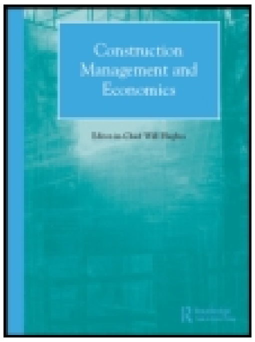

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Business models in industrialized building of multi-storey houses

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The business model construct has been widely used during the last decade, partly because of its potential to provide a holistic view of how companies do business. A test of how prefabrication could form the basis of a construction firm's business model can lead to an understanding of the potential for the competitiveness and profitability of industrialized building. The aim is to adapt a general business model construct and use it to empirically identify the most frequently used and the most viable business model. The theoretical perspective is employed to examine how a company does business and which activities and resources are mobilized through the distinction between strategic and operational effectiveness. The multiple case studies include five major Swedish companies that produce prefabricated timber building systems and the analysis is grounded in pattern-finding. The business model construct includes: market position, offering, and operational platform. The result indicates five business model elements: prefabrication mode, role in the building process, end-user segments, system augmentation and complementary resources. Applying this construct to the five case companies revealed that one out of seven models was found to be viable in terms of both 'market share' and decision-makers' opinions. One important conclusion is to take the prefabrication mode as the starting point for business model design and then adapt the other elements to a good fit.

Keywords: Business model, industrialized building, multi-storey housing, timber.

Introduction

Despite the growing academic interest in industrialized building, studies are needed that link industrialized building to overall company business models (Pan and Goodier, 2012). Putting industrialized building into a broader business context could lead to a better understanding of its potential for competitiveness and profitability. A business model perspective could also help improve the understanding of why the take-up of industrialized building and other modern methods of construction (MMC) has been slower than expected, both in the United Kingdom and in other European countries (cf. Goodier and Gibb, 2007; Pan *et al.*, 2008).

Pan and Goodier (2012) concluded that there is a need to study how industrialized building fits into or, as in this case, is a dominant part of overall company business models. Pan and Goodier (2012) presented a literature review with fewer than 10 references that applied a business model perspective to the building and building materials sectors; this finding provides evidence for the scarce use of this perspective in this empirical context. The analysis by Pan and Goodier (2012) did not view offsite construction methods as defining attributes that differentiate between business models. The authors primarily focused on how offsite fabrication and other (similar but not equivalent) MMC fit into established business models (the most prominent of which is the 'current trader'/'classic private house builder' model in the UK market). The opposite perspective in a two-way process was also acknowledged, i.e. industrialized building as a driving force in forming new or altered business models. Pan and Goodier (2012) stated the need for additional studies at the organizational (company) level as

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opposed to studying individual projects or development at the industrial level.

Therefore, this study differs from other studies by focusing more specifically on different business models that have industrialized building (in the various stages of value added in prefabrication) as a basis. The business model construct is used as an analytical tool, providing a holistic perspective on how a company does business and which activities and resources are mobilized (Kindström, 2005).

Specifically, the empirical context is the industrialized building of multi-storey houses with wooden frames in the Swedish market. Since 1994, the market share within this particular market segment has grown from 0% to nearly 15%. Before 1994 (the year in which Sweden joined the European Union), building wooden-framed multi-storey houses (higher than two storeys) was prohibited. The empirical data used by this article build on a multiple case study of the five dominant Swedish firms leading to this development (which accounted for more than 90% of accumulated production from this market segment).

The overall aim is to identify and analyse the business models of industrialized multi-storey building (with timber frames); this aim is broken down into three sub-aims:

(1) Adapt a general business model construct to the industrialized building setting (choice of major business model elements).
(2) Empirically identify the most frequently used business models.
(3) Analyse the requirements for a good fit between the environment, the business model, and its business model elements.

The first sections of the paper are conceptually oriented to establish important theoretical cornerstones for industrialized building and business model constructs. Thereafter, the section on methods argues for the choice of a multiple case study approach and describes the choice of case companies, data collection methods, and steps in the research process. Four sections present the empirical data and results: (1) a modified business model construct for industrialized building of multi-storey houses (sub-aim 1); (2) empirical descriptions of the business models of the five case study companies structured in accordance with the modified business model construct; (3) the empirically based identification of seven business models (sub-aim 2); and (4) an analysis of the fit between the business models, their business model elements, and the situational factors of the environment (sub-aim 3). The conclusions stress the need to design business models through which other business model elements are adapted to closely fit with industrialized building. Viable business models need to build up strong marketing push mechanisms to 'create' a market for industrialized building.

Industrialized building vs. traditional building

The term 'industrialized building' is the Swedish version of what is known in other countries as offsite construction, offsite production, system building, or non-traditional building (Pan, 2006; Pan and Goodier, 2012). From a technical point of view, industrialized building is defined as the prefabrication of components for elements and complete houses in a factory milieu with product development to support these building systems as products (Björnfot and Stehn, 2007; Höök and Stehn, 2008). The advantages to industrialized building are that it reduces the impact of project orientation and establishes a factory milieu with a high degree of stability in production and coordination with subcontractors, suppliers, and designers. Currently, reliable and fast delivery times are regarded as the most important characteristics of industrialized housing. Generally, competitors implementing traditional, onsite, and project-oriented building are unable to offer these tight time frames that yield fast returns on investments for clients who opt for industrialized building. In addition, lead times for onsite work using volume modules can be reduced to approximately 2–3% of the complete project time (ranging from sales and design to completion of the interior) (Meiling, 2008). The potential drawbacks to industrialized building are reduced design flexibility and the need to intervene with clients and architects/designers at an early stage in the design phase to guarantee proper building specifications and to enable the efficient use of the prefabricated building systems. This balance between prefabrication (standardization) and customization is one of the most studied trade-offs (Schoenwitz *et al.*, 2012).

