THESIS FOR THE DEGREE OF DOCTOR OF TECHNOLOGY

Contractors in Green Construction

Relationships to Suppliers and Developers

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Abstract

Introduction of green changes in different stages of a construction project are reflected in construction processes and products, and in the relationship between contractors and other firms and consequently in the business model of contractors. The aim of this thesis is to understand and analyse contractors' collaboration practices with suppliers and developers in green construction projects and processes, and analyse if there are differences in how contractors collaborate with clients and developers as a result of engaging in green construction.

This thesis is based on three studies. The first study identifies through a systematic literature review probable changes in the business model of construction firms when they engage in green construction, and its results are the foundation for the second and third studies. The second study analyses contractors' relationships with their goods suppliers in green projects, through semi-structured interviews. The third is a case study of how vertically-integrated developers can affect innovation in construction projects, based on semi-structured interviews with a Swedish contractor and its vertically-integrated developer. This is followed by a conceptual investigation of the phenomenon of vertical integration of developers.

This thesis suggests that for contractors to profit from engaging in green construction, simultaneous or co-evolutionary changes in a number of business model elements, including capability and partner network, are needed. This implies that firms in the contractor's partner network act as sources of knowledge. Selection of suppliers with green knowledge and collaboration with them in close relationships were found to be important for both knowledge acquisition and reduction in contractors' costs primarily through reduction of supplier failures to meet green requirements. The integration with developers allows contractors to work more continuously with innovative projects to develop and exploit new capabilities, and also to signal proficiency to the market while mitigating the risks involved in green projects.

Keywords: green construction, contractor-supplier relationship, partnering, TCE, relational capability, purchasing, vertically-integrated developer, innovation

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Shahin Mokhlesian

Gothenburg, November 2014

List of appended papers

This thesis is based on the work in the following papers, referred to by Roman numerals in the text:

Paper I

Mokhlesian, S. and Holmén, M. (2012) Business model changes and green construction processes. *Construction Management and Economics,* **30**(9), 761-75.

The purpose and research design of the paper were developed by Shahin Mokhlesian and Magnus Holmén. Shahin Mokhlesian was responsible for collecting the data. The analysis and writing was a joint effort.

Paper II

Mokhlesian, S. (2014) How Do Contractors Select Suppliers for Greener Construction Projects? The Case of Three Swedish Companies. *Sustainability,* **6**(7), 4133-51.

Paper III

Mokhlesian, S., Bröchner, J. and Sandström, C. (2014) Transaction costs and contractor-goods supplier relationships in green construction projects. *Paper submitted to a scientific journal.*

The initial idea leading to the paper was suggested by Jan Bröchner and then it was developed by all co-authors. The final purpose was a joint effort by Shahin Mokhlesian, Jan Bröchner and Christian Sandström. All the data used in the analysis were collected and sorted by Shahin Mokhlesian. The analysis of the results and the writing of the paper were led by Shahin Mokhlesian, with efforts of all co-authors.

Paper IV

Mokhlesian, S. and Holmén, M. (2012) Innovation and developer integration in a construction group. *Paper submitted to a scientific journal.*

The initial idea of the paper was formed through a series of discussions by Shahin Mokhlesian and Magnus Holmén. Collecting the data and sorting them were done by Shahin Mokhlesian whereas analysing the data and writing of the paper were collective efforts.

Paper V

Holmén, M., Bröchner, J. and Mokhlesian, S. (2014) Construction innovation through internal developers. *Paper submitted to a scientific journal.*

The purpose and research design of the paper were determined jointly by Magnus Holmén, Jan Bröchner and Shahin Mokhlesian. The conceptual analysis was led by Magnus Holmén and Jan Bröchner with contributions by Shahin Mokhlesian.

Contents

1. Introduction

This PhD thesis analyses green construction from the perspective of large Swedish contractors, investigating their relationships with suppliers and developers. Construction consumes a vast amount of resources and creates much waste (Ofori and Kien, 2004; Vijayan and Kumar, 2005; Nelms *et al.*, 2007; Ding, 2008; Bossink, 2011; Hwang and Tan, 2012; Eichholtz *et al.*, 2013; McGrath, 2013). To overcome this, more environmentally friendly construction processes and artefacts are important because they may save the environment from the hazardous aspects of the construction industry (Kibert, 2007; Lan and Sheng, 2014). From a business perspective, moving from conventional to green construction may provide an opportunity as a construction firm may profit from such innovative activities.

Green construction aims to make the construction process or the built artefacts more environmentally friendly; green construction is often expected to differ from conventional construction in a number of ways, such as applying recyclability in design, using environmental-friendlier materials, reducing energy consumption, using sustainable methods in the construction phase and recycling building materials at the end of their life cycles (Presley and Meade, 2010; Kibert, 2012). Green construction covers a broad scope, making the exact distinction between green and non-green (conventional) construction difficult and at times impossible, as the level of greenness varies depending on the extent to which green criteria are met in individual projects and artefacts. From the perspective of this thesis, *green* is a relative concept, suggesting that the term *greener construction*, as compared to conventional use, might be preferable to the term *green construction*.

There are varied motives for the construction industry to become greener. One motive includes external pressures from authorities and governments, typically in the form of stricter environmental regulations (Arif *et al.*, 2009; Kok *et al.*, 2011; Robichaud and Anantatmula, 2011), and from non-governmental organisations (Igarashi *et al.*, 2013) through awarding certificates such as BREEAM and LEED (Hoffman and Henn, 2008; Wiley *et al.*, 2010; Fuerst and McAllister, 2011; Eichholtz *et al.*, 2013). Other external factors include higher energy prices (Arif *et al.*, 2009; Robichaud and Anantatmula, 2011), which are directly related to contractors' ongoing business in terms of turnover and profits. Another external factor is increased social awareness, which not only contributes to reputation but also takes the form of clients' and customers' increased willingness to pay higher prices for green products (Fuerst and McAllister, 2011; Zalejska-Jonsson, 2014).

Strategic choices involve if, and under which circumstances, contractors rely on certificates and how clients' demands are met through certificates (Egbu, 2008). Certificates are important from the perspective of the contractors' image and their ability to signal convincingly to prospective and current employees and customers that they are serious players in terms of sustainability. Incentives ranging from financial to community reputation can motivate companies to be more environmentally friendly (Presley and Meade, 2010) simply because they find business value in it (McMullen, 2001). Finally, tenants can be willing to pay higher rents for greener buildings (Zalejska-Jonsson, 2014).

Despite this, a number of studies (e.g. Meryman and Silman, 2004; Demaid and Quintas, 2006; Hoffman and Henn, 2008; Lam *et al.*, 2009; Berardi, 2013) have reported that adoption and adaptation rates of green technologies and principles in construction are low. We argue that two interdependent factors affect the rate of engaging in green technologies and processes in construction: relationships between firms in the construction supply chain, with implications for the contractors' business models.

Construction innovation depends on relationships between firms and collaborations with external knowledge sources (Miozzo and Dewick, 2002; Drejer and Vinding, 2006; Gluch *et al.*, 2009). However, due to the fragmentation of the construction industry and involvement of different firms with different objectives, none of them tends to take direct responsibility for protecting the environment (Ofori, 2000). Additionally, engaging in green construction can be hindered, as it requires changes in the construction processes (Kibert, 2012).

The contractor's business model, and to what extent and how it is innovated, is another factor that can affect the rate of engagement in green construction. A firm's ability to profit depends to a large extent on its business model. This model may be viewed as stories or logics that show how the business works (Chesbrough and Rosenbloom, 2002; Magretta, 2002) in terms of how it creates and delivers value for, and captures value from, clients and end users (Björkdahl and Holmén, 2013). The inherent value of a technology is latent until it is commercialized; so in order to capture value from a technology investment the business design around the technology has to fit the conditions of the technological or market opportunity (Björkdahl, 2009). The contractor's business model defines which products or services to offer to which clients, how to do it with the help of what other firms, and finally how to profit from it. A contractor's engagement in green construction implies that it may need to innovate its business model. This requires managers to have a sound understanding of their company's current business model(s) (Pekuri *et al.*, 2013).

Furthermore there can be a mismatch between a firm's existing business model and the type of business model that may be appropriate for an innovation. This means that the extent to which, and how, firms innovate their business models affect the rate of engaging in and profiting from green construction. Generally speaking, business-model innovation affects competition (Hamel, 2000; Morris *et al.*, 2005; Teece, 2010) and firms' success (Johnson *et al.*, 2008; Pekuri *et al.*, 2014). Since engaging in green construction implies changes in the construction process, firms' business models might also change. The changes may dramatically affect how construction firms create value for their customers and how they profit from changing the environmental orientation of their businesses (Sayce *et al.*, 2007; Lüdeke-Freund, 2013). However, green is not a straightforward task for contractors making changes in their business model, construction processes, or built environment. A major difficulty lies in how the creation and delivery of social and environmental value might translate into profit and competitive advantage for the firm (Bocken *et al.*, 2014). One reason that managers resist engaging in green construction is that they do not have clear visions for how to reorganise their operations to deliver value to their clients.

A business model does not exist in isolation from other firms and other types of actors. Viewing business models as an activity system implies they are open systems, in which the activities of upstream, downstream, and complementary actors affect the nature and performance of the firm's operations (Adner and Kapoor, 2010; Zott *et al.*, 2011). This means that one change in business models that construction firms may need to make when engaging in green construction is related to how firms should collaborate. Considering the limited literature on the concept of business models in project businesses (Wikström *et al.*, 2010), particularly in the construction business (e.g. Pekuri *et al.*, 2013; Pekuri *et al.*, 2014), studying the changes in construction firms' business models resulting from engaging in green construction can be useful. These changes may indicate how construction firms can engage in green construction, or what they must consider before engaging in green construction. In addition it might yield interesting insights for other project-style industries as well. In particular analysing changes in relationships with other firms when attempting to, and succeeding at, innovating their construction processes and artefacts is important.

The contractor always must deal with clients and suppliers in a construction project. Clients can affect the products and processes of construction projects through their demands and support (Seaden and Manseau, 2001; Varnäs *et al.*, 2009; Qi *et al.*, 2010; Gambatese and Hallowell, 2011), as they are often initiators, funders, and final owners of the project (Boyd and Chinyio, 2006). This implies that contractors must create and maintain good relations with the client. There are various forms of client-contractor relationships, depending on the level of interaction and length of the relationship (Bildsten, 2014). They vary from the traditional, adversarial, short-term relationship to client-contractor partnering (Bresnen and Marshall, 2000; Eriksson and Laan, 2007; Eriksson and Pesämaa, 2007), and even to merging client and contractor into one entity.

This array of client-contractor relationships can be explained by transaction cost economics (TCE) theory (Williamson, 1985), in which selection of the relationships can be explained by the total transaction cost, which consists of *ex-ante* and *ex-post* costs, related to when a contract is signed. Based on TCE, the traditional and partnering (alliances in general) relationships respectively correspond to market and hybrid governance modes. Large Swedish construction groups have created vertically integrated developers. Developers are defined as a special category of construction clients, acting as intermediaries between the property, business and finance sectors by acquiring land and designing, constructing, managing and marketing the constructed asset (Boyd and Chinyio, 2006, p. 114). However, the vertical integration of developers and the effects of this relationship on innovation have yet to be explicitly studied and explained. Studying why some clients are created and integrated into the construction groups and how this vertical integration might influence the greening (innovating) of the construction projects is particularly interesting.

