 that coils are not used for cutting and bending since coils cannot be straightened at sites. Also the maximum bar length for transport to sites is 12 metres and as a result, there is a significant waste of materials from cutting and bending carried out on site, since the whole length is seldom utilized. In addition, reinforcement with special features, such as stainless or acid tolerance, cannot be cut and bent at sites.

5.1.2 EFFICIENCY OF SINGLE ACTIVITIES IN SITUATION 1

Situation 1 also includes performance of single activities. This analysis of efficiency relates to the degree of similarity; illustrated in Figure 5.2.

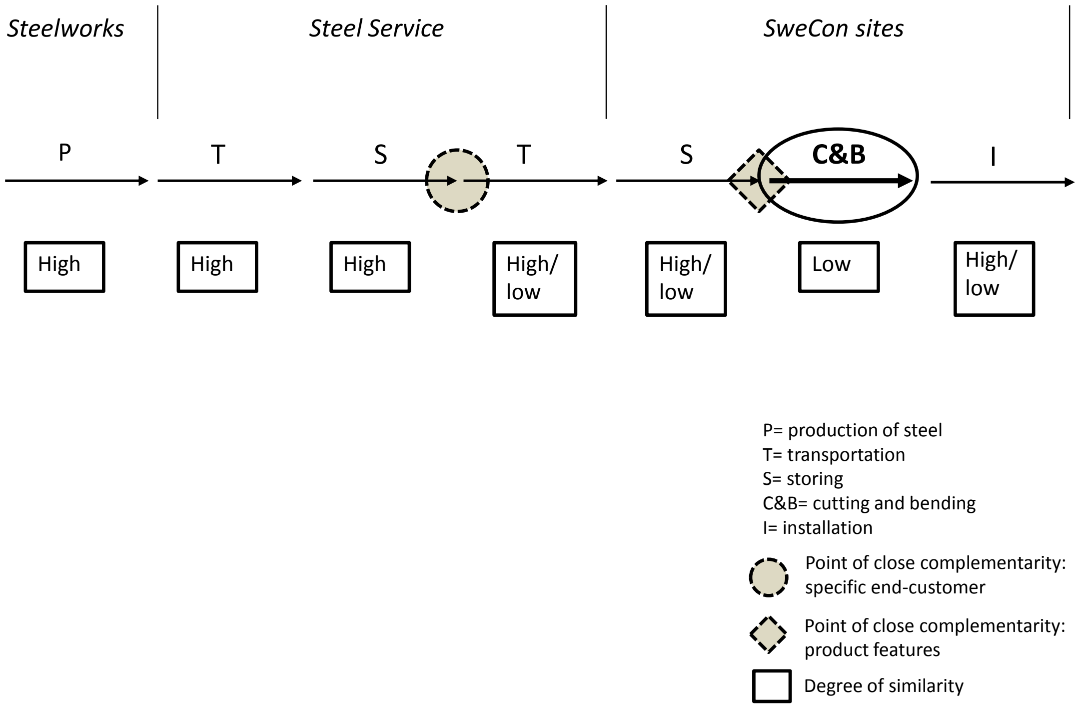


Figure 5.2 Efficiency of single activities in situation 1.

Production at steelworks, transportation to Steel Service and storing at Steel Service are characterized by a high degree of similarity, since these activities are carried out in a standardised way. Economies can be derived from the scale of these operations. Transportation of bars and meshes to sites can be characterized by either high or low similarity, depending on the possibility to co-load products going to the same destination. Steel Service co-loads several reinforcement orders, and may also co-load other products such as beams. Standard routes are used as much as possible for transportation, thereby increasing the degree of similarity and allowing economies of scale, which results in lower prices for transportation for Steel Service's customers. However, delivery of meshes is not conducive to co-loads and similarity because it is not possible to stack anything on top of meshes.

Transportation requires extensive coordination in order to handle the requirements of individual sites and to enable these adjustments at the same time as providing cost advantages. Short notice orders received close to the time of required delivery reduce the possibilities for such coordination and benefits based on similarity in transportation. Thus, the ability to lower the costs of transportation depends heavily on project planning in relation to when orders are placed, and specific delivery requirements.

The trailers used by Steel Service to transport reinforcement to the sites have cranes to facilitate unloading. Depending on coordination among other operations on site which require the building crane and construction workers, storing (including moving materials from the point of unloading, and within the site as conditions change) can be characterized by low or high similarity. Many small batches of materials delivered at different times to the site reduce the ability to move and store materials on a large scale, thus decreasing the degree of similarity in these operations.

Cutting and bending takes place on sites mostly “when there is nothing else to do”. Hence, there is little incentive to benefit from similarities; often current need – for certain dimensions, profiles and quantities - is decisive for this activity. Also, the scale of cutting and bending on site is limited by the limited capacity of the machinery required, which further decreases opportunities to exploit similarities in these operations. Therefore, although profiles are standardized it is not possible to benefit from this standardization in the cutting and bending activities. On the other hand, cutting and bending at the construction site allows individual adjustments to meet specific situations, for instance, additional profiles can be produced. Thus, huge diversity is present in the activity configuration in terms of individual profiles produced from ‘standard’ reinforcement bars, and the timing of their production.

Depending on how the work is planned and the types of profiles available at sites, installation of reinforcement can be characterized by high or low degree of similarity. Interruptions due to lack of the right profiles considerably reduce the similarities in installation. Finally, the installation of reinforcement enables customization in relation to the individual site through the combination of standardized profiles in unique ways during construction.

5.2 SITUATION 2: CUTTING AND BENDING AT STEEL SERVICE

In situation 2 CAB is produced in Steel Service’s steel centres. The various profiles are then transported to the sites for installation. First, the serial relatedness among the activities in situation 2 is analysed, followed by an examination of the efficiency of single activities.

5.2.1 SERIAL RELATEDNESS IN SITUATION 2

Situation 2 involves production of carbon steel bars, steel bars with special features, coils and meshes, in various dimensions. This is followed by transportation and storing, cutting and bending, storing of adjusted profiles, transportation to sites, storing at the sites, and finally, installation. The activities have to be undertaken in this specific order and can be described as complementary activities (Figure 5.3).

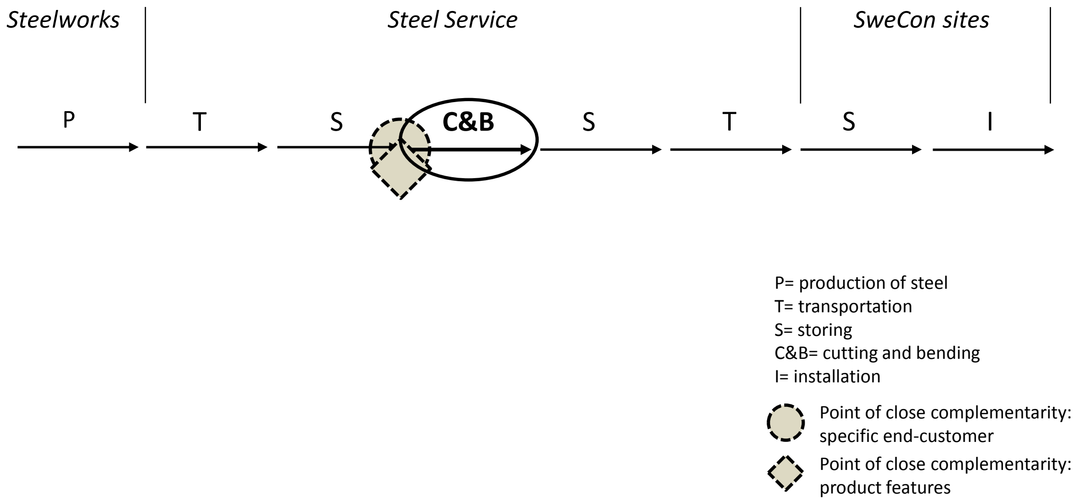


Figure 5.3 Serial relatedness among activities in situation 2.

As in situation 1, the production at steelworks, transportation to Steel Service and storing at Steel Service are based on speculation. The steelworks speculate about the future needs of its customers, such as Steel Service, and Steel Service speculates upon the needs of its customers, such as SweCon sites. Bars, coils and meshes are transported from the steelworks to one of the two steel service centres, where bars and coils are used to produce CAB. Cutting and bending implies close complementarity among the activities related to specific end-customers and product features (Figure 5.3). This applies to standard reinforcement as well as reinforcement with special features. Cutting and bending and other subsequent activities go in a particular direction related to their form, time and place, and are undertaken based on postponement directed by orders from the sites. Cutting and bending, storing at Steel Service, transportation to sites, and storing and installation at sites are complementary activities in relation to individual sites and reinforcement profiles' specific features. Customization related to CAB profiles is based on orders from the sites. For meshes the same conditions apply as in situation 1: meshes get their dimensions in the production at steelworks and the transportation from Steel Service directs them to individual sites.

Coils are used to produce CAB in small dimensions and Steel Service uses 18 metre bars for thicker dimensions. Situation 2 also involves the production of stainless steel CAB, and other profiles with special features.

5.2.2 EFFICIENCY OF SINGLE ACTIVITIES IN SITUATION 2

Next, the analysis examines the efficiency and similarities of the single activities in situation 2 (Figure 5.4).

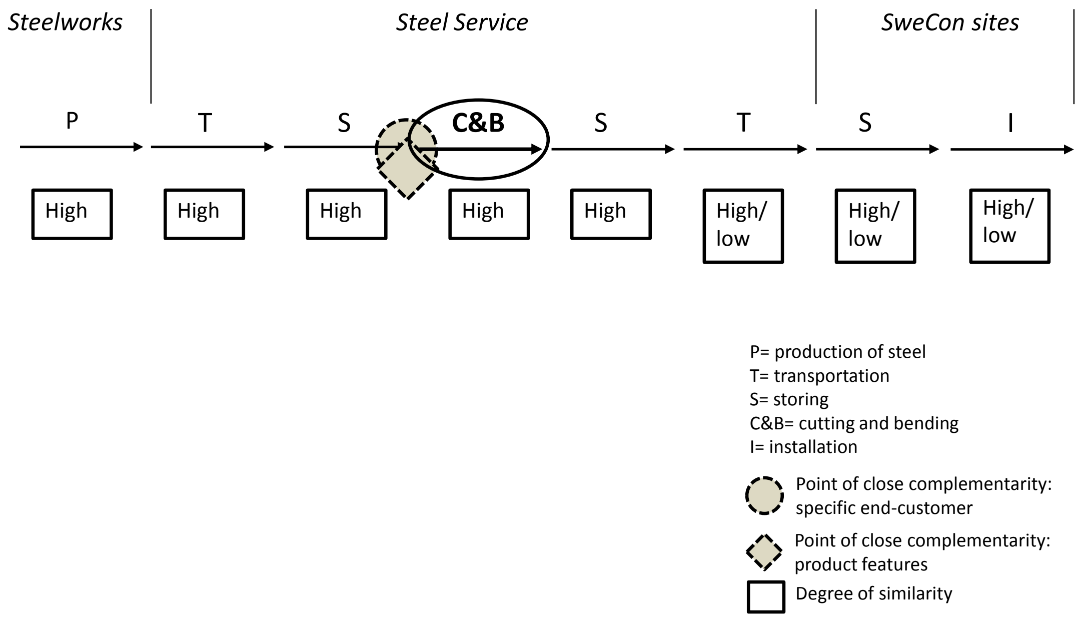


Figure 5.4 Efficiency of single activities in situation 2.

As in situation 1, production at steelworks, transportation to Steel Service and storing at Steel Service are all characterised by high degrees of similarity based on standardization. This allows economies of scale in relation to these operations. Since all the profiles are produced according to Swedish standards this allows economies related to cutting and bending activities. Steel Service aims to keep the cutting and bending machines (and those used for straightening coils) running continuously, with few stops and little waste of material. This requires well planned production and extensive coordination and combining of orders from several customers. These efforts enable cost advantages through economies of scale as a result of exploiting similarities, at the same time as profiles for various sites are produced. Steel

Service's own consultant can via the specifications direct the reinforcement to less complicated profiles in the constructions. This improves the efficiency of cutting and bending operations.

However, achieving economies of scale by combining orders for CAB reduces the ability to adapt to individual customer requirements regarding delivery times. The lead time for CAB is about three weeks, and orders placed at short notice reduce the possibilities of economies of scale based on the degree of similarity. However, situation 2 provides for great diversity in terms of the range of products available to sites: 'standard' reinforcement, special feature reinforcement in various dimensions and profiles, and meshes.

Storing of CAB at Steel Service is characterised by high similarity since it takes place in connection to the batches of CAB profiles. For transportation to sites, the same conditions apply as in situation 1. Transportation to sites is characterized by high or low similarity depending on the ability to co-load products for the same destination. Customer requirements for specifically-timed deliveries and small batches significantly reduce similarity.

When CAB is delivered in small batches on many occasions to sites economies of scale related to storing activities are reduced. In contrast, fully loaded trailers with goods for the same destination enable increased similarity of unloading and storing at the site. Hence, storing is characterized by either high or low similarity depending on how transportation activities can be planned. Finally, use of CAB results in installation characterized mostly by high similarity and large scale, and no need to go back and forth to reinforcement stations to make profiles. Planning installation, including orders for CAB, is crucial for these achievements. If the required profiles are not available when needed, construction workers might have to produce them on site. This requires availability of surplus long bars and setting up of a reinforcement station. Supply of CAB delivered according to a planned schedule enables a high degree of similarity in installation, which can be undertaken continuously. Moreover, construction workers are involved in many operations on site, and their coordination is central to enable economies of scale in these various tasks, such as installation of CAB. As in situation 1, customization in relation to individual sites is enabled by combining standardized CAB profiles in unique ways during installation operations.

5.3 SITUATION 3: CUTTING & BENDING AT THE SWECON FACTORY

In situation 3 SweCon produces CAB in its own reinforcement factory. Various profiles are cut and bent, and transported to the sites for installation. First, the serial relatedness among the activities is analysed, and then the efficiency of single activities is examined.

5.3.1 SERIAL RELATEDNESS IN SITUATION 3

Situation 3 involves production of carbon steel bars, coils and meshes of varying dimensions, which is followed by transportation, storing, cutting and bending, storing, transportation to sites, storing at the sites, and finally, installation. These activities are serially interdependent and have to be undertaken in this precise order and, thus, they are complementary activities (Figure 5.5).

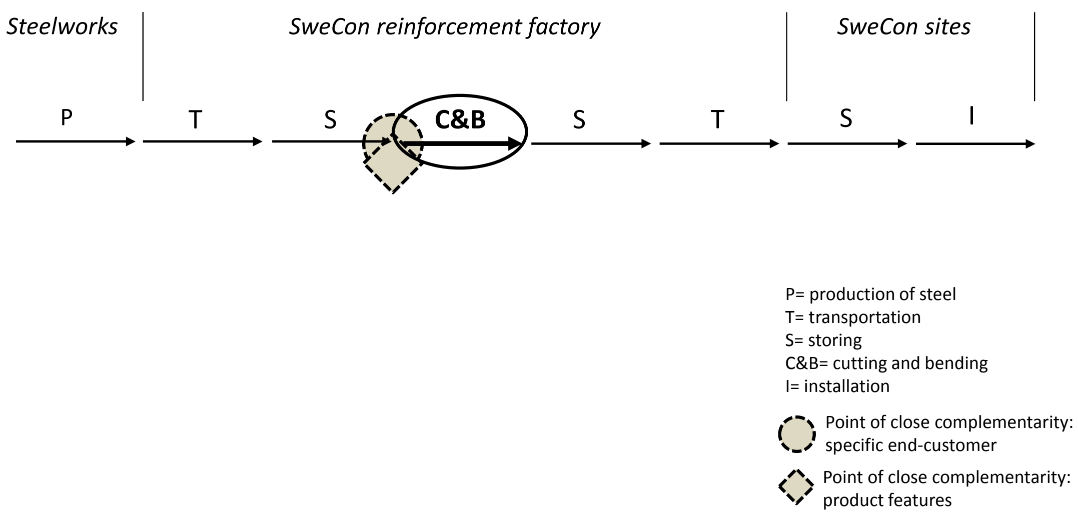


Figure 5.5 Serial relatedness among activities in situation 3.

Speculation directs the production of bars, coils and meshes at steelworks. These products are transported to the SweCon reinforcement factory for storing. Transportation and storing are also based on speculation, in this case regarding the future needs for reinforcement of individual sites. In situation 3, cutting and bending involves close complementarity with regard to specific customers and product features to create CAB profiles and direct them to individual sites (Figure 5.5). Cutting and bending is undertaken in the factory based on postponement regarding time, place and form consistent with orders from the sites. Customization is represented by batches of unique sizes and quantities of standardized profiles to suit individual constructions. Cutting and bending, storing at the factory, transportation to sites and storing and installation at the sites are thus closely complementary in relation to individual sites and also features of the CAB. For meshes the same conditions apply as in situations 1 and 2: meshes get their dimensions in the production at steelworks, and transportation directs them to individual sites.

In situation 3, as in situation 2, coils are used to produce CAB in small dimensions. Although both Steel Service and SweCon use 18 metres bars for CAB, the factory also produces CAB from 15 metres bars which further reduce materials waste in cutting and bending operations. However, the SweCon factory cannot produce CAB with special features.

5.3.2 EFFICIENCY OF SINGLE ACTIVITIES IN SITUATION 3

The following analysis captures the efficiency of single activities in situation 3 by examining the degree of similarity among activities (Figure 5.6).

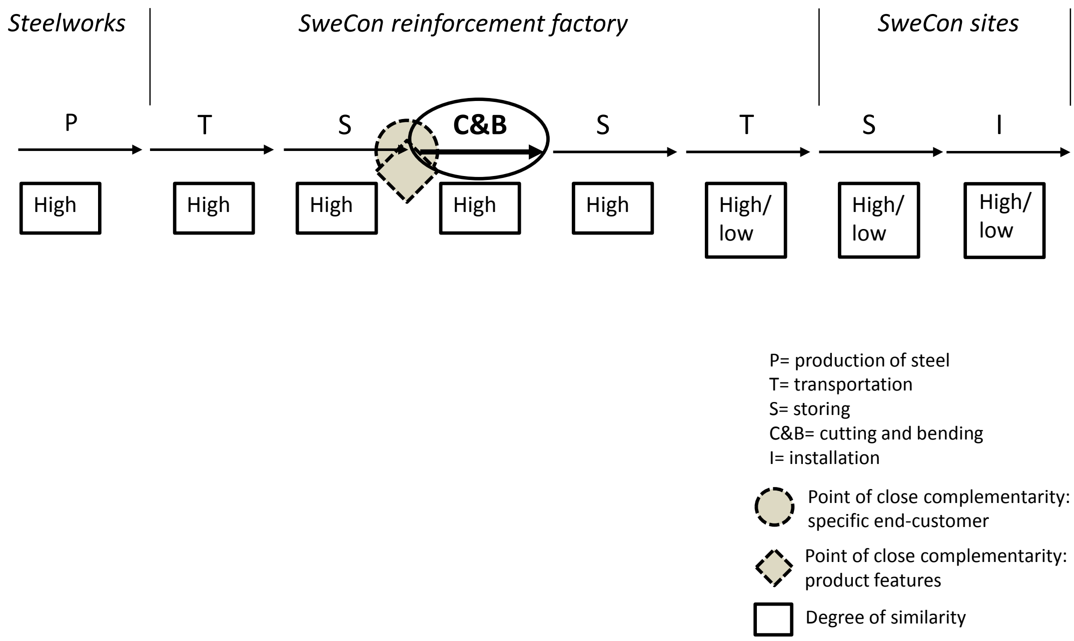


Figure 5.6 Efficiency of single activities in situation 3.

In situation3, as in the case of Steel Service, production at steelworks is standardized resulting in a high degree of similarity. Transportation to SweCon's factory and storing at the factory are also standardized activities allowing economies of scale based on a high degree of similarity. The factory aims to keep the two cutting and bending production lines (including the coil straightening) running continuously with few stops and little materials waste. This requires careful production planning and coordination, and the combining of orders from multiple sites. A high degree of similarity in cutting and bending is achieved which enables cost advantages. The standard CAB profiles, which promote standardization of production, enable such benefits. The surplus from the factory's cutting and bending operations is sold to some 35 customers located geographically near to the factory. This increases the factory's performance allowing large scale production and little waste of material. However, complicated profiles with several three dimensional bends reduce the opportunity for economies of scale in CAB production. Efforts to increase similarity and gain from standardization are a barrier to production of customized goods and specific delivery times and hamper the diversity. Storing of CAB is aligned to cutting and bending activities wherefore similarity among storing is high.

The ability to co-load CAB and meshes to deliver to several sites along a planned transportation route, and to co-load reinforcements responding to multiple orders from the same sites, is crucial. Central management at SweCon has set a target cost which requires co-loading. The factory strives for maximum similarity among all transportation activities; however, many small orders with short lead times, for delivery to several sites, and also large volumes of meshes, decrease the degree of similarity. In order to encourage sites to plan their supplies of reinforcement and place orders well in advance, the factory offers discounts. These discounts are enabled by economies of scale in cutting and bending, and transportation to sites when orders are received at least three weeks before delivery is required.

Depending on transportation activities, storing at sites can be achieved to exploit high similarity in terms of full trailers; many, smaller loads reduce this similarity. For installation the same conditions apply as in situation 2: use of CAB allows installation on a larger scale. However, lack of coordination with other operations on site, and poor availability of CAB result in a low degree of similarity of installation.

The three situations have been analysed separately. The next section compares the three situations analysed above.

5.4 COMPARISON OF ACTIVITY INTERMEDIATION SITUATIONS

The above analyses capture three intermediation situations in which intermediate cutting and bending activities connect the other activities in different ways. These connections affect the efficiency of individual activities and how they function together, which in turn affects the costs of SweCon sites' supplies of reinforcement. This comparison captures the variation in efficiency and costs of combined effects of standardization and customization. Table 5.1 presents the differences among the three situations. [2]

Table 5.1 Comparison of activity intermediation: situations 1, 2, and 3.

	Situation 1: cutting and bending on site	**Situation 2: cutting and bending at Steel Service**	**Situation 3: cutting and bending at SweCon factory**
Costs for SweCon sites (SEK/ton)[2]	• X plus 15%	• X plus 7-8 %	• X
Efficiency: cutting and bending	• Low similarity: No economies of scale	• Very high similarity: combining of orders from many customers, exploiting economies of scale to a very great extent	• High similarity: combining of orders from many sites, exploiting economies of scale to a great extent
Efficiency: transportation to sites	• Great ability to co-load with other steel products	• Great ability to co-load with other steel products	• Ability to co-load only with other reinforcing products
Customization	• Standardized profiles of carbon steel combined in unique ways • Ability to adjust to current conditions at site	• Standardized profiles of carbon steel and special features steel combined in unique ways • Problems to adjust to demands on short notice	• Standardized profiles of carbon steel combined in unique ways • Great problems to adjust to demands on short notice

[2] Cost figures based on input from Steel Service, SweCon reinforcement factory and sites. X is the price a site pays the SweCon factory for CAB. The same amount and type of CAB purchased from Steel Service increase the price to X plus 7%-8%. X plus 15% is the cost for cutting and bending on site and includes the price of the steel, transportation to site and man hours needed for the cutting and bending operations.

Regarding the supply of reinforcement, using CAB instead of undertaking cutting and bending on site, provides cost advantages for the projects. This alternative requires extensive coordination through production planning and combining of orders: at Steel Service from various customers and at SweCon's factory from several SweCon projects. These arrangements increase the similarity in cutting and bending activities, allowing them to be undertaken on a larger scale, which provides cost advantages. Use of coils, and combining orders, reduces waste from the production of CAB. This further increases the cost efficiency of these operations. Steel Service achieves greater economies of scale than the factory: Steel Service serves more customers and Steel Service's centres are used also for other types of prefabricated steel. Complex profiles cut and bent in three dimensions extend production times and reduce economies of scale for both Steel Service and SweCon.

As important as cutting and bending operations for efficient reinforcement supply is transportation to sites. Extensive coordination in relation to co-loading of products for the same destination and according to pre-planned routes is crucial. Steel Service has some advantages owing to its ability to co-load several different steel products and to exploit co-loading for delivery to its warehouses and thence to customers. However, the most cost efficient alternative for SweCon sites is supply of CAB from the factory rather than Steel Service, since the price for CAB is lower.

Efficient supply of reinforcement to sites depends on a combination of standardization and customization. All profiles are produced according to Swedish standards, which enables standardized cutting and bending operations. One aspect of customization is the combining of these profiles in unique ways through installation at sites. This applies to all three situations, but only situation 2 allows for profiles made of reinforcement with special features, since they cannot be cut and bent at sites nor handled by the SweCon factory. The strong focus on economies of scale in situations 2 and 3 reduces the ability to adapt to customers' individual requirements regarding lead times and delivery, compared to situation 1. Both Steel Service and the factory have a lead time for producing CAB of three weeks. Orders placed at shorter notice, and/or specifying a certain delivery time, reduce the possibilities of economies of scale crucial in the production of CAB. Thus, in the production and transport of CAB to sites, good customer planning and use of more standard profiles are critical. Extensive coordination through production planning and combining of orders in the steel service centres of Steel Service and in SweCon's factory is required to achieve the benefits of standardization while also allowing a level of customization. The site managers perceived that Steel Service was better able than the factory to provide customized delivery of CAB at short notice.

In comparison, in situation 1 current demand for reinforcement profiles directs cutting and bending operations. Any adjustments can be made in accordance with the specific situation at the site and, hence, there is greater diversity in the type and amount of profiles required at the time of installation. On the downside, cutting and bending cannot be undertaken on a large scale on site to increase the similarity and gain from economies of scale owing to limited machinery capacity and the need to carry out cutting and bending only 'when construction workers have nothing else to do'. Also, transportation of long bars to sites is more complex than transportation of CAB.

In all three situations, the unique demands from individual sites in terms of profiles, measures and quantity imply that cutting and bending and subsequent activities are executed based on postponement. Thus, despite individual profiles being standardized, orders from sites direct the production of reinforcement profiles. But owing to the long lead times for steel supply from steelworks, both Steel Service and SweCon hold inventories based on speculation on demand. In all three situations the same conditions apply to production at steelworks, and transportation and storing at Steel Service and the SweCon factory.

This chapter has analysed activity intermediation with regard to the supply of reinforcement to SweCon's projects. It showed that increasing the similarity among activities offers cost advantages, but at the same time it is necessary to provide customization through adjustments to individual project needs. The three situations of intermediation identified in the SweCon example entail various prerequisites and constraints.

6 MATERIALS HANDLING & CONSITE LOGISTICS

This empirical chapter deals with materials handling at construction sites in house building projects. These projects involve huge numbers of materials deliveries to the site. Handling of materials refers to unloading (including quality checks), storing the materials and moving them on site, and handling and transporting materials to the site assembly point. A tower crane, elevators, forklifts and other equipment are essential resources, and construction workers spend numerous man-hours on these operations. Materials handling often clashes with other site operations that use the same resources. ConSite Logistics specializes in materials handling outside of regular working hours to ensure efficient logistics flows and minimize production disturbances at the site. Over time, this way of working has evolved to encompass consultants' work with logistics analysis, and the development of a web system for delivery planning. ConSite Logistics' current business includes all-inclusive logistics functions carried out by consultants located at sites. Chapter 6 begins by describing materials handling in detail including common problems encountered at the sites. The chapter describes ConSite Logistics' approach to materials handling and concludes by describing its work of logistics analyses and logistics functions.

6.1 MATERIALS HANDLING AT A CONSTRUCTION SITE

In the construction industry, costs related to materials comprise a significant proportion of total project costs. Studies estimate that material costs account for over 50% of building costs (Asplund and Danielsson, 1991), and statistics from the Swedish Construction Federation show that the average cost of materials for housing projects constitutes 45% of the production costs. These costs involve purchase of materials: the price of the materials plus the costs of delivery to the site and handling on site.

6.1.1 MATERIALS HANDLING VARIES DEPENDING ON THE PROJECT PHASE

In a large construction project, very large numbers of vehicles enter the site, sometimes more than 100,000. Some vehicles are shuttle traffic, others deliver once. Deliveries commonly take place during regular working hours (07.00 to 16.00), at the same time as on-going site operations such as assembly and casting. The intensity of deliveries varies throughout the project, and there are different requirements related to inbound logistics and materials handling. A construction project typically involves three phases. The initial phase involves the presence of few workers on site, but much heavy machinery and its operators. Transportation accounts for a smaller number of heavy vehicles involved in shuttle services to transport demolition material, shaft and detonation bulk from the site, and filling material to the site. In this phase there is relatively plenty of space on site.

The second phase is most intensive in terms of work force: several actors including contractor's personnel and subcontractors are present on site at the same time. Inbound deliveries often include fragile or weather sensitive materials, and many deliveries involve small quantities delivered in vans, which are difficult to foresee and plan for. Several different transport vehicles can arrive simultaneously, and need to drive around the site to unload, and then exit through crowded entrances. In this phase, there is a lack of space at the site.

During the third and final phase, the number of actors on site decreases gradually. The first tenants may begin to move in, creating new requirements on site. The materials involved are often sensitive and require to be handled with extreme care. Towards the conclusion of the project elevators and building cranes are removed, which makes handling of remaining large deliveries problematic. However, this final phase is most characterized by numerous small deliveries, but lack of space, and tenants have to be considered.

The second phase is the most intense phase and the most challenging in relation to materials handling. This chapter focuses on this phase, including handling of gypsum boards, kitchen cabinets, and wardrobes. The site manager devotes much time to coordinating orders and deliveries from multiple suppliers and manufacturers, and checking the quality of incoming materials. It is estimated that around 10% of the site manager's work goes to these tasks. The various materials handling tasks present different challenges.

6.1.2 TRANSPORTATION TO SITES, UNLOADING AND STORING OF MATERIALS

Trailers, with or without cranes, are mostly used to transport materials to the sites. For trailers without cranes, the site tower crane or forklifts have to be used to unload the vehicle. Figure 6.1 illustrates the unloading of kitchen cabinets.

Figure 6.1 Unloading of kitchen cabinets (Source: Lindström and Skude, 2008).

