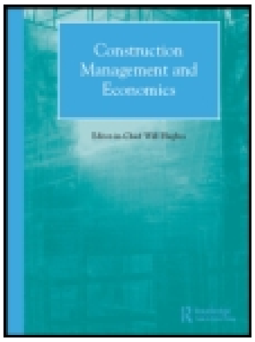

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Business model changes and green construction processes

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Green construction or sustainable construction differs from traditional construction in terms of the materials and processes used. To profit from green construction, firms may need to change their business models, including their offers, activities, networks and revenue models. However there is no explicit study on what changes are required or common in construction companies' business models when they are involved in green construction projects. To systematize prior research a literature review identified changes in business model elements. The results showed that (1) most business model elements can change in a non-trivial manner as a consequence of green construction; (2) value configuration, cost structure, partner networks and capability are the elements emphasized in literature and are expected to be the most difficult and important to change; and (3) to be successful, firms may need to simultaneously change the business model elements of capability, value configuration and partner network on the one hand, and value proposition, cost structure and capability on the other hand.

Keywords: Business model, green building, green construction, literature review, sustainable construction.

Introduction

Following the emergence of sustainability discussions in the late 1980s including the Brundtland Report (World Commission of Environment and Development, 1987) ecologically sustainable construction has received much attention as a result of major environmental and social impacts created by the construction industry and also its lag with other sectors (Myers, 2005). Kibert proposed that sustainable construction is the creation and responsible management of a healthy built environment based on resource efficient and ecological principles (Kibert, 1994; CIB, 1999). Green construction and sustainable construction are terms often used interchangeably (Kibert, 2005) and initially referred to the responsibility and the processes of the construction industry in attaining environmental sustainability (Hill and Bowen, 1997).

Green or ecologically sustainable construction is important because creating and operating buildings are matters that account for about 40% of global annual energy consumption (Kibert, 1994; UNEP, 2007), almost 40% of the global material deployment and also 25% of global waste (Roodman and Lenssen, 1996; Ofori and Kien, 2004; Vijayan and Kumar, 2005; Nelms *et al.*, 2007; Ding, 2008; Bossink, 2011). Therefore becoming market responsive, minimizing waste, integrating the supply chain and engaging all stakeholders should be the aims of the construction industry (Myers, 2005).

The critical issues are how to change the entire cycle of construction materials to reduce the industry's environmental and resource impacts (Kibert *et al.*, 2000), i.e. a shift from a 'cradle-to-grave' strategy to a cradle-to-cradle approach (Kibert, 2007), which means green construction includes the design, implementation, product delivery, and maintenance and refurbishment stages of a construction process (Hill and Bowen, 1997; Sterner, 2002). To separate green construction from 'greenwashing', the implementation of green construction can necessitate major changes in the structure and processes of construction firms (Ahn and Pearce, 2007). These changes are related to changes in the firms' business models since

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they relate to the method or the logic of doing business (Chesbrough and Rosenbloom, 2002). Thus green construction may dramatically affect how construction firms create value for their customers and how they are to profit from changing the environmental orientation of their businesses. Currently, there are not any studies that explicitly analyse green construction from a business model perspective. This is problematic because changes in business models may have large financial consequences, affect the setup of the firm's supplier network, or how the firm is to profit from its innovations (Teece, 1986; Magretta, 2002; Teece, 2010).

However when considering greening of the construction processes, the distinguishing characteristics should be taken into account. A project business differs from other businesses because it is limited in time and often one-off and involves adversarial relationships among actors, separation of design and production, competitive tendering and a high degree of uncertainty and limited possibilities for standardization (cf. Hellström, 2005; Pryke, 2009). Moreover project businesses tend to be risk-averse, reactive and subject to relatively slow rates of change (Bourdeau, 1999; Kibert *et al.*, 2000). As a consequence, construction projects are characterized by low rates of innovation which make them resemble the service sector rather than manufacturing (Bröchner, 2010).

A construction project consists of different players that range from pure manufacturers to dedicated service providers in project settings where all players follow different objectives. Often none of them takes direct responsibility for protecting the environment (Ofori, 2000). A typical construction project starts from the client as the initiator of the supply chain followed by engineers or architects (consultants) followed by the main contractor and subcontractors and finally involves material suppliers (Cox and Townsend, 1998, p. 33).

As yet there is no publication that analyses green construction explicitly from a business model perspective. This implies that our understanding of these processes is poor at best. Fortunately, there are a number of papers that describe or analyse green construction where changes in firms' business models can be inferred. Thus, the purpose of the paper is to review recent green construction publications to investigate what elements of the business model change when a construction-related company undertakes green construction, and ascertain whether there are any specific relations between changes in different business model elements. To do this, green construction publications are reviewed that consider the ecological aspect of green or sustainable construction where the focus is on construction processes rather than the physical building as an outcome. This review is to illustrate common themes in the literature, identify what business elements are the most important or difficult to change and the relation among business model elements.

The paper is organized as follows. The next section characterizes a business model and its constituting elements, followed by a discussion of sustainability. This is done to provide a better conceptualization of how to infer changes in business model elements from the green construction literature. Subsequent sections present the paper's method, before presenting the results. Finally, the discussion and conclusions are presented.