Suppliers are also gaining strategic importance in most companies (Dubois and Gadde, 2000), as they often are the knowledge source in the construction industry (Reichstein *et al.*, 2005; Pinkse and Dommisse, 2009) and provide green goods used in projects. However, their relationship with contractors in green construction has not been extensively studied. In

particular, there is a lack of research on how materials and components suppliers are selected for green projects and how they collaborate on these projects. This is important since without the right goods and materials suppliers, but with inappropriate relationships, contractors may not realise the full potential of green construction in their delivery to external clients.

Given this background, the present thesis aims to understand and analyse contractors' collaboration practices with suppliers and clients in green construction projects and processes, and analyse if there are differences in how contractors collaborate with their clients and suppliers as a result of engaging in green construction. This study is based on the following two research questions:

RQ1: How does contractor engagement in green projects influence the contractors' supplier relations?

RQ2: How is joint ownership by contractors and property developers associated with more innovative projects?

The thesis consists of five appended articles, along with this overview extended summary. This overview document starts with research settings, which provide an overview of green construction and the construction business ecosystem, followed by an introduction to the Swedish construction industry (Chapter 2). Chapter 3 gives an overview of the literature on green construction, followed by the purpose and research questions (Chapter 4). Chapter 5 presents the analytical framework, followed by the thesis methodology (Chapter 6). Chapter 7 summarises the appended papers, and Chapter 8 presents the analysis and discussion. Finally, Chapter 9 presents the conclusions.

2. Research settings

This chapter provides an overview of the research context; portrays green construction, the business ecosystem, the industrial architecture of the construction industry; and provides some notes on the Swedish construction industry and its innovativeness.

2.1. Green construction

Green construction can be defined as the creation and responsible management of a healthy built environment based on resource efficient and ecological principles (Kibert, 2012). It differs from conventional construction in a number of ways, including applying recyclability in design, using environmentally friendlier materials and methods in the construction phase, and deconstructing buildings at the end of their life cycles (Arif *et al.*, 2009; Kibert, 2012; Shi *et al.*, 2013). This definition implies a relative nature for green. In line with this Gibbs and O'Neill (2014) use the analogy of green as being fluid and blurred which shows that green is not a static state. The level of greenness of the process/product depends on the extent to which green changes are included in the construction processes. *Green construction* is often confused with the notion of *green building*. The former is the process, while the latter is an outcome of the process. Green construction processes do not necessarily result in green buildings, and vice versa. Green buildings can be constructed by relying on traditional construction methods. However, it can be argued that most construction firms engaging in green construction aim to achieve green buildings, which might be one reason why the two terms might be used interchangeably. Hoffman and Henn (2008) defined *green building* as a term encompassing strategies, techniques, and construction products that are less polluting or resource-intensive than conventional construction. This definition is very similar to the definition of *green construction* given above, although the two terms imply different things in essence. As a result, it is suggested here that the term *greener* is more appropriate than *green*. However, *green construction* is used throughout this thesis to follow conventional terminology.

Both green construction and green building can be understood from an industrial ecology systems perspective (see Figure 1). These systems consist of firms and other organisations that are linked to each other and their surrounding economic, social, and ecological systems by physical materials, and energy and information flows (Korhonen and Snäkin, 2005).

In the construction industry, contractors work with clients and service/goods suppliers in construction projects. Goods and materials suppliers are companies that provide contractors with various materials and components.

Contractors are not just embedded within an ecosystem from an environmental point of view, in terms of materials and energy inflows and outflows. Contractors are related to other firms by means of value creating and delivering activities, and transactions. They are related to each other and have their own boundaries (Korhonen, 2001) (see Figure 2).

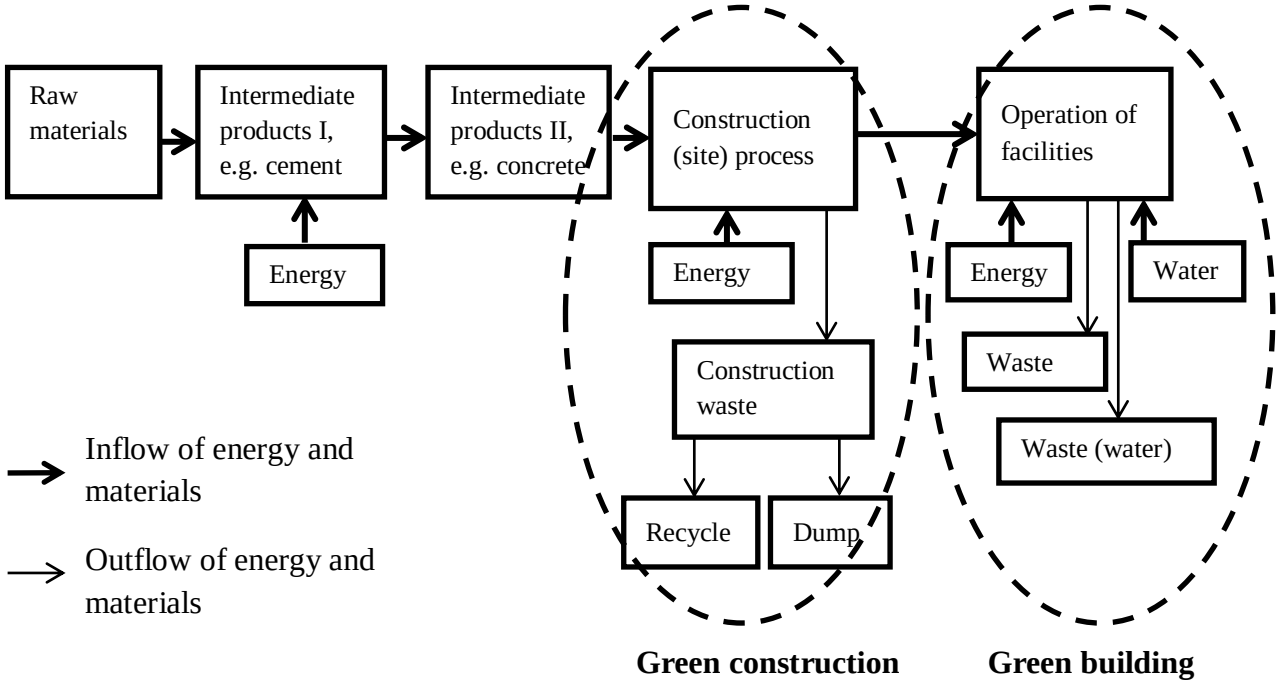

Figure 1. The construction ecosystem

This mesolevel analysis goes under many names, depending on the study focus, including value stream (Davies, 2004), sectoral innovation system (Malerba, 2004), industrial architecture or business ecosystem (Adner and Kapoor, 2010). While the emphasis of each differs, they all focus on what upstream and downstream firms do, how value is created and delivered, and who profits, depending on their positions vis-à-vis others. This thesis refers to this level as business ecosystem.

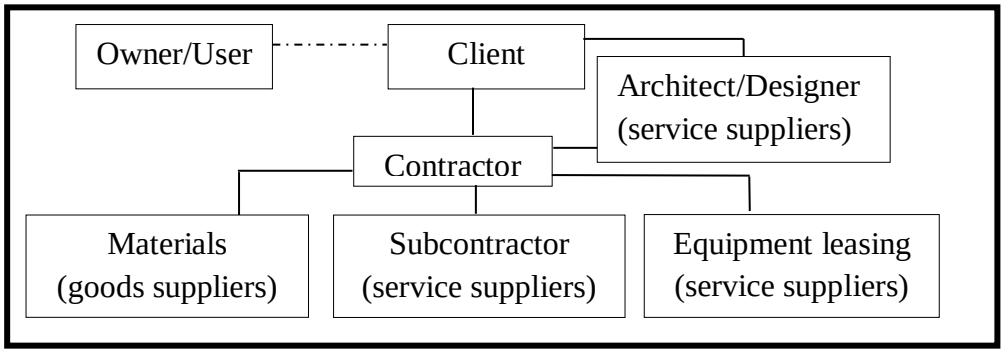

Figure 2. The construction business ecosystem

Changes to contracts or firms' activities within this ecosystem may result in changes to firms' profits and may influence business models. Green construction as a change in the construction ecosystem has consequences for contractors' business models. In a market economy, contractors wanting to engage in green construction must create value for their customers and capture part of the value from changing the environmental orientation of their businesses. This implies that the contractor might need to switch to suppliers that deliver green products and processes to meet the clients' green demands. Therefore, making changes to the

construction process, such as changing toward a closed-loop process, requires both contractor and supplier knowledge. Contractors need knowledge to successfully accomplish a green project and suppliers need green knowledge to deliver materials or services that are appropriate for green construction. The importance of suppliers' knowledge is not limited to the delivery of green materials or services. Contractors can draw on their suppliers' knowledge through collaboration and communication.

2.2. The Swedish construction industry

The Swedish construction industry employs a significant number of people (7 per cent of total employment in 2012 according to Statistics Sweden) and is influenced by government through investments, taxes, and subsidies (Bröchner *et al.*, 2002). The Swedish construction industry is characterised by two important features when compared internationally. First, the architects' role is limited to the early, brief and design phase and developing architectural drawings. Second, private, non-profit and municipal housing companies are influential, large actors in the residential market (Carassus, 2004, p. 168f.). Due to acquisitions and mergers in the Swedish construction industry, there are only three large construction contractors (Skanska, NCC and PEAB) and a few specialised housing contractors. This led to deep, long-term relationships between buyers and sellers (Bröchner *et al.*, 2002). In 2012, there were 29 contractors with more than 500 employees; the vast majority of firms had four or fewer employees.

Large Swedish contractors are decentralised geographically and in their business areas. However, they try to avoid a fragmented approach to innovation activities through establishing mechanisms to collect and disseminate technical information across their decentralised structures (Miozzo and Dewick, 2002). Swedish large contractors often take a leading role in construction innovation and are engaged in activities ranging from extraction and manufacturing across traditional core activities in construction to knowledge intensive business services (Bröchner, 2010b).The corporate governance of the top Swedish contractors is characterised by strong industry and bank ownership, as well as family ownership and employee representation on the board. The combined interest and influence of banks, family, industrial firms, and workers enable the Swedish contractors to invest in firm-specific innovations that demand significant long-term funding (Miozzo and Dewick, 2002). However, the exchange of information in the Swedish construction industry takes place with their closest parties, which leads to groupthink, so the capacity to be innovative and the room for competitive advantage becomes limited (Gluch *et al.*, 2009).