The unloading space on site is often very restricted, which limits the number of vehicles that can enter and leave the site at any one time. The problem is exacerbated if the site is in a central city location. After unloading, materials frequently have to be stored before being moved to another area for installation. Contractors' purchasing and calculation departments often order materials in bulk to get volume discounts and reduce the price per unit, resulting in large volumes of materials arriving at the site long before all of the materials are needed for production. Transportation to the site is often planned also to minimize transportation costs by maximizing the cargo on trailers. Co-loading of various products from materials manufacturers or wholesalers can result in materials arriving at the site prior to the phase of installation. This necessitates provision for storage of large volumes of materials on site, sometimes spread across different locations. Volume discounts for materials and transportation create the need for storage and additional handling on site, which implications are often ignored by planners. Figure 6.2 depicts storage of building materials on site.

Figure 6.2 Materials storage on site (Source: Lindström and Skude, 2008; Lindén, 2011).

Unloading and use of storage area are frequently based on a 'first come, first served' principle rather than being planned. Reinforcement, structural steel, concrete blocks, frame complement materials and other building materials are often 'stored' wherever they are unloaded, which can cause congestion and interfere with vehicle entries and exits, and building operations. It can result in materials having to be moved and re-moved to other areas of the site. On average, every 'bundle' of materials is moved seven times on site, before installation operations are carried out. It is important for materials to be clearly labelled to make them easily identifiable and differentiable from similar materials. It is important for materials not to be stored next to buildings to avoid impeding access. Materials should be stored on timbers or pallets to prevent mud or water damage. Some materials, e.g. gypsum boards, must be stored inside in a completely dry area because they are very moisture sensitive. Open storage areas must be secure to ensure easy access for successive deliveries of equipment and waste removal.

Sites are not suitable for materials storage and bad weather conditions, lack of space and ongoing activities inevitably cause damage. Calculations of building material costs in a project always include an amount for waste. Contractors commonly estimate this at around 10%, i.e. 10% is added to the calculated volumes of materials going into the site. This waste is generated by losses of materials, damage during transportation or unloading, damage during storage on site, and to a smaller extent; damage when installing the materials. Hidden defects add to this waste of materials and thus add extra cost, e.g. if wet gypsum boards used to line interior walls begin to show signs of mould. Hidden defects do not become apparent until later stages in the building process, or even after the building has been completed, and are far more expensive to correct than visible defects. Figure 6.3 shows visible defects on kitchen cabinets unloaded at the site. These cannot be installed.

Figure 6.3 Damaged kitchen cabinets (Source: Lindström and Skude, 2008).

6.1.3 TRANSPORTATION TO THE ASSEMBLY POINT

From the unloading or storage area, the materials need to be moved to the relevant assembly points. Studies show that this part of materials handling accounts for around 14% of a construction worker's daily working hours (Jospehson and Saukkoriipi, 2005). If time spent searching for materials, unpacking and separating them into suitable bundles, sorting them, plus time resulting from waiting for materials and disruption to work flow is added up it can represent a third of the daily working hours on a construction site (ibid.).

Materials are moved from unloading location or storage area to the assembly point by using the tower crane, forklifts or elevators. Other operations on site also involve use of this equipment, and especially the crane is a crucial resource for many operations. For materials handling, the crane may be required for unloading materials from incoming vehicles, moving them from unloading area to storage area, and from storage to assembly points located alongside in inside a building. Figure 6.4 shows how the crane transports materials.

Figure 6.4 Crane transport for materials on site (Source: Lindén, 2011).

Most (90%) of house building projects require a tower crane, and some sites have more than one crane. The contractor commonly sends requests for tenders to crane suppliers during the project planning phase. Suppliers provide tenders that include technical data, equipment requirements, rental periods, rental/day, cost of mounting and demounting and costs for servicing. The contractor selects a supplier to provide the crane(s) for the project. The agreement may include the supplier's crane operator; otherwise the contractor hires an operator separately. Cranes vary in size, and especially height, and are dimensioned to carry a certain maximum weight; the heavier the crane's load capacity, the higher the rental.

The importance of the crane on site is illustrated by the following statement from a site manager: "A busy crane at the site is a good sign; it shows that progress is being made. In fact, often operations queue up to use the crane. This is very good. Since the crane is a very expensive piece of equipment it should not be standing unused. On the other hand, since the crane can only carry out one operation at a time queues cause waiting time, and delay operations. In particular, the extensive need for a crane for 'moving around' materials is frustrating and hampers the operational flows."

In addition to tower crane(s) on site, elevators are used to transport materials and work force to various floors. Safety is vital in relation to use of cranes and elevators which have extensive usage regulations. For example, an elevator must be covered so that if something falls from the building anyone standing inside the elevator will not be injured. Transporting materials in elevators often causes interruptions to site work flows because of the need to transport work force and vice versa, transportation of work force can delay materials handling. Consequently, materials handling has to be coordinated with the many other site operations that use the same resources. If the wrong equipment is used, materials can be damaged. If the elevator does not go high enough to reach the uppermost floors, materials have to be moved again using different equipment which causes extra work and significant time.

Thus, materials handling related to unloading incoming materials, sorting and moving materials, and handling and transportation to points of assembly is challenging. Purchasing behaviour and supply of cranes and elevators have a heavy impact on materials handling. The next section discusses specific problems related to materials handling.

6.2 MATERIALS HANDLING PROBLEMS

The following section describes materials handling related to gypsum boards, from unloading on site, to start of installation by construction workers (see also Karlsson, 2009 for extensive details). Gypsum boards are among the most frequently transported materials related to the frame complement process which includes façade, outer walls, inner walls and wardrobes, kitchen cabinets, etc. The boards are transported to the site in packages which can vary in size and weight. In the example to be described below, the delivery arrived late to the site and there was no one to direct it to the appropriate unloading location. Time was spent finding the right area and waiting for a forklift to unload trailer. Then construction workers found that the temporary materials storage area had not been cleared and prepared for the unloading of materials. The boards had to be unloaded in a temporary location with enough space, with no consideration of how this would affect other operations on site or future plans for that area.

During unloading it became apparent that the packages of gypsum boards were not well labelled. There was no information on the dimensions or final use. This created extra work because the workers could not guide the forklift driver about the sequence of unloading and storage according to order of installation. The boards were unloaded according to no particular logic. To transport the boards on site required loading onto a hydraulic materials transport wagon. However, the available wagon was not equipped correctly. Distances were very short, and it was difficult for the fork lift to load the boards onto the wagon.

There were also problems because the transport wagon did not fit into the construction elevator because of the space taken up in the elevator by its engine. Workers had to break into the packages and remove three layers of gypsum boards in order for the transport wagon to fit beneath the elevator engine. When the elevator arrived at ground level it was not aligned with the door into the elevator, and loading the boards into the elevator resulted in many being damaged. Although scoring damage could have been avoided by carrying the gypsum boards one by one, this option had been rejected on the grounds of the time it would involve. On the destination floor the passages were wide enough to allow the hydraulic wagon to be used to transport the boards to the right area for installation.

This description shows that materials handling on a construction site is problematic, can result in wastage of material, problems of interrupted production flows and numerous extra operations in order to transport the material to the correct assembly point. It underlines the need for various resources to function together to accomplish efficient materials handling of gypsum boards: the presence of construction workers, suitable storage area, good labelling, appropriately sized packages, forklifts, transportation wagon and elevator. ConSite Logistics was established to respond to calls for more efficient materials handling on construction sites. The next section describes the growth of ConSite Logistics.

6.3 GROWTH OF CONSITE LOGISTICS

The founder of ConSite Logistics used to transport building materials from a wholesaler's warehouse to construction sites. One customer asked for materials to be delivered direct to assembly points instead of usual being unloaded at an assigned materials storage area on site. In discussing the price of this extra service it became clear that, on that occasion, it would involve no extra cost for the customer. However, for subsequent deliveries, the customer had to pay an extra charge for this service. ConSite Logistics' founder recognized this request for 'inbound transportation of materials' as a valuable business opportunity and established the firm West Construction Commodities in 1998. The firm started as a traditional building materials dealer, but with delivery of materials to sites in a more structured logistical manner. This firm was unique in having personnel with competences in both the transport and house building sectors as well as experience in the traditional construction supplies. Materials were transported to assembly point on sites instead of being delivered to unloading areas, rendering materials handling on site more efficient.

In 1999, the firm began delivery of materials after regular working hours (after 16.00) to reduce disturbance to production flow on site. This attracted huge interest from customers and the firm was more and more focused on inbound logistics and materials handling compared to 'just selling building materials off the shelf'. In 2002, the firm changed its name to West Construction Logistics to highlight the logistics nature of its business. The demand for logistics services grew, and in 2005 a second office was established in another geographical region. This office focused only on logistical services, and did not sell building materials. At this point the firm was renamed ConSite Logistics. The materials dealer that was part of the original business was disposed of in July 2008 to a regional wholesale building materials distributor chain. ConSite Logistics focused on materials handling at sites, with no involvement in selling materials or transportation to sites. The next section describes materials handling by ConSite Logistics.

6.4 MATERIALS HANDLING BY CONSITE LOGISTICS

Contractors or subcontractors can hire ConSite Logistics to undertake materials handling for house building projects which include residential properties, public buildings such as schools, and refurbishment of existing commercial buildings and hospitals. ConSite Logistics can be hired for occasional materials handling operations, or for all the materials handling operations involved in a project. The number of materials handling operations that ConSite Logistics deals with varies from week to week – ConSite Logistics might have two or seven operations in a week, some of which may be on the same site. For example, at the beginning of 2012 eight construction projects in Sweden were using ConSite Logistics for all their materials handling operations. In one of these projects, materials were being delivered every day and thus materials handling was required daily.

In most cases, ConSite Logistics conducts its materials handling outside of regular working hours. Equipment stationed on site can be used, and materials handling operations neither disrupt nor are disrupted by other operations. The time set for the arrival of a trailer must be precise. If several trailers are set to arrive on the same day, they are scheduled at 30-45 minutes slots. The firm that hires ConSite Logistics, i.e. a contractor or subcontractor, is responsible for communications with the materials manufacturer, wholesaler or other actor responsible for transportation, to give instructions about arrival times. ConSite Logistics does not have direct contact with the supplier of materials. An agreement regarding materials handling and prerequisites for this operation, is made between ConSite Logistics and the contractor/subcontractor, which then instructs the actor responsible for transportation.

The agreements between ConSite Logistics and its customers include very specific instructions about conditions on site required for its materials handling services. A consultant from ConSite Logistics usually visits the site the day before materials handling is scheduled to start, to check the area for unloading and that equipment is available as agreed.

6.4.1 ARRIVAL AT THE SITE

A ConSite Logistics quality consultant (known as the QR) visits the site an hour before transport arrival to ensure everything is set for materials handling. ConSite Logistics provides its own workers, pallet lifts, and equipment required for quality checks and the other materials handling operations. These resources arrive at the site shortly before the delivery of the materials. ConSite Logistics will hire crane operators and forklift operators wherever necessary. The QR and ConSite's workers required for materials handling are hired by hour. If a project includes several phases of materials handling, ConSite Logistics tries to assign the same QR and workers, since their experiences of conditions at the site help to smooth operations.

The materials handling undertaken by ConSite Logistics includes several steps. To begin with, an arrival control is conducted to check for any damage to incoming material, such as broken packages. It is crucial to detect defective material at this stage, and any damage is documented by taking photos to be sent to the contractor or subcontractor, accompanied by the relevant delivery note. Almost all deliveries have some kind of damage. Often, the materials can still be used for building operations because only the packaging has been damaged. The materials undergo many handling steps: production, packaging, transportation from factory, terminal operations, transportation to sites and unloading, so some damage - especially to packaging – is almost inevitable. The documentation related to condition on arrival at the site is very important to determine where and when the materials were damaged; otherwise ConSite Logistics is ultimately responsible for damage sustained through materials handling on site.

6.4.2 Sorting materials and transportation to assembly point

After arrival quality control the materials are unloaded and sorted before being transported to the appropriate assembly point. In the case of several inbound trailers arriving simultaneously, they are dealt with in the order that the materials that arrive first are transported to their final destination last in order to make operations as efficient as possible. After being sorted, the packages of materials are transported via elevators, or the tower crane and platforms, depending on the type and size of the material. Elevators are used as much as possible because this represents the most efficient way to transport materials. However, long goods, such as sprinkler pipes and cable ladders, always require the tower crane because they are too big for an elevator. All other goods are handled using pallet lifts or materials carts in the elevators. Their destination, e.g. house 1, floor 2, apartment 3, is clearly marked on the packages. Inside the apartment or building, the assembly point for placing the pallets or trestles is clearly marked on the floor. This is done according to planned installation. Figure 6.5 shows materials being placed by ConSite Logistics at assembly points.

Figure 6.5 Materials placed at assembly points (Source: Lindén, 2008; 2011).

6.4.3 Requirements for materials handling

Materials handling has a fixed price based on width, length, height and weight of the packages such as palleted goods, bundles on trestles, and long goods (such as cable ladders). Prices are based on experience of how long it takes to handle various types of goods, for instance, handling two pallets that fit into one elevator together. However, these prices are applicable only if the conditions required by ConSite Logistics are fulfilled. Elevators must be 3,200mm in dimension internally, with no internal motor, and capacity to handle 1,500kg. The elevator must be aligned to all floors including the ground floor so that pallet lifts can be used to transport materials on all floors. Packages must be a certain size and weight with specific wrapping and markings. ConSite Logistics never un-wraps an incoming package, since the material can be damaged in the handling operations. All these requirements are set out and communicated to materials suppliers by the contractor/subcontractor hiring ConSite Logistics. Figure 6.6 shows appropriate aligned elevators.

Figure 6.6 Aligned elevators: pallet lifts can be used (Source: Lindén, 2011).

Thus, it is crucial that requirements for free passages at the site, and appropriate elevators and packaging are fulfilled in order for ConSite Logistics to carry out materials handling cost efficiently. If these conditions are not met, handling time increases, which increases the cost. For example, in one case packaging instructions distributed to a manufacturer of window frames were ignored. The frames were delivered to the site stacked upright on pallets, requiring every one to be manually handled. The estimated 18 man-hours handling time increased to 45 man-hours and the requirement for 5 forklift truck-hours extended this a further 9 hours. The cost of this materials handling operation doubled (see Lindén, 2008 for further details of calculations).

ConSite Logistics' very specific requirements can be problematic for other firms. For example, a major supplier of cranes and elevators did not have the requested type of elevator: it was not commonly used on Swedish construction sites. This supplier's elevators were too small to carry kitchen cabinets and other larger packages, and its elevators were not aligned with the ground floor so pallet lifts could not be used. ConSite Logistics also requests fast elevators; otherwise the materials handling operations become inefficient. One type of elevator commonly used for transporting personnel is too slow. So the supplier of cranes and elevators had to augment its fleet of elevators when the contractor hiring ConSite Logistics submitted its request. Currently, this type of elevator is in fairly common use on sites even without ConSite Logistics' involvement.

Packing requirements can also be challenging for materials manufacturers. Materials are packed according to the production logic of the factories resulting in the specific packaging in the previous example of windows not being adhered to: it did not fit with the factory's storage requirements. This may require materials being unbundled by the manufacturer (or wholesaler), and re-packed according to ConSite Logistics' instructions on size, weight, wrapping and palletisation.

6.4.4 CONSITE LOGISTICS'S INVOLVEMENT VARIES

In general, if a contractor handles the materials itself it takes two or three times longer than if ConSite Logistics undertakes the materials handling outside of regular working hours, using its own workers and own equipment, such as pallet lifts. However, if ConSite Logistics' requirements for elevators, packaging and so on are not fulfilled, hiring ConSite Logistics is often an expensive alternative for the customer compared to handling the materials itself.

In addition to the variety of materials and operations that ConSite Logistics manages in individual projects there is variety regarding when ConSite Logistics becomes involved and the scope of the procedures. In some cases the customer is in urgent need of services of 'carrying the material to the right place', and ConSite Logistics will be hired on a very short notice. However, other customers involve ConSite Logistics in the project planning process to improve the conditions for efficient materials handling throughout the project. This ensures more efficient production on site since logistics including materials handling form the basis of an efficient production. Many of the conditions facilitating efficient materials handling are decided early in the planning process, for instance, cranes and elevators, gates and passages in and out of the site. While materials handling was ConSite Logistics' first business, over time the firm gained extensive knowledge about how to plan logistics at sites. ConSite Logistics has a logistics consulting division which plans projects as described in the next section.

6.5 LOGISTICS ANALYSIS BY CONSITE LOGISTICS

The creation of the Site Layout Plan[3] is part of the planning process in a construction project. The plan shows the positions of cranes, welfare facilities, location of temporary electricity supply, and other details, and is updated along the project. The logistics analyses performed by consultants at ConSite Logistics can be seen as a development of the traditional Site Layout Plan. The analysis includes materials and personnel flow analyses and takes account of the project's location and planned rate of progress when defining where all resources such as cranes, elevators, facilities, and building materials should be placed to create satisfactory production conditions. Using this information, the project's progress can be visualized in 3D through animation. ConSite Logistics carries out analyses for the client competing in the bidding process for a new contract, or for a contractor that is planning the establishment at a project site. The content of logistics analyses carried out by ConSite Logistics varies from project to project. It can encompass a specific solution involving just one elevator, or a comprehensive logistics solution for an entire site. However, for ConSite Logistics it is important to be involved early in the planning process of a project. When a project is on-going it is difficult to change logistic conditions and improve materials handling. Thus, logistics analysis regarding planning of the site and materials handling are inseparable. In 75% of cases when a contractor asks for a logistics analysis, the contractor also orders the materials handling operations from ConSite Logistics. In the remaining cases when logistics analysis is provided by ConSite Logistics the contractor assigns its own construction workers to carry out materials handling.

[3] The Site Layout Plan refers to what in Swedish is called the 'arbetsplatsdispositionsplan (APD-plan)'.

Building operations and materials handling at sites are very reliant on inbound supply to the site. Thus, ConSite Logistics also provides services regarding planning and monitoring of deliveries to the site and has developed a web portal that provides a delivery planning system. All deliveries and other important events are logged in the system so that firms, such as the contractor, subcontractors, material manufacturers and others know what takes place and where, and what will arrive in the future. In the logistics analysis, ConSite Logistics plans the routes to be used on the site taking account of entry and exit points from the site, and areas for unloading and storage. All deliveries to the site must book in advance a time slot including arrival at site and equipment needed for unloading. The system will send a message of confirmation or suggest a different time slot. Delivery planning is to ensure no additional waiting hours at sites because of an accumulation of vehicles waiting for unloading, and provision of necessary resources. The system also tracks the recipient of the goods and how the materials will be handled on site.

For large projects, ConSite Logistics offers onsite consultants. This logistics function varies depending on customers' demands, and size and complexity of the project logistics. The most common need is for delivery planning and use of the web portal. In such cases a logistics co-ordinator from ConSite Logistics is stationed on the site. If more detailed planning and co-ordination is needed a logistics consultant is assigned responsibility for overall planning of logistics. In addition, there may be someone responsible for inbound deliveries on site who directs incoming vehicles and inspects the goods, and can refuse deliveries that are not allocated on the web portal.

Thus ConSite Logistics undertakes two types of activity. Logistics analysis including in some cases comprehensive responsibility at the site dominates its business representing 75% of its work; the remaining 25% consists of materials handling. The next section describes an example of where ConSite Logistics undertook materials handling and responsibility for a complete logistics function.

6.6 EXAMPLE OF A LOGISTICS FUNCTION BY CONSITE LOGISTICS

A contractor might hire ConSite Logistics for an all-inclusive logistics function involving logistics analysis, delivery planning, delivery control and materials handling. The described project was a large project in the centre of a big city in

Sweden. Two consultants from ConSite Logistics were responsible for the logistics analysis including number and placement of cranes, facilities, elevator capacity and routes for transportation at the site. The analysis was carried out in the project planning phase. A third consultant from ConSite Logistics was present at the site responsible for all logistics enquiries throughout the project. In addition, in the most intensive phases of the project there was a consultant responsible for planning incoming deliveries, and another responsible for arrival control at the gate. This was accomplished via the web portal developed by ConSite Logistics.

The project was a refurbishment of existing buildings together with new constructions in an area of residential buildings, a library, a shopping mall and other buildings occupying some 36,000m^2, at a cost of 550 million SEK. Approximately 18,000m^2 were new construction. The project started in August 2011, and was completed in 2013. The site was tightly surrounded by a railway and streets with busy traffic, and tenants occupied some of the houses throughout the duration of the project. Deliveries in and out of the site were difficult owing to lack of space. The site conditions changed successively according to progress, and the Site Layout Plan changed several times, requiring transportation routes, unloading areas and other logistics to be constantly updated.

The project estimated a total of 35,120 deliveries of materials excluding shaft vehicles acting as shuttle traffic. At most, over 40 trailers arrived daily to deliver materials to the site. In addition, prefab materials were transported by the shuttle traffic. The site had three unloading areas: unloading crane 1, unloading crane 2, and unloading forklifts. All trailers had to enter through one gate (A), drive along parallel to one of the long sides of the site, and exit through a second gate (T). Figure 6.7 provides the simplified Site Layout Plan in place in November 2011. The Site Layout Plan was designed based on ConSite Logistics's analysis.

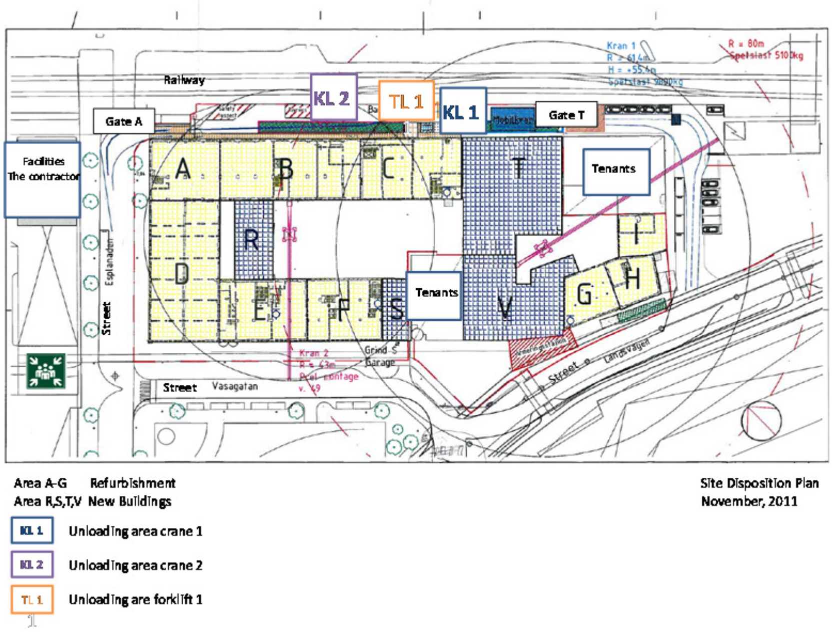


Figure 6.7 Simplified Site Layout Plan November 2011.

Ideally, there should have been a single route for all transportation around the buildings. However, this was impossible because of the crowded nature of the site which had very little space around existing buildings and between the surrounding railway and streets. Several unloading areas were required to avoid trailers having long waiting times, which increase cost. The challenge was to create satisfactory flows for unloading vehicles and for materials handling on site.

The project used ConSite Logistics's web portal for planning all deliveries. Managers at the contractor and subcontractor were responsible for ordering materials including transportation to the site. The web portal provided information such as: type of material, type of vehicle, when the transport would arrive and leave the site, resources needed e.g. crane 1, crane 2, forklift. Bookings were made through the system in a minimum of five days before delivery. A ConSite Logistics consultant was responsible for planning delivery in line with delivery requests posted to the portal. A daily delivery schedule and crane and forklift schedules were created. The person requesting the delivery received an automatic confirmation when the planned delivery had been approved by the system. In cases where the delivery was not approved, e.g. if the equipment requested was not available, another delivery time was scheduled. No deliveries were let into the site unless they had been approved and assigned a time slot on the web portal.

Thirty minutes before arrival the driver had to call the site arrival control to ensure everything was set for unloading. A leeway of 15 minutes was allowed either side of the scheduled delivery time. For shuttle traffic a whole zone at the site was earmarked, and no individual bookings were required for these vehicles. However, shuttle transport drivers were required to call site arrival control 30 minutes before arrival because sometimes the area wass used for other purposes, between shuttle transports.

In this project all materials handling was undertaken by ConSite Logistics. There was no materials transport by elevators during working hours during which period they were used exclusively to transport personnel. Simultaneous use of elevators for materials and personnel causes delays and requires workers to queue up for elevators. Materials handling by ConSite Logistics progressed in accordance with what was described in the section ‘Materials handling by ConSite Logistics’.

As already mentioned, the Site Layout Plan changed throughout the project. After the project was underway, a polluted area was discovered, causing extra decontamination work which affected the planning and progress of the entire project. This required complete re-planning and numerous adaptations. Logistics and building operations are interdependent: when planning for the building operations changes, logistics and materials handling also change. According to the contract conditions, ConSite Logistics’ consultants on site were responsible for making the logistical adaptations, responding to changes and adjusting the logistics flows to fit the new circumstances.

This chapter has described some of the challenges related to materials handling. The prerequisites for this operation are defined in the planning phase of a project, and re-planning is required to respond to unexpected circumstances and other changes at the site. Multiple resources have to function together to accomplish materials handling. Materials handling is often carried out by construction workers and use of a tower crane for transporting materials. Since materials handling and building operations both exploit these resources, there may be queues and delays. This is common at sites where materials handling occurs during regular working hours.

ConSite Logistics materials handling services include services from its expert personnel and provision of physical resources such as pallet lifts. ConSite Logistics prefers to use elevators rather than cranes for transporting materials, and materials handling takes place outside of regular working hours thus optimizing use of available resources. As a result, the tower crane and construction workers are utilized solely for building operations during normal working hours, which increases the efficiency of these operations. These improvements are based on better utilization of resources through contracting with ConSite Logistics for their onsite services. Chapter 7 analyses materials handling with regard to resource intermediation.

7 ANALYSIS OF RESOURCE INTERMEDIATION: MATERIALS HANDLING & CONSITE LOGISTICS

Chapter 7 analyses the resource intermediation with regard to materials handling. Numerous resources are required for materials handling, for example, tower crane, elevators, vehicles carrying incoming materials, and personnel with knowledge to plan for and execute the operations. Materials handling is commonly undertaken by construction workers. Another alternative is to hire a specialist in materials handling such as ConSite Logistics. Accordingly, two situations with diverse conditions of resource intermediation can be identified. In situation 1, resources, for example construction workers, are utilized for materials handling while also being needed for building operations. Similarly, the tower crane is simultaneously needed for unloading and transporting materials on site, and for building operations. Hence, materials handling and building operations tend to interfere with each other, which may cause delays. In situation 2, Con Site Logistics undertakes materials handling after regular working hours using elevators and forklifts on the site to the extent possible and introducing its own resources to the site. This allows the onsite resources to be utilized during the day time almost exclusively for building operations.

Introducing ConSite Logistics as a new resource into the existing constellation of resources affects the utilization of several resources on site, for example the tower crane, which is a critical resource on any construction site. When ConSite Logistics is used for materials handling, utilization of the tower crane changes significantly. Therefore, in line with the analytical framework, the tower crane is positioned ‘in the middle’ as the intermediate element, in analyses of resource intermediation. It is important to note that the features of the tower crane are the same in situations 1 and 2, that is, the tower crane does not change. However, how the tower crane relates to other resources changes as a consequence of introducing ConSite Logistics. This in turn affects utilization of the crane and its interfaces with other resources. This also changes the interfaces among several other resources – on site and in other settings. Analysis of situations 1 and 2 focuses on these aspects of resource intermediation. First, the two situations are examined separately. Second, the two intermediation situations are compared.

7.1 SITUATION 1: TRADITIONAL MATERIALS HANDLING

In situation 1, the tower crane on the site is needed both for building operations and materials handling. Consequently, the tower crane has numerous interfaces with other resources, physical and organizational. Physical resources include vehicles with incoming materials, forklifts, elevators, building materials and the building itself. Organizational resources are construction workers, site manager, and business relationships between contractor and materials suppliers, and contractor and subcontractors. This is illustrated in Figure 7.1.

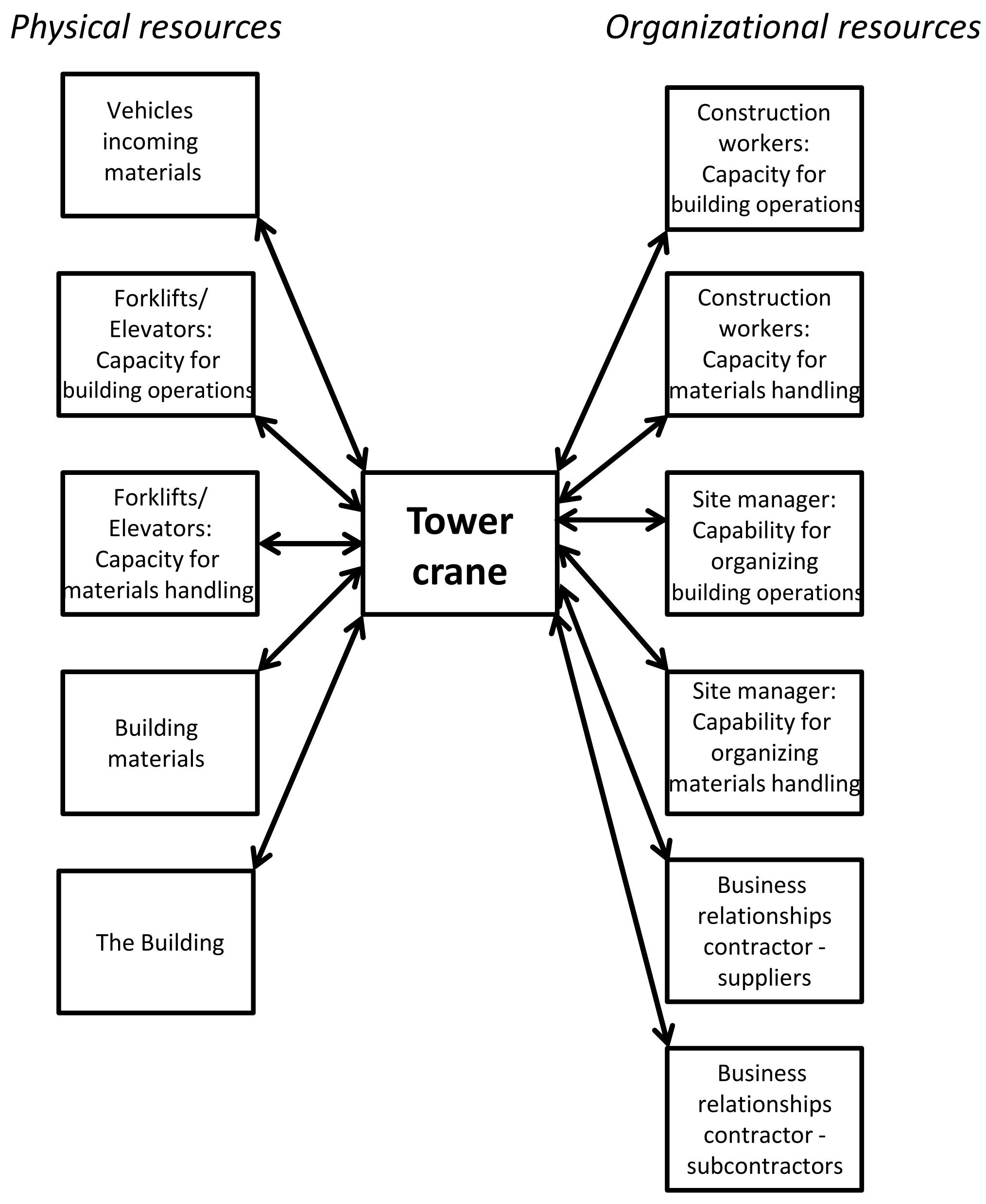


Figure 7.1 Resource intermediation of the tower crane in situation 1.