Business models

A business model refers to a firm's intended or actual response to how value is created or appropriated (Magretta, 2002) or as the method of doing business by which a company can sustain itself through generating revenue (Chesbrough and Rosenbloom, 2002). The business model concept draws from and integrates a variety of academic and functional disciplines (Chesbrough and Rosenbloom, 2002). Some scholars, e.g. Wikström *et al.* (2010), believe that the business model is constructed on the field of business strategy while others (Magretta, 2002; Morris *et al.*, 2005) argue that strategy is about positioning partly by orchestrating the firm's business model. Thus, the list of business model definitions is extensive, but generally refers to the logic of how to run a business by referring to value creation, where some benefit for someone is created in terms of a product or a service by the firm, and value capture, meaning the company profits or gets a return on the created value (Chesbrough and Rosenbloom, 2002; Magretta, 2002; Teece, 2010). To put it simply, a business model is articulating the logic and providing data and other evidence that show how a business creates and delivers value to customers by the architecture of revenues, costs, and profits associated with the business enterprise delivering that value (Teece, 2010). For green construction therefore, key issues include whether the business logic of green construction companies differs from other construction companies and also in what ways construction companies change their business model as they become more environmentally oriented ('greener').

The most frequently quoted review of business model papers lists nine elements which offer a scheme for characterizing business models (Osterwalder *et al.*, 2005). This allows us to differentiate among different types of business model changes (see Table 1).[1]

Table 1 Nine business model elements (modified from Osterwalder *et al.*, 2005)

No.	Business model element	Description
1	Value proposition	Gives an overall view of a company's bundle of products and services.
2	Target customer	Describes the segments of customers a company wants to offer value to.
3	Customer handling/ distribution channel	Describes the various means of the company to get in touch with its customers.
4	Customer interfaces/ relationship	Explains the kinds of links a company establishes between itself and its different customer segments.
5	Value configuration	Describes the arrangement of activities and resources.
6	Capability/core competency	Outlines the competencies necessary to execute the company's business model.
7	Partner network	Portrays the network of cooperative agreements with other companies necessary to efficiently offer and commercialize value.
8	Cost structure	Sums up the monetary consequences of the means employed in the business model.
9	Revenue model	Describes the way a company makes money through a variety of revenue flows.

According to this synthesis a business model is a conceptual tool that contains a set of elements and their relationships that can express the business logic of a firm or a business unit.

A business model should explain the relationship among elements, but currently there is not any business model that shows the relationships among elements for green construction. However, such a model is derived by drawing on the existing theories in this section and subsequently analysing the green construction literature in the discussion section. Based on theories of the firm–market boundary, a basic model of relationships among the different elements of a business model is proposed (see Figure 1). The logic is as follows: the role of a manager is to assemble a bundle of complementary assets, resources and activities which when combined will create value for customers or users (Zenger *et al.*, 2011). This combination will be done partly within the firm, partly exogenously. From a business model perspective, this means that value configuration, consisting of the sequence of activities and resources, the capability of the firm and the partner network together create the value. Value creation is represented in the model in terms of the value proposition and the target customer. The combination of value configuration, capabilities and partner network sets the basis for the cost structure of the firm, largely determining its ability to profit from its innovations. However, value capture is also determined by how the innovations, products and services are distributed in terms of customer interfaces, in terms of customer handling, and the revenue model of the firm (cf. Teece, 1986).

By this simple elaboration, various customized relationships which are related to green construction may not appear. By comparing the differences or mismatches of the model and insights from the green construction literature, an outline of the green construction business model can be constructed.

Method

There is much prior research that empirically analyses features of the business models of green construction, even if the construction literature does not explicitly deal with the nature and the changes of construction firms' business models. To review the literature,

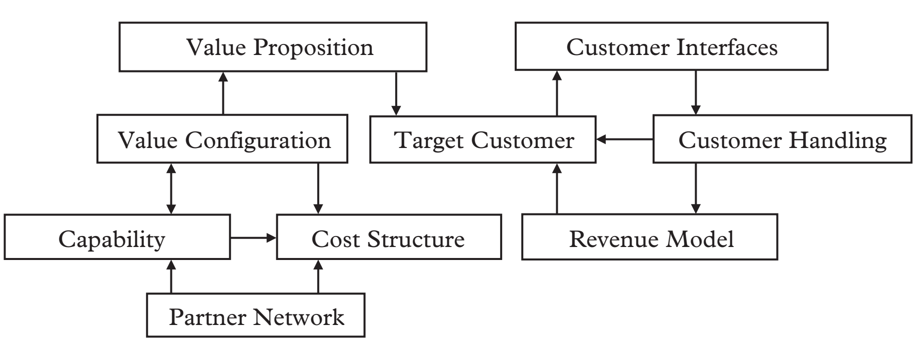

Figure 1 Proposed generic business model and existing relationships among its elements