The business model construct: a holistic perspective on business

The business model construct has been widely used during the last decade, partly because of its popularity among business managers (Baden-Fuller and Morgan, 2010) and partly because of its potential to provide a holistic view of how companies do business (Kindström, 2010; George and Bock, 2011). In the 1990s, business models were primarily used to exploit modern information technology (Timmers, 1998; Mahadevan, 2000) and their academic clarity was deemed 'murky at best' (Porter, 2001, p. 12). However, since then, the construct has been refined and applied in a range of empirical settings, such as computers (Rappa, 2004), retailing (Magretta, 2002), e-business (Amit and Zott, 2001), and pharmaceuticals (Afuah, 2003); despite this, its rooting in strategy and economics theory continues to be questioned (Teece, 2010). The business model construct could be seen as a synthesis of different theoretical streams. For example, Amit and Zott (2001) found theoretical support or influences from a wide spectrum of theoretical frameworks, including value chain analysis, Schumperterian innovation, the resource-based view (RBV), strategic networks, and transaction cost analysis (TCA). These frameworks are sometimes seen as contradictory rather than complementary. This theoretical pluralism could be seen as both a strength and a weakness, but it makes Teece's criticism of the lack of theoretical rooting in more specific theories relevant. However, at the same time, the holistic business model construct has a high degree of descriptive detail and analytical potential that can be reached by combining different theoretical perspectives; the business model construct is a very efficient analytical tool. The main target of the present article is the adaptation and use of an analytical tool.

One well-known definition of a business model is Magretta's (2002) stories that explain how enterprises work, an example of a short and somewhat pragmatic definition. Other definitions are more deeply rooted in strategy and organizational theory and focus on designing transaction and/or activity systems (Zott and Amit, 2007, 2010). A business model construct describes the alignment between the environment, a company's offering, and its internal and external resource base and activity systems (Normann, 1975; Hedman and Kalling, 2003). The specific elements of a business model construct, which should be taken into account when designing a business model, differ among researchers (Chesbrough and Rosenbloom, 2002; Osterwalder *et al.*, 2005).

Business model construct used in this study

The business model construct in the present study includes three major building blocks: market position, offering, and operational platform. The identification of these three blocks is driven by the aim of highlighting the distinction between strategic and operational effectiveness in doing business (cf. Porter, 1996; Abrahamsson and Brege, 2004). The market position defines and distinguishes the roles taken in the marketplace and is closely connected to strategic effectiveness ('are we doing the right things?'). Strategic effectiveness can be measured in terms of market share, brand equity, customer satisfaction and profit margins from premium prices. The operational platform is the resource base and how it is organized and is closely connected to operational effectiveness ('are we doing things right?'). Operative effectiveness can be measured in terms of cost development, quality improvements and lead times to customer and market. Finally, the offering is a sort of intermediate building block that connects the resource base with the market position.

Offering

The offering is perhaps the most important part of the business model because it ends up in a 'value proposition' directed toward customers. The offering is often conceptualized as a bundle of hardware, software, and services, sometimes in combination with a revenue generation model (cf. Nordin and Kowalkowski, 2010). For example, in the construction field, Brady *et al.* (2005) discussed the development toward integrated solutions. In parallel with this development, the revenue models sometimes change from selling a new product or system together with after-sales offerings to getting paid when the offering is used during its life cycle (Oliva and Kallenberg, 2003; Gebauer *et al.*, 2005). The borderline between new sales and after-sales is broken, often with dramatic effects on how a company organizes its business.

Market position

Market position is often described in terms of the segments and relationships through which the value propositions are communicated, negotiated, and adapted/developed. When the proper market segments have been identified, marketing segmentation should lead to the design of unique marketing strategies for each segment, such as in accordance with the four Ps (product, price, place, and promotion) (Kotler, 1997; Albert, 2003; Weinstein, 2004). Because value propositions are often the result of cooperation in company networks between suppliers, partners, and so forth, market positioning must also include the company's position in a broader value network (Hedman and Kalling, 2003).

Operational platform

The operational platform consists of the resources and competences of the company, together with complementary external resources from suppliers and partners, and the manner in which these are organized and used. From a technology perspective, the solution lies in the development of product platform portfolios and component product platforms (Meyer and Lehnerd, 1997; Farrell and Simpson, 2010; Kumar *et al.*, 2009).

In the context of industrialized building and the advancement of operational platforms for different prefabrication levels, lean production philosophies are being systematically introduced (Koskela, 2000; Diekmann *et al.*, 2004; Björnfot and Stehn, 2007; Johnsson and Meiling, 2009). Some of the initial problems related to moving from onsite production to factory-based production (offsite) settings are essentially cultural (Höök and Stehn, 2008). Factory building strategies rely on repetition, which leads to standardization and product platform thinking in design and production, stable organizations with multi-task workers, and pre-planned flexibility.

Business models and risk analysis

Different business models operate on different risk levels and are exposed to different types of risks (Girotra and Netessine, 2011). Within the construction industry generally and not the least in large infrastructure projects, the identification of different sources of risk and the development of risk management systems have been in focus (del Cano and de la Cruz, 2002). The issue of the ownership of risk has given rise to numerous contractual forms. Traditional contracts are based on a detailed specification of client requirements. The constructional risk in housing projects must be estimated using these requirements and should be priced and managed by contractors who may or may not have been involved with or responsible for the design. Therefore, it is usually possible for the contractor to pass on to the client any cost increases resulting from design changes or supply chain problems, provided that the contractor satisfies the terms of the building contract (Gruneberg and Hughes, 2011). Such behaviour enables the contract sum to be magnified during construction, and the risk of increased resource costs is transferred back to the client.

Business models and fit

Mintzberg (1983a, 1983b) took the analytical perspective of contingency theory one step further when using the concept of configuration (see also Miller, 1986). For Mintzberg, a configuration could be a specific combination of various organizational design parameters that had a (good) fit between themselves and the environment. A fit between situational (environmental) factors and the design parameters should meet the objectives of congruence, whereas a fit between the design parameters should meet the objectives of configuration (Mintzberg, 1983a, p. 122). The present study broadens the perspective from organizational structures to business models, although the reasoning is similar. Viable business models should have a good (internal) fit between business model elements (which can be viewed as different design parameters) and should have a good fit (congruence) with the specific environment in focus.

Method

This study was designed as a multiple case study of the five major Swedish companies that produce prefabricated timber building systems. This approach is in line with Merriam (1988), Yin (2003), and Eisenhardt and Graebner (2007), all of whom favoured a case study approach when the studied phenomenon was multidimensional (many variables), where interactive relationships (with unclear cause effects) existed between the variables and with situational factors in the surrounding context (environment), and when systemic properties of the studied phenomenon were in focus. Moreover, to increase our understanding of the systemic aspects, the results should be presented in the form of case descriptions (in our case to better grasp the configuration of business elements in a business model). An early version of the frame of reference and the case studies is presented in Collin and Eckerby (2008).