The analysis of resource intermediation in situation 1 consists of three parts. The analysis examines first, utilization of the tower crane; second, the interfaces between the tower crane and other resources; and third resource combining with regard to the standardized interfaces among the involved resources.

7.1.1 UTILIZATION OF THE TOWER CRANE IN SITUATION 1

Cranes have various features. The tower crane's height, lifting capacity and radius of operations are decided in the project's planning phase. These features are standardized, which enables utilization of the crane for many tasks. In this way, the crane has a great scope of capabilities in terms of various lifting/moving operations, although only within the decided range and weight. The crane is a critical resource on site and represents great economic value since it is utilized in combination with many other resources. However, the crane can only carry out operations 'one at the time', to the opportunities for economies of scale in these operations are rather limited.

The total costs of the crane consist of the costs of mounting, demounting, servicing and rental price/day. Consequently, the crane costs the same whether it is utilized or not. With regard to materials handling the crane is needed for unloading incoming materials from vehicles, storing and moving materials on the site, and transporting materials to assembly points. Large volumes of materials often arrive to the site long before they are required for installation to achieve volume discounts on materials and co-loading in transportation. As a result, materials have to be 'moved around the site', since storage areas are often limited and site disposition changes along the project. This materials moving corresponds to extensive utilization of the crane while, at the same time, the crane is needed for building operations. Thus, building operations are affected negatively when the tower crane is utilized for materials handling. Similarly, materials handling can be delayed if the crane is being utilized for building operations. Thus, materials handling often interferes with other operations, and vice versa. As a result, there is often a queue of tasks waiting for crane capacity. Utilization of the tower crane is next analysed in relation to the numerous interfaces between the crane and other resources.

7.1.2 INTERFACES: THE TOWER CRANE AND OTHER RESOURCES

The resource intermediation of the tower crane involves interfaces with other resources. The interfaces between the tower crane and other physical resources are characterized by certain technical and functional conditions. For instance, the capacity of the crane and the features of the building materials packages represent the combining of physical resources with mainly technically conditioned interfaces: the weight of the packages cannot exceed the lifting capacity of the crane. These features are standardized. Thus, materials packages can be handled at many sites by using tower cranes with the appropriate capacity.

Physical interfaces are considered with regard to the unloading of materials coming in to the site (Figure 7.2).

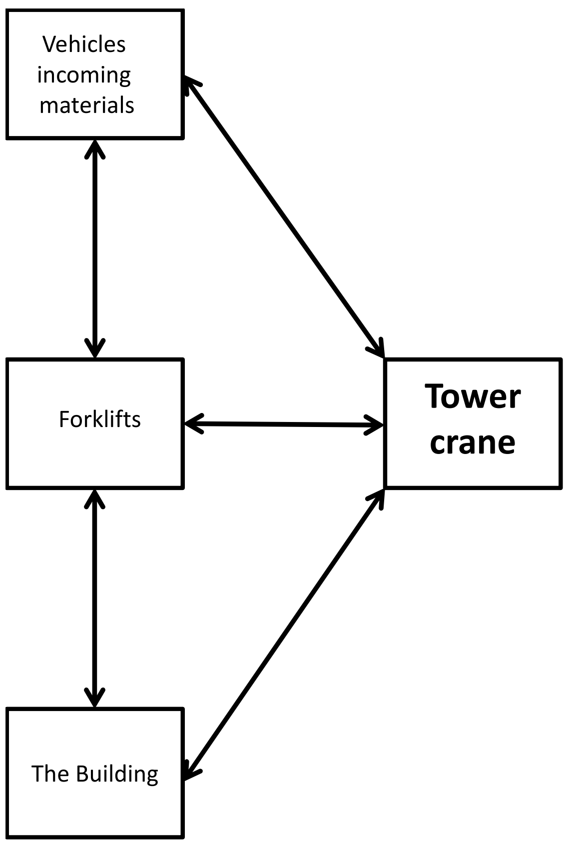


Figure 7.2 Physical interfaces situation 1: unloading of materials.

Regarding unloading, the requirements imposed on the tower crane relate to the interfaces between the tower crane and incoming vehicles carrying materials. If these vehicles are equipped with their own crane, the tower crane on site is not required for unloading. However, vehicles without a crane require the tower crane or forklifts to unload. Accordingly, there are interfaces between vehicles and incoming materials and forklifts. Hence, interfaces between vehicles with incoming materials and the tower crane or forklifts are interrelated. Thus, certain technical features of the incoming vehicles are decisive in relation to utilization of the tower crane or forklifts for unloading. These interfaces also affect and are affected by the interfaces and utilization of the tower crane with regard to the building on the site. In many cases, the tower crane is crucial for moving equipment in building operations.

Next, the tower crane requirements are analysed with regard to moving and handling materials which are stored at various locations on site (Figure 7.3.)

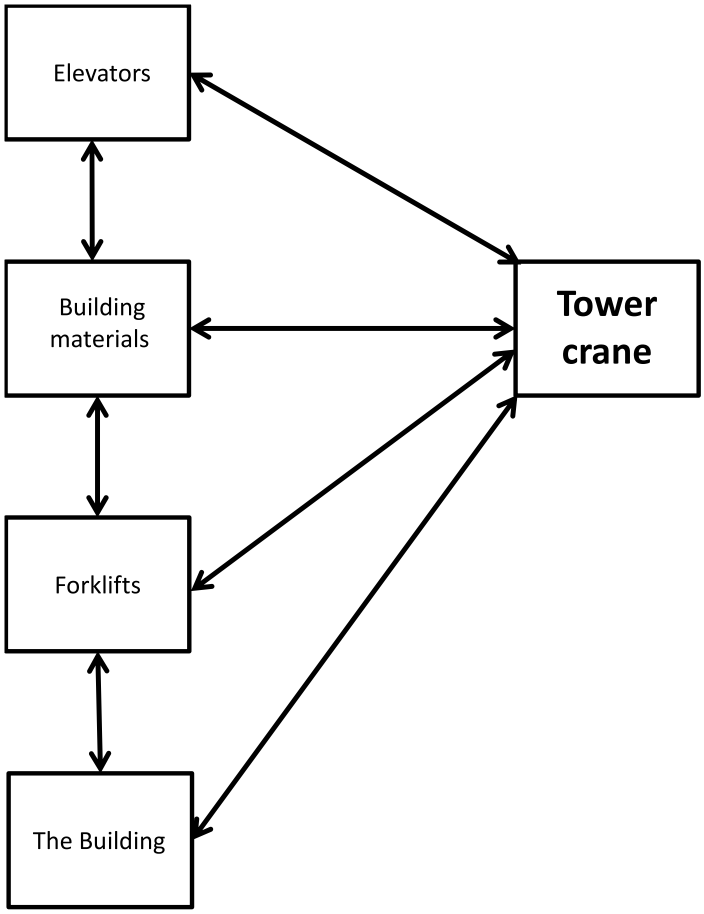


Figure 7.3 Physical interfaces situation 1: moving and handling materials.

Most of 'the moving around of materials' between various storing locations, handling and transportation to assembly points on site require the tower crane. In some cases forklifts can be utilized, depending on the physical characteristics of the materials - weight, size and packaging. Elevators can be utilized only to a limited extent since the materials packages seldom fit into the elevators. Building materials transported in elevators are small packages carried by construction workers on their way to install the materials. How these resources are utilized and their interfaces with regard to moving and handling materials affects the ability to utilize the tower crane for building operations, and vice versa. For example, if elevators are utilized for transporting the building materials to assembly points, tower crane capacity can be directed to other operations. At the same time, the main task of elevators is to transport construction workers, and materials transportation thus restricts that function. This can cause waiting times and delays to installations and other building operations.

Mixed interfaces and organizational interfaces with regard to utilization of the tower crane for materials handling are illustrated in Figure 7.4.

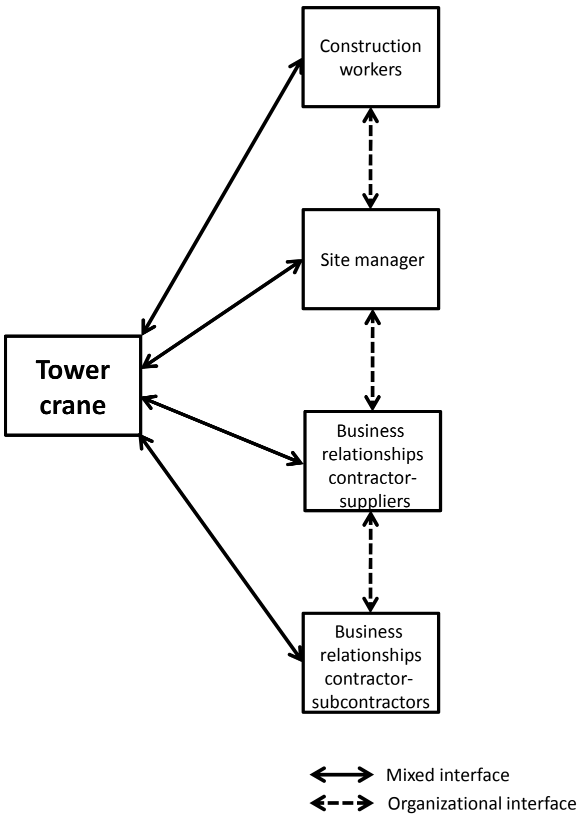


Figure 7.4 Mixed and organizational interfaces situation 1: materials handling.

The interface between the tower crane and the site manager is an example of a mixed interface. The site manger spends a lot of time coordinating orders and deliveries in order to utilize the crane optimally, and to make resources function together in the context on the site. This organizational aspect of resource intermediation is executed on the basis of each individual project, mainly on the site. Planned schedules and work flows often have to be changed to fit the current situation on site and deviations from plans and, thus, the utilization of the crane and other resources has to be changed and adapted to the actual situation. Another mixed interface is that between construction workers and the tower crane. The planning of operations on site directs these resources to materials handling or various building operations.

In addition, interfaces between organizational resources also affect the exploitation of the tower crane. The relationships between the contractor and the building materials suppliers are important for scheduling and coordinating deliveries. These relationships entail communication regarding deviations from plans, for example, if a vehicle's arrival time changes. Also, the business relationships between the contractor and subcontractors involved on the site affect the utilization of the tower crane. These subcontractors bring in materials and equipment to the site that might require the tower crane. Consequently, relationships between the contractor and suppliers/subcontractors are also interrelated.

Hence, resource intermediation occurs via physical, mixed and organizational interfaces. The features of individual resources and the characteristics of the interfaces direct utilization of the tower crane. In addition, intermediation among these resources with regard to the tower crane and its interfaces relate to the interfaces of these resources in other settings. This is further discussed below in the analysis of resource combining in relation to standardized interfaces.

7.1.3 RESOURCE COMBINING: STANDARDIZED INTERFACES

Situation 1 features standardized interfaces among the involved resources. As a result, numerous adaptations are required on site. Although all operations are planned in advance, extensive adaptation is required to suit the actual situation on site, and the most urgent operations are prioritized. This implies that, for instance, materials for installation might have to wait until crane capacity is available for materials handling. Thus, building materials and equipment for the building are combined with the crane depending on what is planned for, needed, and executed, with priority for current critical operations.

To obtain scale economies in materials transportation to the site, suppliers aim to maximize capacity of their vehicles. Hence, large volumes of materials arrive at the site before they are needed for installation, which requires their storage on site. The crane is needed to move the materials on site since storage areas are limited and change throughout the project. Thus, quantity of materials coming into the site at one point in time is often directed by conditions for optimizing the transportation service rather than conditions on site and the current building phase. Regarding the start-up of a project including the establishing of the tower crane and elevators, these resources are planned for and set up rather independently, according to the individual features of each resource. For instance, capacity and radius of the crane and number of elevators for transporting construction workers are decided on independently, although the characteristics of the elevators affect how the tower crane is exploited and vice versa.

The site manger focuses primarily on combining resources at site level, including re-planning of tasks owing to the many deviations from original plans. The combining of site resources is planned for without extensive considerations of the features of external resources. Hence, site conditions direct the utilization of involved resources. For instance, elevators are selected mainly based on the need for personnel transportation on site, without considering the features of building materials although they affect whether the elevators can also be utilized to transport building materials. Thus, the features of building materials packages are not adapted to the interfaces on the site. Instead, production of building materials exploits economies of scale in the factories to the extent possible, which requires standardization in terms of building material packages.

The decisions regarding the combining of resources on site are to a great extent the result of the experience of site managers and other personnel and knowledge gained from previous projects. Such knowledge and experience are important skills. They provide the foundation for the adaptations required for resources combining. This is a challenging task, since numerous resources are utilized on the site simultaneously, often with overlapping needs. Although resources from various firms are related, combination efforts are mainly directed by agreements on types of material, quantities and delivery times. These standardized interfaces between resources result in rather limited interaction at the same time as major adaptations among resources are needed on site. Resources such as building materials commonly have standardized features so that materials may be directed to many sites. In turn, adaptations are needed on the sites to combine these materials with the on-site resources.

Thus, in situation 1 the standardized interfaces and the limited interaction dictate extensive utilization of the building crane for materials handling operations on site. Since the crane is also needed for other operations, this creates problems and extensive coordination and adaptation is needed to adapt to current conditions on site. The next section analyses situation 2 with materials handling undertaken by ConSite Logistics.

7.2 SITUATION 2: MATERIALS HANDLING BY CONSITE LOGISTICS

In situation 2, ConSite Logistics is introduced into the constellation of resources on site. ConSite Logistics undertakes all materials handling operations, which are the same as in situation 1: the unloading of incoming materials, quality checks and storing as well as handling and transportation to assembly points on site. ConSite Logistics brings in its own resources, such as personnel and pallet lifts, and utilizes elevators to the extent possible rather than the tower crane. All materials handling takes place after regular working hours. As a result, during day time no materials handling operations interfere with building operations, and vice versa. Hence, the tower crane can be fully exploited during day time working hours for building operations.

The analysis of resource intermediation in situation 2 consists of two parts. First, utilization of the tower crane and its interfaces to other resources during day time is analysed. Second, resource combining of the many adapted interfaces introduced by ConSite Logistics during evening working hours is considered.

7.2.1 UTILIZATION OF THE TOWER CRANE AND ITS INTERFACES IN SITUATION 2

The resource intermediation in situation 2 with regard to the tower crane and its interfaces with physical and organizational resources is illustrated in Figure 7.5.

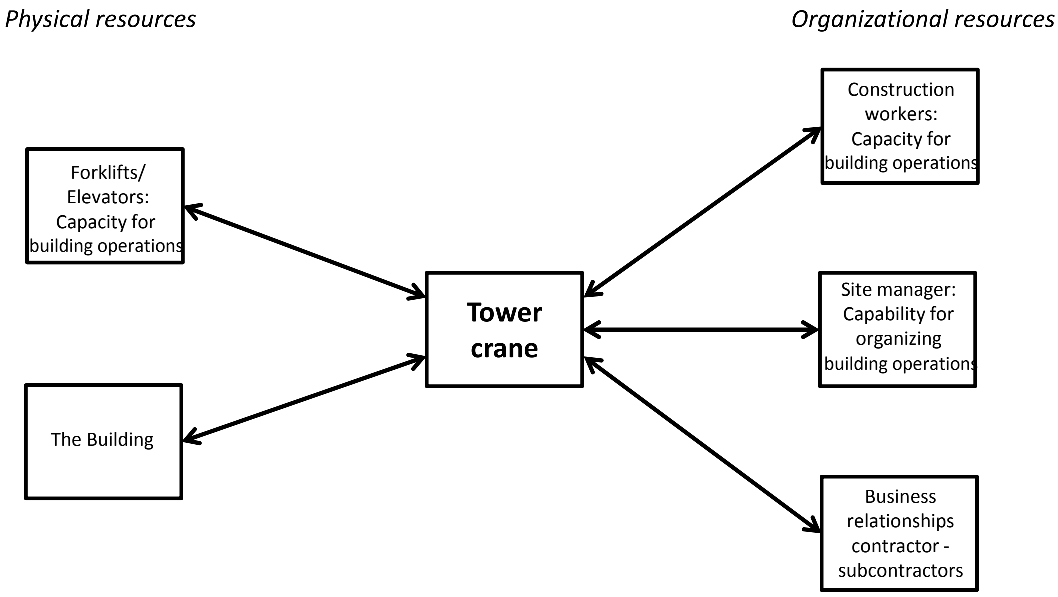


Figure 7.5 Resource intermediation of the tower crane in situation 2.

In situation 2 the tower crane has the same standardized features as in situation 1 with regard to capacity and scope of capabilities. The tower crane is still a critical resource on site and is useful in combination with many resources, although as in situation 1, it can only carry out one operation at the time and the weight of goods cannot exceed the lifting capacity of the crane. Thus, the interfaces between the tower crane and other physical resources are characterized by certain technical and functional conditions. The costs of the crane are also the same as in situation 1.

However, in situation 2 the introduction of ConSite Logistics for materials handling has a major impact on exploitation of the tower crane. Since no materials handling takes place during the day time, resources can be devoted to building operations and there is no need to synchronize utilization of the crane for materials handling operations with building operations. The crane can be utilized exclusively for the building, including moving equipment. This increases the efficiency of building operations significantly. Materials handling never interferes with building operations and there are fewer lost hours waiting for crane capacity for these operations.

In addition, since ConSite Logistics moves materials from the unloading to the assembly points without the need for additional storage, crane capacity is not needed to ‘move around’ materials on site. This reduces waiting times for the crane significantly. The capacity of forklifts and elevators is also utilized solely for building operations during the day time and construction workers' capacity and time is devoted only to building activities such as assembly, installation and casting. This improves operational efficiency on site due to fewer lost waiting hours for the crane, fork lifts and elevators and equipment and other resources needed for building operations. In addition, the capacity for building operations is increased since construction workers are no longer involved in materials handling, and there is no interference between materials handling and building operations.

Since there is no need to synchronize utilization of the crane for materials handling and building operations, the site manager's capability to organize building operations is increased. This includes the coordination in the business relationships between contractor and subcontractors with regard to the latter's utilization of the crane. As in situation 1, this is carried out on basis of the individual project: in line with project planning, but requiring extensive adjustment to deviations and to current conditions on site.

Overall, utilization of the tower crane solely for building operations increases operational efficiency on site. It allows a focus only on building operations without interference from materials handling. Accordingly, utilization of the tower crane, capacities of forklifts, elevators, and construction workers, and capability of the site manager to organize building operations are all focused on building operations. This is enabled by introduction of ConSite Logistics into the constellation of resources, and its resource combining with many adapted interfaces. This is explored next.

7.2.2 RESOURCE COMBINING: ADAPTED INTERFACES

ConSite Logistics undertakes materials handling after regular working hours to avoid interfering with building operations and allow access to resources such as elevators and forklifts when they are not being utilized for building operations. Since materials handling takes place after regular working hours, the elevators are not used for transporting construction workers. ConSite Logistics also brings in resources such as its own personnel, and pallet lifts to conduct materials handling.

Elevators are always utilized to their full capacity to transport building materials to the assembly points. Utilization of elevators is a prerequisite for more efficient materials handling: elevators enable faster transportation and several materials packages to be transported simultaneously. Loading building materials onto pallet lifts in elevators requires less man-hours for materials handling. However, this utilization requires adaptations among resources; the technical and functional conditions of resources such as building materials packages and pallet lifts are adapted to fit into the elevators. These adaptations allow improvements to the joint performance of these resources their interfaces fit better. Building materials packages are thus adapted in size and weight to allow utilization of pallet lifts and for two pallet lifts to fit together into the elevators. The elevators must be capable of a certain size, speed and no internal motor, in order to enable these packages to fit into the elevators to provide fast transportation of materials. Hence, ConSite Logistics requires elevators with these features to be able to undertake materials handling in an efficient way. The contractor using ConSite Logistics must select this type of elevator when planning the site disposition.

Another specific feature of the elevators is that they have to be aligned with the ground to allow utilization of pallet lifts. The value of these resources is enhanced by these adaptations which allow the combination of them to function better. These adaptations of the elevators for materials handling operations do not restrict their usefulness for personnel transportation. Rather, since materials handling occurs outside regular working hours the elevators can be utilized solely to transport construction workers during day time. In addition, the requirement for high speed is beneficial during day time to transport construction workers. Hence, utilization of the elevators is more versatile.

The adapted technical and functional interfaces between elevators, pallet lifts and building materials packages result in more efficient materials handling, since they enable exploitation of the elevators. The tower crane is utilized only for handling extra long goods that do not fit into the elevators. Long goods constitute a small proportion of the materials needed on site and, thus, a minor part of the materials handling undertaken by ConSite Logistics.

To the extent possible, ConSite Logistics uses forklifts to unload materials from incoming vehicles that are not equipped with a crane. This is usually quicker than using the tower crane. These forklifts are already on the site since they are utilized for building operations such as moving equipment during the day time. Thus, utilization of forklifts for materials handling does not add any extra costs.

However, the requirements ConSite Logistics poses upon adapted size and weight of building materials packages fits less well with the materials producing context. Building materials are commonly bundled in packages that fit the conditions in the factories' production processes. However, ConSite Logistics's requests regarding size, weight and number of items, which are crucial to make them function well together with resources utilized for materials handling on the site, require adaptations to packages in the factory contexts. Thus, adaptations of the material packages in accordance with conditions on the site makes them function less well in their produce context in the factories. Building materials need to function in both contexts with varying requirements, and material manufacturers agree to make these adaptations regarding packaging. In addition, such adaptations might also not fit very well with other customers' requirements regarding the packaging of materials. Thus, adaptations made between building materials and elevators for materials handling undertaken by ConSite Logistics indirectly affect other resources.

What is agreed in the relationship between the contractor and ConSite Logistics regarding conditions for materials handling is passed on to the suppliers. ConSite Logistics uses a price list for various types of goods that is only valid if these conditions are fulfilled, otherwise the efficiency of materials handling operations cannot be guaranteed. A consultant from ConSite Logistics visits the site the day before materials handling takes place to ensure onsite conditions suitable for handling the materials. Suppliers' concerns are discussed between suppliers and the contractor, who communicates them to ConSite Logistics.

External resources, such as ConSite Logistics consultant and workers, and pallet lifts are brought into the site, which implies a direct cost for materials handling operations. The adapted interfaces between resources utilized in materials handling are an outcome of making these operations as efficient as possible. These are mostly the result of ConSite Logistics' experiences and knowledge gained from materials handling in numerous projects. Furthermore, combining the resources involved in materials handling on site is planned to allow ConSite Logistics to execute its operations regarding quality control, utilization of pallet lifts and elevators, in a similar way at different sites. For instance, pallet lifts are standardized items used on many sites. Hence, resource combining includes attempts to standardize the utilization of resources necessary for materials handling. This allows ConSite Logistics to exploit its resources on many sites, and gain from standardized resource utilization. What goes on at a specific site is the result of standardization and routines and extensive planning and coordination before execution of materials handling.

ConSite Logistics is involved in resource combining that requires adapted interfaces, in order to benefit from the standardized processes of materials handling undertaken on many sites. The adapted physical interfaces are not developed automatically; they emerge from investments in resources necessary for the intricate organizing of physical resources. When elevators are utilized for materials handling the adapted interfaces entail extensive coordination regarding packages of materials. These requirements are passed on by the contractor or subcontractor to materials manufacturers and transport firms, in order to allow resources on site and external resources to function together. On site, ConSite Logistics is responsible for coordinating the execution of materials handling. This entails efficient utilization of physical resources, for example, elevators and fork lifts, and organizational resources in the form of ConSite Logistics' personnel.

The planning of materials handling varies extensively between situations and projects. Most commonly, the materials handling by ConSite Logistics is planned in advance in accordance with the project production plan or during the bidding phase for a new project. Some deviations from these plans occur depending on project progress. However, forecast materials handling allows rearrangements to be made to time of materials delivery. Deviation from plans is seldom a problem for ConSite Logistics owing to its extensive pool of logistics workers who are hired by the hour.

The prerequisites for ConSite Logistics to undertake efficient materials handling relate to conditions already set in the establishment phase of a project when it is decided where elevators and tower crane should be located on the site. This explains ConSite Logistics increasing involvement in logistical analysis in this phase. ConSite Logistics has the experience and knowledge required for efficient logistics operations, and can exploit them as a business opportunity.

Materials handling is improved by ConSite Logistics since fewer man-hours are needed and elevators, pallet lifts, and fork lifts enable faster and more efficient processes. This is made possible through the many adapted interfaces among resources. In addition, since materials handling takes place after regular working hours there is no interference between materials handling and building operations. As a result, utilization of the tower crane and other resources during day time working hours is improved. Hence, the increased efficiency in building operations is a consequence of introducing ConSite Logistics into the constellation of resources. In the next section this is analysed further by comparing situation 1 and situation 2.

7.3 COMPARISON OF RESOURCE INTERMEDIATION SITUATIONS

The above analyses capture two situations with various conditions for resource intermediation. Utilization of the crane and other resources during day time differs in situations 1 and 2 based on different exploitation of other resources than the tower crane for materials handling in situation 2. In situation 2 ConSite Logistics is brought into the resource constellation and utilizes the elevators after regular working hours. As a result, during day time the tower crane and other resources are utilized exclusively for building operations. Consequently, a change in intermediation regarding one resource, such as when ConSite Logistics is introduced into the constellation of resources, affects the interfaces between other resources. Moreover, a prerequisite for the possibility to utilize the elevators for materials handling is the numerous adaptations among the involved resources. A compilation of the major differences regarding resource intermediation in situations 1 and 2 is presented in Table 7.1.

Table 7.1 Comparison of resource intermediation: situations 1 and 2.

	Situation 1	**Situation 2**
Resources exploited for materials handling	Traditional site resources	ConSite Logistics: consultant, workers, pallet lifts
Main resource on the site for materials handling	Tower crane	Elevators
Tower crane utilization	Materials handling and building operations	Building operations
Interfaces between resources involved in materials handling	Standardized	Adapted
Resource coordination efforts materials handling	Extensive adaptation of materials handling to site conditions	Extensive interaction beforehand to enable standardized materials handling on sites

In both situations the features of the tower crane in terms of height, lifting capacity and radius of operations are the same. These features are decided in the project planning and enable utilization of the crane for many tasks. In situation 1 the tower crane is exploited for materials handling and building operations. Both activities take place during day time implying extensive coordination and planning for efficient utilizing of the tower crane. In situation 2 the crane is utilized exclusively for building operations during day time and elevators are utilized for materials handling in the evening. This affects utilization of the tower crane.

It is the adapted interfaces among resources such as elevators, pallet lifts and materials packages that enable utilization of the elevators for materials handling in situation 2. In day working hours, these elevators are utilized to transport construction workers and in the evening they are utilized to transport building materials, thus the versatility of the elevators increases. Situation 1 is characterized by standardized interfaces among the resources involved. Thus, the elevators are not adapted for materials handling and exploited solely for transporting construction workers during day time.

In situation 2, all materials handling operations are carried out by ConSite Logistics specialized in these operations. ConSite Logistics's personnel have extensive knowledge and experience and utilize their own resources, such as pallet lifts. In comparison, in situation 1 construction workers undertake materials handling at the same time as being involved in many other tasks such as assembling. Consequently, resource combining involves many resources that are simultaneously needed for materials handling and building operations. In situation 2, these resources are dedicated to building operations during the day. In the evening, elevators and fork lifts on the site and resources brought in to the site by ConSite Logistics are utilized for materials handling.

Thus, resource coordination efforts differ. In situation 1, the site manager spends a lot of time on coordination to make the resources function together in the best possible way mainly related to the situation at that moment on site. This is a complex task involving delays. Planned utilization of various resources has to be changed and adapted constantly. Coordination efforts are mainly directed by agreements on types of materials, quantities and times of delivery for building materials with standardized interfaces among involved resources. Situation 2 involves extensive planning of materials handling operations in advance, in which ConSite Logistics' abilities to utilize the same routines and resources on many sites are important. Adapted interfaces, for instance between materials packages, pallet lifts and elevators, are a prerequisite for this resource combining. The site manager is able to focus on coordination of building operations rather than also materials handling on site. In situation 2, extensive coordination is required between contractor and materials suppliers. Also the adapted interfaces make the building materials function less well with factory contexts and, in some cases, transportation to sites.

In both situations coordination efforts regarding materials to be delivered to sites depend on the relationships between the contractor and the many suppliers of building materials. In situation 2 the business relationship between the contractor and ConSite Logistics covers all the details concerning these deliveries, which are passed to the materials suppliers by the contractor and vice versa.