Table 2 Elements covered by selected publications in green construction

Publication	Covered elements	Focus
Miyatake (1996)	5, 6, 7	How resources can be used more efficiently while focusing on roles of R&D and partners.
Ngowi (1998)	3, 5, 7	How procurement system in green construction is affected.
Kibert *et al.* (2000)	5, 8	Principles of green construction and limitations for implementing green construction.
Rwelamila *et al.* (2000)	4, 5, 7	The role of procurement systems in construction firms and how to achieve sustainable construction by them.
Ofori (2000)	1, 2, 5, 7, 8	How supply chain management (SCM) in construction can affect greening construction.
Bon and Hutchinson (2000)	5, 7, 8	Economic challenges of sustainable construction at macro, meso and micro economic levels.
Ngowi (2001)	1, 5, 6, 8, 9	Role of strategy and design in configuring resources and activities related to sustainability leading to competitive advantage.
van Bueren and Priemus (2002)	4, 5, 7, 8	Institutional barriers hindering implementation of sustainable construction through decision-making processes.
Myers (2005)	1	A survey on the role of social corporate responsibility in construction companies.
Williams and Dair (2007)	5, 6, 7, 8	Barriers to sustainable construction implementation.
Revell and Blackburn (2007)	2, 5, 8, 9	How green construction is economically perceived by construction companies and what are the barriers.
Kibert (2007)	1, 5, 6, 7, 8, 9	Current sustainable construction trends and the way that it is expected to be a resources perspective.
Ahn and Pearce (2007)	6, 7	Contractors' experiences and perceptions regarding green construction and sustainability skills and knowledge.
Reed (2007)	5, 6	General advice on how to achieve greener processes.
Sayce *et al.* (2007)	1, 3, 5, 7, 8, 9	Drivers towards sustainability and role of incentives considering the costs and revenues.
Varnäs *et al.* (2009)	2, 3, 7	Procurement process and its problems in green construction.
Chong *et al.* (2009)	1, 5, 6, 7, 8	Factors such as cost and core competency through comparing perceptions of sustainability among professionals in construction.
Gluch *et al.* (2009)	7	Partner network as a source of knowledge sharing and innovation.
Jones *et al.* (2010)	1, 4, 5, 7	Comparison in perception of sustainability concept in different groups of construction firms.
Lam *et al.* (2010)	5, 6, 7	Stakeholder involvement, technical resources and techniques.
Qi *et al.* (2010)	4, 5, 6	Ability of different drivers forcing contractors to adopt green construction practices.
Presley and Meade (2010)	1, 2, 5, 6, 7, 8	Devises a framework for construction companies to incorporate sustainability measures into their activities.
Ball (2002)	2, 5, 8	Investigates role of ISO 14001 and eco-labelling systems in sustainability in construction.
Nelms *et al.* (2007)	5, 7, 8	Investigates a performance measurement framework for stakeholders in green building.
Vijayan and Kumar (2005)	5, 8	Reviews the application of environmental assessment tools.
Nielsen and Glavind (2007)	5, 7, 8	Studying green or environmentally friendly concretes.
Sterner (2002)	3, 5, 6, 8	Green procurement experiences among Swedish construction clients.
Bartlett and Howard (2000)	1, 2, 5, 8, 9	Investigates how to consider environmental and economical measures for decision making processes based on costs of green building.
Hoffman and Henn (2008)	1, 2, 3, 6, 8, 9	Investigates significant social and psychological barriers that hinder green design and construction.

(*continued*)

Table 2 (*continued*)

Publication	Covered elements	Focus
Theaker and Cole (2001)	1, 5, 6, 8	Examines the role of governments in promoting green building.
Meyer (2009)	5, 6, 8, 9	Green concrete.
Curwell *et al.* (1999)	5, 6	Investigates future of environmental assessment tools for construction and green building in UK.
Tam and Tam (2008)	5, 8, 9	Investigates the effects of incentives on waste reduction by construction workers, so-called Stepwise Incentive System (SIS).
Ofori and Kien (2004)	3, 5, 6, 7, 8	Investigates the effects of increased environmental awareness of architects in Singapore on selection of materials.
Retzlaff (2009)	1, 5, 8	Investigates the relationship of LEED and incentives offered by governments.
Kibert (2005) [book]	–	*Sustainable Construction: Green Building Design and Delivery*
Boyd and Chinyio (2006) [book]	–	*Understanding the Construction Client*
Bossink (2011) [book]	–	*Managing Environmentally Sustainable Innovation*

a combination of quantitative and qualitative approaches was used. The quantitative approach was conducted by using the SCOPUS internet database. The search parameters were set to 'green OR sustainable OR sustainability OR building OR construction industry OR construction' in combination with one of 'green building OR sustainable construction OR sustainable building' in the article title, abstracts or keywords field. As the purpose of the study is to capture recent changes in business models of construction-related companies brought about by undertaking green construction, the cut-off date is set to the time span from 1995 to 2010.[2] This generated a list of 756 papers. To limit the number of papers the SCOPUS subject areas of 'Physical Sciences' and 'Social Sciences and Humanities' were chosen whereas 'Life Sciences' and 'Health Sciences' were excluded. To focus on sustainable construction, those focusing on finished products (green building) are excluded. In particular, this also holds true for articles dealing solely with chemistry or biology.

In addition, to narrow the search even more, the review only includes peer-reviewed articles or reviews which are cited at least three times, after which 182 papers remained. While this does not guarantee a high quality of included papers, through reading selected articles many papers of poor quality were removed. Applying these criteria, the number of papers decreased to 35 articles which are found in Table 2. To overcome the downside of the quantitative approach, three relevant books that are extensively used in the field of construction were also added. Finally, papers that were deemed to be relevant despite not (yet) fitting the criteria above were added.

Result

This section will first present the results from the 35 articles and three books for each of the nine business model elements (see Table 1). This is followed by an overview of the relations among business model elements.

Value proposition

The first element of a business model is value proposition which refers to the benefit of an offer from the perspective of the customer. This element encompasses all products and services a company offers to its customers. Common for all construction processes is that the products (especially buildings) are characterized by long lifetimes, with significant resources consumed over their lifetimes. This distinguishes them from manufactured products in terms of a greater individuality and wide variety of constituting components. They are generally one-off products and it is relatively unlikely that their components would be returned to their producers at the end of their life cycles (Kibert *et al.*, 2000).