The Swedish market for prefabricated building systems of multi-storey houses (with wooden frames) has only about 10 companies on the supply side. The five case study companies examined constructed more than 10 000 apartments, which are estimated to constitute approximately 90–95% of all industrialized built multi-storey houses (from the start). Annual average production of multi-storey house apartments between 2006 and 2011 was approximately 15 500, out of which between 10% and 15% were from industrialized building (Statistiska Centralbyrån, 2013). Multi-storey housing accounted for approximately 40% of total housing investments and 1.2% of GDP. Consequently, offsite prefabrication accounted for nearly 0.2% of GDP (with approximately 500–700 persons employed).

From a technical building system perspective, the sample consists of three companies that produce volume modules for closed (company-controlled) building systems, one company that produces solid wood floor/wall elements, and one company that produces prefabricated components based on I-beams. The latter two companies both aim for a more general and open building system.

Steps in the research process and data collection

The first step in the research process was to adapt a general business model construct more specifically to the level of multi-storey housing (sub-aim 1).

Although this step was partly a deductive process of summarizing relevant research in general and within the construction sector, the choice of specific business model elements and an analysis of the relationships between elements were also partly inductively based on the results of a pre-study. A first round of interviews with our case companies (five interviews with top managers in charge of the strategic development, primarily the CEO, and two interviews with experts in industrialized building systems with wooden frames) was input into a theoretical frame of reference for analysing the business models (forming a first round of interaction between deductive and inductive approaches in what is called an abductive research process, according to Alvesson and Sköldberg, 2009).

The second step in the research process applied the adapted business model to the empirical data and identified frequent combinations of positions along business model elements that formed different business models (sub-aim 2). The third step, which was closely connected to this identification, was to analyse the fit (congruence and configuration) between the business model, its business model elements, and the environment (sub-aim 1). The second and third steps also attempted to evaluate whether the business models could be seen as viable (which is closely connected to the estimate of fit between business model elements). In any study, attempting to estimate the degree of success is always problematic. The estimate of a viable business model is based on its 'market share' among industrialized building projects (number of apartments) and whether the case companies continuously prioritized the business model over time. The data analysis identified positions along business element scales that configure business models (pattern-finding; cf. Yin, 2003) based on the interview protocols, secondary data on project portfolios (number of apartments), and financial data. This type of pattern-finding is in line with Mintzberg (1987, p. 12) and his definition of strategy as 'a pattern in a stream of actions', except that instead of looking for strategies, this study sought business models.

For the second and third steps in the research process, a second round of interviews was conducted (another five interviews with the same respondents, with greater focus on sub-aims 2 and 3). To further deepen the analysis in the first and second research steps, the study was updated with seven follow-up interviews (telephone interviews with the same respondents) with all five case study companies, complemented with statistics regarding the number of apartments built and the companies' roles in the building process. In all, 19 interviews were conducted. Our knowledge of the five case companies goes far beyond the aforementioned interviews. Within the Lean Wood Engineering programme, several research projects were implemented with a primary focus on improvements in the operational platforms and in marketing and logistics. Information from these projects provided important background knowledge (pre-understanding) for the case descriptions in this study.

Validity and reliability

The design of the research process in three steps, together with the use of multiple sources for data collection, was a tactic to secure a high degree of construct validity and internal validity (cf. Yin, 2003). In particular, the first step, the pilot study, to modify the general business model framework into an adapted one (to this particular empirical context) was a way to validate that the appropriate business model elements were selected, that positions along these elements could be measured (construct validity), and that the relationships between elements were logical (internal validity). Construct validity was also secured when the respondents approved of the business model characteristics of the case descriptions. The third validity test, external validity or generalization, required more care during the evaluation. However, we think our results could be generalized to a wider number of situations: when construction innovations are introduced into immature markets and when pull incentives from the demand side do not exist and when incumbents have little interest to include this innovation into their dominant business models. Finally, reliability is deemed as good, primarily because the same individuals were interviewed on several occasions.

An adapted business model construct

The adapted business model construct (corresponding to sub-aim 1) builds on: market position, offering, and operational platform. Five elements were identified as being crucial to depicting different business models. The starting point is the prefabrication mode or building system level, which is part of the operational platform. To construct a business model based on prefabrication level, the following four elements are needed as complementary: end-user segments (market position), building process roles (market position), system augmentation (offering), and complementary resources for design and onsite construction (operational platform). The elements meet the following criteria: (1) they are grounded in a general business model construct; (2) the interviewees deemed them as important or defining for a business model of multi-storey building; and (3) they help the analyst to discriminate between projects and companies forming different patterns (business models).

Prefabrication modes

Three prefabrication modes (or levels) of building systems are identified: module elements, floor/wall elements, and component systems. A building system based on module elements is at the highest prefabrication level (approximately 80% offsite and 20% onsite), module elements operate at the lowest prefabrication level (an inverted ratio of 20% offsite and 80% onsite), and the prefabrication level of the floor/wall elements is in between. This categorization follows praxis on the Swedish market and is close to the offsite fabrication levels of Goodier and Gibb (2007).

The three prefabrication modes differ in (in-built) knowledge, intensity, and complexity in terms of coordination. They are different in a technical sense in maintaining and developing the building system and in a business sense in conducting business as projects or as recurring building projects in a process (Lessing, 2006). Each prefabrication mode has pros and cons. For example, the volume module has the advantage of a high degree of factory production but also the lowest flexibility in design adaptation to building specifications, which places demands on early involvement in the design process. Consequently, in-house capability or long-term cooperation with architects/designers is needed, which is why volume element builders display high technical/coordination complexity in maintaining their building systems and, consequently, the highest complexity in the operational platform.

Building process positioning

The low flexibility of the different prefabrication modes, combined with a traditional building process and general or design-and-build contracts that favour onsite construction with a high degree of flexibility, indicate that coordinating many subcontractors and adapting to varying client conditions are major obstacles. Therefore, the prefabrication strategy must be complemented with a strategy for the role that industrialized building companies aim for in the building process.

For volume element producers, a high degree of control in the architectural design phase and total onsite control are particularly important, making the main contractor role the most appropriate. The producers of floor/wall elements offer higher flexibility in meeting client demands and building specifications, which enables them to enter the building process as specialized (frame) subcontractors. Prefabricated element manufacturers have a medium level of onsite coordination and responsibilities in the design phase.