The comparison between the two situations shows that the interfaces among resources change considerably when new resources, such as ConSite Logistics's physical and organizational resources, are introduced into the resource constellation. These changes, in turn, impact on the utilization of resources exemplified by the role of the tower crane in the two situations. Thus, intermediation with regard to a particular resource has implications for intermediation of other resources via their interfaces.

8 BUILDCON: APPOINTING DEDICATED SUPPLIERS

This empirical chapter deals with the building contractor BuildCon and its process of appointing dedicated suppliers. BuildCon needed to increase the efficiency of the building processes to avoid problems related to projects' cost levels and time limits. In particular, materials supply and logistics were considered problematic. BuildCon wanted to change its operations towards standardization among projects and by working closer, and on more long-term basis, with suppliers. Chapter 8 starts by describing the business setting of BuildCon and challenges related to competitive tendering, supply of materials, and the multiple role/responsibilities of the site manager. Thereafter the chapter describes the evaluation process involved before appointing dedicated suppliers, and collaborations with the four selected suppliers. The chapter concludes by discussing some consequences of this reorientation.

8.1 BUILDCON'S BUSINESS SETTING

The starting point for the example is a Swedish construction firm, BuildCon, which operates as a building contractor working in the private and public sectors. BuildCon is a medium- sized firm that has an annual turnover of around MSEK 450. Projects range from MSEK 20-300 and include residential property constructions, public buildings such as schools, and refurbishments of existing commercial buildings and hospitals.

The building process starts by the client publishing a request for tenders for an upcoming project. Contractors compete in the bidding process and provide detailed tenders including project planning and costs. Based on an evaluation of these tenders, the client chooses a contractor for the project. If the client is a representative of a government or municipal authority, the Public Procurement Act comes into force, aimed at securing good quality, and evaluating several contractors following certain directives on the competitive process. Usually, the lowest price tender is accepted.

There are three project delivery methods used for regulating the responsibilities of the parties regarding the design and building processes. A trades contract means that the client sets up contracts with several firms which are responsible for different parts of the project, and the client is responsible for coordinating the work of these firms. The contractor is responsible for the building process, and other firms undertake design, painting, heating, sanitation, etc. Under a general contract, the client is responsible for design including building permits, drawings, etc. The contractor undertakes the building process and is responsible also for selecting suppliers and subcontractors, and for overall planning and coordination of the firms at the construction site. In a design and build contract, the contractor is responsible also for the design process. Thus, a design and build contract is the most comprehensive project delivery method in relation to the contractor's responsibilities.

Figure 8.1 depicts BuildCon's organization. In addition to the CEO, administrative functions and calculation department, BuildCon is comprised of sections that include section managers, site managers and work managers, and craftsmen in numerous professions. Each section may be responsible for several on-going projects, so each requires several site managers and work managers.

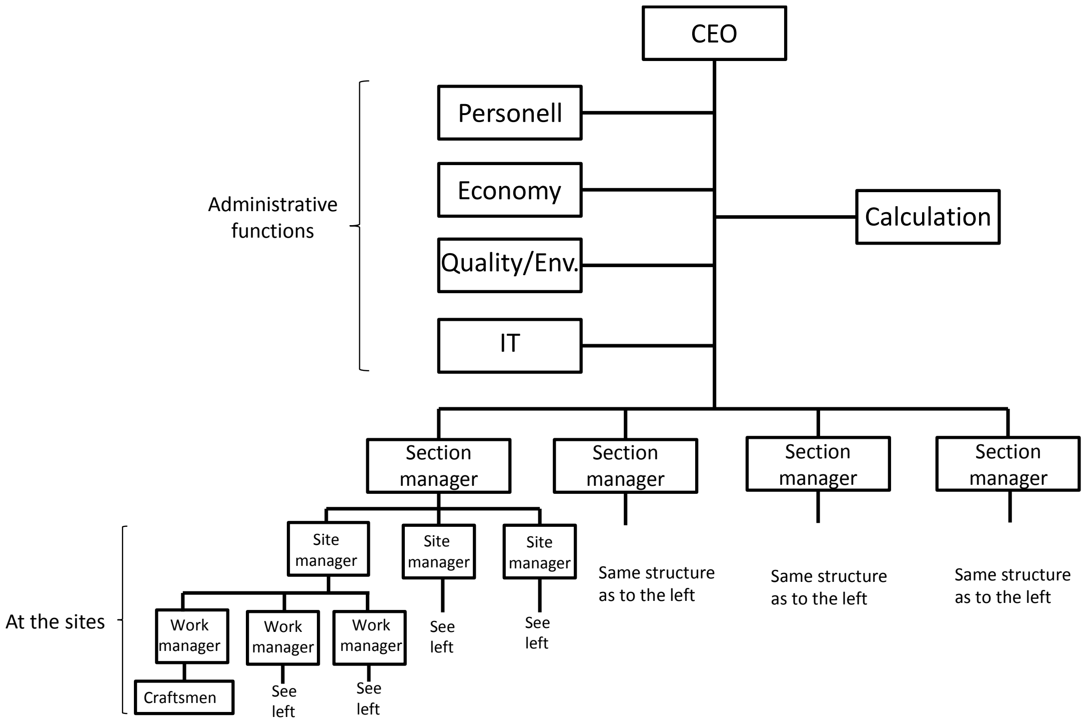


Figure 8.1 BuildCon's organization.

Section managers are responsible for market research to identify upcoming projects and to initiate contact with clients. The CEO, section managers and the calculation department meet weekly to discuss the information collected and decide about which projects to bid for. One section manager is assigned to each project and is responsible for preparing the compilation of the tender and setting up contracts. In the case of a design and build contract, the section manger is also responsible for the project design phase. Compilation of the tender includes the work provided by the contractor with regard to concrete casting, carpentry and other building operations, and tenders for building materials and subcontractors. Equipment costs for tools, and resources needed, such as power solutions, welfare facilities, cranes and elevators, are also included. The calculation department is heavily involved in estimating costs. The compilation of the tender then enters the bidding process competing against tenders from other contractors. If the tender is successful one site manager is assigned and becomes responsible for managing the building process and coordinating between subcontractors and own personnel on site. Several work managers are also employed at the site to support the work of the various craftsmen.

This example refers to one of the sections at BuildCon responsible for the construction of new residential properties (hereafter BuildCon refers to this section). A typical project consists of building new apartment blocks for a private or public client, involving, for example, three new tower blocks with nine floors and a total of 103 apartments, and a roof terrace. This example is a design and build contract and the client is a consortium of companies owned by the city of Gothenburg. The project started in 2010 and was finished in 2012. BuildCon's section for the construction of new residential properties is in average involved in two or three overlapping projects. Figure 8.2 depicts an example of a project for residential properties, which has been built by BuildCon.

Figure 8.2 Exampel of residential properties built by BuildCon.

The building process at the site encompasses three main phases of ground and pile work, followed by frame work and finally, frame complement (façade, outer walls, inner walls, wardrobes and kitchen fittings). BuildCon undertakes the ground and pile work with subcontractors; the frame work is the sole responsibility of the contractor. For the frame complement work, operations are divided among a mix of subcontractors and BuildCon. BuildCon's craftsmen build the façade, outer walls and inner walls, wardrobes, kitchen cabinets, windows and battens. The subcontractors are responsible for flooring, painting, heating and sanitation, ventilation and, in some cases, installation of windows and doors with special features.

The next section describes some of the issues faced by BuildCon which apply to most of its sections, but the example focuses on the above introduced residential building section.

8.2 BUILDCON'S CHALLENGES

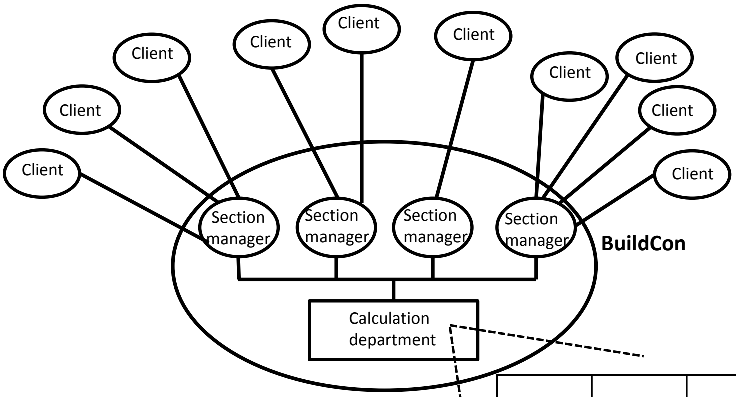
Some years ago, BuildCon decided to address several cost level and time limit related issues in individual projects. They involved cost and time estimations in tendering in bidding processes for new projects and issues related to the building processes including materials supply at sites. The following section describes the conditions encountered.

8.2.1 ESTIMATION OF COSTS AND SELECTION OF SUPPLIERS

In the bidding process for a new project, BuildCon's calculation staff estimated a bill of quantities, requests for tenders for materials, an expenditure calculation (including costs for cranes, welfare facilities, and so on) and other necessary calculations. The number of work hours for craftsmen and the cost for these operations was also estimated by multiplying the bill of quantities by the unit price per craftsman hour. Thus, all estimations were based on prices per unit for hours and list prices, but seldom corresponded to actual project costs – i.e. cost levels and time limits established through these calculations were not adhered to. Since about 60% of the total costs in the compilation of a tender refer to materials and subcontractors, estimation of the bill of quantities and the requests for tenders for materials are crucial for keeping costs down. A low priced compilation of the tender increases the contractor's potential to win the contract.

The selection of materials and suppliers was based primarily on direct costs in terms of list prices, and excluded indirect costs associated with ordering, order surveillance, quality assurance, packaging (including wrapping, use of pallets), transportation, assembling materials and other important aspects. The focus was on ordering quantities that attracted volume discounts. Managers responsible for this purchasing approach were rewarded for achieving 'prices per unit' below calculated budget costs. However, this behaviour generated extra costs in other dimensions. Owing to this approach the tenders for materials included large volumes of materials being delivered in one batch to the construction site for storage and progressive use. The construction site is an unsuitable location for storing materials because of bad weather, lack of space and potential damage from on-going activities. Large quantities of materials had to be moved around the site, causing extra work, and damage to them. These conditions resulted in substantial waste generation.

There was also another obstacle related to the purchasing behaviour. For each type of material, requests for tenders were sent to several suppliers, thus relying on competitive tendering to select 'the right supplier'. There was also a separate tendering process for each type of material consisting enquiry, proposal evaluation and supplier selection (commonly based on 'lowest price per unit') in individual projects, although the same type of material was often used in several projects, or in some cases one supplier could deliver several different types of material. Thus, many individual requests for tenders might involve the same supplier, but refer to different projects. Figure 8.3 illustrates the demand side of BuildCon and the selection of suppliers according to the compilation of tenders to clients in *n* number of projects.



	Project 1	Project 2	Project 3	…	Project *n*
Material 1	Supplier A	Supplier B	Supplier C	…	Supplier *n*
Material 2	Supplier B	-	Supplier C	…	Supplier *n*
Material 3	Supplier A	Supplier B	Supplier D	…	Supplier *n*
. . .	. . .	. . .	. . .	. . .	. . .
Material *n*	Supplier *n*	Supplier *n*	Supplier *n*		Supplier *n*

Figure 8.3 BuildCon's demand side selects suppliers in the compilations of tenders.

This approach made it difficult to benefit from potential economies of scale among the various projects. Once a supplier for each material type had been selected for an individual project a purchasing process was initiated involving ordering, coordination, and distribution of the materials and stipulating quality, time and price. The time and resources devoted to these operations were often substantial - forward planning and daily call-offs and goods receipt at sites. Besides problems related to cost estimations and selection of suppliers, several challenges related to supply of materials and operations at the construction sites with regard to the diverse roles of site managers.

8.2.2 Supply of materials and diverse roles of site managers

For BuildCon, issues related to the supply of materials and the logistics flows were especially frustrating. For example, the site manager is responsible for the coordination of a large number of counterparts in a project (see Figure 8.4 for an illustration of the situation for the residential building section). The same counterparts may be involved in several projects being undertaken by BuildCon at the same time; nevertheless, site managers have individual contacts with them.

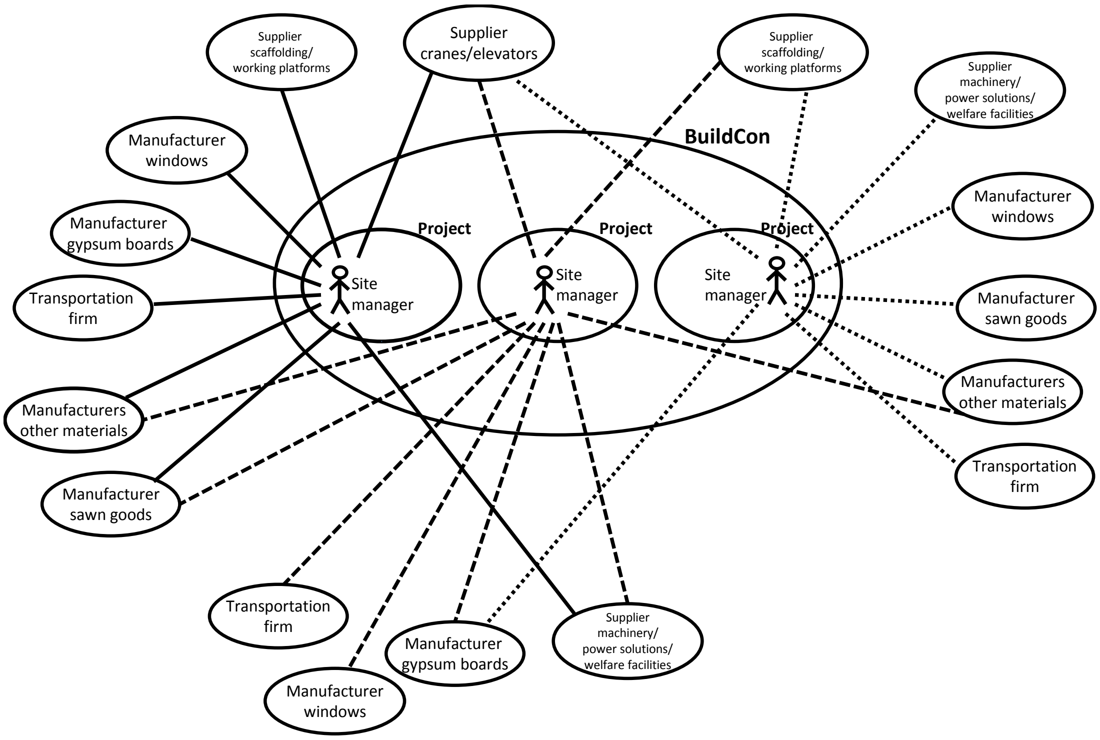


Figure 8.4 BuildCon's supply side including site managers' contacts with suppliers.

Thus, site managers spent an inordinate amount of time on coordinating orders and deliveries from multiple suppliers and inspecting the quality of incoming materials to ensure that building operations could progress according to the project plan. One site manager with experience from the car industry was particularly worried by the fact that missing materials or delayed deliveries often disturbed and delayed the processes at the site. As a consequence of deviations from plans, site managers were constantly required to come up with 'ad hoc solutions'. In addition, craftsmen working on site spent a lot of time unloading, sorting, collecting, and moving materials from the unloading area to the point of assembly.

When a bid was successful in the bidding process there was no time plan or logistics plan in place for the building processes, and site managers then had to create these plans. This represented a heavy work load in the startup phase of the project, and often overlapped with the very intensive finishing phase of the ongoing project. These tasks also added to the site manager's many other tasks including planning, administration, coordination, managing production, information and supervision of the work flow.

Consequently, although the building process was fairly standardized, the procedures involved made each construction project an isolated entity. Although much time was spent on planning, constant deviations from plans consumed much time and resources. The focus on specific site conditions, and efficiency in individual projects were identified as barriers to further performance improvements.

To achieve improvements, first, a subcontractor, ConSite Logistics,[4] was hired for materials handling, outside of regular working hours primarily in the frame complement phase. ConSite Logistics was made responsible for quality checks of incoming materials, unloading from trailers and transportation of the materials to the correct assembly points– e.g. 'house 2, floor 3, apartment 4, location X'. This freed the site managers from quality checks of incoming materials and allowed craftsmen to focus on building processes such as installation, rather than spending time on materials handling. Consultants from ConSite Logistics provided a logistic analysis, which is an extended version of the Site Layout Plan,[5] taking account of the project's location, planned rate of progress and materials and personnel flows. This analysis further improved the conditions at the site since the tower crane could be positioned to optimize logistic flows. However, there were still problems related to supply of materials and the site manager still had multiple responsibilities. Inspired by purchasing behaviour in other industries, the contractor came up with the idea of selecting a few dedicated suppliers instead of having always to engage in a competitive tendering procedure. This is described next.

8.3 APPOINTING DEDICATED SUPPLIERS

BuildCon was keen to adopt operations to increase efficiency by linking the planning stages to the onsite building processes, and looking beyond the individual project. BuildCon hoped this could be achieved through standardization of the house-building process across projects and sites: thus "to work in the same way on sites A, B and C". One approach to accomplishing this would be working more closely and on a longer-term basis, with suppliers. This was identified as advantageous compared to the current practice of competitive tendering for every project, and the work that

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[4] The business of ConSite Logistics is described in more detail in Chapter 6.

[5] Site Layout Plan (or ADP in Swedish) is established by the contractor to assure an efficient and secure construction site. Includes the establishment of welfare facilities, cranes, and power solutions and so on.

involved continually handling tenders and making price comparisons. However, in order to identify suppliers that could and would be able to work with this new approach, suppliers had to be evaluated.

8.3.1 THE EVALUATION PROCESS

Appointing suppliers followed a procedure (see Karlsson, 2009 for further details). An external consultant from ConSite Logistics was asked to develop an evaluation model to assess materials suppliers, based on theoretical studies and previous experiences. Five main categories were identified: performance during tender, past performance, past experience, resources, and price. These categories were weighted from 5% and 30%, summing up to 100%. The categories were broken down further into sub-categories such as time needed to deliver, communication plan, degree of compliance with request for tenders, quality control, types of projects completed, supplier partners, material costs, costs for coordination of material, etc. The model included 32 parameters assigned raw scores from 1 to 5. These parameters were converted into weighted scores depending on the predetermined importance of each sub-category. The categories comprised a model that could be applied to evaluate suppliers and their ability to work closely with BuildCon on a long-term basis, and provide services beyond the focus only on price that is usual in tenders. The evaluation model included ability to comply with delivery plans, tendering/management capability, basic logistics, expertise in bills of quantities and adapted lengths and dimensions of materials among many other aspects.

The model was applied to the request for tenders to three alternative suppliers of inner walls for a project. One supplier almost immediately stated its inability to fulfil all the requirements. One of the two remaining suppliers was selected for the project. BuildCon won the bidding of another project that was going to run in parallel and once again the model was applied to the requests for tenders to the two remaining materials suppliers. This resulted in selection of the other supplier although the previously selected supplier scored higher. Using two different suppliers allowed the contractor to compare performance during the projects. Both suppliers' performance was assessed in the tendering and delivery phases of their respective projects. This resulted in one of them being appointed to be the sole supplier of the building materials - not just inner walls but all materials involved in the frame complement phase (façade, outer walls, inner walls and wardrobes and kitchen cabinets) for future projects. A three-year contract was established between BuildCon and this building materials supplier. BuildCon was not aiming to have dedicated suppliers for the ground and pile work, or supply of reinforcing bars and concrete in the frame work. Although continuity of supply for these goods is important, the supply of such materials is heavily dependent on local availability and the specific conditions at individual sites.

This was the first time BuildCon applied such an evaluation process to select a supplier for the building trade. In order to learn from the model-based tender inquiry and to develop closer, long-term relationships, meetings were held with each supplier that submitted a tender proposal. During these meetings, suppliers were told how they scored in the tender evaluation. BuildCon believed it was useful to explain to the suppliers why these categories were considered important and to highlight possible areas of improvement for suppliers. Suppliers commented on the evaluation model and how they had interpreted BuildCon's requirements. The suppliers perceived it as helpful, and were optimistic about success if implemented in future requests for tenders. The suppliers saw it as an opportunity to learn and to sharpen their strategies as suppliers of materials, and to better communicate their services and abilities to customers. In addition, the well-planned deliveries rather than last-minute demands common in the industry, were also beneficial for the suppliers, allowing them to plan their work much better.

In the two projects where the evaluation model was tested, the consultant from ConSite Logistics also functioned as a logistics coordinator for the projects, undertaking some of the tasks that previously were considered the site managers' responsibilities. This was appreciated by the site managers and allowed them to focus more on actual production and building operations at the sites.

BuildCon has four main procurement categories: (1) building materials, (2) scaffolding/working platforms, (3) cranes/elevators, and (4) machinery/power solutions/welfare facilities. Based on the successful experience of using one supplier for its building materials, BuildCon decided to extend dedicated supply to the other categories. As a result, four dedicated suppliers were eventually appointed, one for each procurement category. All of them had been used in previous projects.

However, in contrast to the written contract between BuildCon and the supplier for building materials, there were no written contracts between BuildCon and the suppliers of scaffolding/working platforms, cranes/elevators and machinery/power solutions/welfare facilities, but they were guaranteed supply of these needs for all BuildCon's forthcoming projects. The procurement categories are discussed in more detail below.

8.3.2 SUPPLY OF BUILDING MATERIALS

The building materials supplier firm, BMS, is part of a regional wholesale chain specializing in the distribution of building materials. BMS focuses on doing business with materials manufacturers, i.e. producers of windows, gypsum boards, kitchen fittings, etc., and provides these materials to contractors and subcontractors. BMS coordinates transportation to sites by involving various transportation firms. Via the subcontractor ConSite Logistics, BMS also offers materials handling at sites, from unloading to specified assembly point, outside regular working hours to minimize disturbance to the work flow on site. BMS is the only division within the wholesale chain that provides materials handling service to its customers. Thus, BMS sees itself as providing 'a niche function', offering services related to materials supply, transportation and materials handling in addition to selling building materials 'off the shelf'. Recently, BMS won a large and prestigious project based on its ability to provide services covering the supply of building materials. For BuildCon, these competences were crucial in order to allow a total focus on the building processes. BuildCon also had positive experiences of working directly with the subcontractor ConSite Logistics.

BMS is responsible for supplying building materials to customers' sites. BMS' motto of "the right materials at the right time to the right place" puts the focus on efficient logistics. Building materials are delivered either directly from materials manufacturers to the site or from BMS's warehouse. BMS strives to reduce transportation costs by focusing on full carrying capacity and co-loading materials deliveries from their warehouse and BMS encourages materials manufacturers to adopt similar practices. BMS also provides requests for tenders to materials manufacturers on behalf of its customers. These tenders are different from the common standard in the construction industry. The tenders cover type of material requested and also specific details regarding packaging, pallet handling, quality assurances and logistics (including precise delivery times, number of deliveries and principles for unloading). These conditions are crucial for achieving efficient materials handling (especially when ConSite Logistics is responsible for this), and building processes on site.

Hence, in addition to materials prices, material manufacturers must provide costs of logistics according to a predetermined template. This 'total cost' must be fixed for the duration of a project. Often materials manufacturers respond with a direct purchase price, in line with the common procedure in the industry. This can result in the tender going back and forth between BMS and the manufacturer three or four times to get all costs included in the final tender. Some manufacturers find BMS requirements too demanding and as causing extra work and, therefore, extra cost. For example, window manufacturers usually package windows according to a logic that fits their production flow. However, BMS has different packaging demands, requiring the windows to be packed according to the logic of their handling at the construction site. BMS requires them packed to enable stacking on pallets and their movement round the site via pallet lifts and construction elevators, to suite ConSite Logistics specifications. BMS requires all materials to sites to be wrapped to avoid damage, and not to be unwrapped in materials handling and avoid loss of loose parts such as door handles and installation components. This requires the manufacturer to re-package its production for BMS.

In some projects, clients demand brands of building materials that BMS does not supply. In these cases, the contractor arranges a deal with the specific building materials manufacturer, but BMS is still responsible for handling the materials, including planning transportation and materials handling on site.

BuildCon's residential building section now buys a service that covers total supply of building materials in the frame complement phase. The dedicated supplier, BMS, acts as a consolidating supplier by gathering materials from a number of manufacturers, and guaranteeing their procurement, transportation to site and materials handling on site (using ConSite Logistics). However, for each separate project, the site manager is responsible for ordering and handling bulk materials, such as coarse sand for the ground and pile work, and screws for the frame complement phase.

Planning is crucial to materials supply. BMS's customers provide time plans including timing of building operations. BMS converts these time plans into delivery plans, which, for each type of material state where it is going to be used in the construction, when to deliver it to the site, and final date for call offs. The final date for call offs depends on the lead time for producing the material to achieve timely delivery on site. In addition to providing production time plans, BuildCon also will prepare delivery plans which it shares with BMS at a very early planning stage in a new project. The time plans and delivery plans are fundamental to BuildCon's and BMS's operations. First, the plans detail BuildCon's processes, second, they detail BMS's responsibilities, allowing BMS to plan calls for tenders and issue call-offs for materials at the right time. Considerable time and resources are devoted to the project planning phase, covering production (according to the production time plan) and also flow of materials (according to the delivery plan). The focus shifts from narrow price considerations towards a broad total cost perspective: the costs of materials provided to the site (price of materials, transportation, order surveillance, packaging and other indirect costs). The contractor claims that "the costs for planning are not worth mentioning compared to what it used to cost us to deal with inefficient material flows and disturbances in the building of houses".

The next step is for BMS's suppliers to be evaluated using the evaluation model used to appoint them as sole suppliers of building materials. By adapting the parameters in the model BMS will be able to appoint materials manufacturers that will respond to the materials, packaging, transportation and other specifications. This procedure is still in the planning stage, and is the subject of ongoing discussion with various materials manufacturers.

8.3.3 Supply of Scaffolding and Working Platforms

The supplier of scaffolding and working platforms, SWS, has supplied this equipment to BuildCon in previous projects. Being appointed the dedicated supplier has advantages for SWS. If BuildCon wins a bidding process, SWS can be assured that it will be required to supply scaffolding and working platforms for that project. This allows better planning of its operations and allows it to: "work in a way that benefits us both". If SWS prices its services too high BuildCon might not win the bidding process, and thus, SWS will lose the opportunity to participate in the project. BuildCon's requests for tenders differ from those of other SWS customers. BuildCon prefers to use working platforms wherever possible, rather than scaffolding. Working platforms are more expensive, but result in overall low costs since assembly time is a fraction of the time needed to assemble scaffolding. Also, most of SWS's customers provide only one alternative to scaffolding and are interested in the cost of that solution, while BuildCon always requests tenders for different combinations of scaffolding and working platforms. In one project the contractor asked for four alternative solutions regarding the mix of scaffolding and working platforms. SWS calculated for all these alternatives, and suggested modifications that might further improve the solution. BuildCon selected the optimal alternative in terms of flow of materials and personnel, and the building process, which was not the lowest price solution.

Scaffolding, working platforms and assembly/dismantling requirements change continuously during a project, so these extra costs are added to the tender price. Many of SWS's customers have to pay lots of extra costs to cover mismatches in their planning. BuildCon accomplishes to cover almost every contingency in its planning procedures, resulting in only a small cost being added to the specification in the tender.

8.3.4 SUPPLY OF CRANES AND ELEVATORS

The supplier of cranes and elevators, CES, and BuildCon initiated their joint business during one of the evaluation projects in which the dedicated supplier of building materials (BMS) was selected. In this project, the subcontractor ConSite Logistics, responsible for materials handling at the site, had some very specific requirements regarding elevators. ConSite Logistics use elevators as much as possible in preference to a tower crane on site, in order to handle materials in the most cost efficient way. This requires larger elevators than normally employed on Swedish construction sites with the engine on the outside of the elevator to allow large bundles of materials, such as kitchen fittings, to fit inside the elevator. The elevator must go down with the ground level to enable use of pallet lifts, and it must be approved for transportation of materials and personnel. It needs also to be fast. In the search for a dedicated supplier of cranes and elevators, only CES said it could meet these criteria; it had to import elevators which extended its fleet of cranes and elevators for the construction industry.

BuildCon contacts CES early in the planning process of a new project, and provides drawings and a logistics map describing how the materials handling at the site needs to be done. Although BuildCon will suggest how many tower cranes will be needed, and their dimensions, number of hooks, placement, number of elevators and their features, CES may make suggestions and modifications. In some situations the contractor will send several alternative requests for tenders to which CES responds, providing tenders for each solution. BuildCon then selects one solution. According to CES, it is common in the construction industry for contractors and subcontractors to issue requests for tenders to several suppliers and based on the information thus obtained, including price calculations, contact other suppliers to see if they can 'match' the price. This step is not possible when there is a dedicated supplier and in responding to a request for tender issued by BuildCon, CES knows that it will not be rejected and their work will pay off.

CES is made aware of BuildCon's needs at least six months in advance, which smooths the planning process related to allocating cranes and elevators among its various customers, and assembly and dismantling of cranes. BuildCon mostly manages to keep to its time schedules, and where it fails this is often due to weather conditions which are beyond its control. Overrunning times are never more than a few weeks. Other CES customers may modify their original plans, and change the timing of dismantling of tower cranes and elevators several times. Sometimes they want to keep the equipment for longer than originally indicated if the project is over-running severely. Some delays can run into many months. This causes problems for CES since elevators and tower cranes are scheduled for dismantling and then servicing before delivery to another customer.

8.3.5 SUPPLY OF MACHINERY/POWER SOLUTIONS/WELFARE FACILITIES

The supplier of machinery/power solutions and welfare facilities, MPWS, and BuildCon have been working together for more than 15 years. The need for machinery, power solutions and welfare facilities varies along a project, but BuildCon communicates all of its needs to MPWS in the project planning process.

During the project, MPWS receives regular updates on needs. As with the other of the contractor's suppliers, MPWS is involved from the planning phase and can make suggestions related, e.g. to temporary power solutions based on different methods and thus, costs.