Green construction and conventional construction differ partly because they follow different rules and techniques across the stages of construction. Although some processes in green construction would be the same as conventional construction, by definition green construction has a different value proposition from conventional construction because a part of the benefit is that the processes underlying the product or services should be more environmentally oriented than normal practice. Green products can for instance consist of green materials compared to conventional materials such as cement. Examples of green construction products can be found in the studies on application of pulverized fuel ash (PFA) and waste tyres as environmentally friendly cement products in road construction (Snelson *et al.*, 2009) and environmentally friendly concretes or green concretes with high volume fly ash and better CO_2 footprints (Obla *et al.*, 2003; Glavind *et al.*, 2006; Malhotra, 2006; Nielsen and Glavind, 2007; Meyer, 2009). From the perspective of the product, three issues seem to be of great concern for the green construction value proposition: (1) depending on the purpose of the building the actual sustainability effect of the building may occur at various stages; (2) the expected life of commercial property may shift the burden to later stages as the life of the project increases; and (3) a 'closed' loop aspect to management of the built environment properties, i.e. materials and land may be reused or made useful for other purposes at the end of a product's life (Presley and Meade, 2010). This indicates that the green construction value proposition may be difficult to discern for the customers.

However, there are green services that can enable better transparency. Services include green design where green or sustainability guidelines are formulated into the designs and delivered by architecture firms to clients and customers. According to Nelms *et al.* (2007) one of the reasons contributing to the under-performance of green buildings is the difficulty in defining measures and the optimistic assumptions of designers. However, notable examples of 'green services' include services related to a number of internationally recognized construction-related assessment tools for evaluating green buildings' performances. Two well-known ones are the Building Research Establishment Environmental Assessment Method (BREEAM) which was launched in 1990 (Baldwin *et al.*, 1990; Vijayan and Kumar, 2005; Chong *et al.*, 2009) and Leadership in Energy and Environmental Design (LEED) (Curwell *et al.*, 1999; Vijayan and Kumar, 2005; Hoffman and Henn, 2008; Chong *et al.*, 2009; Retzlaff, 2009).

BREEAM is a tool which is applied for evaluating and measuring the life cycle costs of a building by focusing on ecological and global effects of construction whereas less emphasis is put on issues like management and construction methods. LEED is a tool used to measure the technical information on site concerning daily environmental performance (Vijayan and Kumar, 2005).

Criteria for evaluating green construction processes include design guidelines and resources consumptions both of which are found in BREEAM and LEED systems, while waste management is found only in the LEED system. This implies that new products, e.g. green buildings, will not be the same product as conventional buildings any longer as a result of their new distinctive features such as more sustainability oriented designs. These methods are created so as to meet performance criteria in a range of environmentally focused categories such as resource use reduction while they also include life cycle impact assessment, technology performance assessment, and simulation tools that may be used by decision-makers to evaluate sustainable technologies (Nelms *et al.*, 2007) for example to achieve market recognition and promotional opportunities (Retzlaff, 2009).

There are many examples of the problem of the murky green construction value proposition. Examples of reluctance in the form of uncertain implications for clients can be found in procurement systems. Sterner (2002), who has investigated green procurement among Swedish construction clients, argues that clients found the evaluation of environmental impacts difficult because of lack of operational models; consequently methods that help clients in their evaluations are required in procurement, in tender evaluation and in the evaluation of the environmental impact of materials.

Target customer

A change in the value proposition (element 1) simply means that the bundle of products and services has undergone major or minor changes regardless of who the customer is. Obviously, green construction may entail targeting new or different types of customers. The first player in the construction supply chain is most likely the organization or group of people that initiates a construction project, contracts with other parties and by the termination of the project has legal ownership (Boyd and Chinyio, 2006, p. 5). Nonetheless determining the customer of the construction business is not straightforward (Ofori, 2000) and, considering the long lifetime of constructed products, the identity of the customer extends beyond the initial client to include all users and subsequent owners over the life of the building (Ofori, 1999) which are categorized into: (1) public governmental clients; (2) private corporate customers; and (3) individuals (Blackmore, 1990).

Depending on which groups are targeted, different implications should be taken into account by the construction-related company. Qi *et al.* (2010) claim that clients are one of the most important stakeholders in the construction industry; they are present from the outset of the construction project and strongly shape the products and processes. Among clients, two groups may be more interested in greener products and services: conscious ones and those who are economically driven in case of a substantial decrease in energy sources (Bossink, 2002, 2011) since construction clients are demanding guarantees for their buildings' long-term economic and environmental performance and costs (Bartlett and Howard, 2000). This is interesting since green buildings cost only a little more to build than conventional buildings (Kats and Capital, 2003). According to Qi *et al.* (2010) the design and production of construction facilities are triggered by clients articulating particular green requirements for contractors, for example, and forcing project participants to improve buildings' life cycle performance. Therefore failure to meet these requirements may lead to the removal of the contractors concerned from tender lists.

Revell and Blackburn (2007) believe that it is the tendencies and desires of the client that push architects to comply with sustainability in their designs. This issue gains even more weight when we take into account the role of architects in pushing the rest of the construction industry towards sustainability. Therefore the clients' demands are motives for the whole chain of the construction industry to adopt sustainability. This means that, on the one hand, both groups of client will make construction companies change their value proposition (element 1) according to clients' demands and, on the other hand, if a construction company defines or redefines the value proposition, target customers should be defined or redefined as well.

When considering the financial implications of design the client has the simple measure of price which can be compared with other options (Ball, 2002). Therefore, not all clients are interested in green features. One reason for the reluctance of clients to seek greener products and services is the higher costs of green products and services compared to non-green ones (financial implications) or even the uncertain implications for clients which make them cautious. Sixty-four per cent of potential home buyers in a study by McGraw-Hill mentioned high costs of green building as a barrier while 90% of current green home owners mentioned operational cost savings as a great motivation for buying their houses (McGraw-Hill Construction, 2007).