End-user segments

A number of segmentation variables are in play in the literature, including topography, quality, and different types of life style attributes (Grigsby *et al.*, 1987; Leishman, 2001; Kauko *et al.*, 2002; Lipscomb and Farmer, 2005). The literature together with the

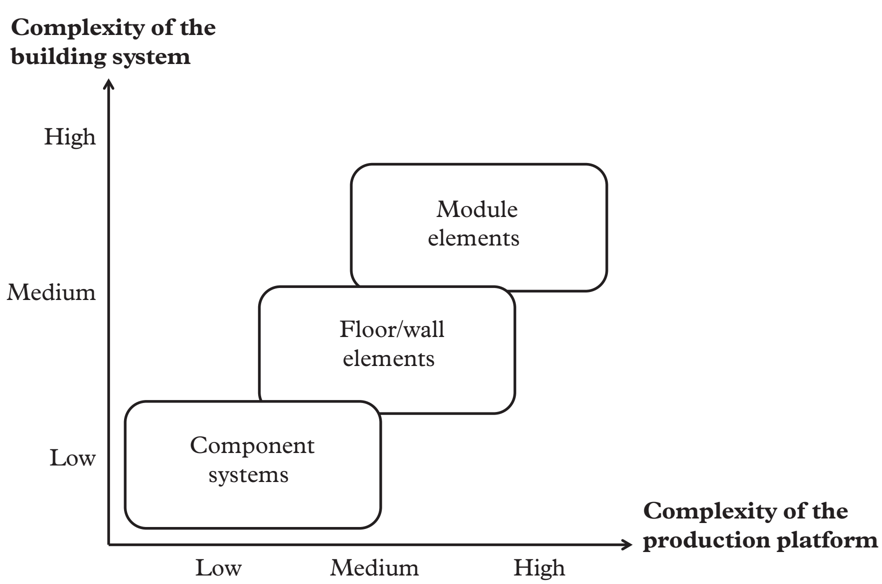

Figure 1 Prefabrication mode as the degree of complexity of building system and production platform

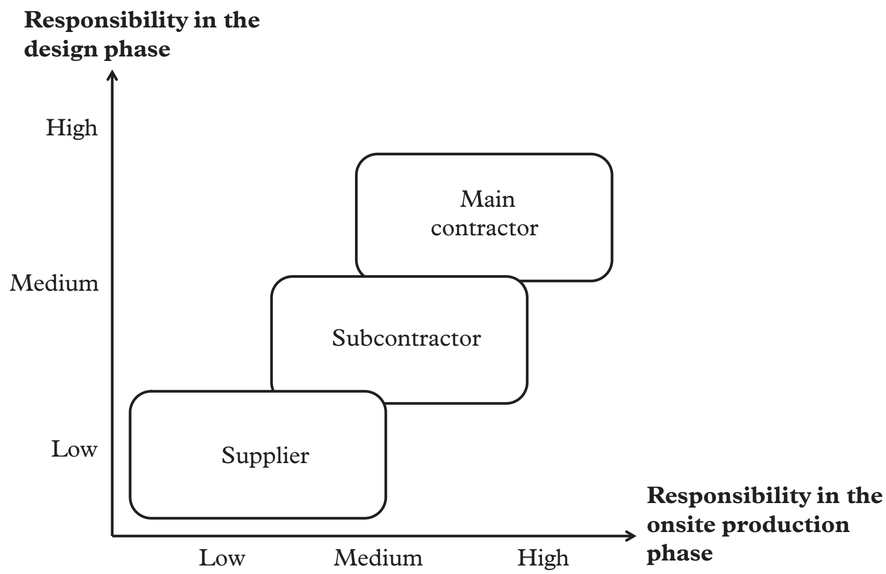

Figure 2 Role in the building process based on degree of responsibility

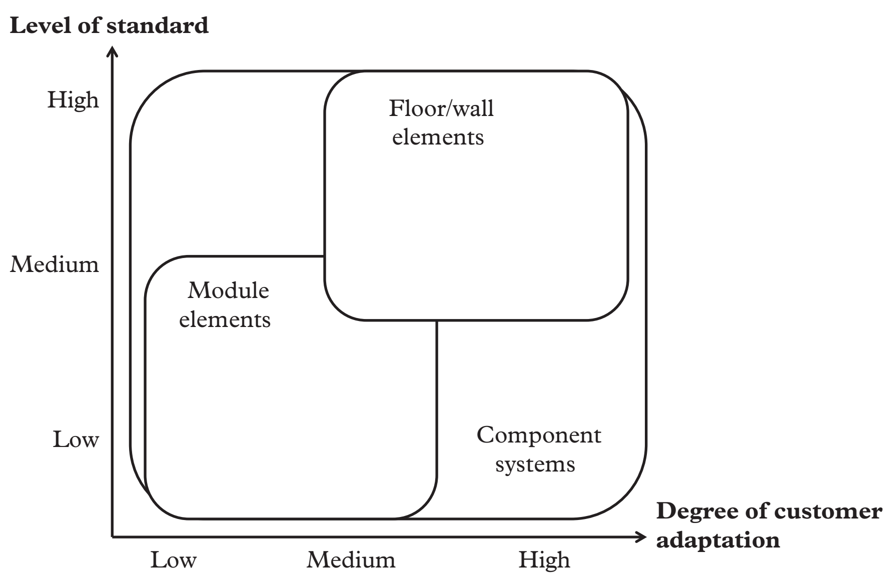

Figure 3 End-user segments are the combination of level of standard and degree of customer adaptation

empirical findings on the behaviour of industrialized housing companies and the strategic behaviour of Swedish developers show that the following interconnected dimensions are important:

- level of living and architectural standard/quality: high, medium, low;
- attractiveness of the location: high (A), medium (B), low (C);
- type of living: family, elderly, students, others; and
- the tenure of a dwelling: rental or condominium.

When end-user segments are linked to prefabrication mode, these segmentation criteria could be condensed into two variables: (1) the level of living and architectural standard; and (2) the degree of customer adaptation (or potential for larger volumes of standardized deliveries). The module element mode delivers primarily standardized solutions, which logically leads to a choice of a low to medium standard (for ‘normal’ families, the elderly, and students in B and C locations). The floor/wall elements producer normally targets a higher standard and customer adaptation in A and B locations and the producer of component systems is able to cover the entire market.