The government has not endorsed partnering or collaborative contracting despite the Swedish collaborative culture where contractual relations in construction are thought to be less antagonistic than in the UK and US (Bröchner *et al.*, 2002). Collectivism is a core value of the Swedish system of industrial relations, and it results in conflict resolution at work being addressed through collective procedures, involving trade unions and employers (Ahlberg and Bruun, 2005). The Swedish construction industry has one of the strongest inter-organisational relationships between different firms. A fundamental characteristic of contractual

relationships in the Swedish construction industry is that very few conflicts are settled by formal dispute resolution mechanisms. Collaborations are mainly informal and based on personal relationships, so project managers mostly resolve potential conflicts by compromise and mutual understanding (Bröchner *et al.*, 2002). As a result, the Swedish construction industry has a tightly knit, integrated conflict-management system (Teague, 2009) that depends on collective agreements (Kjellberg, 2009) and self-regulation (Kadefors, 1995; Teague, 2009). Clients seem reluctant to change the traditional allocation of responsibilities and ways of working (Kadefors and Bröchner, 2014).

Sweden has traditionally led in areas such as energy efficiency and indoor climates (Kadefors and Bröchner, 2014). Most of the larger firms active in the Swedish construction industry are involved in environmental work and employ skilled personnel and advanced environmental management systems (Gluch *et al.*, 2010, p. 170).

3. Review of the green construction literature

In the last two decades, green construction and green building has gained considerable attention among researchers. Research publications have focused on the origins, principles, and frameworks of green construction and green buildings (Hill and Bowen, 1997; Kibert *et al.*, 2000; Kaatz *et al.*, 2005; Pearce, 2006; Barrett, 2007; Bakhtiar *et al.*, 2008; Sev, 2009; Yudelson, 2010; Kibert, 2012). The literature often concerns technical issues, such as green design (Wang *et al.*, 2006; Yudelson, 2008; Attmann, 2009; Wiley *et al.*, 2010; Kibert, 2012), green materials (James and Yang, 2005; Hoang *et al.*, 2009; Hoang *et al.*, 2010; Spiegel and Meadows, 2010), lifecycle costing for green buildings (Bartlett and Howard, 2000; Cole and Sterner, 2000; Kishk et al., 2003; Gluch and Baumann, 2004; Yin and Bai, 2014), and environmental certificates such as LEED and BREEAM (see Turner and Frankel, 2008; Newsham *et al.*, 2009; Sabapathy *et al.*, 2010; Karhu *et al.*, 2012; Liu *et al.*, 2012; Ding and Forsythe, 2013; Feige *et al.*, 2013). Occasionally, the principle of reducing waste, as being central to Lean Construction, has been invoked (Lapinski *et al.*, 2006; Ogunbiyi *et al.*, 2013).

Another stream of literature has discussed motives and obstacles for engaging in green construction. Obstacles such as cost (Kats *et al.*, 2003; Hoffman and Henn, 2008; Zhang *et al.*, 2011), risks in implementing green (Robichaud and Anantatmula, 2011; Lu *et al.*, 2013; Yang and Zou, 2014), behavioural factors (institutions, organisations, individuals) (Rohracher, 2001; Hoffman and Henn, 2008), lack of knowledge (Choi, 2009; Hwang and Tan, 2012; Hwang and Ng, 2013), lack of client support (Ivory, 2005; Hwang and Tan, 2012), and lack of green suppliers (Lam *et al.*, 2010; Häkkinen and Belloni, 2011; Shi *et al.*, 2013) are found in the literature. However cost is not necessarily a barrier, provided that the customer or client is willing to pay (Chau *et al.*, 2010; Ward *et al.*, 2011; Park *et al.*, 2013; Zalejska-Jonsson, 2014). One reason for lack of client support is mainly due to insufficient technical competence of clients (Nam and Tatum, 1997; Ivory, 2005) which leads to their risk-averse attitude (McCoy *et al.*, 2009), as well as deficient understanding of the relation between the benefits of green and their businesses (Ivory, 2005), though highly competent customers are more willing to embrace innovation than those with lower internal capabilities (Bröchner, 2010a, p. 757). Removing these barriers may lead to stronger client support for green projects.

Increased social awareness (Robichaud and Anantatmula, 2011), increased energy prices (Arif *et al.*, 2009; Robichaud and Anantatmula, 2011), image and reputation (Presley and Meade, 2010; Tan *et al.*, 2011; Zhang *et al.*, 2011), and financial profits (Robichaud and Anantatmula, 2011; Lu *et al.*, 2013) are among motives for green construction discussed in the literature.

All these studies took the project-based nature of construction projects into account. One main theme in many studies is the inter-firm relationships and their effects on innovation and green construction (e.g. Ofori, 2000; Miozzo and Dewick, 2002; Bossink, 2004; Drejer and Vinding, 2006; Faith-Ell *et al.*, 2006; Šaparauskas and Turskis, 2006; Gluch *et al.*, 2009; Ho

et al., 2009; James and Card, 2012). For instance Ofori (2000) when he identifies positive effects of SCM on green construction; Miozzo and Dewick (2002) writing on positive effects of factors such as long-term relations between firms and collaborations with external sources of knowledge on the development of strategic innovations and operational capabilities; Bossink (2004) on innovation drivers at transfirm, intrafirm, and interfirm levels to develop the quality and the cooperative structure of the industry as a whole; and Gluch *et al.* (2009) on absorptive capacity and knowledge acqusition on green innovation. These contributions are relevant to this thesis as relationships between firms are one of the main themes here.

Among different organisations in a green project with whom a contractor can interact, clients and suppliers have been the focus of many studies. Many studies that dealt with client-contractor relationships argued that firms must move from traditional, client-contractor relationships toward more integrated, cooperative, trust-based relationships, such as partnering, to engage in green construction (Bresnen and Marshall, 2000; Matthews *et al.*, 2000; Maqsood and Akintoye, 2002; Eom *et al.*, 2008; Eriksson, 2010; Gadde and Dubois, 2010; Bemelmans *et al.*, 2013). However, the argued benefits of partnering, such as improvements in quality, sustainability, dispute resolution and innovation (Chan *et al.*, 2003a), are not easily obtained. This is reflected in a number of studies (Akintoye *et al.*, 2000; Glagola and Sheedy, 2002; Saad *et al.*, 2002; Chan *et al.*, 2003b; Bresnen, 2007; Eriksson and Nilsson, 2008). Researchers have addressed the procedures for benefiting from partnering (Brown *et al.*, 2001; Briscoe *et al.*, 2004; Topcu, 2004; Swan and Khalfan, 2007; Eriksson, 2010). Eriksson (2010) argued that there are different levels for partnering, which can be mapped on a coopetition continuum (Eriksson, 2008), in which a suitable level of cooperation can be facilitated through specifying the right procurement method. Although client-contractor partnering can lead to a number of benefits among various types of clients, developers have been given scant attention in research. In particular, the developer-contractor relationship when developers are vertically integrated in little understood.

Not only is the developers' role in innovation largely ignored in the research literature, the relationship between contractors and suppliers of goods and materials in green construction has been under-investigated. Suppliers in the construction literature are split into two main categories: subcontractors and other service suppliers; and suppliers of goods and materials. There is a vast body of literature dealing with contractor-subcontractor relationships in construction projects (Hartmann *et al.*, 2008; Mbachu, 2008; Lee *et al.*, 2009; Gadde and Dubois, 2010). Despite the importance of suppliers of goods in green projects due to the green products and materials they can produce and their knowledge (Reichstein *et al.*, 2005; Pinkse and Dommisse, 2009), there still has not been much attention paid to how suppliers of goods are selected for green projects and how they collaborate with contractors when they are engaged in green projects.

Previous literature has relied on different theories to study inter-firm relationships. Several studies have used transaction cost theory (TCE) (Williamson, 1985) to study contractor-subcontractor relationships (Eccles, 1981; Brahm and Tarziján, 2014) and the relationship of contractors to goods suppliers (Bemelmans *et al.*, 2012). Another theory that can analyse

inter-firm relationships is the industrial network approach (Håkansson, 1987; Snehota and Håkansson, 1995; Ford *et al.,* 2003; Håkansson *et al.,* 2009). The present thesis draws on TCE mainly because it provides a basic model for supplier-contractor relationships, gives a first explanation for the extant state of a relationship, and predicts changes in the relationship when circumstances change. It also explains why firms choose to work with other firms in market, hybrid, or hierarchy modes, while considering the creation and development of these relationships isolated from the rest of the world. As a result, TCE explains the relationship between vertically integrated developers and contractors, which is important in relation to this thesis. When industrial network theory (Håkansson, 1987) deals with buyer-supplier relationships between firms, it considers the relationship between each firm with other firms in a network, and the external factors that shape and develop the relationships. The network issues are not where the emphasis of the present thesis lies.

Studying developer-contractor and contractor- supplier relationships in green projects is important due to the influence these relationships can have on other aspects of construction firms' business model(s). Changes in how construction firms interact with other firms and how they run their businesses imply a change in their business models. The concept of the business model has been much studied in other industries and more recently also by construction researchers, but the concept and its application is less known to construction managers (Pekuri *et al.,* 2013). A number of investigations have now dealt with business models in construction (Duyshart *et al.,* 2003; Seaden *et al.,* 2003; Brady *et al.,* 2005; Callcutt, 2007; Li *et al.,* 2008; Ekholm and Molnar, 2009; Li *et al.,* 2009; Tykkä *et al.,* 2010; Forsman *et al.,* 2012; Aho, 2013; Pekuri *et al.,* 2013; Brege *et al.,* 2014; Nasrun *et al.,* 2014; Pekuri *et al.,* 2014), but very few have dealt with green construction or building (Gibbs and O'Neill, 2014). Therefore, how construction companies can offer value to their clients and appropriate part of that value in a green construction context by changing their business models is less studied.

4. Purpose and research questions

When implementing green projects, contractors may need to change their business logic, especially with regard to others in the supply chain, and also may need to acquire new capabilities and knowledge. Besides the contractors, this thesis focuses on two types of firms that may have a crucial role in engaging in green construction: suppliers of goods and materials, as well as developer clients. The former is the manufacturer of green products and a potential source of green knowledge, due to producing tangible goods that can influence construction processes (Börjesson and Gustavsson, 2000). In addition, innovativeness of their products is more tangible and more likely to have environmental effects than service deliveries. The client initiates and funds the project and can have an influential role in supporting or vetoing greenness in projects. Here, the focus is on developer clients.

This thesis aims to understand and analyse contractors' collaboration practices with suppliers and developers in green construction projects and processes and analyse if there are differences in how contractors collaborate with suppliers and developers as a result of engaging in green construction. As already stated, this study is based on two research questions:

RQ1: How does contractor engagement in green projects influence their supplier relations?

RQ2: How is joint ownership of contractor and property developer associated with more innovative projects?

This thesis studies the role of developer clients from two perspectives: the reasons for developers' vertical integration within construction firms, and the effects of such integration on green construction projects.

5. Analytical framework

This chapter describes the theories used in this thesis. As this thesis deals with changes in contractors' business models when they engage in green construction, the concept of a business model is first discussed. In the next section, transaction cost theory (TCE) is outlined because it explains the nature of the contractual relations between contractors and their suppliers, followed by an overview of the field of supply chain management (SCM), as far as it covers the relationships among construction project participants.