MPWS makes clear that in order to provide its optimum specialized skills it is crucial to be involved early in a project. If planning, including the Site Layout Plan, has already been finalized, options regarding power solutions become limited and costs usually increase. Most customers consider only the 'price per electricity cabinet', and accordingly, choose the supplier with fewest electricity cabinets. However, power solutions depend on the available power sources geographically close to the site, which requires consideration of the total solution for power; where to position the wiring and number of electricity cabinets. MPWS emphasizes that close involvement in projects depends on connections between individuals and mutual trust in each other's particular skills and capabilities.

Welfare facilities comprise offices as well as workers' facilities. They are based on a modular system where the interior can be adapted to the requirements of individual customers. BuildCon and MPWS have worked out a standard layout for facilities for all the contractor's projects. MPWS also offers this layout to its other customers.

To summarize, the idea of appointing a dedicated supplier of building materials developed to include appointment of dedicated suppliers also for scaffolding/working platforms, cranes/elevators and machinery/power solutions/welfare facilities. This approach is used in the section that works on residential buildings at BuildCon. The aim of improving efficiency brought other changes, mainly internal to the contractor as described next.

8.4 ADDITIONAL CHANGES TO THE ORIENTATION

The section working solely on residential buildings at BuildCon has abandoned competitive tendering in the procurement categories described in the previous section. The dedicated suppliers are used for all projects and are promised full supply for BuildCon's residential building section; the building materials supplier is on a three year contract; the others work according to verbal agreements. BMS handles all dealings with materials manufacturers and arranges with the subcontractor ConSite

Logistics for materials handling. This relieves the site managers in individual projects of these planning responsibilities, and construction workers on materials handling operations.

8.4.1 APPOINTING A LOGISTICS MANAGER AND A PROJECT COORDINATOR

To further improve materials supply and facilitate the logistics processes, BuildCon has appointed a logistics manager. This manager learned from the ConSite Logistics consultant in the evaluation to appoint suppliers, and now is fully responsible for all coordination regarding materials supply, for all projects. The logistics manager creates time plans related to production, and converts them into delivery plans to be shared with BMS before the start of a project. These plans enable satisfactory supply of materials, and rigorous planning minimizes disturbances to production flows at sites. The logistics manager undertakes work previously done by individual site mangers who did not collaborate between projects. The job of the logistics manager comprises the same routines applied to all projects, and enables an overview of what is happening in the projects. A communication pattern has been established allowing exchange of information between the logistics manager at BuildCon and a contact at BMS to agree rules regarding call-offs and confirmation of materials. This communication is standard for all projects. The logistics manger and the BMS contact work closely together throughout an entire project.

BuildCon also appointed a project coordinator who is involved in extensive planning of individual projects and creating accurate time plans and cost levels. While the logistics manager works closely together with the supplier of building materials throughout projects, the project coordinator works with the other three dedicated suppliers. Their cooperation is most intense in the planning phase, although adjustments are required throughout the project. BuildCon emphasizes the benefits associated with having dedicated suppliers extending beyond the individual project. It induces mutual trust and allows the various suppliers to make suggestions and propose improvements before final decisions. BuildCon describes the cooperation as including extensive trust between the parties: “The mutual commitment from us and the suppliers is core in this type of collaboration, we cannot – and will not – persuade anyone to work on these premises”. BuildCon also stresses the importance of the suppliers not becoming too dependent on BuildCon, and continuing to work with other customers, which helps to extend suppliers' skills which, in turn, benefits BuildCon. Figure 8.5 depicts the appointed dedicated suppliers and the internal organizational arrangements including the logistics manager and the project coordinator.

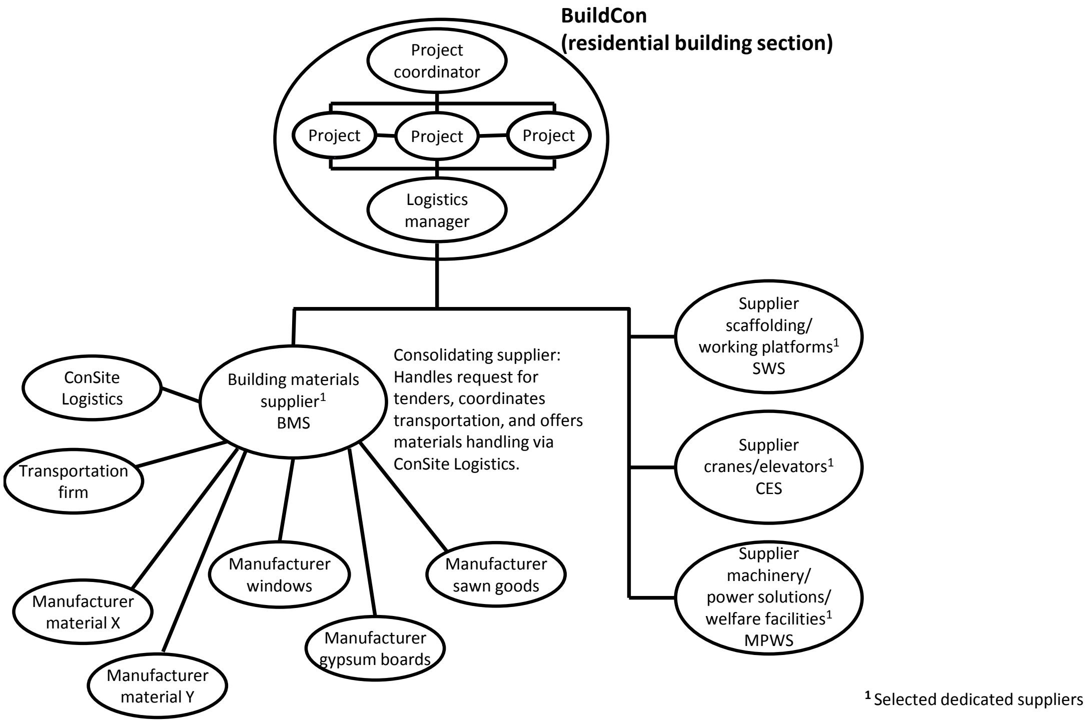

Figure 8.5 The dedicated suppliers and BuildCon logistics manager and project coordinator.

Neither the logistics manager nor the project coordinator is located at BuildCon's head office. Both are located on sites, and share facilities with the site managers, craftsmen and other people employed at the site. Communication takes place between the project coordinator and the same individuals at the dedicated suppliers over time. In some cases, e.g. in relation to assembly and dismantling of tower cranes, there is also a need for coordination between the suppliers and BuildCon's site manager. The work undertaken by the logistics manager and the project coordinator has relieved pressure on the site managers allowing them to focus on production, including improvements which can be transferred to future projects. It also has reduced the number of mistakes made in projects. BuildCon considers the the site managers and other personnel crucial, since its well-functioning and new ways of working depend on the long term commitment of these individuals.

8.4.2 EMPHASIS ON THE PLANNING PHASE

A major consequence of the new working arrangements is the importance assigned to the planning phase and the time and resources devoted to producing as detailed plans as possible, and to include everything in the request for tenders. The section manager and the calculation department still provide preliminary costings to the client in the bidding process for a new project. These include the number of craftsmen work hours and their cost, calculated by multiplying the bill of quantities with the unit price per hour for craftsmen's work. The project coordinator also estimates the number of production hours, but in this case based on previous experience and using cycle times and reference lists. The calculations of the section manger and calculation department are compared with the project coordinator's calculations and adjusted to arrive at the most accurate approximation. The project coordinator also estimates the costs of scaffolding/working platforms, cranes/elevators, machinery/power solutions/welfare facilities including heating and maintenance costs, which are included in the compilation of the tender provided to the client. Thus, BuildCon is able to provide detailed calculations of the total costs of a project already in the planning phase; and final costs are sometimes lower than these estimates. Thus, more time and resources are devoted to planning: compiling a tender for a client costs around SEK 300,000-400,000. However, this rigorous planning enables a smooth production process without unnecessary disruptions to the production flow and no unexpected problems requiring costly ad hoc solutions. Figure 8.6 depicts BuildCon's organization including section manager, calculation department and project coordinator involved in compilation of tenders.

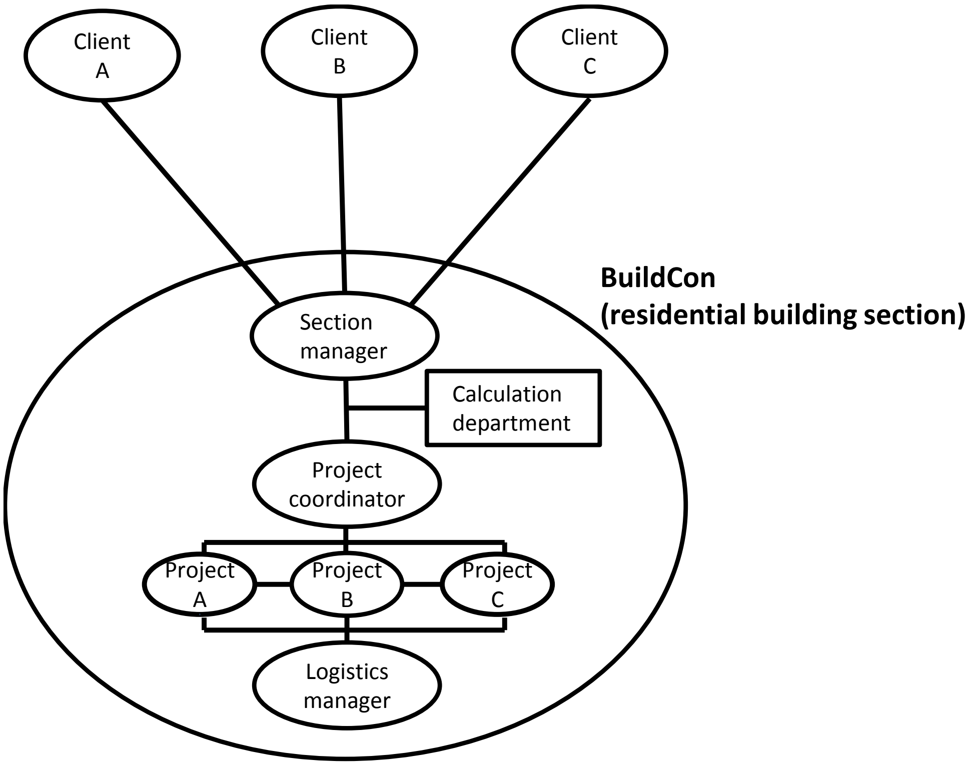

Figure 8.6 BuildCon: work towards clients with compilations of tenders.

8.4.3 THE BUILDING PROCESSES

Key to this reorientation was BuildCon's evaluation of its processes, and how and when a project can be considered successful. It is difficult to compare projects since each is unique. BuildCon considers a project successful if craftsmen hours and expenditure costs are kept within budget and if the project is completed on time. Safety and a smooth building process are also used to estimate success, as they provide cost efficient production flows that allow workers to focus on individual tasks with minimum disruption. Finally, BuildCon aims for high quality; unsatisfactory quality can have repercussions involving substantial costs to fix flaws. Quality guarantees extend for five years after completion of the project.

Based on its positive experiences BuildCon is beginning to evaluate what and how changes can be implemented in the actual house-building processes on site. The modifications being considered are related to alternative processes for craftsmen to enable them to benefit from a standardized production process, and the collaborative arrangements with dedicated suppliers. BuildCon consider it important to emphasize learning in order to achieve improvements, and transfer successful implementations to other situations and projects.

BuildCon also has some additional ideas regarding supply for projects. The need for subcontractors varies from project to project. Subcontractors currently are hired through a traditional competitive tendering process, focused on a single project and 'a low price per unit'. This does not take account of experience gained from previous projects and does not have a long-term perspective. For example, a subcontractor might be successful in the tendering process for a new project based on offer of the lowest price. However, this same subcontractor might have caused a lot of extra costs in previous projects due to problems in the planning and execution phases. BuildCon is keen to hire subcontractors in a more consistent way, and similar to the procedures related to using dedicated suppliers. However, the approach has been applied only to the section working on residential buildings. Other BuildCon's sections that focus on public buildings and commercial buildings still use competitive tendering on individual projects and for all types of supply. These projects are more individual, and involve a higher proportion of craftsmen compared to residential buildings. Hence, opinion on the utility of appointing dedicated suppliers as a procurement strategy differs among sections and individuals at BuildCon. The issue is the topic of ongoing heated discussion. However, BuildCon generally emphasizes a process of 'continuous improvement' and the creation of new ideas and ways of working to further strengthen its position as a successful building contractor.

8.4.4 THE CLIENT SIDE

As a consequence of the new arrangements the residential building section barely participates in the bidding process if the client is a representative of a government or municipal authority or a public company. Since compliance with the Public Procurement Act is mandatory in these cases, evaluation does not recognize the benefits of the extensive planning undertaken by BuildCon and its arrangements with dedicated suppliers. Unit prices dominate the evaluation procedure, which situates BuildCon in an unfavorable position. Also, past performance is not allowed to be taken into account although BuildCon values this highly in its assessment of suppliers. Consequently, BuildCon prefers to work with private clients, and to a greater extent in design and build contracts in which client and BuildCon work together intensively from a very early stage in order to achieve a successful project. Under such premises BuildCon's procedures are considered very valuable.

BuildCon has completed four projects using dedicated suppliers. In some the production technology and clients' demands extended materials supply beyond what BMS could provide. BuildCon has acknowledged that there needs to be some flexibility: the dedicated suppliers provide most of the services, but adjustments to individual projects sometimes require more than the suppliers can supply owing to clients' demands.

8.4.5 CONTINUOUS EVALUATION OF WORKING ARRANGEMENTS

BuildCon is considering alternatives to CES, the current supplier of cranes/elevators. Cranes are an extremely important resource on site, and CES is not providing a sufficiently high level of service when problems arise with cranes. This has resulted in production delays. BuildCon considers it is buying an important function from a strategic supplier and, thus, has high expectations of the service and commitment from the supplier based on guaranteed business. CES also provides other equipment to construction projects such as welfare facilities and scaffolding. CES is instructed by its central management to concentrate on customers who are willing to exploits its extensive fleet of equipment. For BuildCon's projects, CES only provides cranes and elevators; BuildCon uses other suppliers for equipment such as welfare facilities and scaffolding. BuildCon is satisfied with this supply and is not willing to switch to CES for all these needs. Due to problems related to CES services for cranes and elevators, BuildCon is considering finding another supplier.

In all other ways, BuildCon is very pleased with the new working arrangements including dedicated suppliers: "We are working together and together we can always find the technical solutions and the economy to carry out them". In addition, "when problems arise, as in one project when a wet wall board got cracks owing to tensions in the walls, there is a dialogue upon what went wrong and who is responsible. If this wet wall board had been bought in a competitive tendering process, it would have been a long and drawn-out process to settle an agreement upon responsibility". BuildCon emphasizes the continuous efforts required over arrangements with suppliers and internally: "We can always improve, and we need to evaluate current situations to be able to take the next step in the right direction." Chapter 9 analyses BuildCon and the supply arrangements with regard to actor intermediation.

9 ANALYSIS OF ACTOR INTERMEDIATION: THE BUILDCON EXAMPLE

This chapter analyses actor intermediation in the BuildCon example. BuildCon originally relied on competitive tendering for obtaining its supplies: each material type had its own tendering process, and each project was dealt with individually. This way of working provided challenges related to meeting individual project cost levels and time limits. BuildCon wanted to increase the efficiency of the building process through greater standardization among projects and closer working on a longer-term basis with suppliers. Following an extensive evaluation process BuildCon appointed four dedicated suppliers for all its projects. Two situations with varying conditions of actor intermediation are identified. In situation 1, BuildCon's organizational arrangements are decentralized and each project is treated in isolation, with individual site managers carrying huge responsibility for materials supply. The business relationships are characterized by low involvement and competitive tendering procedures that direct the interaction. In situation 2, BuildCon applies a much more centralized organizational approach, with several activities reassigned from site managers to a project co-ordinator and a logistics manager, both working across project boundaries. The appointment of dedicated suppliers entails extensive interaction among the parties in high-involvement relationships.

In line with the analytical framework, BuildCon is positioned 'in the middle' as the intermediate element in the analysis of actor intermediation. BuildCon intermediates between the same elements in situations 1 and 2: the dedicated suppliers in situation 2 also supplied BuildCon in situation 1, and many of the clients are the same in both situations. Instead, as BuildCon reorganizes to gain from closer collaborations it is BuildCon's behaviour that changes. The work so far has focused on suppliers, however, through the efforts BuildCon hopes to gain towards clients. The change to dedicated suppliers is considered a first step in its change of behaviour. The analysis of actor intermediation in this chapter investigates the connections between BuildCon and its suppliers.

The changed behaviour of the intermediate actor means that the form of intermediation changes towards the actors defined as suppliers, and the content of the relationships involved. Thus, the interactions between BuildCon and its suppliers differ in the two situations, which in turn affect how resources are utilized and the efficiency of activities. Analysis of situations 1 and 2 focuses on these aspects of actor intermediation. The two situations are first analysed separately, and then compared.

9.1 SITUATION 1: COMPETITIVE TENDERING IN INDIVIDUAL PROJECTS

In situation 1 competitive tendering procedures prevailed: on the demand side in the bidding processes towards clients, and on the supply side, in the selection of suppliers. Individual transactions are optimized aiming at obtaining the best prices, and each project is dealt with as self-contained. Figure 9.1 depicts BuildCon's position in situation 1 with regard to its connections with suppliers, and simplistic examples of clients.

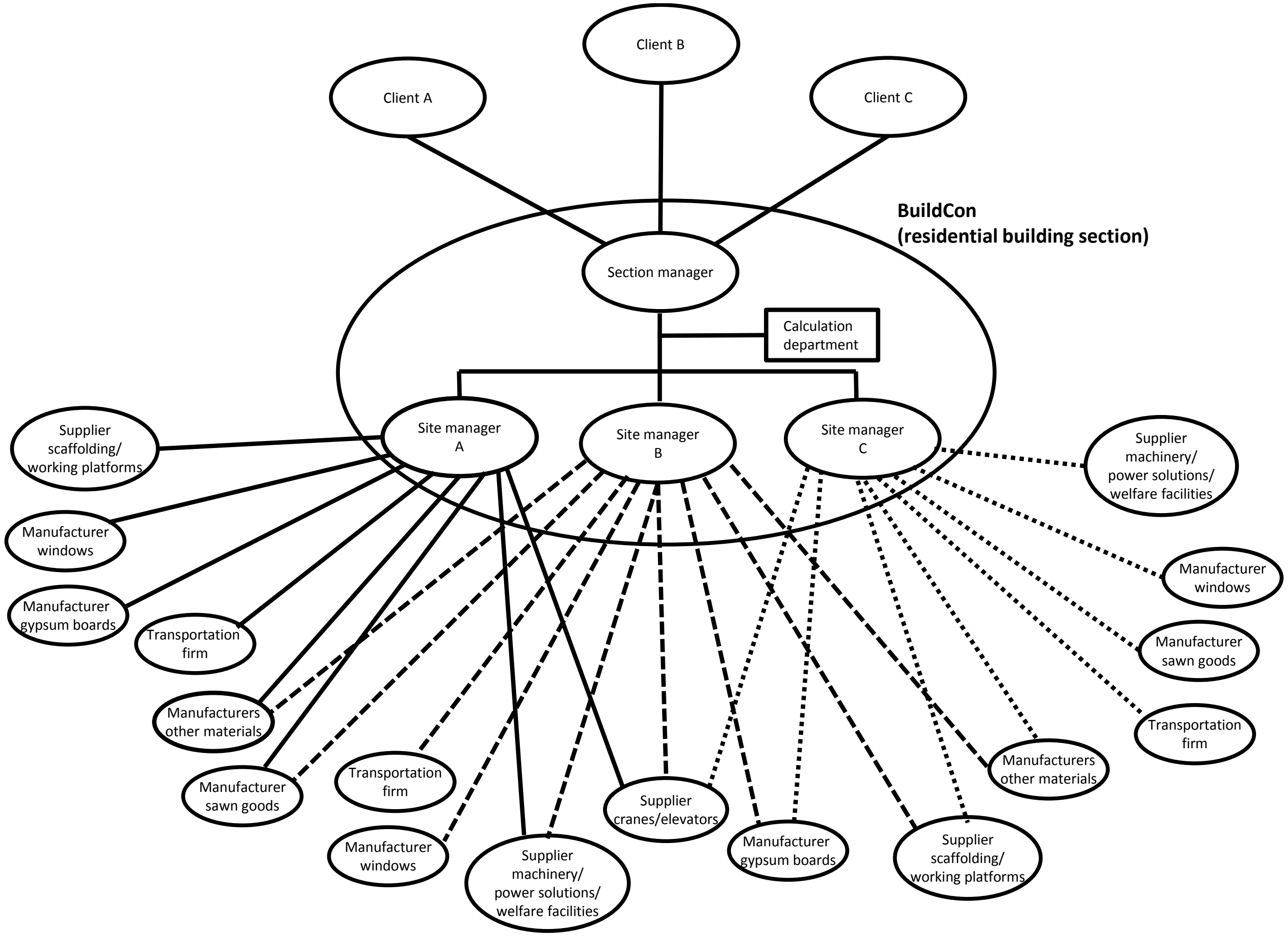

Figure 9.1 BuildCon's position in situation 1.

The position of BuildCon is examined in relation to decentralized organizational arrangements. This is followed by an analysis of interaction in the business relationships with features of low-involvement.

9.1.1 DECENTRALIZED ORGANIZATIONAL ARRANGEMENTS

In situation 1 BuildCon takes a decentralized approach to its internal arrangements, focusing on individual projects. In these projects the section manager and the calculation department are involved in inter-organizational arrangements related to the demand side, and in interaction with clients. Their work entails planning cost levels and time limits in projects and though competitive tendering selecting counterparts to act as suppliers and subcontractors. Individual site managers are responsible for the inter-organizational arrangements in the project execution phase including coordination of orders and deliveries, and production of time plans for managing the building processes. There is no coordination of activities and resources across projects, even though the same suppliers are used in several projects running simultaneously. BuildCon's internal organization allows limited interaction among activities and resources, on the demand and supply sides respectively. Project planning includes 'conditions' which become the responsibility of site mangers to deal with in the execution phase of projects. This approach does not encourage information sharing and limits the internal transfers of knowledge at BuildCon. Thus, experience gained in projects about arrangements with suppliers, for example, is not taken into account in the selection of suppliers for new projects. Interactive problem-solving at sites is seldom transferred to other projects. Finally, since projects are handled in isolation, potential economies of scale through the coordination of activities and the combining of resources, for instance, with regard to materials supply, are not exploited.

9.1.2 LOW-INVOLVEMENT RELATIONSHIPS

Situation 1 follows the widely adopted logic in the construction industry aimed at economic efficiency through competitive tendering, with a strong focus on 'lowest price'. This provides short term benefits related to the low prices of materials/equipment in individual transactions, but previous patterns of interactions and expectations concerning the future have little impact on the selection of suppliers. This implies that business between BuildCon and suppliers/subcontractors is characterized by irregularity and low levels of loyalty because of frequent switching among potential suppliers. Switching among suppliers is enabled by availability of standardized materials and equipment provided by many vendors. Analysis of involvement in business relationships concerns activities and resources. Standardized activities and resources imply that resource ties are minimized and activity links are weak. This requires substantial adjustments and adaptations on site, to combine resources and coordinate activities. Site managers, work managers and craftsmen devote substantial time and resources to these tasks. The need for coordination at site level, and the possibilities for developing the substance in the relationships with supplies are neglected. Since interaction is centred on current problems in individual projects, what goes on in parallel projects is not taken into consideration.

Thus, in situation 1, relationships with suppliers are cost effective in terms of low prices and low relationship handling costs. However, there are 'hidden costs' related to storage of large volumes of materials on site, risk of damage to the materials, and the costs for adapting resources and coordinating activities on site. There are also costs related to preparing and sending requests for tenders to multiple suppliers and evaluating them. Suppliers also incur costs in responding to these tenders.

These low-involvement relationships feature arm's-length conditions, and BuildCon's avoidance of dependence on single suppliers. In the same way, the suppliers also keep distance to BuildCon. In the competitive tendering process, suppliers are selected based solely on price provided in the tender, and the information and calculations provided in individual tenders allow contractors to check whether other suppliers can 'match that price'. Consequently, suppliers invest minimal effort in generating tenders, since devoting time and resources to provide detailed tenders with extensive plans and information including alternative solutions, are not valued in the selection process and could be used to obtain a lower price from a different supplier. Thus, the interactions between BuildCon and suppliers do not foster collaboration. Instead, interaction is characterized by low levels of commitment and trust. In some situations adversarial conditions dominate, for example, problems regarding an installed material can create conflicts that develop into a legal case about responsibility.

Overall, although BuildCon and some of its suppliers have been involved in business transactions over many years, and the same people have been communicating over the years, very little attention is paid to the relational elements of these transactions. A consequence of the limited interactions and distances in the relationships is the lack of mutual orientation. Mutual orientation cannot evolve since the actors avoid adaptations of resources and activities consistently.

In situation 2, which is analysed below, intermediation involves BuildCon and the appointed dedicated suppliers.

9.2 SITUATION 2: DEDICATED SUPPLIERS FOR ALL PROJECTS

In situation 2, as far as clients are concerned, BuildCon participates in bidding processes regulated by competitive tendering for new contracts. This is the same procedure as operated in situation 1. However, on the suppliers' side, the residential building section in BuildCon has abandoned the competitive tendering procedures and instead appoints the appropriate dedicated suppliers BMS (for building materials in the frame complement phase), SWS, CES and WPWS. In addition, BuildCon has assigned a project co-ordinator and a logistics manager as part of its internal organization. Figure 9.2 depicts BuildCon's position in situation 2 with regard to its connections towards suppliers, and simplistic examples of clients.

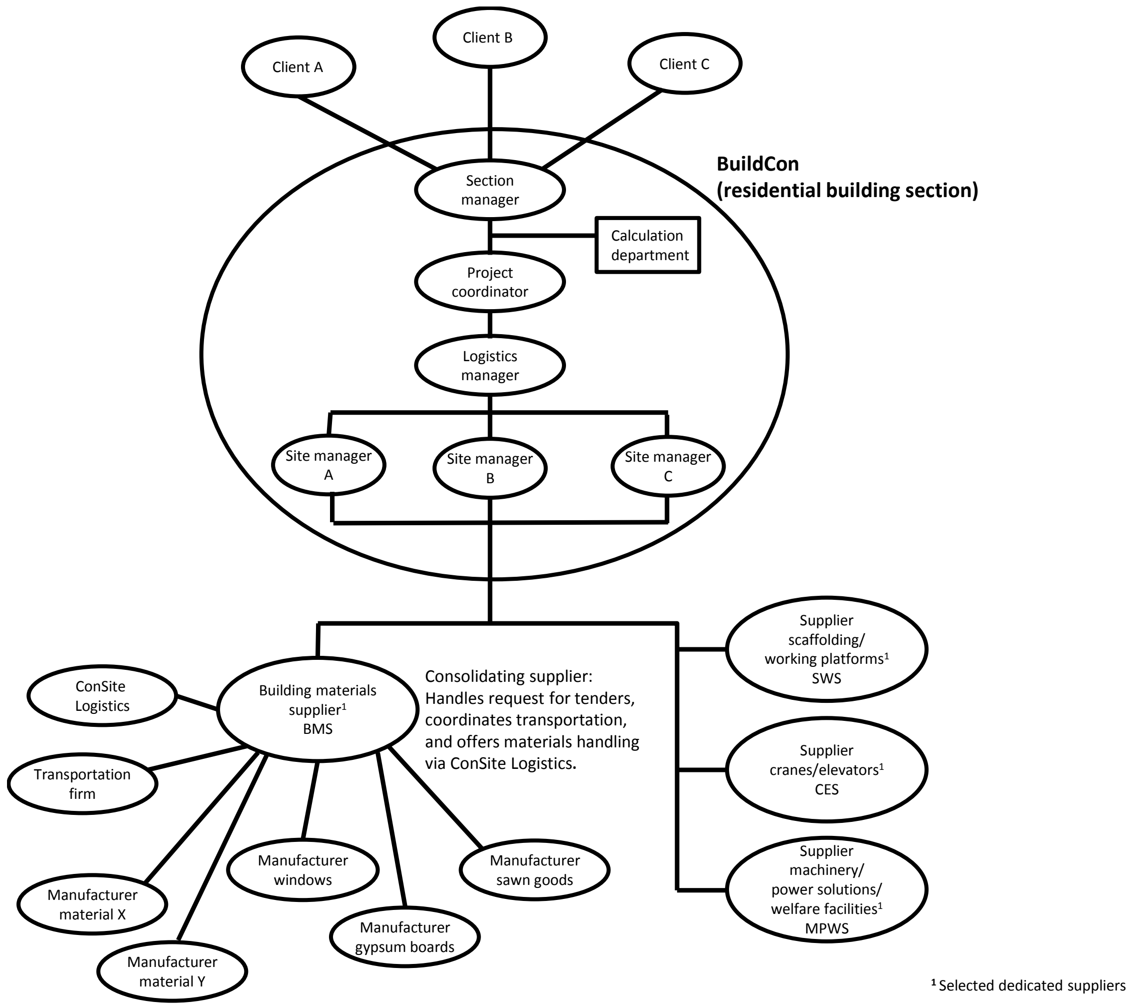

Figure 9.2 BuildCon's position in situation 2.

Next, the position of BuildCon is examined in the context of the centralized organizational arrangements. Then, interaction in the high-involvement business relationships is analysed.

9.2.1 MORE CENTRALIZED ORGANIZATIONAL ARRANGEMENTS

In situation 2, BuildCon's internal organization is extended by the addition of a project coordinator and a logistics manager. Their appointment increases centralization. Both are heavily involved in planning activities: the project coordinator mainly in relation to the demand side, and the logistics managers mainly on the supply side. This improves the interaction among various projects substantially, with regard to on-going parallel projects and over time between previous and future projects.

Internal resources are assigned to enable standardization across projects with accompanying benefits in terms of economies of scale. Routines to coordinate activities and resources supplies on site are in place already in the project planning phase. This allows very detailed tenders with comprehensive calculations, including accurate time limits and costs levels, to be provided to clients in the bidding process for new contracts. This is considered to be beneficial, at least in relation to private clients. On the supply side, time and resources devoted to extensive planning allow efficient building processes and fewer delays on site.