System augmentation

The offering element in the business model is defined as system augmentation (increased value added in the offering) and could be analysed as a combination of the degree of prefabrication of the building system and the role of the company in the building process. The offerings are expressed in functional terms. A turnkey offering is often accomplished by combining a main contracting responsibility and a volume element prefabrication mode. When the industrialized housing company combines the main contracting role with a developer role, the outcome is a build-operate solution, or long-term ownership by the company. When a subcontracting role is combined with a floor/wall element prefabrication mode, the functional result is a climate-proof structural frame or even a complete climate shell with cladding erected on site. Finally, the combination of a supplier role (subcontractor or sub-subcontractor) and a

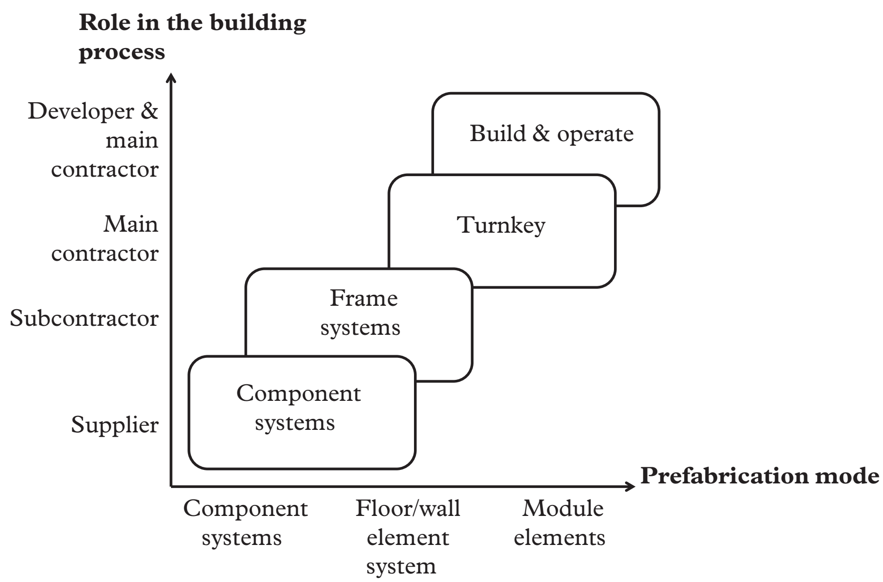

Figure 4 The offering combines the role in building process and type of prefabrication mode

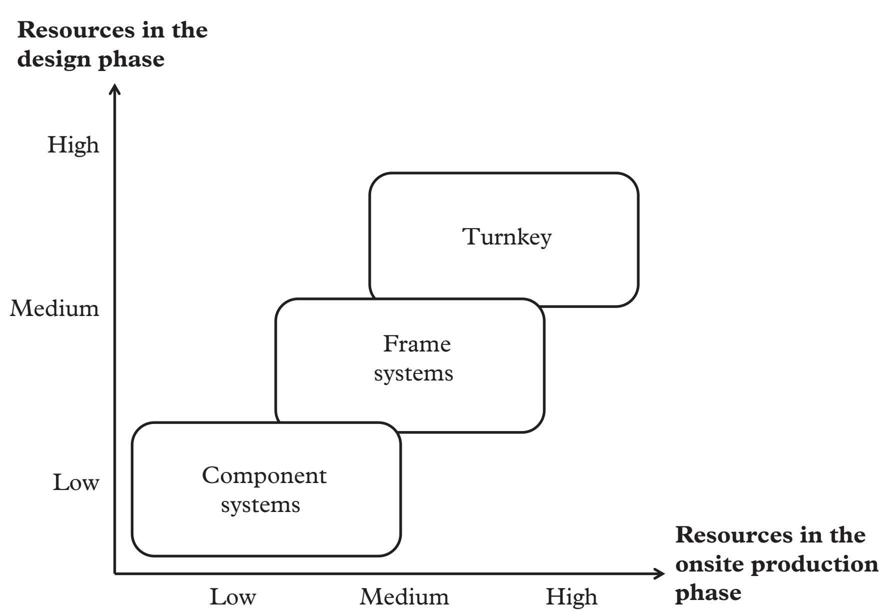

Figure 5 Complementary resource base indicates the degree of control of resources for design and onsite phases

component prefabrication strategy results in a component systems offering.

Complementary resources

Complementary resources are those directed toward the design and onsite production phases, such as architectural resources, design capabilities, and assembly teams and resources (for example, onsite machinery, cranes). The turnkey (and the build-operate) offerings demand the highest degree of complementary resources in both the design and onsite production phases. The floor/wall element offering (climate-proof structural frame) is in the middle of the three types, whereas the component system offering demands the lowest complementary resources. However, the problem for frame systems suppliers, depicted in the middle of Figure 5 is that elements can come complete with technical installations, indicating that a customer may request, or the company may offer, liability for functional performance. This possibility implies risk taking in terms of contracts and a capacity for onsite assembly and coordination in the design phase with other technical sub-consultants. Such a situation creates tension in terms of the responsibilities in both design and onsite production in the frame system producer's business model.

The entire model

In sum, when the prefabrication mode was expanded into a business model construct, it was broadened using four business model elements. Together, these elements formed theoretically possible configurations and myriad combinations.

Case descriptions

The empirical presentation of the cases is structured in accordance with the adapted business model.

The cases of Lindbäcks, Moelven, and Setra: volume element producers

Prefabrication mode

The modules consist of wall, floor, and ceiling elements assembled into a closed three-dimensional structure. The modules are as complete as possible, including interior finishing, before being transported to the construction site, where they are assembled. The prefabrication degree (that is, the amount of money and time spent inside the factory, including transportation, compared with that spent on site) is approximately 75–85% for all three companies. The building system is based on timber studs or solid wood, and the typical size of the modules varies between 4×3 (width $\times$ height) and 8 or 12 (length) cubic meters. Technically, module size implies no difference, although smaller volumes reduce flexibility in terms of apartment layouts. An apartment is constructed using from one up to five modules. The choice of modular sizes also depends on transportation considerations. From a structural perspective, Setra's solid wood volume modules can be built (currently) up to six or seven storeys, whereas the modules of Lindbäcks and Moelven are feasible up to five storeys. Increasing the efficiency of factory production is the focus, and all companies are gradually implementing lean production techniques and tools. Manufacturing is carried out using companies' own personnel, many of whom have been improving their skills over several years.

In recent years, consultants have been more closely connected to companies through long-term agreements. Moreover, a considerable proportion of traditional subcontractors (electricians, heating, ventilation, and air conditioning (HVAC) installers, carpet layers, and others) is now found in-house or is engaged through long-term contracts.