Customer interfaces

To enable green construction, the literature shows that procurement and contracts have a problematic role compared to green construction, limiting the use of environmental criteria. Lam *et al.* (2010) argue that both the specifications in the contract and the effectiveness of the supply chain and monitoring mechanism are important factors in enhancing sustainability of construction resources. For example, when the contractual arrangement 'design and build' is used, the design is carried out after the procurement, which makes it less meaningful to introduce certain types of environmental preferences in the procurement stage (Varnäs *et al.*, 2009). In the same vein Ngowi (1998) claims that the procurement system in the construction industry suffers from problems which are derived from the particular characteristics of the construction industry including adversarial contract conditions and unsatisfactory competitive tendering. Another reason for limiting the application of environmental procurement preferences was lack of knowledge, since at times it may be hard for customers and clients to formulate environmental preferences that are specific, measurable and verifiable (Lützkendorf and Lorenz, 2005; Varnäs *et al.*, 2009).

In their study on procurement systems in Swedish construction companies Varnäs *et al.* (2009) found that while environmental parameters are often taken into account in procurement of construction contracts, environmental evaluation criteria, however, are less applied due to the risk of appeals that may delay the project, a desire to simplify the tendering procedure and also the fear of bringing increased costs and limitations to the project. Also the way in which environmental requirements are stipulated in procurement documents is significant for the development of a project's environmental features (Varnäs *et al.*, 2009). The requirements must be stipulated in a way that enables them to be fulfilled by the contractor and verified by the client. The successful implementation of the technology on a demonstration project does not guarantee its performance and success in all project contexts or with respect to differing project objectives (Nelms *et al.*, 2005).

Customer handling

Customer handling refers to how a construction-related company and its partners and suppliers relate to their client. This business model element is not well articulated in the studied articles. The reason for this is probably that there are no substantial changes in the way that construction-related companies deal with clients, at least as reflected in the studied publications (the exception is the issue of public tender and private contracts which belong to the customer interface). Thus, it seems as if companies undertaking green construction projects are relating to their clients in the same manner as companies undertaking normal construction projects.

Therefore the way that construction companies, whether contractors or designers, deal with their customers and their needs is highly important and disregarding their needs in sustainability issues might result in losing their customers. This clearly shows that on the one hand the customer handling element of business model is related to expertise of the construction company to meet its customers' needs and on the other hand the target customers that a construction company identifies would define the way that the company has to deal with its customers.

Value configuration

Value configuration refers to the arrangement of activities and resources, which means it stands in close relation to many of the other business model elements. A construction firm generally needs to radically change its design and use of materials to be consistent with sustainable construction principles (Kibert *et al.*, 2000). This is because natural resources are being depleted at a rate faster than their replenishment (Lam *et al.*, 2010) and to maintain fair access to the world's resources is unachievable at the current rate of improvement by means of incremental and fragmented efficiency, thus significant and radical changes are required (Reed, 2007). This includes converting non-renewables to renewables, high levels of waste to high levels of reuse and recycling, and also substituting the life cycle costs (LCC) with lowest first costs products. More importantly a new concept for materials and energy use in the construction industry is said to be needed if sustainability is to be achieved.

According to Presley and Meade (2010), sustainable construction seeks not only locally but globally to reduce or prevent pollution such as waste materials or release of contaminants to the environment through selection of sustainable material in the whole supply chain and finding contractors and subcontractors with corporate socially responsible practices. Nonetheless lack of regulatory control and enforcement, lack of motivation and lack of experience were three main reasons that prevented construction contractors from embracing waste reduction practices (Tam and Tam, 2008). This suggests that for a construction company to be able to rearrange its value configuration (element 5), it needs to change its capability (element 6) and partner network (element 7) as well.

Following the same line of argument, Miyatake (1996) also believes that to adopt green construction some changes in the processes of creating built environments in the construction industry should take place so that the conventional linear construction in all phases changes to a cyclical process. This change imposes a substantial increase in the use of recycled, renewable and reusable resources, and a significant decrease in the consumption of energy and resources so that without this change, green construction would be almost meaningless. Thus changes in the cost structure are expected (element 8).

There are some barriers in applying the closed loop system for construction materials such as the use of non-recyclable or low-recyclable materials in components, the lack of obligations on producers to take back waste or worn-out products, the fact that buildings are not currently designed or built to be disassembled, and the fact that products used in buildings are not designed for disassembly (Kibert *et al.*, 2000). In addition material suppliers feeding the construction sector are so intertwined that assessing the overall environmental effect of different materials, components and procedures used by the construction sector is very difficult, if not impossible (Bon and Hutchinson, 2000).

Another set of barriers in this regard might be observed in the procurement process. Williams and Dair (2007) found that construction companies might not be searching to use sustainable materials since they are confronted with problems in procuring them as some materials can only be obtained from one supplier. This problem can be attributed to the customer interface (element 3) of the business model. While local markets have been established to sell secondary materials, it is necessary that clients accept the reuse of materials and that guarantees can be given to make reuse successful (Sterner, 2002).

The changes in processes include for instance, careful siting, design of buildings with prudent choice, better use, reuse and recycling of buildings materials at all stages, the use of energy and water efficient building techniques and elements as well as adequate maintenance and operation (Rwelamila *et al.*, 2000). Although such changes seemingly belong to value configuration (element 5) in a business model some of them can also be attributed to capability (element 6). For example superior environmentally friendly design belongs to the capability element and not to the value configuration element of a business model.

The value configuration is closely related to other business model elements. Changes in the products and services (element 1) make a construction company bring about changes such as life cycle cost (LCC) techniques that have implications for cost structure (element 8). In order to make the changes relevant capability (element 6) is required. At times, such changes are difficult to undertake without the cooperation of other parties within the network (element 7) and providing the right procurement method to meet the customers' demands (element 3). Nevertheless, life cycle analysis (LCA) has not been particularly successful in practice in the construction sector, principally because of problems concerning the availability of input data and the complexity of LCA analysis in its present form. So far, LCA has mainly been used on products (Sterner, 2002).