The use of the subcontractor ConSite Logistics for materials handling changed the division of labour among the parties, since craftsmen working on site are no longer involved in materials handling, and site mangers do not have to conduct quality checks on incoming materials. Site mangers had to devote significant time to coordinating materials handling and materials deliveries with building activities to ensure efficient flow of operations on site. Subsequent organizational changes mean that these activities are the responsibilities of the project co-ordinator and logistics manager, and are part of the planning stage of a project rather than the early execution phase. Site managers are now able to focus on the building activities on site: to standardize them and propose solutions to problems related to their execution. This improves the performance of building activities.

The exchange of information between project co-coordinator, logistics manager, site managers and representatives of the four dedicated suppliers follows a standardized communication pattern from the start of a new project. Together with the long-term nature of their interaction this approach promotes enhanced information sharing and improves the transfer of knowledge between BuildCon and suppliers within individual projects and across projects. Hence, the more permanent constellation of those involved enables joint learning and increased understanding of parties' business conditions over time.

9.2.2 HIGH-INVOLVEMENT RELATIONSHIPS

The dedicated suppliers were all known to BuildCon through previous involvement in projects. However, in competitive tendering each interaction episode was dealt with individually, and focused on lowest prices for materials and equipment in each transaction. By appointing four dedicated suppliers, their mutual goals were to improve interaction in order to increase levels of involvement in the relationship.

The interactions among the project co-ordinator, logistics manager, site managers and suppliers' representatives enable increased coordination of activities concerning establishment on the site, and precisely planned delivery of building materials, materials handling and building activities. The elevators, packaging of materials, increased content in requests for tenders are just examples of the resource adaptations that are prerequisites for this close coordination. These efforts of extensive coordination and adaptations among resources are achieved through increased inter-organizational interaction, with stronger activity links, resource ties and actor bonds. This is crucial for improved information exchange, knowledge sharing and planning of routines. This close interaction reduces uncertainties and generates trust between the parties. The suppliers trust BuildCon not to use their tenders for comparison with other suppliers. The new approach also creates commitment, and suppliers know that their contributions affect BuildCon's chances in the bidding process for new projects. These relationships include a collaborative working element and take account of both parties' business interests, while providing a favourable solution for clients.

The suppliers SWS, CES and WPWS are loosely connected to BuildCon. Still each of them is important within its respective field, and each contributes with particular knowledge and skills. They are involved in intense interaction with BuildCon mainly in the planning phases of projects including coordination of equipment when establishing the site. These decisions are made early in the project, including changes necessary in accordance with the project's execution phases. At times, some adaptations are needed, for instance, to develop customized solutions regarding the use of platforms and the layout for welfare facilities. During construction activities there is no need for close interaction between suppliers and BuildCon. Nor is direct interaction needed between these suppliers.

For BuildCon, the relationship with the supplier of building materials, BMS, is most crucial. BMS takes full responsibility for the activities of ordering, physical delivery and materials handling at sites. Thus its logistical skills and capabilities are critical organizational resources for the coordination of activities undertaken by materials manufacturers, transportation firms, ConSite Logistics and BuildCon. There are strong connections between BMS and ConSite Logistics allowing adaptations to meet specific demands related to physical features, administrative routines and coordination of activities. The coordination between activities on site and activities related to materials supply has improved, and some activities have been transferred from the site to BMS. The changes with regard to content of tenders to materials manufacturers are a prerequisite for these improvements.

When BMS undertakes activities such as ordering materials, their physical delivery and coordinating materials handling, BuildCon can focus on building activities on site. This is a form of specialization which improves both quality and economies of scale, since site managers, work managers and craftsmen can devote all their resources to building activities. The transfer of planning activities from site managers to project co-ordinator, logistics manager and BMS enables this specialization. In this way BMS's resources are also better utilized since BMS is involved in the process at an earlier stage.

Competitive tendering applies to the business transactions between BMS and materials manufacturers and transportation firms. In some cases demand for customized solutions from BMS on behalf of its customers, such as BuildCon, generate difficulties for the material manufacturers. For example, adjustments in the packaging of windows which improve handling on site can have disadvantages for the scale of operations in the window manufacturer.

Although BuildCon is not directly involved in competitive tendering with its suppliers, the process still remains in the network and does apply to transactions between BMS and materials manufacturers and transportation firms. Thus, these transactions occur in a different part of the network. In BMS's tendering procedures each customer's tender is considered in isolation, but what they represent together adds up to significant volumes of materials. Because of the discounts that large volumes attract, BuildCon (and other customers) can benefit from lower prices compared to when BuildCon tendered for materials. Thus, BMS is a larger customer for materials manufacturers than BuildCon whose materials orders only represent a small part of manufacturers' total production. Thus, if BMS has special requirements related to adjustments of packaging and delivery, material manufacturers are willing to adjust to this large customer.

Overall, these high-involvement relationships entail tight coordination among activities and adaptations related to resources, as well as a more or less intense interaction among individuals at BuildCon and at the suppliers. The choices made by the parties are interdependent and affect both commitment to and trust in the relationships. These high-involvement relationships have a relationship handling cost related to coordination, adaptation and interaction. However, BuildCon benefits from reduced costs in the fulfilment of projects; including costs for materials supply and the ability to accomplish projects with planned man hours and budget within the project time limits. This also benefits suppliers since improved planning results in improved resource utilization.

For BuildCon's residential building section, the ability to deliver high quality to clients in relation to planning and the end-product is beneficial since substantial costs can be generated if there are flaws that need to be fixed after the house-building process is complete. These benefits are associated with an investment logic; however, compliance with the Public Procurement Act does not allow their full exploitation. Some aspects, for example, previous performance, are not allowed to enter the consideration. As a result, the residential building section in BuildCon is increasingly focusing on design and build contracts with private clients. This allows

BuildCon to take advantage of the benefits deriving from its new organizational arrangements and supply side high-involvement relationships on the demand side and collaboration with clients.

The appointment of dedicated suppliers has resulted in four relationships, three of which work very well. The relationship with CES, the supplier of cranes and elevators has been less successful and has resulted in lower levels of commitment and poorer ability to provide the service level expected by BuildCon. This can be explained by a network effect. CES offers a broad range of equipment for construction sites, but BuildCon is interested only in cranes and elevators. Thus, CES customers that utilize the whole range of equipment take precedence, and are prioritized, since the strategic aim of CES is to provide the full range of its equipment to customers.

The next section compares the two situations of intermediation in the actor layer. This highlights the major differences in organizational arrangements and degree of involvement in the relationships.

9.3 COMPARISON OF ACTOR INTERMEDIATION SITUATIONS

The analyses of situations 1 and 2 reveal various conditions for intermediation in the actor layer. This section compares organizational arrangements, activity coordination and resource combining, and level of involvement in the business relationships including characteristics of the interaction. Table 9.1 summarizes this comparison.

Table 9.1 Comparison of actor intermediation: situations 1 and 2.

	Situation 1	**Situation 2**
Organizational arrangements BuildCon	• Decentralized approach, in accordance to individual projects • Competitive tendering for selecting suppliers	• Increased centralized approach, through appointing a project co-ordinator and a logistics manager • Appointing four dedicated suppliers, long-term relationships
Activity coordination and resource combining	• Materials and equipment standardized: extensive coordination and adaptations are needed on sites	• Extensive coordination and adaptations through increased inter-organizational interaction: less adaptations needed on site, enables increased standardization in building processes
Economic efficiency	• Low prices and low relationships handling costs • Substantial handling costs for tendering procedures and 'hidden costs' owing to adaptations at sites	• Cost benefits: reduced costs in production and materials flow • Economies of scale in planning across project boundaries • Increased interaction, including inter-organizational activity coordination and resource adaptations, entail costs
Level of involvement	• Low	• High
Pattern of interaction	• Limited and irregular interaction • No impact on current interaction from previous episodes and expectations about the future • Interdependency is avoided	• Close and continuous interaction • Previous episodes and expectations about the future impact on the outcome of a current episode • Interdependency
Interaction atmosphere	• Potentially adversarial	• Collaborative features • Commitment • Trust
Mutual orientation	•Lack of mutual orientation since adaptations are avoided	• Evolves through continuity in interaction

In situation 1 the main issue is to make resources and activities at individual sites to function together. Materials and equipment are standardized, which requires many adjustments and adaptations on site. In situation 2 activities are reassigned from sites to the supplier of building materials, the logistics manager and the project co-coordinator, and coordination of activities and combining of resources are carried out to obtain synergy effects between projects. This allows standardization of the building processes at different sites. In the bidding process for new contracts, in situation 1 design, communication and compilation of tenders are the responsibilities of the section manager and the calculation department, based on individual projects. In situation 2, the project coordinator is heavily involved in these processes of extensive planning, which reassign activities from site managers to the central organization of the residential building section in BuildCon.

Through extended interaction with dedicated suppliers, reliance on competitive tendering is reduced. Competitive tendering is an impediment to the development of close relationships. Tendering procedures are also costly for all the parties involved due to the extensive resources devoted to providing tenders and evaluating them. Through interactions that extend across projects it is possible to gain economically from knowledge exchange and scale of operations. At the same time, these efforts constrain decentralization and reduce the ability for local decisions. Therefore, increased centralization should be introduced with care to avoid undermining positive aspects in parts of the organization. For BuildCon, previous experience with the suppliers that were later appointed as dedicated suppliers, and the procedures for evaluating them, reduced the risks of the new arrangements being perceived as 'centralized forced decisions'. Competitive tendering is still used in the interactions between the building materials supplier and materials manufacturers and transportation firms, and between BuildCon and prospective clients in the bidding processes for new contracts. BuildCon's business is focusing more and more on design and build contracts with private clients which allow the benefits derived from its new organization to be exploited.

This increasing relationship involvement is beneficial in many ways, but also involves costs and is resource demanding. Therefore, under some circumstances high-involvement is the right approach; in other conditions a different approach is more appropriate. BuildCon has a high-involvement relationship with a group of suppliers that cover the materials supply needs in the frame complement phase, and establishment on sites. For ground and pile work, and frame work, the supply of reinforcement bars and concrete is heavily dependent on local availability and the specific conditions on site, which is better suited to low-involvement relationships although the continuity of the transactions with these suppliers is considerable. In the case of BuildCon's sections working on public buildings and refurbishment projects, low involvement relationships are more appropriate. Notice that the level of involvement is not dictated by BuildCon through its efforts to change its behaviour; the extent of the relationships depends on the interaction among the parties. Hence, although BuildCon may set out certain organizational goals, the other parties involved, such as suppliers, also have organizational goals and the higher the level of involvement between these two parties the larger the number of issues on which some agreement has to be found. In addition, the interaction among the parties is affected by these parties' interactions with other organizations, and vice versa.

So far the analysis of intermediation has focused on separate network layers. Chapter 5 described activity intermediation with regard to supply of reinforcement to SweCon; Chapter 7 discussed resource intermediation with regard to materials handling; the present chapter analyses actor intermediation in the BuildCon example. These analyses all examine various intermediation situations with particular conditions. However, in reality all three network layers are interrelated. Chapter 10 examines impact of intermediation on the interplay between the network layers in the three empirical examples.

10 IMPACT OF INTERMEDIATION

Chapter 10 discusses the impact of intermediation on the interplay between the network layers in the three empirical examples. The analyses in previous chapters focused on intermediation in each single network layer: activity intermediation in relation to supply of reinforcement to SweCon sites, resource intermediation in relation to materials handling, and actor intermediation in analysis of BuildCon appointing dedicated suppliers. These investigations include comparisons of how intermediation differs from one situation to another in that specific layer: how one intermediate activity/resource/actor connects other activities/resources/actors, and the effects of those interrelations. Thus, interrelation in each separate network layer is analysed. In reality, the three network layers are closely intertwined, and analysis of the impact of intermediation requires investigation of the interplay between the three network layers, to complement the analyses of the respective layers.

Since network layers are intertwined, an intermediation situation in one network layer relates to all three network layers. However, analysing the simultaneous impact of intermediation on the activity layer, resource layer and actor layer would be too complex. Therefore, this impact is analysed in the relation to the network layers, two by two: thus, the impact on the interplay between activities and actors, the impact on the interplay between activities and resources, and the impact on the interplay between actors and resources. This type of analysis has been fruitfully applied to examine the complex connections among network layers (Gadde, 2014). To get an understanding of these different types of interplay, the main features of each layer are recaptured. The activity layer captures what is done (the activities) in the network. Various actors carry out these activities. Thus, the impact on the activity-actor interplay centres on the distribution of activities among actors, which covers the *division of labour* in the network. The resource layer involves the resources used to undertake the various activities. Performance in the activity layer is contingent on how available resources are utilized, thus, the impact on the activity-resource interplay has implications for *efficiency*. Finally, actors control the resources. Thus, the impact on actor-resource interplay deals with *control* of significant resources through ownership or by accessing other actors' resources.

The features regarding division of labour, efficiency, and control of resources in a particular intermediation situation have a profound impact on what can be achieved, how it is achieved, and for whom. Figure 10.1 illustrates the interplay between the network layers with regard to division of labour, efficiency and control.

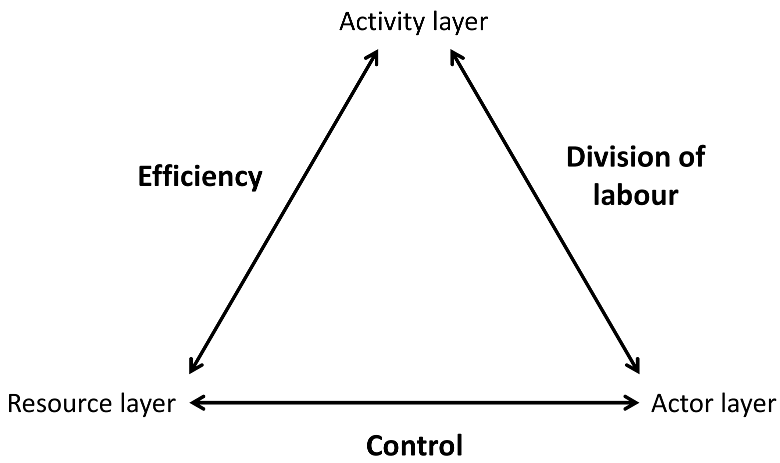

Figure 10.1 The interplay between network layers in a particular intermediation situation.

Furthermore, the analysis of the impact of intermediation needs to take account of different intermediation situations. The previous analytical chapters compared intermediation situations in the network layers separately; this chapter compares the interplay among all three network layers. Consequently, each empirical example is analysed in terms of how division of labour, efficiency and control of significant resources differ in the various intermediation situations. This provides an increased understanding of the impact of intermediation in business networks.

Next, each empirical example is analysed separately with regard to how division of labour, efficiency and control of significant resources differ among the intermediation situations. The first section analyses the impact of intermediation with regard to supply of reinforcement to SweCon sites. The second section analyses the impact of intermediation in the materials handling example. The third section analyses the impact of intermediation in the BuildCon example.

10.1 IMPACT OF INTERMEDIATION: SUPPLY OF REINFORCEMENT

The analysis in Chapter 5 identified three situations with various conditions of activity intermediation. The intermediate element, cutting and bending, connects other activities in situation 3 than in situations 1 and 2. Cutting and bending are in principle executed in the same way in all situations, although the scale differs. The analysis shows that these differences in activity intermediation have consequences for the overall configurations of activities and, hence, affect their function and performance. Chapter 5 discusses the interrelation through intermediation with regard to activities. Below the three situations are analysed with regard to the impact of intermediation on the interplay between the network layers. Differences in division of labour, efficiency, and control of resources are analysed regarding supply of reinforcement to SweCon sites.

10.1.1 SUPPLY OF REINFORCEMENT: DIVISION OF LABOUR

SweCon's aim in establishing its reinforcing factory was to benefit from increased efficiency in cutting and bending operations. Thus, supply of reinforcement to SweCon sites changed from Steel Service to the reinforcing factory: from situations 1 and 2 to situation 3. Accordingly, division of labour changed when the intermediate element, cutting and bending, was transferred in the activity configurations from the sites, as in situation 1, and from Steel Service, as in situation 2, to SweCon's reinforcement factory, as in situation 3. Thus, the establishment of the SweCon factory represents 'insourcing' of cutting and bending activities: from the sites, but also from Steel Service, to control by SweCon. This change resulted in tensions since, in general, the sites perceived cooperation with Steel Service as functioning well; but it had to be abandoned in favour of the SweCon factory.

Interaction among the actors alters with changes to the division of labour. Previously, a central agreement implied that Steel Service supplied all SweCon projects with reinforcement whether long bars or CAB. Interactions took place at two levels. The central organizations in SweCon and Steel Service set up a long term business including contracts; SweCon's decentralized project organizations and Steel Service's various service centres and warehouses interacted with regard to supply for specific projects. The most important relationships were those between project organization people on site and Steel Service. Each project involved intense interaction to coordinate the supply of reinforcement with the activities on site, especially in relation to of CAB. In addition, Steel Service created delivery plans and reinforcement specifications, and interacted with steelworks for the purchasing of steel.

In the changed situation, the most important interaction takes place between site managers and the SweCon factory. This interaction requires extended contributions from site managers, who are responsible for creating reinforcement specifications and setting up delivery plans. Hence, site managers are required to undertake a larger proportion of activities in the supply of reinforcement than when Steel Service was involved. The transfer has been not been positive for some sites. For instance, poorly marked profiles and mismatched delivery orders create extra work at the sites, since CAB is often delivered as spillikins which require sorting before installation can begin. Also, continuous dealings with Steel Service had established an interaction pattern that allowed for late placement of orders for reinforcement profiles despite a three week delivery time. Steel Service was able to cope with most urgent orders and to arrange deliveries at a specific time required by the sites. The reinforcement factory is less able to provide profiles at short notice, and this combined with mismatched orders, has increased the perception on site that supply of reinforcement has become more problematic.

The central organization of SweCon thus exploits its power over individual projects by redirecting supply of reinforcement from Steel Service to the SweCon factory. This transition has broken established interaction patterns, including routines and personal connections between individuals, and between SweCon projects and Steel Service, and has been met with resistance. The intention of the factory to produce CAB and deliver to sites in the most cost efficient way sometimes conflicts with the sites' need for flexibility and adjustments. In addition, intense interaction is required between the factory and the various steelworks to assure availability of long steel bars, coils and nets, in the right dimensions, in the factory.

The establishment of the SweCon factory means that SweCon is engaged in steel supply, CAB production and coordination of reinforcement deliveries to sites. This seems to be outside the current core competences of SweCon. Although improved planning and more efficient production processes have increased factory output, problems remain, including those related to deliveries and transportation. Improvements to these activities require the involvement of both the factory and the sites and increased information sharing and joint planning. In contrast, Steel Service specializes in activities related to steel products: purchasing materials, transportation and prefabricated production. Over time this specialization has increased: Steel Service no longer owns its own trailers, but instead purchases all its transportation services. Specialization is analysed below in the activity-resource interplay concerning efficiency.

10.1.2 Supply of reinforcement: efficiency

As the analysis of activity intermediation shows, efficiency is ensured by increased scale of operations. This includes the capacity of the involved resources. The utilization of resources for producing profiles on site or producing CAB either at Steel Service or in the SweCon factory differs. These three cases all involve standard profiles and standardized machinery with certain technical and functional conditions, but the machinery on site has limited capacity and involves a high level of manual operation. Thus, production of CAB is carried out on larger scale and is more automated. The greater economies in the production of CAB are explained by the capacity utilization of machinery at Steel Service and in the SweCon factory. Thus, supply of CAB to sites offers cost advantages for the projects compared to undertaking cutting and bending on site. Since reinforcement profiles are standardized, orders can be combined to exploit economies of scale in cutting and bending operations in the production of CAB. Steel Service enjoys greater economies of scale since it serves more customers than the factory, and produces other types of prefabricated steel than reinforcement. Also, cutting and bending on site results in more waste of material than if CAB is supplied. This contributes to less favourable economic conditions if cutting and bending occurs on site.

The utilization of resources in the transportation of reinforcement to the sites is important for obtaining an overall cost efficient solution regarding supply of reinforcement. Steel Service and the SweCon factory apply co-loading to the extent possible, and deliver to sites according to predetermined routes. Steel Service can exploit its central warehouse and the other five warehouses for co-loading, and reinforcement can be co-loaded with other steel products. This increases the utilization of transportation resources while, at the same time, Steel Service has the ability to provide high service levels to its customers with room for adaptations regarding specific delivery times.

CAB from the SweCon factory is the most cost efficient alternative for the sites, since the factory is obliged by central directives from SweCon to keep prices down. However, supply of reinforcement relies on a combination of standardization and customization. When cutting and bending are undertaken on site there is more flexibility to adjust to the conditions on site regarding what to produce, how much of it, and when. CAB on the other hand must be ordered at least three weeks in advance, although both Steel Service and the SweCon factory try to cope with orders with shorter lead times. In general, Steel Service has more ability to adjust to short notice orders. The SweCon factory faces difficulties related to obtaining the customization required to produce CAB at short notice and to adjust to delivery time demands from the sites. In addition, the factory cannot produce CAB with special features, and cannot obtain cost efficiencies related to delivering reinforcement to sites in northern Sweden. Therefore, Steel Service still supplies these sites with reinforcement, and also provides all SweCon sites with steel with special features.

There are differences related also to site deliveries. Steel Service's trailers are always equipped with a crane with the result that the site tower crane is not needed for unloading. This is beneficial because the crane is a critical resource on site and is often needed for several operations simultaneously, which results in lost hours due to waiting time. Some trailers with CAB from the SweCon factory are not equipped with cranes which require the site tower crane to be used for unloading. However, the main difference regarding utilization of the tower crane is between CAB and undertaking cutting and bending on site. The second case involves extensive use of the tower crane to carry the long steel bars from the unloading storage area to the machines, and to carry the profiles to their storage. This negatively effects the efficiency of building operations which are delayed when the crane is occupied with operations related to reinforcement.

Mixed and organizational interfaces are crucial for efficient coordination of resources. For example, Steel Service's own reinforcement consultant creates reinforcement specifications with suggested adjustments to amount and type of profiles to better fit the production conditions and improve efficiency. Now, site managers are responsible for creating reinforcement specifications and they do not have the insight to make the changes that would improve efficiency in the production of CAB.

The interfaces between the physical resources, such as coils and machinery, are standardized. The utilization of these resources can be improved via adaptations to the organizational interfaces with regard, for instance, to administrative routines. The factory's output records show progress in terms of produced volumes obtained with the same machinery and the same personnel as when the factory was established. This is a result of learning over time which has improved skills related to how and when resources such as machinery used for cutting and bending can be adapted, which improves the combining of resources. For instance, by directing customers to a computer based system for placing orders, mistakes derived from manually created production orders can be avoided.

Performance improvements involve specialization. Over time, activities are fine-tuned in relation to each other, in order to function together as efficiently and effectively as possible. However, the greater the specialization of activities, the more resources must be devoted to coordination. Steel Service specializes in steel products such as reinforcement, beams, sheet metal and stainless steel. Thus, Steel Service is well placed to be at the forefront of the specific technology related to such operations and development in steel products and applications. This Steel Service specialization has generated substantial organizational skills and capabilities for organizing supply of products to its customers, including purchase of steel, and its production and transportation. Steel Service's coordination capabilities are required to satisfy customers' requirements and to provide solutions that function well with customers' activities. The two steel service centres plus the central warehouse and the five other warehouses enable apposite production and logistics conditions for providing reinforcement to sites, and other customers located nationwide. When CAB was purchased from Steel Service, SweCon was not involved in the production of CAB. This is a dimension of specialization.

Thus, how resources are exploited in the undertaking and coordination of activities affects the conditions for efficiency. In this context, control of resources is a critical task. The actor-resource interplay is analysed next.

10.1.3 SUPPLY OF REINFORCEMENT: CONTROL OF RESOURCES

When bars are cut and bent on site the resources involved are controlled by the decentralized SweCon project organization and economy in individual projects is emphasized. Intense coordination is required on site since resources, such as the tower crane and construction workers, are needed for creating reinforcement profiles at the same time as they are needed for other building operations. However, SweCon only had ownership control of the resources on the site since Steel Service interacted with the steelworks and the transportation firms. When Steel Service supplied the SweCon sites with CAB, this left SweCon with no ownership control of the resources needed for supply of reinforcement. At the same time, the previous concentration of all SweCon's purchasing of reinforcement in Steel Service provided benefits related to opportunities for joint development of solutions regarding amounts and types of profiles required for various constructions. SweCon also gained from Steel Service's interaction with other customers and the developments resulting from these interactions. In addition, SweCon had indirect access to Steel Service's relationships with steelworks and transportation firms. As content of interaction develops over time, SweCon could benefit from the previous interactions of these firms, based on mutual learning, and acquired skills and routines.

On site, CAB from Steel Service or the SweCon factory means that there is no need to establish a station for cutting and bending. This is beneficial since sites are often crowded with little space for reinforcement stations or storage of long steel bars. It is crucial to have the amounts and types of profiles required for reinforcement installation in the constructions. Hence, many sites, especially in infrastructure projects where space is not a problem, prefer to have access to a small storage of bars, and establish a reinforcement station so that, if necessary, additional profiles can be cut and bent, Thus, supply of CAB is combined with some cutting and bending on the sites.

Through the establishment of its reinforcement factory, SweCon has achieved ownership control of the resources needed to produce CAB, and direct access to steelworks and transportation firms through interaction. At the same time, SweCon has lost the benefits of access to Steel Service's long experience, and accumulated knowledge and skills regarding supply of reinforcement. Ownership is a resource intensive means of securing control. Therefore, SweCon still relies on Steel Service for supply of reinforcement with special features, and for deliveries to sites in the northern part of Sweden since it is not economically feasible for SweCon to have ownership control of the resources needed for these solutions. As a result, although the change was intended to eliminate supply from Steel Service, SweCon and Steel Service still cooperate to some extent. Hence, access to Steel Service's resources in these contexts is still crucial for SweCon.

SweCon has also invested in physical resources, for example, the factory and machinery, and organizational resources, such as personnel with knowledge and experience. Also, the content of the interaction with steelworks and transportation firms is an investment process. Building relationships is demanding in terms of time and resources. When SweCon has invested in the resources to supply its projects with reinforcement, it is advantageous and more profitable if these resources can be used over a long period of time. This creates a 'lock-in' effect, where switching to an alternative would be very costly for SweCon since these investment advantages would be lost.

10.2 IMPACT OF INTERMEDIATION: THE CONSITE LOGISTICS EXAMPLE

The analysis in Chapter 7 identified two situations with diverse conditions of resource intermediation. Introduction of the new resource, ConSite Logistics, changed how the intermediate element, the tower crane, interrelates with other resources such as forklifts, elevators, construction workers, and the content of business relationships between the contractor and suppliers. Thus, interfaces among resources are affected on site and also with regard to offsite settings. Analysis of resource intermediation shows that several resources are utilized in a more efficient way with the introduction of ConSite Logistics to the constellation of resources involved in materials handling. Building operations are more efficient since they are not disrupted by materials handling requiring the same crucial resources such as the tower crane and construction workers. Materials handling is improved since forklifts and elevators are utilized to their full extent, which reduces the number of man hours needed for materials handling. These improvements have been enabled by adaptations of elevators, pallet lifts and material packages.

Chapter 7 discusses the interrelation through intermediation with regard to resources; here the two situations are analysed in terms of differences in the division of labour, efficiency, and control of resources.

10.2.1 THE CONSITE LOGISTICS EXAMPLE: DIVISION OF LABOUR

In traditional materials handling, construction workers undertake several activities including quality checks on incoming materials, storing, moving materials, and the necessary handling and transportation to the assembly point on site. These activities provide construction workers with materials for the ensuing installation. Construction workers also carry out building operations other than installation. All this takes place during day time working hours on site. These conditions result in a scattered activity structure, with construction workers constantly moving between tasks in accordance with pre-planned work flows, and adjustments to current conditions on site. As a result, materials handling activities are seldom undertaken in an established sequence. Instead, materials can be unloaded at one point in time, placed in storage for a long period, and then transported to the assembly point by construction workers when it is time for installation.

When hiring ConSite Logistics for materials handling these activities are transferred via outsourcing to ConSite Logistics. Thus, the transition includes when activities are undertaken: ConSite Logistics undertakes materials handling after regular working hours, and the following morning construction workers can immediately start installation since the materials are available at the assembly point. Using ConSite Logistics for materials handling allows construction workers to specialize in building operations. Consequently, building operations performance increases since construction workers do not have to interrupt their work to collect materials. The configuration of materials handling activities has also changed: moving materials on site from one storage location to another is not necessary when Con Site Logistics is involved. Instead, materials handling by Con Site Logistics requires that materials are transported from unloading directly to assembly point, without additional storing. Thus, the division of labour has changed such that storing and moving of materials is no longer needed. This helps in the context of a crowded site, and takes away the need for man hours to be devoted to moving materials.

The site manager used to spend a lot of time on coordination to adapt to current conditions on site and prioritize among the various tasks and adapt the utilization of the many resources. Interaction with materials suppliers regards call offs of materials and the many deviations from plans, which cause re-planning. Thus, the site manger interacts extensively with the construction workers on site when managing materials handling, installation and other building activities. To make this as efficient as possible the site manager interacts with the many materials suppliers in relation to planning and continuous updates to plans. This coordination is troublesome and time consuming. When ConSite Logistics undertakes materials handling, more extensive coordination is required with suppliers to manage delivery at precise times in the evening, and to specify materials packages. These adaptations are a prerequisite for ConSite Logistics services as a specialist in materials handling, allowing it to exploit its resources to many sites using a standard procedure. They are also a prerequisite for effective installation of materials by construction workers. The site manager and ConSite Logistics interact intensively to ensure that the conditions for materials handling are met. Thus, specialization needs to be supplemented by coordination. There is enhanced interaction between site manager and materials suppliers, and without deviation from plans the building process performance on site is increased. During day time working hours the site manager focuses on managing the onsite building operations. Thus, specialization provides significant means of performance improvements. This is analysed further below in the discussion of activity-resource interplay regarding efficiency.