Role in the building process

All companies aim for the main contractor role and exclusively (at least in recent years) work with

Table 1 The business model and elements for industrialized building of multi-storey dwellings

Business model blocks	Business model elements	Variance
Market position	End-user segments	Level of standard, degree of customer adaptation
	Role in the building process	Developer and main contractor, main contractor, subcontractor, supplier
Offering	System augmentation	Turnkey, climate-proof structural frame, component systems
	Prefabrication mode	
Operational platform		Volume modules, floor/wall elements, component systems
	Complementary resource base	Design and onsite production resources

design-build contracts. The obligations and rights sections of these contracts are sometimes modified through a performance-based contract adaptation. Setra aims to take part of the responsibility of a developer or work with developers early in the planning and financing phases. However, of the three case study companies, only Lindbäcks has actually built-to-own and developed student apartment areas close to universities in Sweden. In fact, this type of activity was the starting point for Lindbäcks' overall business idea in the late 1990s. Build-to-own displayed the potential of its system and the company gradually developed its techniques over the years.

Early involvement in the conceptual phase of a building project is crucial because design decisions affect the ability to efficiently use the module building system. All companies devote resources and are able to enter into discussions early in the design and planning phases of a project. Effective interaction between sales and design is a core skill for our case companies; however, the companies vary in terms of their organizational solutions and the manner in which they approach customers or the customers' architects.

Offering and end-user segments

The end-user segments are the same for all three companies: medium level of living in B locations of attractiveness (typical suburb), apartments for medium income earners and, for example, students or the elderly. However, clients and end-users are offered detailed fit-out specifications that enable them to tailor internal design and sanitary facilities, and even flexible internal walls.

Complementary resources

A key complementary resource is architectural design. Therefore, significant effort goes into communicating the pros and cons of building systems to architects. In fact, all three companies work with universities on research and development to verify, present, and develop methods to facilitate the design of their building systems and collaborate closely with selected architectural firms. Setra has a long-standing practice of cooperation with a larger architectural firm and bases its development on a scientific approach to construction and architectural engineering.

Other key resources that the three companies identified, maintained, and developed are transportation, logistics, and onsite construction work. Lindbäcks and Moelven have their own trucks and drivers, whereas Setra uses subcontracted transportation companies. All three companies have key personnel at the building site, and the key personnel of Lindbäcks and Moelven report directly to company management. The assembly is quickly (a matter of days) done by the companies' own specialized teams that also supervise the few subcontractors used (for example, for façades).

The case of Martinsons Building System

Prefabrication mode

Martinsons Building System manufactures solid wood floor/wall elements combined with glulam. These elements constitute the frame system for multi-storey dwellings. The elements themselves are prefabricated to approximately 90–95%. The system offers high structural performance and the open span length is approximately 12 m, which provides a large degree of freedom for the floor layout. Depending on the overall contractual agreement and the client, the elements can be delivered complete with cladding and with all technical installations. Technical solutions are available for both factory and onsite completion of installations. A climate-proof structural frame, or even the complete climate shell with cladding (for example, façade, windows, doors), can be transported to the site and sometimes even erected on site. Transportation and some assembly are subcontracted.

Role in the building process

Martinsons works exclusively through design-build contracts. The company's role varies, which can strain the business model. For most of its projects, Martinsons acts as a specialized frame subcontractor to the main contractor, which means that the company's responsibilities are prefabrication and transportation, design, design coordination, and onsite assembly of a complete climate shell. Martinsons is then responsible for the coordination of subcontracted workers and the building's functionality, which requires that the company maintain such internal competencies. In the past, Martinsons sometimes acted as the main contractor to enter a market. However, lately the company has more frequently played the role of material supplier (lower prefabrication degree, no assembly, and less design coordination).

To be influential in the design-build design phase, Martinsons' marketing and sales are directed not only toward public and private clients and architects, but also to large main contractors. Martinsons has a large business network and is a well-known brand in Sweden, largely because of its background in glulam delivery and 50 years of experience with advanced project-specific design of large structures. A staff of advanced structural designers maintains and supports this network through which the company is able to enter discussions at early stages, even in the

Table 2 Empirically identified business models

Business model	Prefabrication mode	Role in building process	Offering	End-user segments	Complementary resource base	Viable business model?
1. Systems supplier: turnkey	Module elements	Main contractor	Turnkey house	Medium to high standard/ low and medium customer adaptation	High on design and onsite production/ coordination	Yes, 80% of total volume (including in-house developer)
2. Systems supplier: free factory	Module elements	Supplier	Building system: free factory	Low standard and low/ medium	Design resources but rather limited	No, only a few projects, bad experience given unclear responsibilities
3. In-house developer and system supplier	Module elements	Developer + main contactor	Build and operate	Low standard and low/ medium adaptation	High on design and onsite production/ coordination	Yes, approximately 15% of total market (included in the 80% above)
4. Frame system supplier	Floor/wall elements	Subcontractor	Climate-proof structural frame	Medium to high on both	Medium on design and onsite coordination	Not entirely, 2–3% of total volume
5. Frame system supplier: free factory	Floor/wall elements	Supplier	Structural frame free factory	Medium to high on both	Design resources but rather limited	Yes, reasonably; 5% of total volume
6. Component system supplier: tech support	Components customer adapted	Supplier	Component system + technical support	All market segments	Low on design and onsite production/ coordination	Yes, reasonably; about 5% of total volume
7. Component system supplier	Components customer adapted	Supplier	Component system	All market segments	None	Yes, reasonably; about 7–8% of total volume

conceptual phases, of a building project. A few years ago, Martinsons acquired a project management and assembly team, which added complementary competences to the company.

Offering and end-user segments

Martinsons targets the larger building volumes found in building projects that have high to medium levels of living and locations of attractiveness (A or B locations of attractiveness, city centres in medium-sized municipalities, and suburbs in larger cities) and apartments designed for average- to high-income earners. The building system was also sold to clients who then use it to increase the density of city centres by adding two to four storeys on top of existing buildings.

Complementary resources

The building system is general and open (unlike the closed and company-controlled volume modules), enabling any architect or structural designer to work with it. To support the work of architects, Martinsons must maintain, develop, and promote handbooks. Martinsons has its own resources that work with these issues, and the company cooperates directly with some architectural firms. With cooperation from academia and leading software suppliers, Martinsons has developed a number of computer software programs to facilitate design and, therefore, the choice of building system. Much of the verification and technical development is research-based, making scientific and advanced engineering competencies and networks crucial to Martinsons.