Capability

Green design or the design and manufacture of materials which are consistent with sustainability principles belong to the capability (element 6) of a business model. This business model element is crucial as environmentally friendly design or manufacturing materials require the right knowledge and routines.

Williams and Dair (2007) claim that there is a substantial knowledge and skills gap among stakeholders in construction projects. Lack of information and lack of expertise to implement sustainable projects among stakeholders lead them to choose a more routinized low risk solution which is most likely not a sustainable construction project.

Even if the capability is in place there are often major problems in sharing. Bossink (2011, p. 17) argues that although participants in a green project are willing to share their green-related expertise; it is difficult to exchange knowledge and cooperate with the more traditional architects, consultants, contractors, clients and producers. He believes that various reasons are hindering sharing, including limited opportunities for cooperation, problems for knowledge exchange among parties involved, risk aversion due to differences in interests and different focuses, where architects, contractors and real estate managers focus on green design, cost, production and risk minimization and price, respectively. Ofori and Kien (2004) believe that lack of understanding of the impacts of construction on the environment, overestimation of costs and lack of reliable information about the environment are most common barriers in this regard. A change towards a greener value proposition, e.g. greener buildings, can require some changes in the capability (element 6). For instance Design for the Environment (DfE) is one of several initiatives that a construction company might add to its processes in order to adopt green construction. Kibert (2005) defines DfE or green design as an integration of environmental considerations into product and process engineering procedures. Even though the design of material is the central point for DfE, depending on the context, design for disassembly and deconstruction might also need to be included. According to Kibert (2007) the shift from a 'cradle-to-grave' strategy to a cradle-to-cradle approach is required. Compared with the manufacturing industry, product recovery in the construction industry is problematic because of the heterogeneity of buildings and constituent materials (Kibert *et al.*, 2000; Schultmann and Sunke, 2007).

One of the problems in undertaking green construction lies in the design stage where materials should be selected. The knowledge of architects about materials and sustainability is not vast and is based on mostly ambiguous and intuitive criteria leading to poor decisions (Kibert *et al.*, 2000). Ofori and Kien (2004) also in their survey in Singapore found that barriers for architects to adopt green design are difficulties in obtaining, evaluating, managing and updating environmental information, and the non-existence of comprehensive tools and data to enable detailed comparisons between alternatives.

To make matters worse, although green-minded architects are willing to share their knowledge they find it very difficult to do so when dealing with traditional contractors, architects, clients and also consultants (Bossink, 2011, p. 22). To overcome such a barrier Ngowi (2001) suggests that implementing environmentally friendly building practices at the strategy level can lead to technologies that reduce the impact on the environment. As most of these decisions are taken at the design stage it requires that the whole building industry gets educated and convinced that environmental improvement makes good business sense. For a construction company it is not simple to acquire green knowledge on its own, especially if the size of company is small. A R&D department can generate green knowledge but having such a department is mainly possible for large construction companies with a dedicated budget and specialized staff. For smaller construction companies, the option would be to use other sources of knowledge, i.e. external knowledge sources or on-the-job training. Gluch *et al.* (2009) claim that external knowledge sources are related to the inter-organizational relationships and formalized communication routines between different parties involved in construction projects. Chong *et al.* (2009) in their study found that in order to promote sustainability in the construction industry measures such as networking, learning from peers, and conducting research on new ideas could be effective. In addition governments can play an important role in this regard through raising awareness of the benefits of green design in public, providing designers and builders with the green design-related knowledge (e.g. best practices) and reforming their own regulations that hinder green design (Theaker and Cole, 2001).

Knowledge sharing among different players within the network is not without problems either, partly because of underlying institutions in construction-related companies. Rohracher (2001) who focuses on the role of institutions argues that broad dissemination of the new technologies is hindered by factors at the level of social interaction such as lack of available services, lack of collaboration between different groups of professionals and construction-related companies, lack of articulate demand, or even inappropriate regulations. Bossink (2011) showed that successful sustainable firms traced, identified and developed knowledge on sustainable matters by changing the internal organization and by concentrating on acquiring knowledge and capabilities of others in terms of cooperation.

Partner network

The partner network is closely related to capabilities because when firms discover they do not have access to or can create the right capabilities for green construction, they often search for partners or collaborators (Bossink, 2011, p. 85). This means they need to acquire and exploit capabilities and competences of other firms either within or outside their partner network. Within the partner network this can consist of companies within their supply chain, which in construction includes all the organizations that are involved and active in the process from the extraction of raw materials to the demolition of the building and disposal of its components (Ofori, 2000).

One of the process-oriented principles of ecologically sustainable construction is the interdisciplinary collaborations and multi-stakeholder partnerships between parties (Hill and Bowen, 1997). That is, firms within the construction industry have to manage networks with complex interfaces, and for products and services to be delivered collaboration between firms is required since performance and competitiveness depend not only on the single firm, but on the entire network and the way it functions (Gann and Salter, 2000). Contractors and design firms have different capabilities, motivations, aspiration levels and strategic approaches towards sustainability (Chong *et al.*, 2009; Jones *et al.*, 2010; Bossink, 2011).

Green construction presents challenges to project stakeholders whose objectives may conflict. The insufficient understanding of the technology risks, actual benefits accrued, and their beneficiaries, and the willingness to pay for these benefits, is a particular concern where the consequences of failure can be significant (Nelms *et al.*, 2007). Indeed, the fact that there are differences in value systems among different parties and stakeholders calls for a framework to overcome likely conflicts over trade-offs among actors (Nelms *et al.*, 2007). Jones *et al.* (2010) believe in engagement, communication and careful alignment between client, construction and design companies if the aim is to achieve corporate sustainability efforts by partnering.