5.1. Business models

The term "business model" came to broader attention during the latter half of the 1990s (Osterwalder *et al.,* 2005; Pekuri *et al.,* 2013; Pekuri *et al.,* 2014). According to Chesbrough (2010), a business model should fulfil seven functions: articulate the value proposition(s); identify a market segment; specify the revenue-generation mechanism; define the structure of the value chain required to create and distribute the offering; detail the revenue mechanism(s); estimate the cost structure and profit potential; describe the position of the firm within the value network; and formulate the competitive strategy. It draws on and integrates a variety of academic and functional disciplines (Chesbrough and Rosenbloom, 2002; Brege *et al.*, 2014), including value-chain analysis, innovation, the resource-based view (RBV), strategic network, TCE (Amit and Zott, 2001), and business strategy (Wikström *et al.*, 2010). However, as a complex whole, it still lacks a coherent theoretical grounding in economics or in business studies and has no established place in economic theory (Teece, 2010). Therefore, the concept of business model means different things to different authors.

Thus the literature shows that a business model can be defined as: a statement of how the firm produces profit (Stewart and Zhao, 2000); how a firm organises its inputs, transforms them into valuable outputs, and gets customers to pay for them (McGrath and MacMillan, 2000); how a firm depicts the design of transaction content, structure, and governance to create value by exploiting business opportunities (Amit and Zott, 2001); or even stories that explain how the enterprises work (Magretta, 2002). It can also be the method of doing business that allows the company to sustain itself through generated revenue (Chesbrough and Rosenbloom, 2002) or it describes the key components of a business (Hedman and Kalling, 2003). Finally, it explains how a firm interacts with its external stakeholders to create value for all exchange partners (Zott and Amit, 2007). Different researchers assume different elements for a business model (Chesbrough and Rosenbloom, 2002; Osterwalder *et al.*, 2005; Brege *et al.*, 2014).

A business model can focus on internal processes and infrastructure design that enables it to create value (Morris *et al.,* 2005) or it can extend beyond the entity of the firm to its customers and shareholders, and include value captured for key stakeholders (Zott *et al.*, 2011; Beattie and Smith, 2013). Although this variety in understanding has led to several definitions for business models, it is easy to claim that every successful company is built on a sound business model, whether or not that model is explicitly understood and articulated by managers and staff (Magretta, 2002; Johnson *et al.,* 2008; Teece, 2010; Pekuri *et al.,*

2013; Pekuri *et al.,* 2014). Despite the abundance of literature on business models in different industries, the business model phenomenon has been less studied in construction literature (Pekuri *et al.,* 2013; Pekuri *et al.,* 2014).

Pekuri *et al.* (2013) studied managers' understandings of the term "business model" in the Finnish construction industry and showed that the managers had no clear idea of what a business model was or what it did, so they mostly understood it as a tool for capturing value for their company through generating revenue. Lack of understanding about business models and how to change them becomes important when a construction firm needs to modify several elements of its business model as a result of engaging in green construction. The business case for sustainability is created only if economic success through voluntary social and environmental activities is achieved (Schaltegger *et al.,* 2012). Going green is not an easy task for firms, as a sustainable business model may not be economically viable at the start, even if it may become so in the future due to regulatory or other changes. True green changes require a fundamental shift in the business purpose and almost every aspect of how the business is run (Bocken *et al.,* 2014). This involves more than changing the value proposition, such as changing how business is done, so one must go beyond process and products (Amit and Zott, 2012). Changes may include how the contractors' business models are positioned vis-à-vis other firms in the industry, the supply chain, or the business ecosystem. The nature of competition depends on the choices made when designing a model (Pekuri *et al.,* 2014),

Since the concept of a business model relies on a range of theoretical grounds, an investigation of its elements might require drawing on different theories. Transaction cost economics is one of these theories, which can be used to analyse business models, mainly because a business model involves choices (such as vertical integration) about firm boundaries (Morris *et al.,* 2005).

5.2. Transaction cost economics and other theories of the firm

A central assumption in transaction cost economics (TCE) is that firms minimise transaction costs. The theory explains how partners can choose from the set of possible institutional alternatives that protects their relationship-specific investments at the lowest total cost (Shelanski and Klein, 1995). Hobbs (1996) defined transaction costs as "the costs of carrying out any exchange, whether between firms in a marketplace or a transfer of resources between stages in a vertically integrated firm, when the neoclassical assumption of perfect and costless information is relaxed." These costs can be either *ex ante* transaction costs (the costs before signing the contract, such as costs of preparing contracts and selecting other firms) or *ex post* transaction costs of signing the contract (costs that may result from monitoring and handling potential conflicts after the contract is signed).

Any transaction can be characterised by uncertainty; the frequency with which transactions recur; and the degree to which durable transaction-specific investments are incurred, leading to asset specificity (Williamson, 1979). These dimensions are aligned with three governance structures: hierarchy, hybrid and market. Hybrid modes are neither clear markets nor clear

hierarchies and are formed where there are long-term contracts or strategic alliances between independent companies (Williamson, 2008). Although asset specificity is in direct relation with opportunism, and TCE predicts that hierarchy can safeguard specific assets, in addition to hostage-taking (Stump and Heide, 1996), another way is designing and using detailed, complex contracts with suppliers. Complexity is defined as "the extent to which [outsourcing] contracts are composed of elaborate clauses" (Barthélemy and Quelin, 2006, p. 1777). Another way is through relational mechanisms, including arrangements that help build trust and social identification (Pittino and Mazzurana, 2013).

Ex-ante controls before signing a contract are incomplete (Williamson, 1979), so there is a need for subsequent monitoring (Zhu and Geng, 2001) or evaluation of supplier performance after the contract is settled and products or services are delivered (Igarashi *et al.*, 2013). Despite all this, TCE has been criticised for ignoring the interrelatedness in multiple exchanges (Griffith *et al.*, 2009); focusing mainly on problems related to opportunism and shirking behaviour; neglecting the social, institutional context in which the transaction is embedded and cooperation and personal relationships between actors (Everaert *et al.*, 2010); failing to take into account the relationship between firm-specific attributes and governance structures choices; and not taking into account the effect of firm-specific attributes on governance structures choices by incorporating firm strategy in TCE models (Wever *et al.*, 2010).

In the construction industry, the hierarchy governance mode is at one end of the spectrum and can be found in the form of a construction firm with a number of acquired subsidiaries, such as in-house architect and engineering, or in-house property developer. At the other end of this continuum is the market governance mode, in the form of traditional relationships between construction firms, such as arm's-length, short-term and adversarial relationships. The hybrid governance mode is between these two poles and consists of different types of collaborative relationships.

Madhok (2002) suggested that a firm's choice of boundaries must depend not only on the characteristics of the transactional conditions, but also on its strategic objectives, the features of its own capabilities, and the governance context it has created. Therefore, even though TCE deals with different governance modes of transactions and inter-firm relationships, it does not consider the evolutionary processes within firms or industries (Jacobides and Winter, 2005). To address changes in the boundaries of firms, such as influenced by firm diversification or (dis-)integration, TCE needs to be complemented by the capability-based view (Argyres and Zenger, 2012) which is powerful in explaining firm heterogeneity and competitive advantage as industries and technologies evolve (Kapoor and Adner, 2012). Therefore TCE and capability logic need to be combined in order to be able to explain the firms' boundary choices (Argyres and Zenger, 2012). This claim is reflected in a number of recent empirical studies showing the complementary roles of transactional and capability considerations in firm decisions (Walker and Weber, 1984; Poppo and Zenger, 1998; Schilling and Steensma, 2001; Afuah, 2001; Hoetker, 2005).

5.3. Supply chain management

Numerous attempts have been made to define supply chain management (SCM) (see e.g. Stevens, 1989; Cooper *et al.*, 1997; Lee and Ng, 1997; Christopher, 1999; Handfield and Nichols, 1999; Mentzer *et al.*, 2001; Simchi-Levi, 2005; Lambert, 2006; Seuring and Müller, 2008; Stadtler, 2008). However the application of SCM also varies depending on the definition. Croom *et al.* (2000) saw SCM as applying both for internal matters of a company or externally between companies; as a substitution for vertical integration, and also for identifying and describing the relationship a company develops with its suppliers. For Vrijhoef and Koskela (2000), SCM means managing the interdependency in the supply chain and integration of business processes, whereas Ofori (2000) considered the supply chain as a unit in itself that can compete against other supply chains, with the customer as the only source of income for all members of the chain. As Giannakis *et al.* (2004) noted, all of the definitions of SCM refer to the management of operations across organisational boundaries. Therefore, SCM can be defined as: "the task of integrating organizational units along a supply chain and coordinating material, information and financial flows in order to fulfil (ultimate) customer demands with the aim of improving the competitiveness of a supply chain as a whole" (Stadtler, 2008, p.11).

Supply chain management contributes to company performance improvement (Aloini *et al.*, 2012), and has established itself as a source of competitive advantage (Burgess, 1998). Many leading companies have realised that the real competition is not between individual companies, but between supply chains (Christopher, 1992). While SCM originated and flourished in the manufacturing industry and in the field of quality control (Harland, 1996; Vrijhoef and Koskela, 2000), it has evolved based on a series of fragmented technical disciplines and their functional groupings (Ofori, 2000; Giannakis *et al.*, 2004). It has developed and been informed by four theories: system theory, TCE, game theory, and inter-organisational relationships and industrial network theory. This implies that SCM is not a theory itself, but a field of theorisation (Giannakis *et al.*, 2004).

SCM lies somewhere between transactional-type relationships and acquisition and assumes a variety of economic organisational forms (Ellram, 1991). Consequently, there are opportunities within the Operations Management (OM) discipline for evaluating many supply-chain-management-related issues from the TCE perspective (Grover and Malhotra, 2003). While TCE tends to focus on individual contractual relationships, the SCM introduces a broader systems perspective and tries to understand many interdependent relationships as the unit of analysis (London and Kenley, 2001; Williamson, 2008).

In the construction sector, however, it can be difficult to apply SCM models that have been developed for other industries (Akintoye *et al.*, 2000; Love *et al.*, 2004; Bankvall *et al.*, 2010; Lönngren *et al.*, 2010). Consequently, the adoption of SCM in the construction industry has been scattered and partial (Gadde and Dubois, 2010). Aloini *et al.* (2012) associated the difficulties in SCM application in construction with the construction–specific context of temporary multiple organisation, the difficulties in managing networks of a large number of

involved firms, supplying materials, components and multiple services. Most of the work in the construction industry is done by suppliers and subcontractors, and only a small part by the main contractor (Dubois and Gadde, 2000; Segerstedt and Olofsson, 2010). The construction industry is still fragmented and characterised by adversarial relationships (Aloini *et al.*, 2012) and it is believed that the lack of communication and coordination between project participants leads to low productivity in the construction supply chain (Love *et al.*, 2004; Bankvall *et al.*, 2010). Thus, there has been increased interest among SCM approaches in understanding and characterising the problems and in suggesting solutions to improve the coordination of the often many subcontractors and suppliers in the construction supply chain, in an attempt to mitigate its internal and external inefficiencies (Segerstedt and Olofsson, 2010; Aloini *et al.*, 2012).