Because Martinsons is occasionally responsible for assembly or even all site activities, assembly managers and assembly crews are an important resource. Martinsons must allocate its own trained onsite crews for coordination and onsite work. However, because the company's contractual role varies, this resource is difficult to maintain and was recently reduced for housing projects.

A third important complementary resource is a weather protection system, an advanced tent structure complete with overhead cranes mounted to cover the entire structure (even up to eight storeys). This system shelters the timber frame during assembly to ensure that it meets quality and fit-for-purpose guarantees. Martinsons partly owns a specialized company that it subcontracted for this purpose. However, the significant cost involved (approximately 2–4% of the production costs) led Martinsons to seek new solutions.

The case of the Masonite Flexible Building System

Prefabrication mode

The Masonite Flexible Building System is an open/general system solution based on three elements: Masonite's own prefabrication of different types of I-beams; lightweight floor/wall elements prefabricated separately by a project-specific manufacturer or through longer-term agreements; and design and assembly instructions. The building system company is part of the Masonite Group, which also produces commodity I-beams and engages in general building projects. The manufacturing of I-beams is highly mechanized with a high volume output. Lately, the company made efforts to increase efficiency and planning by implementing lean production techniques and tools.

Depending on the prefab element manufacturer, the Masonite open building systems offer good- to high-structural performance, and six storeys are now technically possible. Structural composite floor solutions with a span length of approximately 10 m provide architects with a large degree of freedom to design an open floor layout. The complexity of the system is deliberately kept low by using standardized components and design/assembly guides that enable architects and structural engineers to combine them as they see fit.

Role in the building process

Masonite has the knowledge to act as a building component supplier (excluding assembly) to a specialized frame subcontractor. The company's main competence is manufacturing of tailored I-beams and coordination of floor/wall elements manufacturers' delivery of 'building kits' with assembly instructions to the main contractor.

The company's role is categorized as a specialized and versatile subcontractor that assumes technical responsibility to architects, contractors, and developers for handling its system. However, from a contractual perspective, the company assumes both the risk and the low design responsibility of a traditional subcontractor or materials supplier under several forms of general to design-build contracts.

As a group, Masonite is a well-known international brand based primarily on its production of Masonite board and I-beams. Somewhat loosely, Masonite uses its market position to focus its marketing on developers. However, its key customers are structural designers at large developing companies (primarily large contractors) for which its competence in structural knowledge is a key asset.

Offering and end-user segments
The vast majority of Masonite's customers are private developers or property owners that sell off the facilities to private housing associations and single-family manufacturers for their own production or as subcontractors.

The general building system has high flexibility in design adaptation. For this reason, depending on the type of project, all levels of end-user segments are addressed, from high to low levels of living, architectural standard/quality and location attractiveness, to different types of living. The low weight of the prefabricated system makes it interesting for clients to add two to four storeys on top of existing buildings.

Complementary resources
Masonite has few key complementary resources. Drawing on the group's selling/marketing resources, tendering and selling are maintained as a whole. Masonite does not operate the onsite work. However, to facilitate assembly, the company includes practical training for the contractors' onsite personnel on a test building that can be assembled or de-assembled before the site work.

The second key aspect is sustaining and updating the design and assembly instructions. This aspect includes assuring the quality of the open building process using decision-making checkpoints and 'what if' scenarios. The instructions are co-developed by academia and through close cooperation with key manufacturers, architects, and designers (primarily small and medium-sized enterprises (SMEs)).

Analysis

The analysis of the cases is grounded in pattern-finding that leads to the identification of business models (sub-aim 2), and then to an evaluation of how well the identified business models respond to the test of congruence with the environment and configuration (a good fit) between business model elements (sub-aim 3).

Empirically identified business models

The empirical data identified seven business models in terms of configurations of the five parameters presented in the frame of reference (see Table 2). One of these business models stands out as being particularly viable during this period with respect to the 'market share' of apartments (business model no. 1).

No. 1: Systems supplier with turnkey offering
The dominant business model is the system supplier with volume element prefabrication and a turnkey offering mode. This business model accounts for approximately 80% of the total deliveries of our five case companies (including in-house ownership; see business model no. 3 below). The configuration is built around the module element prefabrication mode; additional business model elements are the main contracting role in the building process, a turnkey offering toward volume end-user segments such as medium-quality family houses in B locations, dwellings for the elderly and students, and, finally, a highly upgraded resource base with complementary resources. The three case companies producing module elements (Lindbäcks, Moelven and Setra) all developed this business model and Setra also attempted to assume the additional role of developer.

The case descriptions show that, during the introduction of prefabricated timber solutions on the multi-storey housing market, taking the main contracting role in the building process was extremely important. This position was vital to persuade clients to use timber frame solutions and to gain control in the design phase. To a large extent, the three case companies were forced to 'create' this market segment by themselves, which would have been more difficult to accomplish from other positions in the building process.

To achieve economies of scale, the offering was directed toward volume segments in the market, for families in B locations and dwellings for students and the elderly. The technical limitations of the volume element mode imply reduced flexibility in building solutions, making competing for A locations more difficult. Complementary resources in both design and onsite assembly were necessary to support the main contractor responsibility. This business model is the most exposed to risk (excluding acting as an in-house developer). However, at the same time, following this business model the industrial builder has invested resources to handle the higher risk and has a key position in the building process (responsibility and position to execute control go hand in hand). An industrial builder that implements some of the other business models is sometimes forced to assume more responsibility than its position in the business process actually 'demands'.

No. 2: Systems supplier with free factory offering
This system supplier business model takes the position of selling free factory. Apart from some technical assistance in the design phase, the business model

remains 'inside the factory'. The end-user positioning is the same as the system supplier/module business model. To date, selling the prefabricated module system free factory has been used very infrequently and with questionable results. Moelven had bad experiences with inexperienced customers that could not handle the onsite assembly, resulting in discussions about which party bore the responsibility.

In contrast, this business model is very successful within the Swedish market for small houses and for selling construction barracks (Brege, 2009). The immature status of the market is a key explanation for the difficulty encountered when this model is implemented in the multi-storey segment. No widespread knowledge exists within the industry (or in the university system) on designing and building using prefabricated wood elements.