Studying the partner network, it is wise to look at the network at two different levels: project and industry levels. At the project level, one of the problems that most construction-related companies might confront is handling the complex relationships between diverse players who might belong to different sectors with differing knowledge and expertise in different disciplines and in different projects (Ngowi, 1998; Gann and Salter, 2000; van Bueren and Priemus, 2002). In addition, due to their different areas of expertise architects and contractors concentrate on different issues; the contractors concentrate on cost, production and risk minimization whereas the architects' focus is on green ambitions and design (Bossink, 2011).

At the industry level and with regard to the low rate of innovation in the construction industry, Winch (1998) believes in the role of partnering as an incentive for innovation improvement in the construction industry when competitive tendering is substituted by partnering. However construction-related companies can improve innovation if more collaboration with other construction-related companies within the industry takes place. Product definition, development, simulation, testing and production usually involve transfer of knowledge within complex networks of suppliers and include a large number of interactions between many different specialists. This involves the need to deal with technical decisions in which the interdependency between components and subsystems creates the need for an exchange of technical know-how across a range of professional and engineering disciplines. In line with this argument Dubois and Gadde (2002) claim that efficiency is supposed to be encouraged by competitive tendering and by doing this conditions for the relationship among the parties are set.

As green construction is project-based, the knowledge only slowly accumulates which leads to a slow rate of innovation. Another reason for the relatively slow progress within firms and the industry is found in the fragmented and extended chain of tasks and the separation of responsibilities for producing materials, design and construction, operations, maintenance and refurbishment, and disposal that disconnects functions. This leads to a breakdown of feedback loops among different players involved in this industry (Kibert *et al.*, 2000). Although networks can be beneficial to construction-related companies in undertaking green construction there is a lack of attention to sustainable construction within the network (van Bueren and Priemus, 2002; Williams and Dair, 2007) which can be caused by myopic interaction patterns and fragmented decision making (van Bueren and Priemus, 2002). Moreover, there is no platform for stakeholders to integrate the fragmented knowledge of sustainable construction within the industry (Chong *et al.*, 2009).

Another explanation for a perceived slow rate of green construction innovation is that sustainability objectives tend to be addressed by all of the involved stakeholders wherever specific measures are stipulated by regulations, otherwise these objectives are not on the agenda. This adds to the problem that for specific stakeholder types, their participation is limited to specific time periods, or they are brought into projects rather late. As a result the opportunity to introduce sustainability objectives is limited (Williams and Dair, 2007).

Cost structure

Green construction may require radically different activities, capabilities and resources compared to conventional construction. Consequently, improvements in environmental performance are often a cost burden to the builder, which must either be absorbed by the firm or be passed on to the customer if builders are to maintain their profit margins. Therefore new visions should be set so that social and environmental benefits go hand in hand with lower costs and higher profits on the other hand (Myers, 2005). A particular concern is that end users tend to be unwilling to pay for public environmental benefits; this means that a shift to green construction may end up as a matter of regulation instead, where again cost is transferred to the end users (Nelms *et al.*, 2007).

The increasing popularity of green construction and implementation of sustainable technologies in green buildings primarily based on their environmental performance presents challenges to project stakeholders whose objectives may conflict. The popularity of sustainable technologies, given the insufficient understanding of the risks of the technology, actual benefits accrued, their beneficiaries, and the willingness to pay for these benefits, is a concern where the consequences of failure can be significant (Nelms *et al.*, 2007). Use and reuse of resources and how to handle waste are actions that have to be taken into account when green construction is undertaken. However this is problematic because from the outset there might be cost-related issues which hinder construction-related companies from adopting green construction.

Both the supply side of the construction industry including architects, contractors, and suppliers of materials and the demand side, i.e. customers and clients, are concerned about costs relating to green construction. Therefore few clients show interest in, and commitment to, sustainable design (Ofori and Kien, 2004). Revell and Blackburn (2007) believe that the supply side is not interested in sustainability measures, as suppliers tend to distrust the ability to orchestrate a green construction business, nor are the customers and clients interested in an increased environmental orientation even if such a change leads to lower running costs because short-term capital costs are likely to increase. However, buildings with better environmental performance can offer substantial cost savings (Ofori and Kien, 2004) as the extra cost for protecting the environment is currently only 1% of construction cost (*Building*, 1999).

For example in a case study by Tam and Tam (2008), it was shown that for lowering the amount of waste in construction projects, a system called Stepwise Incentive System (SIS) that offers incentives to construction workers by reducing waste was applied, which achieved a 23% waste reduction. This leads to lower costs for the company. In another case McDonald and Smithers (1998) investigated the economic aspects of waste management in Australia. They showed that implementation of waste management during construction reduces waste produced on site by 15%, with 43% less waste going to land, which generated cost savings of c. 50%. A similar example in Hong Kong (Poon *et al.*, 2001) showed that contractors were reluctant to engage in waste management on site since they believed that the sorting interfered with normal construction activities, was labour intensive and, consequently, more costly. So the only mechanism available to the supplier to make contractors pledge to undertake waste management was by means of contract terms (Sterner, 2002).

The uncertainty because of the immaturity of green construction is a concern, as it may lead to extra costs incurred by either the client or the construction firms. However there are ways to calculate the green construction project costs. One way is to determine the target which would include calculating project costs and comparing them to estimates of what other companies would charge. Another way would be to estimate how the firm's cost performance against competitors is viewed (Presley and Meade, 2010). Chong *et al.* (2009) claim that existing green building and environmental systems do not address costs of implementing sustainability and more work is required in considering the concerns of possible cost overruns and schedule delays resulting from undertaking sustainable construction as a complex system. To invest in sustainable buildings, one option is to consider the building's potential to be cheaper or cost neutral, or provide an increase in value sufficient to compensate for any further costs (Sayce *et al.*, 2007).