10.2.2 THE CONSITE LOGISTICS EXAMPLE: EFFICIENCY

The utilization of ConSite Logistics comes at a cost that is visible in the tender. However, the efficiency of materials handling is improved, and fewer man-hours are required for these activities. This is a consequence of Con Site Logistics exploiting the elevators to the fullest extent possible for transporting materials. This represents a faster and more effective way of transporting materials to the assembly points. Previously, standardized interfaces between resources, such as materials packages, and elevators, implied that elevators were not suitable for materials handling. The ability to utilize elevators to transport materials required adaptations. ConSite Logistics uses pallet lifts, and it is necessary for two pallet lifts to fit into the high speed elevator. The elevator must be aligned with the ground, and the packages of materials must be adapted to fit on the pallet lifts. Thus, efficiency of materials handling is increased by adapted combining of resources to suit materials handling. However, the adaptations to the materials packages fit less well with the activities in the factories packaging these materials owing to the logic of production. The adapted packages are of smaller size and include changes to the placement of loose parts such as handles. Thus, the efficiency of packaging the materials in the factories is reduced.

Also, use of ConSite Logistics has implications for efficiency of transportation of materials to the site. Previously, large quantities of materials were often delivered to the site in one batch, to increase transport efficiency. This required storage on site and movement of the materials according to changes to the site disposition. This behaviour affected site efficiency negatively since it exploited construction workers and the tower crane for these activities, diverting them from building operations. Delivery to the site by ConSite Logistics involves specific quantities of materials. The customized quantities of materials are delivered straight to the assembly point with no need for additional storage before installation; this means that the same type of material will probably have to be delivered several times throughout the project. There is less waste of materials on the site since they are not kept in storage on site for long periods and liable to damage from ongoing operations and weather. Thus, when resources are adapted to the conditions required by ConSite Logistics, efficiency in materials handling increases, but hampers efficiency in transportation to the site.

In addition to greater efficiency in materials handling, the scale in building operations increases since construction workers can specialize in these activities without having to divert to move materials. Similar conditions apply to the installation of materials since construction workers can start installing immediately, compared to having first to transport the materials from the storage locations on site. This results in more continuous flow of building activities.

As the tower crane is no longer utilized for materials handling during day time working hours, efficiency of operations that require the crane is increased. Waiting time for crane capacity is reduced, which contributes to the increased efficiency of building operations. Similarly, the elevators can be utilized solely to transport personnel in the day time resulting in reduced loss of time due to construction workers waiting for transport to the various floors in the building. This adds to overall site operational efficiency.

Thus, utilizing ConSite Logistics' specialization in materials handling improves the performance in several operations on site, but has negative consequences for transportation to the site and materials packaging in the factories. These efficiency effects originate from the introduction of ConSite Logistics into the existing constellation of resources. It highlights the need to combine resources in ways that suits the undertaking of activities. Securing control over significant resources is critical for achieving desired outcomes. This is explored further in the analysis of actor-resource interplay.

10.2.3 THE CONSITE LOGISTICS EXAMPLE: CONTROL OF RESOURCES

In traditional materials handling all resources needed on site are rented; this includes the tower crane, elevators and fork lifts and contractors' site managers and construction workers. These resources are under a sort of 'ownership control' of the contractor during the project. The contractor plans the utilization of resources and interacts with materials suppliers to coordinate materials deliveries to the site. Since resources are needed simultaneously for materials handling and other building operations the benefits of specialization are not available. These multiple demands result in lost time due to waiting, and resource capacity for moving around materials and for switching between the various operations. This is a resource intensive way of securing control since the personnel and equipment costs are the same whether they are being utilized efficiently or not.

Hiring ConSite Logistics gives the contractor access to ConSite Logistics's skills, knowledge and routines with regard to materials handling, including resources brought onto the site in the form of personnel and pallet lifts. This affects the content of the interaction between the contractor and the materials suppliers, over packages and delivery times. Communicating what has been agreed between the contractor and ConSite Logistics to the materials suppliers is the responsibility of the contractor. Increased interaction is a prerequisite for accomplishing the adaptations needed for materials handling and the interaction between the contractor and the materials suppliers is dependent on the interaction between the contractor and ConSite Logistics. Requirements related to adaptations of resources are critical for ConSite

Logistics to ensure that materials handling can be carried out in a standardized way at many sites. This includes access to the elevators and forklifts on site. In this way, ConSite Logistics exploits this equipment for their materials handling activities, turning their use into a profit making opportunity. It would not be possible for ConSite Logistics to introduce these resources to the sites.

The building contractor relies on competitive tendering procedures and avoids interdependencies with individual suppliers. This applies whether construction workers or ConSite Logistics are used for materials handling. As a result, suppliers might be less keen to adapt to the materials packages requirements of ConSite Logistics, which the building contractor communicates to suppliers. These adaptations are costly for suppliers as they apply to only a small part of their production. If demand was more frequent it would be feasible to make a standardized solution that could be offered also to many customers. The limited interaction between BuildCon and many suppliers severely impedes the possibilities of gaining from the adaptations and adjustments in the relationships between the contractor and ConSite Logistics.

The interaction between a building contractor and ConSite Logistics can extend also to consultancy related to logistical analysis and systems for arrival control of delivery of materials. Logistical analysis is part of the project planning process and is designed to create a beneficial site disposition with regard to flows of materials and personnel. It also allows the building contractor access to ConSite Logistics' specialist skills and knowledge in logistics. This competence has been built over several years based on ConSite Logistics' experience of their business relationships with multiple building contractors. By hiring ConSite Logistics the building contractor gets indirect access to other contractors' solutions. Thus, building contractors share the resources developed by ConSite Logistics, which creates opportunities that the individual building contractors could not exploit on their own.

10.3 IMPACT OF INTERMEDIATION: THE BUILDCON EXAMPLE

The analysis in Chapter 9 identified two situations with various conditions of actor intermediation. The intermediate element, BuildCon, changes its way of working towards suppliers into closer collaborations. Through these efforts, BuildCon hopes for advantages in relation to clients. The analysis shows that the business relationships between BuildCon and suppliers change from avoiding interdependence, and limited interaction with many suppliers, to close interaction with a few suppliers through collaboration features and atmospheres of commitment and trust. Thus, interaction changes in the composition of high involvement relationships compared to the previous low-involvement relationships. This affects the utilization of resources and the efficiency of activities. Regarding costs, the previous emphasis on low prices in individual transactions promoted 'hidden costs' for adjustments on site, and extensive costs of handling the tendering procedure. In the present situation, costs of production and materials flows are reduced, but the increased interaction is costly.

Chapter 9 discussed the interrelation through intermediation with regard to actors. The two situations are analysed below, and the differences in division of labour, efficiency and control of resources are discussed.

10.3.1 THE BUILDCON EXAMPLE: DIVISION OF LABOUR

BuildCon's new ways of working with suppliers has resulted in extensive changes to the division of labour. This includes transfer of activities from sites to suppliers, and from the project organization on site, to BuildCon's centralized organization. In addition, some planning activities are moved up to an earlier phase in the project. Even before introduction of the new approach of closer and longer-term interaction with dedicated suppliers, BuildCon had outsourced the materials handling activities to the subcontractor ConSite Logistics. This meant that construction workers were no longer involved in materials handling, and could specialize in building operations on site.

Previously, the section manager and the calculation department in BuildCon were involved in interacting with clients when competing for new projects. In the execution of a project, site managers coordinated orders and deliveries, and managed production including time plans in the building phase. This structure was common to all projects, although each project was dealt with as an individual entity. When BuildCon altered its interaction with suppliers, activities were transferred from the sites to the building materials supplier, BMS. BMS now coordinates all deliveries to sites, including materials handling by ConSite Logistics and tendering procedures with materials manufacturers. Thus, activities related to materials supply are outsourced to BMS, which is a specialist in these matters.

BuildCon's project coordinator is involved in the bidding for new projects including planning the positioning and establishment of cranes, elevators and facilities. Thus, the project coordinator is responsible for interaction with the suppliers of this equipment. Also, this occurs earlier in the project planning phase and with increased involvement of suppliers. Thus, the project coordinator's planning activities occur in the bidding process for a new project, and solutions and costs are presented to the client at an early stage. This allows suppliers to provide input based on their extensive knowledge and skills in their respective strengths, which contributes to more efficient and effective building processes on site. The logistics manager is responsible for time plans and delivery plans. The tasks of establishing the site and formulating time plans and delivery plans were previously the site mangers' responsibility. Through the transfer of these activities to the project coordinator and the logistics manager in BuildCon's central organization, synergy effects are created between projects. Instead of several site mangers in different projects interacting independently with the same suppliers, the project coordinator and the logistics manager interact with suppliers for multiple projects. This allows site managers to focus on managing the building processes on site; they are responsible only for ordering bulk materials, which is a form of specialization.

Consequently, specialization exists at many levels as means of performance improvements: the project coordinator and logistics mangers specialize in planning, site mangers are specialized in managing the building processes, construction workers are specialized in building operations, and suppliers contribute their particular expertise. In addition, in order to gain from the efforts made towards suppliers, BuildCon increasingly targets private clients and design and build contracts, which is also a form of specialization. Specialization is analysed further below in the activity-resource interaction related to efficiency.

10.3.2 THE BUILDCON EXAMPLE: EFFICIENCY

Before the changes were introduced, standardized materials and equipment required substantial coordination and adaptation on site. Similar coordination was carried out at many sites simultaneously, which was time consuming and involved extensive resources. Efficiency in individual projects was possible, but overall efficiency was not; resources were utilized less efficiently. This applied especially to the planning of projects, including supplies of materials and equipment. For instance, each material type followed its own tendering procedure which involved extensive evaluation of tenders; although same suppliers were involved in many projects there was no coordination among projects. The same suppliers could be involved in several projects over time, but each new projects did not build on previous experience and interactions.

By appointing dedicated suppliers, activity coordination changed to include more adaptations and increased inter-organizational interactions. This allowed economies of scale in various operations. For example, the centralization of planning resources, such as the project coordinator and the logistics manager, helped increase efficiency. These organizational resources specialize in planning and have the appropriate skills and capabilities which span the boundaries of individual projects. In addition, suppliers' skills and knowledge within certain areas are being more exploited allowing suppliers contribute to more efficient and effective building processes on site.

In relation to efficiency, BMS is more capable than BuildCon of achieving economies of scale since BMS serves many customers for materials supply. BMS specializes in the coordination of materials supply including tendering procedures and materials handling on site via ConSite Logistics. This includes administrative routines to provide contractors with materials from several different manufacturers. In relation to the impact in the wider network, the business transactions between the suppliers of building materials (BMS) and the materials manufacturers are based on competitive tendering. BMS has specific requirements with regard to packaging, handling of pallets, logistics operations and other activities. The 'total cost' of these requirements has to be set for the entire project when materials manufacturers provide tenders. Material manufacturers are unfamiliar with this form of tendering, which differs substantially from what is common for other customers. This means that suppliers have to treat BMS differently, and adapt their business logic to that of BMS. It is difficult to convince materials manufacturers to consider these requests, and they are frequently frustrated by BMS's demands. This prolongs the tendering processes and requires extra efforts on the part of both BMS and the materials manufacturers. BMS requires the adaptations in order to achieve the standardization needed for materials handling undertaken by ConSite Logistics, and for customers such as BuildCon in its building operations. This also requires adaptations to the interactions among BMS and its customers, when requirements are communicated by BMS to materials manufacturers, in order to obtain the required standardization on sites and increase efficiency of building operations.

The reluctance of materials manufacturers to adapt is based on the fact that BMS's requirements tend to differ from the demands of other customers. Thus, BMS's requirements reduce the manufacturers' ability to achieve economies of scale in their production, packaging and transportation operations. The adaptations provide increased efficiency for BMS and its customers, but negatively affect the efficiency of materials manufacturers' operations.

BuildCon aims for standardization across projects, to achieve standardized utilization of resources in relation to individual projects. This is only achievable through the many adapted interfaces among resources; for instance, materials packages coming into the site, and the routines between the contractor and BMS. This creates a better fit between the resources on site. In addition, BuildCon invests in 'extra resources' such as the project coordinator and the logistics manager, which are costly. Although BuildCon and dedicated suppliers have worked together before in previous projects, the joint development efforts are emphasized through extended interaction. Thus, although BMS also previously was a supplier to BuildCon, the changes introduced in the intermediation increase the importance of this collaboration, and BMS with its access to materials manufacturers becomes a crucial resource for BuildCon. Thus, resource exploitation in the undertaking and coordination of activities is related to efficiency, and control of resources is a critical task. The actor-resource interplay is analysed next.

10.3.3 THE BUILDCON EXAMPLE: CONTROL OF RESOURCES

A construction project implies the bringing together of numerous resources from multiple actors to provide a satisfactory solution during the project. For BuildCon access to other actors' resources (for example through renting cranes, elevators, scaffolding and facilities) has always been considered important and BuildCon has always purchased materials to be used in building operations from many suppliers. However, this mainly involves physical resources. The avoidance of interdependence in low-involvement relationships, and switching among many suppliers through competitive tendering procedures, do not provide access to the organizational capabilities, skills and knowledge residing in suppliers; exchanges involve only the physical features of equipment and materials, and price negotiations.

BuildCon and the dedicated suppliers had worked together on several projects. By appointing them dedicated suppliers and alter the interaction in character of high involvement relationship, BuildCon gets access to the suppliers' extensive experiences and specialized skills. The physical features of the equipment in terms of cranes, elevators and scaffolding remain the same. It is how these resources are organized on site in order to gain from increased efficiency in building operations that has changed. At the same time, suppliers also gain from access to BuildCon's experience in utilization of equipment and materials. For example, BuildCon and WPWS have jointly developed layouts of welfare facilities, which WPWS can now offer to other customers.

It is especially crucial for BuildCon to cooperate with the supplier BMS to get access to its skills in coordinating materials supply. Since BMS serves many customers it is better able to influence the materials manufacturers than BuildCon which is just one small customer among many others. BMS has more power to achieve desired outcomes regarding adaptations of materials packages and transportation. Thus, by 'sharing' BMS as a resource with other building contractors, BuildCon in this example is able to exploit opportunities that would be unavailable to a small customer of the materials manufacturers. When BuildCon had ownership control of tendering procedures with materials manufacturers the potential benefits of BMS's specialization could not be exploited since BMS was just a supplier among several others and was evaluated as such in the price list procedures.

Access to the skills and knowledge in BMS and the other suppliers required modifications to the relationship between BuildCon and them with increased involvement. The cooperation was favoured by both BuildCon and the suppliers to allow exploitation of the potential in high involvement relationships. Since this level of cooperation is resource demanding, BuildCon targeted a few suppliers.

To sum up, this chapter has analysed the impact of intermediation on the interplay between the network layers. Features of a particular intermediation situation in one layer affect the division of labour, efficiency and control of resources. Comparison of the different situations revealed differences in the division of labour, efficiency and control of resources. Chapter 11 discusses these issues from a theoretical point of view.

11 CONCLUDING DISCUSSION

This chapter addresses three themes related to the role of intermediation, based on the analyses in previous chapters. First, intermediation and networks are discussed in relation to how one intermediation situation impacts simultaneously on the activity layer, resource layer and actor layer, and their interplay in the network. Second, although the study as such does not capture dynamics, its composition of various situations allows some exploration of the dynamic nature of intermediation in terms of modifications of intermediation. The continuous changes to interdependencies, interfaces and interaction give intermediation a dynamic character since one intermediation situation alters to become a new situation. This alteration is discussed with regard to four principal types of modifications. Third, discussion of intermediation turns towards a managerial perspective. Managing intermediation is challenging, but in one way or another every actor must handle intermediation. Dealing with intermediation is described as a balancing act in the three layers of activities, resources and actors. The chapter concludes with some final remarks on this study of the role of intermediation and suggestions for future research.

11.1 INTERMEDIATION AND NETWORKS

Analysis of activity intermediation, resource intermediation and actor intermediation provides important insight into how one intermediate element connects other elements and, thus, into the connections and interrelation among elements. Since the three network layers are closely intertwined, the consequences of one particular intermediation situation simultaneously affects the activity layer, resource layer and actor layer. In line with the analysis in Chapter 10, this interplay can be considered from the perspectives of division of labour, efficiency, and control of significant resources in the business network. What follows is a more general discussion about intermediation and networks with regard to the interrelation among elements and the accompanying circumstances in the business landscape.

Operational efficiency in networks is contingent on the ways that resources are exploited in order to carry out activities. Thus, the activity-resource interplay concerns *efficiency*. Increasing scale of operations promotes efficiency in the activity layer. The more the capacity of a resource is utilized, the greater will be the economies of scale (Håkansson et al., 2009). It is important to note that the efficiency achieved as the result of the interplay between one activity and one resource is not an isolated achievement. It is contingent on how the activity and the resource relate to other activities and resources. Activities are interdependent and the interrelation among them affects the activity configuration's function and performance. Resources are related through various interfaces, and the way a particular resource is utilized depends on its interfaces with other resources. Consequently, the impact of intermediation on efficiency involves analysis of the interrelations among activities, and interrelations among resources, and the activity-resource interplay.

Specialization is a significant means to increase the performance of the activity-resource interplay (Gadde, 2014). A focus on specialized activities and the involved resources, generates skills and capabilities related to how to organize them, and these efforts result in performance improvements. Through a narrow focus the involved actors in these operations are in a position to invest in the most advanced technical resources within their specialized field, with the result that activities can be carried out more efficiently. However, specialization always needs to be complemented by coordination, since the outcome of individual firms;' specialized activities must be "re-assimilated into a cognitive form where they have economic meaning" (Piore, 1992, p. 442). The greater the specialization among activities, the more resources must be allocated to coordination. Hence, although specialization provides gains in terms of increased efficiency in the interplay of activities and resources, it also consumes more time and resources for coordination. In their study of specialization and division of labour, Becker and Murphy (1992) conclude that specialization increases productivity, but is accompanied by increased coordination costs. Consequently, efficiency and specialization are related to the division of labour, or the allocation of activities among actors.

Efficiency can often be increased by changing the allocation of activities among actors, through 'insourcing' and 'outsourcing' (Dubois, 1998). Efficiency increases because the utilization of the involved resources alters. Thus, intermediation also entails conditions related to the interplay between efficiency and *division of labour*. In essence, it is impossible for one firm to undertake 'everything', and at the same time to achieve excellent performance in the various tasks involved in 'everything'. Transfer of activities among actors is aimed at enhancing performance since the resources can be utilized in ways more suited to the activity. In addition, several studies highlight the importance of access to specialized capabilities achieved through outsourcing (Holcomb and Hitt, 2007; Barreyre, 1988). Thus, there are opportunities residing in the exploitation of other actors' resources. At the same time, outsourcing and increased reliance on resources outside the firm's boundaries can be problematic for innovation if the resource base of the firm becomes too narrow (Broedner et al, 2009; Gadde, 2013). In addition, the transfer of activities is not an isolated event, since activity configurations entail history from previous episodes. For instance, activities can become fine-tuned over time allowing them to function together efficiently and effectively. Single activities can be adjusted to improve efficiency in the current activity configuration, through continuous efforts. A change promoted by the transfer of activities will break the established patterns and change the nature of the interdependencies, which will call for new adjustments.

Activities and resources are embedded in current arrangements, created through considerable investment. Changes in the division of labour might be economically rational, but might cause tensions between actors, since some will benefit from the change, and some will lose what from their perspective was a beneficial arrangement. In addition, changes create outcomes that cannot be predicted. An actor acts based on its perspective; a decision to change is based on limited knowledge of the interrelations in the network. In addition, change to one part of the network will 'bounce back' as reflections and reactions. Also, current firms are involved in complex activity patterns and resource constellations characterized by considerable interdependence, stretching over an extensive number of firms' boundaries. Along these lines, Lind and Thrane (2010) claim that the decision to transfer activities through outsourcing operations is now a much bigger undertaking. In addition, it can be difficult for a firm to relocate what has been outsourced.

If the division of labour involves a scattered structure of activities and resources distributed among many actors, coordination is crucial. Handley and Benton (2009) point to the importance of developing cooperative and mutually committed relationships to realize performance expectations. Hence, the features of business relationships are central to coordination in order to secure *control* of resources, and the possibilities to affect resource utilization. Achieving control over important resources is a critical part of business for all actors (Håkansson et al., 2009). Control is about influencing others to "predict events and achieve desired outcomes" (El-Ansary and Robiecheaux, 1974, p. 2). Thus, control is a prerequisite for combining resources in the undertaking of activities, and to accomplish efficient division of labour. Control provides direction for the achievements. Ownership control enables an actor to achieve desired outcomes in the coordination of its resources and activities in line with its own agenda. However, this internally focused approach makes it difficult to be at the forefront of the specific technology applied in its operations, since resource involvement always requires investment. Ownership is a very resource intensive means of securing control, particularly in the case of highly specialized resources (Gadde, 2014). Therefore, specialization goes hand in hand with an indirect form of resource control: access to other actors' resources. In this way, actors achieve access to each other's specialized physical resources, skills and knowledge, including how to organize the resources. This resource sharing can improve the joint performance of the actors. In order to achieve this advantage of resource-sharing opportunities, close interaction among the actors is crucial. In low-involvement relationships characterized by arm's length conditions and avoidance of interdependence, only limited 'sharing' is possible. Typically, access to skills and knowledge residing in specialized actors and their exploitation in joint problem solving for example, requires cooperation and features of high involvement relationships. Through enhanced interaction the actor learns more about the conditions of the other actor, which contributes to fruitful combining of resources, and coordination of activities. At the same time, such cooperation is resource demanding and not all business relationships are able to, or should, include these features.

Intermediation is a central phenomenon in the business landscape, which is challenging, owing to the numerous interrelations that intermediation provides. The discussion above reveals that analysing the conditions for intermediation and its impacts with regard to separate network layers and the interplay among them, is not straightforward. In principle, intermediation is dynamic and involved the complex interplay among numerous factors and continuous transformation. The next section discusses intermediation dynamics in more depth.

11.2 MODIFICATIONS OF INTERMEDIATION

This study involves comparisons of various static intermediation situations. As 'snapshots' of reality the situations differ with regard to various interrelation characteristics. However, intermediation is dynamic in nature since interdependencies, interfaces and interactions change continuously. The three empirical examples in the study illustrate this dynamics: changes with regard to supply of reinforcement activities, and materials handling resources, and BuildCon and suppliers actor interactions. From this it follows that one intermediation situation alters to a new situation. This alteration is discussed below with regard to four principal types of modifications.

One intermediation situation can be defined by the specific interrelation among the intermediate element and the elements it connects. As a starting point for the examination of modifications, this refers to an 'original set'. Figure 11.1 illustrates this original set with regard to how one intermediate element (X1) connects other elements (X2 and X3) and their connections (arrows). As a result, certain characteristics of the interrelation among the elements are formed. This is applicable to any of the three network layers of activities, resources and actors.

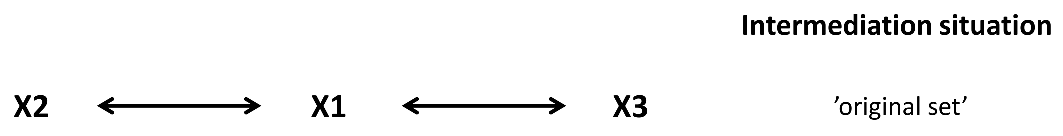

Figure 11.1 Intermediation situation: original set.

Thus, an intermediation situation entails features related to its elements and the connections among them. Through various modifications, this situation can be altered, resulting in a new situation with new interrelation characteristics among the elements. As shown here, the modifications of intermediation capture the intermediate element and the two principal elements it connects. These two elements are 'brought together' by the intermediate element. It should be noted that analysis of intermediation in business networks always includes several connections established via the intermediate element, including indirect connections. However, here, for the purpose of identifying principal modifications the intermediate element and the two principal elements it connects are used as illustration.

This study identifies four principal modifications of intermediation, each resulting in the 'original set' being altered into a new intermediation situation, thus a 'new set'. The transition brings about alterations to the features of the elements and the connections, not only those directly involved in the modification, but all those in the intermediation situation. This conforms to the important finding that no element is isolated: all are involved in an interplay. The four principal types of modifications: *transfer* of intermediate element, *switch* of intermediate element, *change in content* of intermediate element, and *change of features* of other elements, are discussed below. The modifications are illustrated in Figure 11.2 - Figure 11.5, where the alterations from the 'original set' are coloured grey.

Figure 11.2 illustrates the modification *transfer* of intermediate element. The intermediate element (X1) is transferred into a different constellation of elements and hence connects new elements (X4 and X5), compared to the 'original set'.

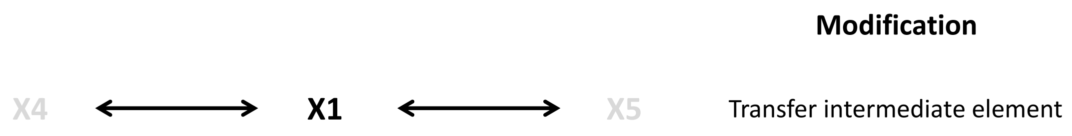

Figure 11.2 Intermediation modification: transfer of intermediate element.

One example of transfer of an intermediate element, in line with Figure 11.2, could be the outsourcing of activities, where one intermediate activity connects other activities than it originally did through its transfer to a new activity arrangement. Previously the activity was undertaken internally and connected other internal activities in an activity configuration within the actor firm boundaries. Through the outsourcing of the activity it is transferred to a new configuration of activities and becomes an external activity that intermediates between other external activities.

Figure 11.3 illustrates the modification *switch* of intermediate element. In this case the intermediate element (X1) in the 'original set' is replaced by another intermediate element (X6). Thus, through the modification, elements X2 and X3 are now connected via a new element.

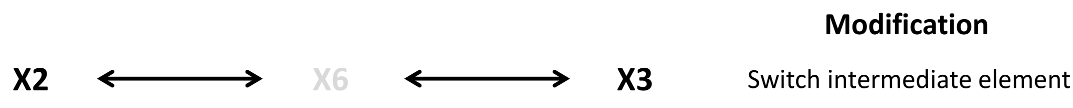

Figure 11.3 Intermediation modification: switch of intermediate element.

One example of switching of an intermediate element is replacement of a resource by a new type of resource made possible through technological development. Another example might be in distribution when a producing firm decides to abandon an established relationship with a distributor and switches to a new distributor as a business partner. In this case, it is element X2 or X3 that decides to switch from the intermediate element X1 in the 'original set' to X6 instead.

A new situation of intermediation can arise also as a result of a change to the *content* of the intermediate element. Figure 11.4 depicts how the intermediate element is modified (and thus becomes X1´: the 'same' element but with new content) including content in the connections (arrows) to other elements. Thus, the elements in the 'original set' remain, but the interrelation among elements is modified with regard to content, which results in a new situation.

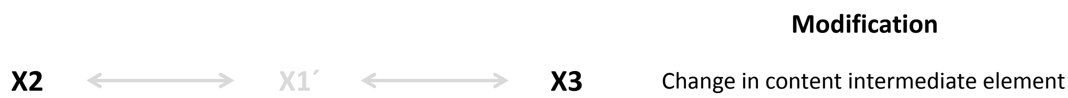

Figure 11.4 Intermediation modification: change in content of intermediate element.

An example of change to the content of an intermediate element is modification of resource utilization. Utilization of an intermediate resource is characterized by standardized interfaces with other resources, for instance, a truck used to transport different food supplies from farmers to the food market. The mixing of food supply types can be problematic since some goods may be damaged during transportation. In the changed situation, the truck is equipped with a superstructure and its utilization is adapted to transport only cattle. Thus, the truck as an intermediate element is modified including adapted interfaces instead of the previous standardized interfaces between farmers and the food market.

Finally, modification can consist of altered *features* of an element. This is illustrated in Figure 11.5: the intermediate element (X1) and the other elements (X2 and X3) remain the same; however, the features of one of the 'other' elements changes (to become X3´). This modification stems from the connections this element have 'outside the original set'. As a result of this alteration of features, the interrelation in the defined 'original set' of elements changes, since the resource's new features are mirrored in the constellation of resources.

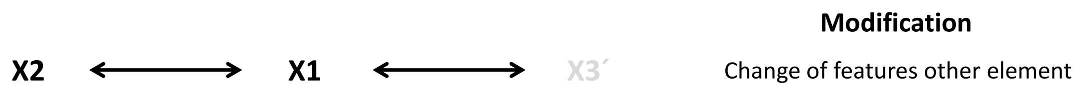

Figure 11.5 Intermediation modification: change of features of other element.

Change of features of other element can; for instance, involve a resource's features altered because it is being combined with a new resource outside the 'original set'. For example, chemicals are used as input to a special lamination technique (X3 in the 'original set') used for protective clothing for fire fighters (resources outside the 'original set'). The lamination technique is developed further with regard to the context outside the 'original set' and acquires new features. The changing features of the lamination technique mean that the chemicals used for the lamination are altered. Thus, as the lamination technique is developed, corresponding to X3´ in Figure 11.5, the changing features affect its interrelation with regard to the intermediation situation in Figure 11.5.

These four types of principal modifications apply to all network layers. Since the network layers are closely intertwined, modification in one layer is mirrored in the other two layers. It should be noted that the outcome of the respective modification is that all elements and connections are somehow affected and somehow transformed. Elements and connections thus 'absorb' the modification throughout the network, not only via direct connections but also via indirect connections. This absorption brings about positive effects for the interrelation of some elements and negative effects for others. Also, what is perceived as an essential modification in one part of the network, thus bringing positive outcomes there, can result in negative effects in other parts of the network. These effects in turn, are reflected back onto the network. Thus, it is impossible to foresee the 'complete' outcome of a modification taking place somewhere in the network.

Finally, the underlying reasons for modifications are always to achieve something that otherwise would not have been possible in the 'original set', and in some way to benefit from the modification. However, a modification can also bring loss: the 'original set' in an intermediation situation disappears. This situation of intermediation might have been fine-tuned over time to function very well in terms of how the elements interrelate and the outcomes of these connections. However, this functionality is wiped out by the modification. Also, in this case, it is impossible to grasp all the consequences of such a 'loss'. However, at the same time, although the outcome of a modification might be less beneficial than hoped, the modification paves the way to new achievements.