Many researchers have sought to remove adversarial inter-organisational purchaser-supplier relationships in construction and its fragmented business processes (Saad *et al.*, 2002; Gadde and Dubois, 2010; Aloini *et al.*, 2012). Basically, suggestions have been made to change the methods in managing the supply chain (Agapiou *et al.*, 1998) so that a fundamental shift in the management of relationships between participants will improve the efficiency and effectiveness of construction supply chains (Fearne and Fowler, 2006). It has also been said that the adopting firms should properly manage managerial, organisational, relational, and technological issues in order to effectively apply SCM principles, models, and techniques and to overcome the barriers to construction supply chain application (Palaneeswaran *et al.*, 2003). Accordingly, more integration between different participants in construction projects has been recommended (London and Kenley, 2001; Love *et al.*, 2004; Briscoe and Dainty, 2005; Bankvall *et al.*, 2010), despite the difficulties that result from the discontinuity of demand for projects, the uniqueness of each project, and the complexity of each project in terms of the number of actors involved (Skaates *et al.*, 2002).

Since the focus of this thesis is the relationships between different firms in a supply chain, I have made frequent references to the SCM literature. From a supply chain perspective, the implementation of green construction (building) depends on collaboration between different participants of a construction project. Many of the studies dealing with supply chain collaborations in innovative construction projects have centred their arguments on supply chain integration in both traditional relationship and partnering relationships (e.g. Akintoye *et al.*, 2000; Black *et al.*, 2000; Matthews *et al.*, 2000; Maqsood and Akintoye, 2002; Cheung *et al.*, 2003; Eom *et al.*, 2008; Eriksson *et al.*, 2008; Bemelmans *et al.*, 2013).

6. Research approach and design

6.1. Background, processes and methods

There are a number of reasons why the construction industry is worth studying. It is a major source of employment in most economies. It has also a major negative impact on the environment by consuming energy and materials and also producing high volumes of non-recyclable and hazardous materials and wastes. In addition, the industry is project-based and fragmented, consisting of many different companies with different objectives working with each other in a project and disbanding after the project is completed. Having this in mind, in recent years many Swedish construction companies have put efforts into becoming more environmentally friendly by focusing on green projects. The move towards green construction has attracted a great deal of attention, both in research and in practice in Sweden. Although a good deal is known about green construction in general, the relationship between different firms in green projects is much less studied and suffers from a lack of empirical data.

Consequently, an exploratory and mainly qualitative research strategy was chosen for this thesis. Except for the first paper, which combines qualitative and quantitative methods, this thesis is based on qualitative methods, which are appropriate for both understanding and generating theory (Eisenhardt, 1989; Flick, 2006; Bryman and Bell, 2007). The first paper is based on a systematic literature review, but all the empirical data collected for this thesis result from semi-structured interviews, as this type of interview allows interviewees to express their opinions and thoughts. I finish the thesis by contributing towards general statements about the changes in supplier selection process, contractor-supplier and internal developer-contractor relationships in green projects.

Engaging in green construction requires changes in the processes and products (Kibert, 2012). Consequently, changes are expected in the business models of contractors because the business model explains the logic of doing the business. Despite the lack of empirical studies that have explicitly identified the changes in construction companies' business models, many studies appeared to have dealt implicitly with changes resulting from adopting green construction. This was a good starting point for this thesis, as reviewing earlier studies that have addressed changes resulting from adopting green construction could serve as a basis for interpreting what changes have actually taken place in contractors' business models.

A systematic review of the extant literature on green construction was chosen as the method for Paper I, as such an exercise can clarify what has already been done in this area and highlight opportunities for future research (Hart, 1998). Paper I investigates how engagement of green construction affects the contractor company's business model by conducting a systematic literature review of articles and books that have dealt with green construction. It identifies the most important changes resulting from green construction and infers changes in business model elements of a construction company. Moreover, it investigates whether there are interdependencies between the business model changes. Paper I provides a foundation for the entire thesis, as its results show the direction for the other four papers.

Drawing on the findings from Paper I, Paper II investigates an important interdependency between two business model elements shown in Paper I, namely the relationship between capability element and partner network of the contractor company's business model. Paper II deals with how the perception of contractors of their goods and materials suppliers' green knowledge affects their decisions in the supplier selection process. Here the term *perception* is used, as the only source of data collection was interviews with staff in the contractor companies. Suppliers of goods and materials were chosen as they are providers of knowledge to the construction industry and produce products that are more tangibly 'green' than service products. The initial aim of Paper II was to capture opinions of both the Swedish contractors and their suppliers of goods and materials about the supplier selection in green projects. However, the people who were contacted in supplier companies originally agreed to take part in interviews but subsequently cancelled. This could have been due to sensitivity about the subject in question or because of language.

Potential interviewees in the contractor companies were contacted between November 2011 and June 2013. The data collection took a long time because of difficulties reaching people. Many potential interviewees were reluctant to participate in the interviews because they were conducted in English. However, interviewees were more willing to take part in the interviews for Paper III and also Paper IV thanks to the trust built between them and the interviewer. Despite the fact that most interviewees had a good level of English proficiency, some misunderstandings did occur between the interviewer and interviewees. Sometimes the interviewees could not properly comprehend or answer the questions. Consequently, follow-up calls for clarification were often made.

Since the perception of the staff at the contractor company was the focus of Paper II, exploratory semi-structured interviews were conducted to collect data. A retrospective study method was used as it allows the perspective on the processes that are analysed to be extracted from the view of interviewees (Flick, 2006). Semi-structured interviews were used as they are appropriate in situations where the perceptions and opinions of the interviewees are needed (Flick, 2006; Bryman and Bell, 2007). The interviewees in the contractor companies were asked about their opinions about the green projects with regard to their suppliers over the past three years. The results from this study showed that the three Swedish contractors would rather work with their suppliers of goods and materials in a partnering and long-term relationship. Although the contractors mentioned their own reasons why they prefer such a work setting with their suppliers of goods and materials, we were interested in finding out how the Swedish contractors, after selecting their suppliers of goods and materials, work with them in green projects. This led to Paper III.

Once the interviews had been conducted in the contractor companies for Paper II, it was possible to continue with the process of contacting other people in these companies. Some interviewees from Paper II were selected for Paper III as well. They were also asked to nominate other colleagues within their company who were relevant for Paper III and, due to their direct contacts with suppliers, were asked to nominate a number of goods suppliers. As was the case for Paper II, a number of the people in goods supplier companies were unwilling

to take part in interviews for Paper III, although some others did agree. Consequently, the number of interviewees in the supplier companies was rather low.

The research design in Paper III was basically the same as that in Paper II. Data were gathered from a set of semi-structured interviews with both the Swedish contractors and their suppliers of goods and materials between September 2013 and February 2014. One of the main difficulties with collecting data for Paper III was the nature of the interview questions. Paper III used transaction cost economics as its theoretical framework, which meant that the interview questions had to be designed in a way that maintained simplicity in the language and format of questions but also represented the concepts of TCE. Language was a barrier, as it had been in Paper II, so there was a risk that the questions would be misunderstood. These difficulties led to some ambiguities being found in the results after the data had been collected. Consequently a set of follow-up questions was designed and used for interviews with seven employees in the contractor companies, which were intended to resolve the ambiguities and were conducted in June and July 2014. None of the interviewees in the supplier companies agreed to take part in the follow-up interviews. TCE allowed us to understand why contractors prefer close relationships with their suppliers of goods and materials for green projects. However, we found that in green projects, opportunism is less of a challenge than misunderstandings and errors concerning green requirements. Therefore, relational capabilities as a specific asset was our main explanation why both interviewees in contractor companies and suppliers preferred to work on a long-term and repeated basis, reducing transaction costs such as the costs of searching for new suppliers, of preparing documentation, and of monitoring and conflict resolution.

Apart from the importance of the close relationships between contractors and their suppliers in both Paper II and Paper III, another obvious point derived from both papers was the importance of clients in green projects. This was something that failed to emerge in Paper I. Therefore, the focus shifted to clients and their relationships with contractors in green projects.

The main focus in Paper IV was at first to study clients as an important source of knowledge for green construction as they formulate their project requirements to contractors. Although the effects of closer relationships between clients and contractors in projects have been well-studied in the literature, it was necessary to identify any particular effects of this relationship in green projects. While the idea for Paper IV was evolving, we learned that one of the large contractors that had been interviewed for Papers II and III had its own vertically integrated developer; this presented an opportunity to ‘kill two birds with one stone’. Paper IV attempts to shed light on the role that vertically integrated developers play in greening construction projects. Accordingly, Paper IV is based on our findings from the previous papers and asks how vertically integrated developers affect greening construction projects.

In Paper IV, the single case-study method was used (Flick, 2006), as this is an appropriate method for ‘how’ and ‘why’ questions, especially in examining contemporary events and when the relevant behaviour cannot be manipulated (Yin, 2014). A drawback of the single

case study method is the problem of generalisability (Flick, 2006; Bryman and Bell, 2007; Yin, 2014). Data were collected in several ways in order to triangulate. First, semi-structured interviews were conducted with both the vertically integrated (internal) developer and the contractor company, supplemented by data from the group website, annual reports and internal documents. In addition, one of the researchers was present at the company two days a week for a period of nine months to ensure access to data and direct contact to people. Having direct day-to-day contact with people in both companies who were located in the same building, as well as conducting two rounds of interviews with people in the contractor company (Paper II and Paper III), made it easier to convince people to be interviewed.

Most interviewees in the internal developer company had several years of experience in property development, whereas the interviewees in the contractor company had only a few years of experience in their jobs, at most. The interviewees in the internal developer company were asked about how they worked as developers, and how they interacted with the contractor. The contractor interviewees also were asked about their method of collaboration with the internal developer, the advantages of working with the internal developer, and how working with them affects innovation in their projects.

Three issues should be considered with regard to the methods used to collect data in this thesis. First, although green construction is currently popular among many construction firms, and many of them are either engaged or are planning to engage in it, there is still a risk of green-washing by companies, which can affect the results. Second the issue of conflicts between contractor and suppliers discussed in Papers II and III can also be biased as the interviewees can potentially underestimate the conflicts. Third, the method by which suppliers are nominated by contractors in Paper III can also be a source of bias. The interviewees in the contractor companies can choose suppliers they are more familiar with, have better relationships with or even find more suitable for interviews in favour of their company.

Table 1 gives an overview of the research method, the data collection method and the unit of analysis for each of the five papers included in this thesis.