Revenue model

The green construction literature pays scant attention to the revenue model. However, according to Ngowi (2001), setting a higher price or enjoying lower costs than competitors are the only ways to achieve superior profitability. Presley and Meade (2010) present a framework for key performance indicators (KPIs). In their framework the relationship between project performance and company performance has been demonstrated. Among different project performances, client satisfaction and profitability are directly related. There are barriers for construction companies in implementing green construction with regard to revenue.

Revell and Blackburn (2007) found in their study on sustainability in SMEs that the perception of losing profit by applying environmental measures among architects and contractors is one of the main potential problems in the adoption of sustainability because of the unwillingness or the inability of customers to pay for more advanced solutions. Indeed, Sayce *et al.* (2007) claim that investors found no business case to support sustainability-related changes due to the lack of increased value in terms of rents and yields complicated by the attitude that 'going green' would increase building costs.

Relation among business elements

Based on the green construction literature review, this section discusses the importance of the different business model elements and suggests relations among them. By drawing on Table 2, the previous section came up with three main findings:

(1) Value configuration, partner networks and capability elements are the most important or problematic aspects of green construction.
(2) During green construction, most business model elements can change substantially.
(3) Some combinations of business model element changes are more common than others because one business model element change can require or bring changes to other elements.

First, the results showed that value configuration, capability and partner networks are the most investigated business model elements in the green construction literature. Tentatively, we infer that these elements are not just important but also difficult to change for the firms. A rationale for this inference is that empirical research is likely to focus on aspects that are of practical relevance. This may sound like a naive view in that there are many reasons why researchers focus on a particular topic while ignoring others. Reasons for being cautious to overstate the implications from the literature review include that access to data, availability of research funding, fads, etc. may all mean that some but not other aspects of green construction will be more in vogue than others. On the other hand, we do claim that the literature review does indicate that the identified issues for each of the three elements are both problematic and important from the perspective of practitioners.

Second, while any business model element can change in principle, the review did not indicate that all elements often change or need to change. A case in point is that at present the discussions concerning target customers, customer handling, and the revenue model are less detailed than discussions of other elements. The implication is not that these three are irrelevant; instead it may be that the situation does not differ from conventional construction. In addition, possible solutions for these three may be trivial to visualize, but difficult in practice to do anything about.

To avoid the ecological fallacy, we stress that even if the first two interpretations are 'roughly right' for the entire population of green construction projects, the findings cannot explain or predict the difficulty or importance of changing business model elements for an individual green construction project or firm. Reasons include the great variety among clients and their needs on the one hand, and very heterogeneous firms and projects with different functions and contexts. Thus it is important that further research proceeds to systematically analyse all of the business model elements relative to green construction through empirical studies to contextualize, demonstrate or refute the accuracy of this study.

Third, by drawing on the results in Table 2, we suggest that by undertaking green construction several elements of a business model in a construction-related company need to be changed in parallel. The reason for this is that a change in one business model element may require a substantial alteration in another for the business model to be viable.

There are two main constellations of business model elements which seem to have a strong relation in that a change in one of them leads to or requires a change in the other. The first block consists of value proposition (element 1), capability (element 6) and cost structure (element 8), while the second block consists of value configuration (element 5), capability (element 6) and partner network (element 7). For the first block this can be understood in that a construction firm creates value for a customer by formulating a value proposition. Based on the green construction literature, a key problem with green construction compared to conventional construction is to have the capability to deliver the environmentally oriented value proposition. In addition, a change in the value proposition will affect the cost structure of the company. The second block is based on the logic that as the construction firm shifts towards green construction, many of the key activities, i.e. the value configuration, change. To manage these changes the firm needs to exploit its capabilities internally or draw on the abilities of its partner network. While these two blocks may not be surprising, we argue that they are key managerial issues to handle in unison.

Notably capability (element 6) belongs to both of the two blocks. Given that, the greater the novelty of green construction compared to conventional construction is, the more important and difficult it will be for a firm to acquire and exploit the necessary capabilities, regardless of what other business model elements change.

Conclusion

The aim of the paper is to contribute to explaining why and how construction firms are successful in terms of creating and capturing value when engaging in green construction. This is important given that green construction may require substantial changes in how a firm operates, at times leading to great increases in costs paired with much market, technological and organizational uncertainty. Green construction is a situation where construction firms and their clients may need to leave their 'comfort zone' of conventional construction. To analyse the nature of the obstacles, changes in business model elements as a consequence of green construction were reviewed. The results showed that most business model elements can change substantially. The value configuration and cost structure elements were the most emphasized in the literature followed by partner network and capability elements. The paper also investigated whether there are any specific relations among changes in different business model elements. Relations that seem to be of great importance include capability, value configuration and partner network on the one hand and value proposition, cost structure and capability on the other hand.

The results can be generalized to other heavy project industries as they also follow similar characteristics due to the arrangement of the capability and partner network elements.

However it is likely that there is at present a mismatch between the green construction literature and the empirical reality because the green construction literature at times is normative with limited empirical evidence. Thus we suggest business model oriented research on green construction based on data from the construction industry. One important research topic to include would be to establish the relation among different business model elements, including which are the most difficult to change and how can this be managed.

Notes

1. In Table 1 three of the labels of the nine business model elements are changed to reflect the current terminology in the business model literature.
2. The study found 19 papers published prior to 1995.

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