11.3 INTERMEDIATION AS A BALANCING ACT

On the basis of the previous discussions on intermediation and networks and modifications of intermediation, it follows that dealing with intermediation is challenging. Elements and connections entail complex interrelations and are continuously altered to display new characteristics. Some of these modifications stem from the firm's conscious actions, but most originate from the actions of other firms. This means that every actor is required to deal with intermediation in some way. This section covers intermediation in terms of the managerial implications; what an intermediate actor needs to handle. This demanding task can be described as a balancing act in the three layers of activities, resources and actors: balancing interdependencies, balancing interfaces and balancing interaction. Actors are required to balance interdependencies in activity intermediation with regard to similarities and diversity. Actors also need to balance the interfaces involved in resource intermediation with regard to standardization and adaptation. Finally, actors have to balance interaction in actor intermediation with regard to involvement, to provide for coordination of activities and combining of resources. Table 11.1 illustrates intermediation as a balancing act in the three network layers.

Table 11.1 Intermediation as a balancing act.

Balancing interdependencies	Diversity vs. Similarity in activity intermediation
Balancing interfaces	Standardisation vs. Adaptation in resource intermediation
Balancing interaction	Low involvement vs. High involvement in actor intermediation

With regard to activity intermediation the actor has to provide both diversity and similarity. Thus, the organizing of activities calls for a balancing of the *interdependencies* to reap the benefits of economies of scale and similarity on the one hand, and individualization and diversity on the other (Håkansson et al., 2009). Diversity stems from adjustments in relation to individual business partners and their specific demands. At the same time, this might restrict the usefulness of this specific activity in relation to other activities. Thus, efforts to enable diversity may satisfy individualization, but may make it difficult to exploit similarity and to benefit from economies of scale in the undertaking of activities. Similarity is achieved through standardization which enables utilization of the same resource constellation to provide for cost advantages. For instance, if a weaving firm makes standard collections to offer to many customers, it will benefit from high utilization of its resources owing to the similarity among simultaneous weaving activities (Sundquist, 2011). In this case, the weaving facility's resources are being used at full capacity, which explains the efficiency of the activities. At the same time, there will be customers who demand customized fabric, with unique designs, produced exclusively for them. This requirement for individualization reduces the ability to gain from economies of scale in weaving since producing these orders utilizes only part of the weaving facility capacity while, at the same time, other fabrics cannot be produced. Thus, the weaving firm's effort to achieve similarity must be balanced so as not to interfere with individual customer demands for specific offerings.

It is crucial for actors to carry out their activities in a cost efficient way in order to benefit from economies of scale, while also providing diversity and customization. Efficiency is contingent on a combination of similarity and diversity. One aspect of this balancing act is that the actor must evaluate which activities are suited to being undertaken within the firm's ownership boundaries and which should be obtained from other firms. However, regardless of which actor undertakes the activities, the various activities need to be coordinated to create a coherent and meaningful totality. Thus, an actor involved in intermediation deals with the intricate balancing of interdependencies. Consequently, the most appropriate strategy for intermediation is to combine the benefits of similarity and diversity (Ford et al., 2011).

With regard to intermediation and resource *interfaces* the actor has to balance standardization and adaptation (Ford et al., 2011). The features of a resource can include its range in relation to scope and capacity. However, resources entail versatility in terms of their ability to be utilized in combination with other resources (Jahre et al., 2006). At a particular point in time a resource might be combined in a specific way and might be perceived as 'given'. However, owing to the multiple features of resources, there will always be alternative ways of resource combining. Utilization of a resource for a specific purpose exploits only some of its features, leaving others hidden. A resource's versatility is revealed though the combinations to which it contributes. When the exploitation of a resource is standardized it results in low levels of versatility. Resource interfaces can also involve adaptations that lead to differentiated exploitation which increases the versatility of the resource. These aspects are present in the example above of the weaving firm. The standardized utilization of resources in the production of standard fabrics offered to many customers results in low versatility with regard to adaptations to individual customer demands. This provides cost advantages for the weaving firm and its customers, since this utilization fits with conditions for effective utilization of capacity. Customized fabric can be produced through adaptations in the utilization of weaving resources. There may be reduced cost advantages, but at the same time it is crucial for the weaving firm to provide adaptation in order to meet individual requirements from customers. Hence, the more standardized the utilization, the greater the efficiency in terms of economies of scale, but at the same time, the less the opportunities for customization.

Thus, the features of interfaces among resources affect the utilization of individual resources. The ways resources are combined is thus crucial task for the actors. Actors involved in intermediation deal with the intricate balancing act of standardization and adaptation in resource utilization. This balancing must be considered in relation to the resources of other firms. Standardization of resources is one way to combine various resources which provides cost benefits. At the same time, these cost effects must be considered with regard to possible negative effects on other resource combinations. In addition, there is always economic potential inherent in new forms of resource interfaces in order to improve their combination with other resources.

With regard to intermediation and *interaction* an actor must balance its extent of integration in terms of level of involvement in business relationships. Low involvement involves limited coordination, adaptation and interaction costs. In general, this is the case when the contents of the business relationship and the context are fairly stable (Gadde and Snehota, 2000). This type of interaction is potentially cost effective since it requires low relationship handling costs. However, substantial costs may arise on both sides of the interaction since this approach calls for adaptation to make resources fit together. These problems are alleviated in the case of high involvement relationships, but heavy involvement is costly because the coordination, adaptation and interaction entail costs. These relations are associated with an investment logic aimed at exploiting skills and capabilities of the respective actors over time, which makes these relationships highly resource demanding. Bensaou (1999) argues that a firm needs several different types of relationships since they lead to different costs and benefits. Hence, actor intermediation involves a balancing act between the features of the business relationships including degree of involvement, which, in turn, affects the number of relationships in which the firm can be involved in. Close interactions make choices of the actors more interdependent and have a significant impact on the coordination of activities and combining of resources.

A balancing act in one of the network layers affects the balancing in the other two layers. Also, this balancing act is by no means an isolated achievement within firm boundaries. It is never a one-sided decision, by one actor. The balancing act is always influenced by other actors through the interdependencies, interfaces and interactions across firm boundaries. There is also a time element related to this balancing act. The balancing at a particular point in time is dependent on previous episodes, and will affect how balancing will take place in the future. Thus, this balancing is not a ‘once and for all’ task, but requires continuous managing to cope with the circumstances in business reality.

11.4 FINAL REMARKS

Intermediation captures how one intermediate element connects other elements, and consequences of this interrelation. The phenomenon highlights the significance of what resides ‘between’ elements with regard to the impact on the outcome of the interrelation. Intermediation from a network perspective acknowledges the importance of connections by considering interdependencies among activities, interfaces among resources, and interaction among actors. Elements are filled with content through their connections; at the same time connections entail content depending on the features of the elements they are connecting. Thus, there is interplay among elements and connections. This study acknowledges the importance of considering not only direct connections but also indirect connections in the analysis of intermediation. These indirect connections have a considerable impact on achievements through intermediation.

This study contributes to a complementary understanding of the phenomenon of intermediation by also addressing activity intermediation and resource intermediation in addition to the more common focus on actor intermediation. An industrial network perspective on intermediation is useful for the analysis since the view of intermediation is extended by considering the activity layer and resource layer as of equal importance as the actor layer. Three complementary views of business reality are accommodated, and contribute to an improved understanding of current conditions in the business reality. Analysis of activity intermediation reveals that how an intermediate activity connects other activities affects the performance of single activities and the overall activity configuration’s function and efficiency. Examination of resource intermediation shows that the ways an intermediate resource connects other resources have a profound impact on resource utilization, including the interfaces among resources. Exploration of actor intermediation discloses the crucial nature of the interaction in the connections between an intermediate actor and other actors, for activity coordination and resource combining. In addition, intermediation has generally become more important in contemporary business contexts that include outsourcing, specialization, customization, build-to-order manufacturing, and other network like arrangements of interdependent activity configurations and resource constellations.

The study contributes also to explorations of the interplay among network layers. It adds to the understanding of the ways activities, resources and actors within their respective network layers interrelate, and the interrelation among network layers. Studies of business networks tend to focus on one of the network layers to scrutinize a phenomenon defined within that layer. In a first step, the phenomenon is analysed thoroughly with regard to this specific layer, and then some implications of the phenomenon in the other two layers are derived. The fact that the three network layers are closely intertwined, with intricate interplay, calls for further research into interrelations among layers. This intertwinement of the layers suggests that individual network layers can only be fully understood by considering the interplay among network layers.

The empirical context of this study is the Swedish construction industry. The construction industry is characterized by an emphasis on the efficiency of individual projects with decentralized decision-making and financial control. Shirazi et al. (1996) claim that construction is mainly about coordination of specialized and differentiated tasks including expensive adjustments at site level. The strong reliance on competitive tendering and avoidance of interdependence go hand in hand. Thus, relationships are commonly characterized as arm’s length. These conditions within the industry provide for a certain impact with regard to the connections among elements and the effects of intermediation. A different empirical context would entail other characteristics and, thus, other implications for intermediation. These differences are applicable not just to various empirical contexts. Every study reveals intriguing differences in the business reality. However, the framework developed in this thesis is likely to be applicable for analysing the role of intermediation in various contexts.

This study has hopefully provided new insights and prompted new reflections on the phenomenon of intermediation. An interesting area for future research would be to scrutinize more closely the variety of features residing in the connections among elements and their effects on what can be achieved through intermediation. In addition, there are dynamic aspects inherent in intermediation, since interdependencies, interfaces and interaction change continuously. This study points to some aspects of these dynamics by identifying some principal modifications related to how one situation of intermediation changes into a new situation with different characteristics. Much more needs to be discovered with regard to the dynamics of intermediation. Thus, the findings from this study are now passed on to the next ‘runner’ in the intermediation research relay race.

REFERENCES

Alderson, W. (1950) Marketing Efficiency and the Principle of Postponement, *Cost and Profit Outlook,* September, Vol. 3, No. 4, Alderson & Sessions, PA.

Alderson, W. (1954) Factors Governing the Development of Marketing Channels. In: Clewett, R. (ed.), *Marketing Channels for Manufactured Products*. Richard D. Irwin, Homewood, Illinois.

Alderson, W. (1957) *Marketing Behaviour and Executive Action*. Richard D. Irwin, Homewood, Illinois.

Alderson, W. (1965) *Dynamic Marketing Behaviour. A Functionalist Theory of Marketing*. Richard D. Irwin, Homewood, Illinois.

Andersen, P.H. (2005) Export Intermediation and the Internet: An Activity-unbundling Approach, *International Marketing Review*, Vol. 22, No. 2, pp. 147-164.

Anderson, J.C., Håkansson, H. and Johanson, J. (1994) Dyadic Business Relationships Within a Business Network Context, *Journal of Marketing*, Vol. 58, No. 4, October, pp. 1-15.

Asplund, E. and Danielson, U. (1991) *Räta ut byggsvängen*. Svenska byggbranschens utvecklingsfond (SBUF).

Balabanis, G. (2005) Determinants of Export Intermediaries' Service-mix Configurations, *International Marketing Review*, Vol. 22, No. 4, pp. 436-459.

Baraldi, E. (2003) *When Information Technology Faces Resource Interaction*. Doctoral thesis no.105, Department of Business Studies, University of Uppsala.

Barney, J.B. (1991) Firm Resources and Sustained Competitive Advantages, *Journal of Management*, Vol. 17, pp. 99-120.

Barreyre, P. (1988) The Concept of 'Impartition' Policies: A Different Approach to Vertical Integration Strategies, *Strategic Management Journal*, Vol. 9, No. 5, pp. 507-520.

Becker, G.S. and Murphy, K.M. (1992) The Division of Labour, Coordination Costs, and Knowledge, *The Quarterly Journal of Economics*, Vol. CVII, No. 4, November, pp. 1137-1160.

Bensaou, M. (1999) Portfolios of Buyer-Supplier Relationships, *Sloan Management Review*, Summer, pp. 35-44.

Benston, G.J. and Smith, Jr., C.W. (1976) A Transactions Cost Approach to the Theory of Financial Intermediation, *The Journal of Finance*, May, pp. 215-231.

Boyle, E., Humphreys, P. and McIvor, R. (2008) Reducing Supply Chain Environmental Uncertainty through E-Intermediation: An Organisation Theory Perspective, *International Journal Production Economics*, Vol. 114, pp. 347-362.

Broedner, P., Kinkel, S. and Lay, G. (2009) Productivity Effects of Outsourcing, *International Journal of Operations Management & Production Management*, Vol. 29, No. 2, pp. 127-150.

Bryman, A. and Bell, E. (2007) *Business Research Methods*. (2nd ed), Ney York: Oxford University Press.

Bucklin, L. (1965) Postponement, Speculation and the Structure of Distribution Channels. *Journal of Marketing Research*, Vol.2, February, pp. 26-31.

Caster, R. and Deuschl, G. (2007) *Armeringsmetoder för att uppnå ett effektivt industrialiserat byggande*. Master Thesis, Gotheburg: Chalmers University of Technology.

Christopher, M. (2000) The Agile Supply Chain Competing in Volatile Markets, *Industrial Marketing Management*, Vol. 29, pp. 37-44.

Colomo-Palacios, R., García-Crespo, Á., Soto-Acosta, P., Ruano-Mayoral, M. and Jiménez-López, D. (2010) A Case Analysis of Semantic Technologies for R&D Intermediation Information Management, *International Journal of Information Management*, Vol. 30, pp. 465-469.

Dubois, A. (1998) *Organizing Industrial Activities across Firm Boundaries*. New York: Routledge.

Dubois, A. and Araujo, L. (2004). Research Methods in Industrial Marketing. In Håkansson, H., Harrison, D. and Waluszewski, A. (eds.), *Rethinking Marketing: Developing a New Understanding of Markets*, Chichester: Wiley.

Dubois, A. and Araujo, L. (2007) Case Research in Purchasing and Supply Management: Opportunities and Challenges, *Journal of Purchasing and Supply Management*, Vol. 13, No. 3, pp. 170-181.

Dubois, A. and Gadde, L.-E. (2002) Systematic Combining: An Abductive Approach to Case Research, *Journal of Business Research,* Vol. 55, pp. 553-560.

Dubois, A. and Gadde, L-E. (2014) Systematic Combining - a Decade Later. *Journal of Business Research,* Vol. 67, pp. 1277-1284.

Dubois, A., Gadde, L.-E. and Mattsson, L.-G. (1999) *Activity Structures in Distribution: A Framework for Analysing Efficiency*. In Gauri, P. (ed) *Advances in International Marketing*, pp. 43-62,Cambridge: JAI Press.

Dubois, A. and Gibbert, M. (2010) From Complexity to Transparency: Managing the Interplay between Theory, Method and Empirical Phenomena in IMM Case Studies, *Industrial Marketing Management*, Vol. 39, pp. 129-136.

Dubois, A., Hulthén, K. and Pedersen, A.-C. (2004) Supply Chains and Interdependence: A Theoretical Analysis, *Journal of Purchasing & Supply Chain Management*, Vol. 10, pp. 3-9.

Dunning, J.H. (1981) Explaining the International Direct Investment Portfolio of Countries: Towards a Dynamic or Development Approach, *Weltwirtschaftliches Archiv*, Vol. 117, pp. 30-64.

Eisenhardt, K.M. (1989) Building Theories from Case Study Research, *Academy of Management Review*, Vol. 14, No. 4, pp. 532-550.

Flick, U. (2006) *An Introduction to Qualitative Research*. London: Sage Publications.

Ford, D. (1980) The Development of Buyer-Seller Relationships in Industrial Markets, *European Journal of Marketing*, Vol. 14, No. 5/6, pp. 339-353.

Ford, D., Gadde, L.-E., Håkansson, H. and Snehota, I. (2003) *Managing Business Relationships*. Chichester: John Wiley & Sons Ltd.

Ford, D., Gadde, L.-E., Håkansson, H. and Snehota, I. (2011) *Managing Business Relationships*. Chichester: John Wiley & Sons Ltd.

Forsström, B. (2005) *Value Co-Creation in Industrial Buyer-Seller Partnerships: Creating and Exploiting Interdependencies*. PhD Thesis, Åbo: Åbo Akademi University Press.

Freedman, C. (1977) Micro Theory of International Financial Intermediation, *American Economic Review*, Vol. 67, pp. 172-179.

Gadde, L.-E. (2004) Activity Coordination and Resource Combining in Distribution Networks – Implications for Relationship Involvement and the Relationship Atmosphere, *Journal of Marketing Management*, Vol. 20, No. 1-2, pp. 157-184.

Gadde, L.-E. (2013) Strategizing at the Boundaries of Firms, *Paper presented at the IMP Journal Seminar*, Marseille, France. Forthcoming in the IMP Journal (2014).

Gadde, L.-E. (2014) Distribution Network Dynamics and the Consequences for Intermediaries, *Industrial Marketing Management*, Article in press: accepted.

Gadde, L.-E. and Dubois, A. (2010) Partnering in the Construction Industry – Problems and Opportunities, *Journal of Purchasing and Supply Management*, Vol. 16, No. 4, December, pp. 254-263.

Gadde, L.-E. and Ford, F. (2008) Distribution Research and The Industrial Network Approach, *The IMP Journal*, Vol. 2, No. 3, pp. 36-52.

Gadde, L.-E. and Håkansson, H. (2008) Business Relationships and Resource Combining, *The IMP Journal*, Vol. 2, No. 1, pp. 31-45.

Gadde, L.-E., Håkansson, H. and Persson, G. (2010) *Supply Network Strategies*. Chichester: John Wiley & Sons Ltd.

Gadde, L.-E. and Snehota, I. (2000) Making the Most of Supplier Relationships, *Industrial Marketing Management*, Vol. 29, No. 4, July, pp. 305-316.

Goffin, K., Raja, J., Claes, B., Szwejczewski, M. and Martinez, V. (2012) Rigor in Quality Supply Chain Management Research, *International Journal of Physical Distribution & Logistics Management*, Vol. 42, No. 8/9, pp. 804-827.

Gressetvold, E. (2004) *Product development – Effects on a Company's Network of Relationships*. PhD Dissertation, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology.

Handfield, R.B. and Nichols, E.L. (1999) *Introduction to Supply Chain Management*. Prentice Hall.

Handley, S. and Benton, W. (2009) Unlocking the Business Outsourcing Process Model, *Journal of Operations Management*, Vol. 27, No. 5, pp. 344-361.

Harrison, D. and Waluszewski, A. (2008) The Development of a User Network as a Way to Re-Launch an Unwanted Product, *Research Policy*, Vol. 37, pp. 115-130.

Havila, V. (1996) *International Business-Relationships Triads. A Study of the Changing Role of the Intermediating Actor*. Doctoral thesis no.64, Department of Business Studies, University of Uppsala.

Haythornthwaite, C. (1996) Social Network Analysis: An Approach and Technique for the Study of Information Exchange. *Library and Information Science Research*, Vol. 18, No. 4, pp. 323-342.

Herbig, P. and O'Hara, S. (1994) Industrial Distributors in the Twenty-First Century, *Industrial Marketing Management*, Vol. 23, pp. 199-203.

Hessel, I. and Gadde, L.-E. (2013) Supply Side Organising – Linking Three Overlapping Domains, *The IMP Journal*, Vol. 7, No. 1, pp. 24-45.

Holcomb, T. and Hitt, M. (2007) Toward a Model of Strategic Outsourcing, *Journal of Operations Management*, Vol. 25, pp. 464-481.

Holma, A. (2009) *Adaptation in Triadic Business Relationship Settings: A Study in Corporate Travel Management*. PhD Dissertation, Hanken School of Economics.

Holmen, E. (2001) *Notes on a Conceptualisation of Resource-Related Embeddedness of Interorganizational Product Development*. PhD Dissertation, Institute for Marketing, University of Southern Denmark.

Howells, J. (2006) Intermediation and the Role of Intermediaries in Innovation. *Research Policy*, Vol. 35, pp. 715-128.

Huemer, L. (1998) *Trust in Business Relations: Economic Logic or Social Interaction?*, Umeå Borea.

Hulthén, K. and Gadde, L.-E. (2007) Understanding the 'New' Distribution Reality through 'Old' Concepts – A Renaissance for Transvection and Sorting, *Marketing Theory*, Vol. 7, pp. 184-207.

Håkansson, H. (ed.) (1982) *International Marketing and Purchasing of Industrial Goods: An Interaction Approach*. New York: John Wiley & Sons.

Håkansson, H. (1987) *Industrial Technological Development: A Network Approach*. London: Croom Helm.

Håkansson, H., Ford, D., Gadde, L.-E., Snehota, I. and Waluszewski, A. (2009) *Business in Networks.* Chichester: John Wiley & Sons Ltd.

Håkansson, H. and Snehota, I. (1995) *Developing Relationships in Business Networks*. London: Routledge.

Håkansson, H. and Snehota, I. (2006) No Business is an Island: the Network Concept of Business Strategy, *Scandinavian Journal of Management*, Vol. 22, No. 3, September, pp. 256-270.

Håkansson, H. and Waluszewski, A. (2002) *Managing Technological Development. IKEA, the Environment and Technology*. London: Routledge.

Jahre, M., Gadde, L.-E., Håkansson, H., Harrison, D. and Persson, G. (eds.) (2006) *Resourcing in Business Logistics – the Art of Systematic Combining*. Liber & Copenhagen Business School Press.

Jensen, L.-M. (2010) Opportunities and Constraints for Intermediaries in Distribution: the Challenge of Variety, *The IMP Journal*, Vol. 4, No. 3, pp. 194-219.

Johanson, J. and Vahlne, J.-E. (2009) The Uppsala Internationalization Process Model Revisited: From Liability of Foreignness to Liability of Outsidership, *Journal of International Business Studies*, Vol. 40, pp. 1411-1431.

Josephson, P.-E. and Sukkoriipi, L. (2005) *Slöseri i byggprojekt – behov av förändrat synsätt*. FoU-Väst rapport 0507, Sveriges Byggindustrier.

Karlsson, T. (2009) *Effective Material Logistics in Construction: Lessons from a Swedish Apartment-Block Project*. Master Thesis, Division of Construction Management, Gothenburg: Chalmers University of Technology.

Klerkx, L. and Leeuwis, C. (2008) Matching Demand and Supply in the Agricultural Knowledge Infrastructure: Experiences with Innovation Intermediaries, *Food Policy*, Vol. 33, pp. 260-276.

Knemeyer, M., Ponzurick, T. and Logar, C. (2002) A Qualitative Examination of Factors Affecting Reverse Logistics Systems for End-of-life Computers, *International Journal of Physical Distribution & Logistics Management*, Vol. 32, No. 6, pp. 455-479.

Kvale, S. (1997) *Den kvalitativa forskningsintervjun*. Lund: Studentlitteratur.

Lampel, J. and Mintzberg, H. (1996) Customizing Customization, *Sloan Management Review*, Fall, pp. 21-30.

Lincoln, Y.S. and Guba, E.G. (1985) *Naturalistic Inquiry*. London: Sage Publications.

Lind, J. and Thrane, S. (2010) Towards Accounting in Network Settings, In Håkansson, H., Kraus, K. and Lind, J. (eds.) *Accounting in Networks*, pp. 60-79, London: Routledge.

Lindén, S. (2011) *Costs for On Site Material Handling in Housing*. Master Thesis, Division of Construction Management, Gothenburg: Chalmers University of Technology.

Lindén, S. (2011) Effektiv Bygglogistik. http://www.tmr.sll.se (29 November 2011).

Lindström, F. and Skude, J. (2008) *Logistik: Logistik för kökskedjan*. Bachelor Thesis, Halmstad: Högskolan i Halmstad.

Löfgren, I. and Gylltoft, K. (2001) In-site Cast Concrete Building – Important Aspects of Industrialised Construction, *Nordic Concrete Research*, Vol. 26, No. 1, pp. 61-81.

Masson, R., Iosif, L., MacKerron, G. and Fernie, J. (2007) Managing Complexity in Agile Global Fashion Industry Supply Chains, *The International Journal of Logistics Management*, Vol. 18, No. 2, pp. 238-254.

Merton, R.C. (1995) A Functional Perspective of Financial Intermediation*, Financial Management*, Vol. 24, No. 2, Summer 1995, pp. 23-41.

Morgan, R. and Hunt, S. (1994) The Commitment-Trust Theory of Relationship Marketing, *Journal of Marketing*, Vol. 58, No. 3, pp. 20-38.

Normann, R. (1980) *A Personal Quest for Methodology*, Scandinavian Research for Administrative Research, Lund.

Peng, M.W. and Ilinitch, A.Y. (1998) Export Intermediary Firms: A Note on Export Development Research, *Journal of International Business Studies*, Vol. 29, No. 3, (Third Quarter 1998), pp. 609-620.

Penrose, E.T. (1959) *The Theory of the Growth of the Firm*. New York: Oxford University Press.

Persson, M. (2011) *Kunskapsbaserade arbetsmetoder*. Halmstad: Högskolan Halmstad.

Piekkari, R., Plakoyiiannaki, E. and Welch, C. (2010) 'Good' Case Research in Industrial Marketing: Insights from Research Practice, *Industrial Marketing Management,* Vol. 39, pp. 109-117.

Piore, M. (1992) Fragments of a Cognitive Theory of Technological Change and Organizational Structure. In: Nohria, N. and Eccles, R. (eds.), *Networks and Organizations. Structure, Form and Action*. Boston: Harvard Business School.

Pittaway, L., Robertson, M., Munir, K., Denyer, D. and Neely, A. (2004) Networking and Innovation: A Systematic Review of the Evidence, *International Journal of Management Reviews*, Vol. 5/6, No. 3&4, September/December, pp. 137-168.

Popp, A. (2000) "Swamped in Information but Starved of Data": Information and Intermediaries in Clothing Supply Chains, *Supply Chain Management: An International Journal*, Vol. 5, No. 3, pp. 151-161.

Porter, M. E. (1980) *Competitive Strategy*. New York: Free Press.

ProQuest (2014) http://www.proquest.com, Access: ProQuest – Summon – Chalmers Library (8 April 2014).

Purvis, L., Naim, M.M. and Towill, D. (2013) Intermediation in Agile Global Fashion Supply Chains, *International Journal of Engineering, Science and Technology*, Vol. 5, No. 2, pp. 38-48.

Ragin, C.C. and Becker, H.S. (1992) *What is a Case? Exploring the Foundations of Social Inquiry*. Cambridge: Cambridge University Press.

Richardson, G.B. (1972) The Organization of Industry, *The Economic Journal*, September, pp. 883-96.

Rosenbloom, B. (1995) *Marketing Channels – A Management View*. New York: Dryden Press.

Rosenbröijer, C.-J. (1998) *Capability Development in Business Networks.* Doctoral dissertation. Swedish School of Economics and Business Administration. Helsinki. Finland.

Sandberg, J. and Hjort, B. (1998) *Rationell armering: Ekonomi, ergonomi, miljö*. Halmstad. Tryckmedia.

Scholtens, L.J.R. (1992) On the Theory of International Financial Intermediation, *DE Economist*, Vol. 140, No. 2, pp. 470-487.

Shirazi, B., Langford, D. and Rowlinson, S. (1996) Organizational Structures in the Construction Industry, *Construction Management and Economics*, Vol. 14, No. 3, pp. 199-212.

Shunk, D.L., Carter, J.R., Hovis, J. and Talwar, A. (2007) Electronics Industry Drivers of Intermediation and Disintermediation, *International Journal of Physical Distribution & Logistics Management*, Vol. 37, No. 3, pp. 248-261.

Sieg, J.H., Wallin, M.W. and von Krogh, G. (2010) Managerial Challenges in Open Innovation: A Study of Innovation Intermediation in the Chemical Industry, *R&D Management*, Vol. 40, No. 3, pp. 281-290.

Silverman, D. (1993) *Interpreting Qualitative Data*. London: Sage Publications.

Skarp, F. (2006) *Adaptations of Products to Customers' Use Contexts*. PhD Dissertation, Division of Industrial Marketing, Chalmers University of Technology.

Snehota, I. (1990) *Notes on a Theory of Business Enterprise*. Doctoral Dissertation, Department of Business Studies, University of Uppsala.

Spulber, D.F. (2003) The Intermediation Theory of the Firm: Integrating Economic and Management Approaches to Strategy, *Managerial and Decision Economics*, Vol. 24, No. 4, June, pp. 253-266.

Stern, L.W., El-Ansary, A.I. and Coughlan, A.T. (1996) *Marketing Channels* (5th ed.). Prentice-Hall, Upper Saddle River, NJ.

Sundquist, V. (2011) *Intermediation in Business Networks: A Case Study in the Textile and Clothing Industry*. Saarbrücken: Lambert Academic Publishing.

Sundquist, V. and Gadde, L.-E. (2010) Intermediaries and Intermediation in Business Networks, *Paper presented at the 2nd Nordic Retail and Wholesale Conference (NRWC)*, Gothenburg, November 10-11.

Thompson, H. (2002) *Reflexiva intervjuer*. Lund: Studentlitteratur.

van Hoek, R.I. (2001) The Rediscovery of Postponement A Literature Review and Directions for Research, *Journal of Operations Management*, Vol. 19, No. 2, pp. 161–184.

Verona, G., Prandelli, E. and Sawhney, M. (2006) Innovation and Virtual Environments: Towards Virtual Knowledge Brokers, *Organization Studies*, Vol. 27, No. 6, pp. 765-788.

Wedin, T. (2001) *Networks and Demand: The Use of Electricity in an Industrial Process*. Doctoral thesis no. 83, Department of Business Studies, University of Uppsala.

Wernerfelt, B. (1984) A Resource-Based View of the Firm, *Strategic Management Journal*, Vol. 5, pp. 171-180.

Williamson, O.E. (1975) *Markets and Hierarchies, Analysis and Antitrust Implications: A Study in the Economics of Internal Organization*. New York: Free Press.

Wynne, C., Berthon, P., Pitt, L., Ewing, M. and Napoli, J. (2001) The Impact of the Internet on the Distribution Value Chain The Case of the South African Tourism Industry, *International Marketing Review*, Vol. 18, No. 4, pp. 420-431.

Zinn, W. and Bowersox, D.J. (1988) Planning Physical Distribution with the Principle of Postponement, *Journal of Business Logistics*, Vol. 9, No. 2, pp. 117-137.

Yin, R.K. (1984) *Case Study Research: Design and Methods*. Beverly Hills, California: Sage Publications.