Table 1. Methods used in the five papers

Paper	Research method	Data collection method	Unit of analysis
I	Exploratory, inductive, combination of qualitative and quantitative	Systematic literature review by Scopus database	Model elements
II	Qualitative, exploratory, inductive, retrospective	Standardized semi-structure interviews with three Swedish contractors	Contractor-supplier relationships
III	Qualitative, exploratory, inductive, retrospective	Standardized semi-structure interviews with three Swedish contractors and four goods suppliers	Contractor-supplier relationships
IV	Qualitative, case-study, explanatory, inductive	Standardized semi-structure interviews with one Swedish contractor and its internal developer, internal documents, annual reports, trade magazines	The vertically-integrated developer firm
V	Conceptual	Literature review	The vertically-integrated developer firm

6.2. Paper I

This paper aims to understand and analyse the changes in the business models of contractor companies when they adopt green construction, and to identify whether there are any interdependencies between the changes. This paper is based on both quantitative and qualitative research methods, with the Scopus database used for the systematic literature review. This review, specifically of the literature that has implicitly addressed the changes of construction firms' business models, enables us to analyse features of the business models of green construction. MacInnis (2011) judged the comprehensiveness of a literature review paper in terms of the sources it examines and Randolph (2009) noted the importance of two different researchers choosing essentially the same papers when selecting which sources to include in a literature review. Thus, the quantitative approach was implemented by setting the search parameters such as cut-off dates and the inclusion or exclusion of different subjects in the Scopus database, aiming at only peer-reviewed or reviews that have been cited at least three times, and did not deal with only finished products (green building).

To overcome limitations of Scopus as a database, three relevant books that are extensively used in the field of construction were added. Finally, we also added papers that were deemed to be relevant despite not (yet) fitting the criteria above. Despite all this, Paper I could not project thoroughly all the changes in business models. This could be due to exclusion of some subject areas that could potentially be relevant, or to the fact that the target customer (client) does not change much between green and conventional projects, but the relationship between the client and the contractor could. Although this paper could not identify the changes in the target customer element in business model, the results of Paper IV indicate that the results gained in Paper I related to target customers are rather incomplete than necessarily incorrect.

6.3. Data collection for Papers II, III, and IV

The exploratory method was used in three out of five papers in this thesis – Papers II, III and IV – and data were collected through use of semi-structured interviews, as these allow new insights and understanding to emerge during and between the interviews. A common feature of these three papers is that the Swedish contractors were interviewed. In Papers II and III, staff of three Swedish contractors were selected and interviewed based on two factors: the size of the company and its involvement in green projects. The size of the companies mattered as it was assumed that the larger the companies, the more they would be involved in green projects (e.g. Drejer and Vinding, 2006). The three selected contractors dominate the Swedish construction industry. The first company is internationally active in Europe, North America and Latin America. The second company, although active internationally, is mainly focused on Scandinavia. The third company is also active in Scandinavia but on a smaller scale than the other two. Although the Swedish contractors are involved and active in the field of green construction (Gluch *et al.*, 2009), we checked their websites and Swedish construction magazines for green projects during the last three years in order to ensure that the selected companies had not just been selected for their size and were truly active in green projects. Over the last three years, all three companies have had (and continue to have) ongoing green projects. The three-year time span was considered because the interviewees might have found it difficult to remember facts and events from far in the past. In Papers II and Paper III, the interviewees in the contractor companies were selected based on the functions that had most contacts with suppliers and knew about contractor-supplier relationships, due to the nature of the interview questions. Therefore, the interviewees came from a variety of departments: procurement, environmental, business, project and technical.

Unlike in Paper II, only staff from the procurement, environmental, and project departments in the three contractors were interviewed in Paper III; four of their suppliers were also chosen for interviews as well. Although the problem of reaching goods suppliers in Paper III was largely solved compared to Paper II, the number of staff members who agreed to take part in interviews was still low, mainly due to the language barrier, as the interviews in the three papers were all held in English. To identify these four suppliers for Paper III, the contractors were first asked to name a few suppliers of goods and materials they have worked with in green projects during the past three years. The interviewees in the contractor companies were

then asked how they ranked suppliers based on the importance of green goods and materials they produce, which resulted in four suppliers.

In Paper IV, only one of the contractors interviewed for Paper II and III was selected and combined with interviews with a developer belonging to the same construction group. This can be understood as a single-case study (Yin, 2004; Flick, 2006). In Paper IV, the presence of the interviewer in the office building shared by the companies helped gaining access to people in both companies whenever required. The interviewees in the contractor company were selected based on their familiarity with green projects and their ties to the internal developer company. To select the interviewees in the internal developer company, the people who were involved in the commercial department of the internal developers were contacted and all took part in the interviews.

The data in the three papers were collected using a standardised semi-structured interview guide. One interviewer conducted, recorded and transcribed the interviews for both papers and took notes whenever an interesting or unexpected issue emerged. Most interviews in Papers II and III were conducted by telephone, whereas all of the interviews in Paper IV were face-to-face and were supplemented by direct observation, some internal documents (limited access), and reviews of website, magazines and annual reports of the case company. Interviews lasted an average of between 30 and 60 minutes. The recorded interviews were then transcribed for further analyses. Follow-up calls were made whenever an ambiguity arose. As Table 2 shows, interviews for Paper III were held with a variety of employees belonging to various organisational functions, including both contractors and suppliers.

Table 2. Interviewees in companies according to their functions (Paper III)

Company	Procurement	Environmental	Business	Project	Technical
Contractor A	8	3	-	3	-
Contractor B	-	1	-		-
Contractor C	-	3	-	1	-
Supplier D	-	-	-	-	1
Supplier E	-	-	2	-	1
Supplier F	-	-	2	-	-
Supplier G	-	-	1	-	-

7. Summaries of appended papers

7.1. Paper I

Title: Business model changes and green construction processes

Paper I proposes a generic business model for contractor companies adopting green construction, based on a systematic literature review of 35 articles and three books. This paper starts with the origins of green construction and its drivers and goes on to explain how changes in the routines and process might affect the business logic of construction firms involved in green construction. This paper infers changes in business model elements through a systematic literature review of the articles and books that have touched upon the changes and shows that adoption of green construction does not necessarily affect a few business model elements directly related to the construction activities, but also can also affect other elements. However some elements are substantially affected by green construction more than other elements. The paper also shows that there are interdependencies between different elements, which means that a change in one element in a business model can bring changes to other elements too. According to the results, the elements that are expected to be most affected by undertaking green construction are those that deal with arrangement of activities and resources, cost structure, capability and partner networks. Another finding was that the literature suggests that certain business models elements change simultaneously when a construction firm implements green construction, including the capability and partner network of the construction firm. The paper concludes that the findings can be generalised to other heavy project industries as they also follow similar characteristics.

7.2. Paper II

Title: How do contractors select suppliers for greener construction projects?

Paper II relies on the findings from Paper I and argues that implementation of green construction may require a new set of knowledge, and capability in general, which can be gained through contractors' collaborations with their suppliers of goods and materials in their partner network. The paper continues with a literature review that compares the differences between procurement methods in conventional and green construction projects, and also compares knowledge exchange between those two types of projects. This paper is based on a set of semi-structured interviews with three large Swedish contractors regarding how they select their suppliers of goods and materials for green projects.

The analysis of the data collected shows that although green and conventional projects differ in certain ways, the supplier selection methods that the Swedish contractors use for green projects are not substantially different from those that they use for conventional construction. In addition, the three contractors often use the same suppliers but in a partnering setting, where the knowledge exchange with suppliers is easier due to more trust and commitment in the partnering relationship. We also found that client pressure is an important motivation for

the entire supply chain to pursue and apply green initiatives for the three Swedish contractors. We also found that the contractors perceive the barriers to forming supply-chain relationships as being a lack of interest in, or low importance given to green; a lack of green knowledge; and an unwillingness on the part of their clients to pay the higher costs of green.

Therefore, monitoring costs can be reduced by initial screening and qualification of an exchange partner. In other words, the complexity is positively related to the level of environmental uncertainty, asset specificity and ex-post costs.

7.3. Paper III

Title: Greener construction projects: Contractor relations to suppliers

Paper III continues what was studied in Papers I and II. In Paper I the relationship between capability and partner network in a generic business model of contractor companies was identified. This led to Paper II, which studied how three large Swedish contractors select their knowledgeable suppliers of goods and materials for green projects. Paper III deals with how the three large Swedish contractors and their suppliers of goods and materials collaborate in green projects. The study was based on a set of semi-structured interviews with 19 people in three large Swedish contractors and seven people from their suppliers of goods and materials.

The paper uses the relationship between the three Swedish contractors and their suppliers of goods and materials as a unit of analysis. TCE theory is used to analyse the results, as this enabled us to explain why contractors select suppliers for forming a long-term relationship and to identify the benefits of such a relationship. Paper III shows that, apart from including certain green requirements, contracts for green and conventional construction projects are not substantially different for the three Swedish contractors and for their suppliers of goods and materials. However, the contracts were found to be more complex to the contractors than to the suppliers, mainly because of the suppliers' failure to deliver according to requirements. This paper shows that supplier failures are potential sources of conflicts with contractors and, together with switching costs, will increase the ex-post costs for contractors. In green projects, opportunism is less of a challenge than misunderstandings and errors concerning green requirements.

Moreover, we found that the human asset specificity of corresponding to relational capabilities is much higher than suppliers' technical knowledge of particular green solutions. Therefore, relational capabilities strengthen the contracts between contractors and their suppliers so that contracts and relational adaptation were found to be two ways to prevent the other party from behaving opportunistically. Relational capabilities as a specific asset is the principal explanation why interviewees in both the contractor companies and the suppliers preferred to work on a long-term and repeated basis, reducing such transaction costs as costs of searching for new suppliers, preparing documentation, monitoring and conflict resolution.

7.4. Paper IV

Title: Innovation and developer integration in a construction group

Paper IV aims to analyse an integrated developer's role within a construction group and how it affects construction innovation. Clients may foster innovation by novel demands but most construction clients are risk averse because of the high technological uncertainty and durability associated with physical buildings. One type of client is the developer who procures regularly and is involved in construction processes from buying land to selling the property. Most developers are external to contractors, but a specific type of developers is the internal developer, which is wholly owned by a corporate group including a construction firm or by the contractor itself. While both the market and hybrid governance structures of clients and contractors have received much attention, the vertical integration governance structure of developers and contractors has been less treated by researchers, especially with regard to innovation.

The paper is based on a case study of a vertically-integrated construction property developer (DevInt), a business unit of a large Swedish construction group. Nineteen face-to-face semi-structured interviews have been held with employees of a developer firm and a contractor firm. To ensure construct validity and reliability, the interview findings were supported with internal documents and public information from the group website and the group annual reports, and by follow-up interviews by the principal investigator. The results show that with increasing client demands for green properties, by being entirely devoted to green construction, DevInt develops more green properties and generates a more regular flow of green projects for the internal contractor. This suggests that integrating contractor and developer activities within the corporate group safeguards continuity in project flow, which is important financially and for both expansion and preservation of capabilities. Additionally, external market positions within the segment for green construction are strengthened.

From a transaction cost perspective, the integration of DevInt is strategically meaningful because transaction costs are high between external developers and a contractor, making project coordination difficult. Integration also appears meaningful in from a capability based view of the firm, where the firm has - or intends to create - comparatively superior capabilities required for future business.

7.5. Paper V

Title: Construction innovation through internal developers

The aim of Paper V is to explain why property developers internal to construction firms are created, especially why construction firms that face opportunities for more than incremental technological innovations may choose to integrate and coordinate developers and contractors. Clients are mostly unwilling to test more innovative technologies as construction innovation is characterised by high technological and market uncertainty, durable goods and sunk costs.

In order to convince clients to procure non-trivial construction innovations, alternative modes of transmitting costly signals, relying on standards or partnerships, are weak as they are more appropriate for incremental innovation. In contrast, an internal client by owning and operating the property for some time would mitigate technological uncertainty and moral hazard for external clients.

The paper analyses the scope of the construction firm from three perspectives: market size and the Youngian division of labour, transaction costs economics and the capabilities based view of the firm as recent theorizing shows that no single theory can explain why firms move downstream. The explanation is here that integration allows the contractor to work continuously with innovative projects to develop new capabilities, which in turn allow the construction firm to signal proficiency to the market, employees and the investment community. In a sense, the internal developer acts as a marketing department with an internal and commercially oriented R&D laboratory. By coordinating developer activities with the contractor, the contractor's capabilities are developed but this requires the internal developer to be specialized, as integration only through joint ownership will not provide sufficient coordination between the internal developer and the contractor.

A question is why the creation of internal developers as innovation engines has appeared only recently. The paper suggests that there are two explanations: latent demands for greener buildings and an increased ability to use routines able to handle more systemic innovations. One limitation of the analysis is that it does not investigate how internal developers as an organizational arrangement is sensitive to risk such as arising from major shifts in demand and financial crises.

8. Discussion

The application of different principles in green projects means that a contractor might need to change how it works, how it relates to other firms in supply chain, and how it profits from adopting and adapting green projects. As stated in the introduction, the aim of this thesis is to understand and analyse contractors' collaboration practices with suppliers and developers in green construction projects and processes, and to analyse whether there are differences in how contractors collaborate with clients and developers as a result of engaging in green construction. This chapter consists of two sections and discusses the papers and their findings in light of the two research questions.

8.1. Influence of contractor engagement in green projects on the contractors' supplier relations

Green construction is now practised among many construction firms, in the sense that construction firms have adopted and adapted green principles and technologies in their processes and products. One issue is whether and how firms involved in green construction have changed their business models in order to create value for customers and achieve profits for themselves. Introducing innovation in construction projects in the form of green construction may require the contractor to make changes to its business model. Devising a new business model is necessary to profit from an innovation, either when a company innovates its products or processes or when the technology cannot successfully employ the established business model (Björkdahl, 2009). This suggests that the rate of contractor engagement in green construction is affected by the way that the contractor's business model is innovated and to what extent. Failure to devise an appropriate business model will result in the technology failing to yield its full potential to, or the withdrawal of the firm from commitment to a potential technology or from the market (Chesbrough and Rosenbloom, 2002). Although a business model is the logic of doing business (Magretta, 2002), it may be the case that managers of contractor companies do not have a clear idea of what a business model is and what it does (Pekuri *et al.*, 2013).

Innovation in a contractor's business model implies changes in its business model elements. Mapping the results of the review of green literature onto the business model elements suggested by Osterwalder *et al.* (2005) shows that three business model elements are the most changed or the most difficult to change when contractors engage in green construction. These are the firms' value configuration, which describes the arrangement of activities and resources; the partner network, which refers to the network of cooperation with other firms; and capability, which is the competencies necessary to run the company's business model. Changes in any of these elements will bring about changes in the two other elements.

The activities and resources needed for green projects might be different from those of conventional construction (Kibert, 2012). Differences in activities and resources used in green construction will depend on how green the project is, so that activities and resources might

not be substantially different from conventional construction, if the process is only meeting minimum green criteria.

Even the least green projects might require application of resources that differ more or less from those of conventional construction, and which the contractor might not have access to in-house, forcing it to draw on other firms' resources. These resources can be either physical, such as equipment, or intangible, such as capability or knowledge required for green construction. Green construction may need a type of knowledge (Williams and Dair, 2007) that the contractor lacks, which will force it to rely on other firms for green knowledge. Although a contractor may choose to acquire specialised green knowledge using consultancy services independently of particular construction projects, it is reasonable to believe that they will rely on other firms' knowledge within projects, mainly because accomplishment of an innovative project requires collaboration between firms within the company' partner network (Drejer and Vinding, 2006). However, adding green to a standard construction project typically leads to rearrangement of the roles and relationships among the various actors (Hoffman and Henn, 2008). Therefore, the traditional way of working in projects, characterised by arms'-length, short-term, adversarial relationships (Sarhan and Fox, 2013; Fulford and Standing, 2014), is expected to change to a more integrated type of collaboration based on trust, commitment, and shared objectives. These factors enable firms to share their knowledge (Gadde and Dubois, 2010) and improvements, not only in the areas of only sustainability but also dispute resolution, cost reduction, and innovation (Chan *et al.*, 2003b; Eriksson, 2010).

This is important since a contractor that is engaged in green projects needs to collaborate with green goods suppliers and other suppliers that can act as sources of knowledge (Pinkse and Dommisse, 2009). Changes in contractor-supplier relationships allow knowledge sharing between both parties. Nonetheless, the changes in relationships might not occur easily and are partly determined by changes in how the contractor selects suppliers for a single project or a family of projects. For green construction, the relationship between contractors and their suppliers is probably more dependent on trust and common objectives in projects than in conventional construction. Thus, it is expected that the contractor selecting goods suppliers has a sound understanding of green construction in order to select those suppliers that are capable of delivering both relevant knowledge and the required goods and materials.

However, the results of this thesis do not show substantial differences between supplier selection methods for green and conventional projects and, as expected, the interviewees were unable to define more precisely what green construction is and how it is distinguished from conventional projects. Indeed, an important finding of this thesis is that contractors work according to a relative view of what green construction is; that is, both that projects are to be greener today than they used to be and also that what is currently considered to be deep green may considered to be conventional construction in the future. This explains the uncertainty about what exactly green is in the eyes of the contractor interviewees.

Throughout this thesis, green construction is viewed as a relative concept rather than as an absolute and objective entity. This means that the degree to which a green change is

introduced in one project compared to earlier projects determines the level of greenness rather than being defined according to fixed normative criteria. From a relative perspective, a green change to a construction project can be stipulated as being more environmentally friendly compared to what is thought of as a similar but conventional construction project at a given point of time. There are two problems with viewing green construction from a relative or comparative perspective. First, although the uniqueness of construction projects should not be overstated, as in practice it tends not to be a dominating concern for construction firms (Håkansson and Ingemansson, 2013), there are always some differences between construction projects. That is, construction projects tend to be unique, at least in some aspects, even if techniques or processes are reused and the applied principles and contracted suppliers are the same. Therefore, comparing two projects means that determining which one is greener depends on their contexts. Second, due to the relativity of greenness, a green project today might not be a green project in the future, as changes associated with green construction, reflected in routines, materials use, energy consumption, etc., diffuse into other projects in the industry.

The contractors' use of almost identical procedures for selecting their suppliers in green and conventional projects can indicate their desire to retain knowledge accumulated in previous projects by continuing to use the same suppliers, and also reflect influences from other parts of their organisations or requirements from clients. Although partnering has been studied primarily in client-contractor relationships, the results of this thesis confirm that contractors engaged in green projects select and retain important suppliers for partnering relationships. Since partnering is a type of close relationship that is characterised by mutual trust, it can reduce the risk of receiving obsolete knowledge from suppliers, allow contractors to have a smaller supplier base and reduce the transaction costs resulting from negotiation and frequent selection of suppliers for different green projects. The results of the thesis suggest that the contractors evaluate their experiences of supplier capabilities when selecting suppliers, and may ask other construction firms that have worked with them before about suppliers' adherence to tender specifications. They may also rely on assessments made by the contractor's environmental and purchasing functions, in addition to negotiations and interviews. For the contractor, these procedures are intended to ensure two things: (1) that the selected suppliers are reliable and can deliver what they have promised; and (2) that the suppliers are generally trustworthy for a partnering relationship.

Despite the similarity of supplier selection for green and conventional projects according to most aspects discussed in the present study, there is one important difference: a number of green requirements that raise the degree of contractual complexity are stipulated in the documentation. Both contractors and suppliers perceive contracts for green projects as complex, but in different ways. Contractors find them cumbersome to handle because they need to manage a great number of suppliers and subcontractors. Suppliers find the contracts to be more of a burden because of the difficulty in complying with the additional requirements specified by contractors.

When including green requirements in the contracts as an *ex ante* control, the complexity of the contracts for both contractors and suppliers raises the issue of monitoring, as well as how contractors can avoid conflicts arising from suppliers' opportunism, which increases the *ex post* costs. Contractors can rely on various mechanisms to prevent the other party from behaving opportunistically, such as 'taking hostages' where one party has access to the specific investment of the other party (Stump and Heide, 1996). However, the findings of the present study show that both parties perceive knowledge and human resources (and not property-based assets) as the two most important assets in their relationship in green projects. In addition, contractors and suppliers are both prone to softer, less formal ways of *ex post* controls through complementing the relational governance mechanisms with formal governance mechanisms. In particular, relational governance mechanisms are better for handling knowledge-based properties (Hoetker and Mellewigt, 2009) and, when combined with formal governance mechanisms, are more efficient and reduce the probability of opportunism (Schepker *et al.*, 2013). This point indicates that contractors in green projects primarily focus on relying on and acquiring their suppliers' knowledge and preventing suppliers from misunderstanding the requirements and from failing to meet them. It also raises an issue that is not covered by the set of concepts belonging to the theory of transaction costs economics: incompetence and failures in meeting requirements by suppliers as a source of conflict in projects.

8.2. Effects of joint ownership of contractor and property developers for more innovative projects

The goods suppliers are not the only firms within the contractor's partner network that the contractor must collaborate with when engaged in green projects. The target customer element of business models, the one that describes the segment of clients or customers the contractor wishes to offer its services to, has not been evident as an object of major changes according to the initial literature review. Nonetheless, the interview results suggest that clients can have influential roles in green projects. However the importance of clients was weakly represented in the publications that were identified in the first study, probably because the target customer (client) for both green and conventional projects where viewed in the literature as basically the same.

Clients can affect the products and processes of construction projects through their demands and support (Seaden and Manseau, 2001; Varnäs *et al.*, 2009; Qi *et al.*, 2010; Gambatese and Hallowell, 2011), as they are often initiators, funders, and final owners of the project (Boyd and Chinyio, 2008). This implies that contractors engaging in green construction must create and maintain good relations with the client. In addition, clients can support or veto innovations introduced in projects (Ivory, 2005). The term 'client' can include almost any individual or firm or other type of organisation that provides funds and owns the project. Therefore, clients' level of understanding and acquaintance with the relevant construction processes varies greatly. Consequently, depending on the type of clients, their effect on innovation can also vary. Certain types of clients can play a prominent role in innovation

(McCoy *et al.*, 2009) if they as clients (for example, developers) are familiar with construction processes.

It is not only the type of client that affects innovation in projects, but also how clients interact with and are related to contractors. The traditional client-contractor relationship, like most other inter-firm relationships in construction projects, suffers from short-termism and adversarial relationships (Sarhan and Fox, 2013). Therefore, this type of relationship has been held responsible for inefficiencies and a lack of innovation in construction projects (Dubois and Gadde, 2002). Although the remedy for these inefficiencies was partly found in a more integrated relationship between clients and contractors (such as partnering) (Gadde and Dubois, 2010), the results of this thesis suggest that, for engaging seriously in green construction, a higher degree of vertical integration between developer and contractor may be necessary.

The results show that a vertically integrated developer, combined with an innovative business model and partnering with the contractor, can be beneficial for a construction group in at least three different ways: (1) cash flow internalisation, (2) continuous flow of green projects, and (3) knowledge transfer and knowledge integration. The business model of the vertically integrated developer has been devised in a way that the part of revenues earned from developing green properties circulates within the construction group and the contractor. This strengthens the contracting group financially and also, due to the partnering between the vertically integrated developer and the contractor, facilitates knowledge sharing and retention. Moreover, a vertically integrated developer that is focused on green projects and its financial power is capable of generating a continuous flow of green projects, which can enhance the contractor's capability in green construction projects.

From a business model perspective, it can be seen that the collaboration between the vertically integrated developer (as a firm within the contractor's partner network) and the contractor affects the way in which resources and activities are arranged and also the capability of the contractor. Although most construction clients are risk-averse (Drejer and Vinding, 2006; McCoy *et al.*, 2009), the results of the present thesis suggest that the risk of engaging in green construction can be reduced greatly by the vertically integrated developer's business model, which allows circulation of the cash within the construction group, and by the fact that the immediate market risk is reduced for particular projects. As with many innovative products, the market risk of green buildings is high. The immediate market risk arises at least partly from external clients who are hesitant to invest when they face uncertainty regarding the long-term properties of green buildings. By having a vertically integrated developer who owns these properties for a period of time, the construction group may signal to prospective tenants, clients and property investors that the risk associated with complex and systemic innovations related to green technologies is low. It is in line with this policy that the properties remain in group ownership and are first leased for a few years and then sold after presenting clear indications that the systemic green innovations function properly and that uncertainties related to emerging defects and malfunctions are reduced. Unlike other used

products, such as cars, such used buildings reveal their hidden durability qualities to the market.

9. Conclusion

This thesis has aimed to understand and analyse contractors' collaboration practices with suppliers and developers in green construction projects and processes, and analyse whether there are differences in how contractors collaborate with clients and developers as a result of engaging in green construction. The findings of the thesis can be summed up based on the five papers. Paper I is a systematic literature review that identifies probable changes in contractors' business models when they are engaged in green construction. Papers II and III are exploratory and based on semi-structured interviews, and investigate contractor-supplier relationships in green projects. Paper IV is a single-case study that analyses how the vertical integration of a developer affects innovation in construction projects. Paper V is conceptual and explains why some contractors vertically integrate developers when engaged in green projects.

The construction industry is thought to have a low rate of innovation and technological innovation is often incremental. Although green construction is mostly characterized by incremental innovation, it does sometimes contain radical innovations, such as those related to new systems for heating or cooling buildings. The level of innovation associated with green construction is linked to the level of greenness in the project, which depends on the extent to which green changes are introduced to various stages of construction processes. Green construction is a dynamic and relative concept; what is green today might be conventional tomorrow. The level of greenness or innovativeness of particular projects is determined by several factors, many of which originate with construction clients, government regulations and financial incentives provided as reduced taxes or subsidies, and obviously by the profits the contractor can make from innovations.

Innovation in green projects affects the contractor's business model, where changes are primarily expected in terms of value configuration, partner network, capability and also target customer elements, where the changes in the first three elements appear to be interdependent. Targeting the market for green construction implies that investment in new capabilities and technologies is needed, particularly when the contractor lacks the capabilities in-house, and must therefore draw on other capabilities in other firms. Therefore, engagement of a contractor in green construction depends on its capabilities, its partner network, and how it collaborates with the firms in its partner network. Contractors are likely to apply methods to ensure that knowledgeable firms are identified and selected as partners. In principle, these firms can be either upstream or downstream in the supply chain, although there is a higher probability that the contractor will choose firms upstream. Among other firms upstream, this thesis has focused on goods suppliers because they provide green goods and materials, where technology innovation is tangible, as they are important sources of green knowledge. This does not exclude the possibility that suppliers of services, such as engineering consultants and specialist subcontractors, can act as knowledgeable partners.

However, it was found that large contractors' supplier selection for green projects does not differ substantially from their supplier selection in conventional construction, especially when they intend to identify suppliers for closer, trust-based relationships. In fact, the interviews

showed that a main concern of contractors in their supplier relations is not suppliers' opportunism, which was predicted by the transaction cost economics literature, but rather their failure to meet green requirements specified in the contract documents. This has an influence on how contractors and suppliers combine relational and formal governance mechanisms. Closer, trust-based relationships with goods suppliers allow contractors to use supplier knowledge, and also reduce the costs of dealing with the project consequences when suppliers fail to meet particular green requirements.

Returning to the business model perspective, one of the model elements that is expected to be affected as a result of engagement of contractors in green construction is the 'target customer'. This is mainly because of the risks involved in green projects, as the immediate market risk arises at least partly from external clients who hesitate to invest when faced with uncertainty regarding the long-term properties of green buildings. Therefore, an internal developer who develops complex projects for a contractor belonging to the same construction group is more efficient at reducing uncertainty due to unobservable long-term quality compared to external clients, who seldom demand more than incrementally innovative technical solutions. Alternatives such as building certification systems support incremental innovations, warranties suffer from double moral hazard in the long run, and risk allocation in public-private partnership projects often fails to encourage complex innovations.

There are two main ways in which a vertically integrated developer can greatly reduce the risk of engaging in green construction. The first is through its business model, which involves internalising the cash flow earned from leasing and then selling the properties within the construction group; by doing so, the properties become more valuable after having been owned and visibly operated. This may be viewed as a reversed market for lemons logic. The second way is through the developer's integration within the construction group, which enables the contractor to work continuously with innovative projects to develop new capabilities; this, in turn, enables the firm to signal proficiency to the market, employees and the investment community.

9.1. Implications for practice

In an attempt to understand and analyse contractors' collaboration practices with suppliers and clients in green construction projects and processes, I have tried to both contribute to the academic literature on green construction and produce findings that have implications for managers.

One of the practical implications of the results of this thesis is that the dynamics of the concept of green construction imply that 'green' carries different meanings for different people, even within a company engaged in green construction. These different interpretations might lead to problems when contractors engage in green at various stages of the construction process, such as planning activities in project management, in dealing with suppliers and subcontractors and, not least, when the company interacts with its clients, potential or actual. Ultimately, confusing interpretations of 'green' might have consequences for the construction

firms in terms of the profit they can derive from their innovations. Therefore, it is important in practice to establish conceptual stability for the 'green' terminology.

The results of Papers II and III suggest that the need for closer-than-traditional relationships within partner networks increases for construction firms engaging in green construction. Otherwise, it is difficult to rely on other firms' knowledge and capabilities, although the appropriate level of integration will depend on the firm's position in the value chain and its function. Contractors should consider establishing closer relationships with upstream suppliers, whereas downstream, there is an argument for vertical integration through joint ownership in order to exploit opportunities for more radical and systemic green innovations. Monitoring suppliers in green projects serves more the purpose of preventing and discovering unintentional errors in deliveries, which is why contractors need to rely on softer conflict resolution methods rather than adversarial means of handling conflicts. Following up on these findings, the managerial implications derived from Papers IV and V concern the role of internal developers within construction groups. By vertically integrating developers and devising suitable business models for them, the risks inherent in innovative green projects can be diminished. This business model should have a synergic effect through internalising cash flow, which increases the financial strength of the construction group and, through working only with the upstream vertically integrated contractor, providing a more continuous flow of green projects. This will enhance the capabilities of both the developer and the contractor, while integration also helps signal the hidden qualities of green properties, thereby increasing the property market potential of its green projects. Such attempts are unlikely to work from day one; coordination of development and contractor activities can take years if not decades.

9.2. Implications for future research

In this section, I suggest opportunities for future research that I believe could help expand the current state of the knowledge related to project-based firms that engage in systemic technology innovation.

Papers II, III and IV were all based on interview data collected from staff in large Swedish construction companies. Since the volume of data collected is small and the range of firms studied is limited, it would be valuable to conduct broader surveys that include medium and small contractors and also firms outside Sweden so that the impact of a variety of institutional contexts could be analysed. It is not known whether institutional factors affect the results and, if so, how. I suggest that future research should focus on collecting data related to both large and small construction firms, their institutional settings and how their engagement in green construction affects their relationships with their suppliers and clients. It is also important to investigate how contractors engaging in green projects relate to suppliers with whom they do not form close relationships.

The results in Paper IV are collected from only one construction group and suggested that there is a need for closer relationship between the vertically integrated developer and the contractor. However, the pros and cons of such a closer relationship are still unclear and more

work needs to be done to understand the effects of the internal relationship when the vertically integrated developer also works with external contractors. Does a closer or looser vertical relationship lead to more or less innovation? Does it help the construction firm to market its products more efficiently? In order to analyse these issues, I suggest that the effects of such relationship be objects of further study.

9.3. Limitations and further research

This thesis has analysed the relationships between Swedish construction firms and their suppliers of goods and also how one construction group integrates a developer firm. One of the limitations of the thesis is that the results gained from Paper I are dependent on the search criteria set there for the literature review. In addition, there are more studies that investigate the business model in a broader construction industry context. These broader studies were not included in Paper I, and the recent and growing interest in the applicability of business model concepts in construction has resulted in a number of newer publications.

One limitation of Paper II is that the results are based only on the opinions of the contractors' employees. Although the paper aimed to understand the perceptions of the people in contractor companies about the supplier selection process when they engage in green construction, the lack of suppliers' opinions on the same issue is a drawback. Interviewing suppliers could have changed the results of Paper II by including their views of the selection process in green projects. The suppliers interviewed for Paper III were nominated by the three large contractors and are probably among the most innovative suppliers for green projects, being atypical to some extent.

Another limitation in Papers III and IV is that the interviewer was non-Swedish speaking so the interviews were all held in English with respondents whose mother tongue is Swedish. The resulting difficulties could have led to some finer points being missed. Another language – or, rather, terminology – barrier sometimes made itself felt when conducting the interviews for Paper III, given that most interviewees were unfamiliar with transaction cost economics.

In Paper IV, which is a single-case study, the results were gained based not only on interviews with one contractor and its vertically integrated developer, but also on facts found on the company website, its annual reports and in company internal documents. However, question marks remain as to whether the results can be generalised to a broader group of project-based firms that exploit opportunities for green innovation. Nevertheless, the conceptual analysis found in Paper V does add credibility to the general applicability of findings reported in Paper IV.

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