No. 3: In-house developer and systems supplier with the build-and-operate offering

Among the case companies, the only in-house developer was one of the module element producers (Lindbäcks). The in-house developer strategy was estimated to account for approximately 15% of the total market for prefabricated (wooden-frame) multi-storey houses. This business model is well suited to the early stages of market introduction because the contractor produces for its own real estate company, but also as a possible way to level off fluctuating market conditions. A company that produced for itself may offset low demand and keep the factory going.

No. 4: Frame system supplier with climate-proof structural frame offering

The frame system with a climate-proof floor/wall element prefabrication strategy was used in less than 5% of the total building volume of our five case companies. The business model configuration built around the floor/wall element prefabrication mode is the subcontracting role in the building process, together with a functional offering in terms of a climate-proof, structural frame directed toward the higher quality segment of family multi-storey houses. The need for complementary resources is medium to high regarding both the design phase and the onsite production (assembly) phase. One case company, Martinsons, was 'forced' into this business model to 'get things done'. However, Martinsons now attempts to avoid this business model because the profitability was not high enough relative to the risks involved in the subcontracting (close to main contracting) position.

No. 5: Frame system supplier with free factory offering

The frame system supplier business model could also take a selling position free factory. This model has been used more frequently than the module element free factory business model (no. 2), accounts for an estimated 5% of the total market volume, and produces more positive results. This business model avoids the responsibilities and risks involved with a subcontractor position in the building process (as mentioned in business model no. 4).

No. 6: Component system supplier with technical support offering

The component system supplier business model is built on delivering a customer-adapted component system that is sold with additional technical assistance in design and onsite assembly. This component system is widely used and customers from all market segments could be viewed as potential customers (and customers from other markets, such as detached houses). This business model can be viewed as an adaptation from the supplier (Masonite Beams) to meet customer demand and an adaptation to the low level of knowledge and understanding among architects regarding the system's technical requirements/obstacles. This business model represents approximately 5% of total volume.

No. 7: Component system supplier with a material supplier offering

This business model with a material supplier offering sells customer-adapted components free factory. In all other respects, the model is similar to the component system supplier business model (no. 6). It is a relatively viable model and represents approximately 7–8% of total volume. A supplier (Masonite Beams) prefers this business model, with its lower risk profile and the potential for highly standardized and scale-efficient production and delivery.

The tests of congruence and configuration

According to the analytical logic of this study, a viable business model should have a good fit or congruence with the environment and the different design parameters (configuration) should have a good fit among themselves.

Congruence with the environment

Entering the design phase at an early time is important to retain the possibility of using a design that is built on the different prefabrication modes (and particularly module elements, which impose the greatest restrictions on design). The building process could be said to have very good congruence with the traditional onsite and project-based business model. Therefore, at an early and immature stage of the development of industrialized building, the best way to achieve good congruence with the environment is to take control of the process through a main contractor position.

No one other than the industrialized builder (as opposed to the 'traditional builder') was willing to steer the process toward prefabrication, at least not on a broader scale (passing some pilot projects). The key to introducing industrialized building with timber frames seems to be taking the main contractor position and, in some cases, combining that position with the in-house developer role. Certain problems must still be overcome, such as opening up the possibilities for industrialized building in public procurement processes because of the need to initiate discussions early on (pre-contract), which could be difficult to establish.

The second issue of congruence is actually a prerequisite for the first, which is the demand from clients for turnkey solutions and main contractors. Between 1994 and 2011, approximately 80% of all apartments in multi-storey houses in Sweden were produced using turnkey (or design-and-build) contracting.

A third issue between the business model and the environment is the size of the market segments and the production volumes (number of apartments) required for a profitable business. Industrialized building modes, particularly the module element mode, tie up more capital, indicating greater demands on economies of scale and scope (Pan *et al.*, 2008).

Fit between building process position and prefabrication mode

The volume element prefabrication mode imposes the strongest restrictions on design flexibility; therefore, taking a main contractor position and control of the design process at a very early stage is most important. The other prefabrication modes are more able to later influence the design process.

Because 80% of production costs are incurred off site, the module element producers arguably have the best control over the greater risks connected to the main contractor position. For the two other prefabrication modes, the step to take overall responsibility is much greater.

Fit between end-user segment and offering and prefabrication mode

In the discussion on congruence between the environment and the business model, the importance of a scale economy in prefabrication and the need for market segments of a certain size were emphasized, particularly with respect to module element prefabrication, which ties up the largest amount of capital. Another restriction on the end-user segment imposed by prefabrication modes is the flexibility and, to some extent, the (perceived) standard of the apartments. The empirical data show that the module element producers opt for volume segments, medium standard in B locations for families, and student and elderly living. The floor/wall element prefabrication mode based on solid wood (the Martinsons case) targets a higher standard and A locations, but with the consequence of lower demand in terms of the number of apartments. The component business model targets the entire market.

Fit between offering and prefabrication mode and complementary resources

The turnkey offering is the most demanding in terms of resources and risk. The question is which prefabrication mode requires the shortest step from delivering free factory to offering a turnkey solution. In this regard, a module element production is believed to be the best option. The relationship between the offsite cost and the onsite cost in the production phase is the highest (in favour of offsite cost), indicating that the (relative) 'extra investment' in complementary resources is the lowest. The empirical experience also shows that the risks connected to a subcontractor position in combination with a floor/wall element prefabrication mode have been high; that is, the need for complementary resources and for overall control has been high relative to the position in the building process and the type of offering. The risks that a company takes are high, relative to the resources and competences it possesses and the control over other parties that it is allowed to exercise.

A comparison of the extent and risk of an undertaking with the control that can be exercised and the resources and competences invested shows that the risk exposure of the subsystem business model is higher than both system and component supplier business models.

Conclusions

An adapted business model construct has been presented based on three business model blocks and five business model elements. The business model blocks are:

- market position;
- offering;
- operational platform.

The five business model elements are:

- prefabrication mode (operational platform);
- role in the building process (market position);
- end-user segments (market position);
- system augmentation (offering);
- complementary resources (operational platform).

This construct was developed through an abductive process (Alvesson and Sköldberg, 2009); that is, an interaction between deductive and inductive analysis in several steps. Applying this construct to five case companies revealed seven business models (as configurations of business elements). One model was found to be particularly viable in terms of both 'market share' and decision-makers' opinions (the data are not consistent enough to evaluate and compare profitability). This business model, 'systems supplier with turnkey offering' (no. 1), was sometimes used in combination with the 'in-house developer' role (no. 3). An examination revealed it showed the best fit between the environment and the internal business elements: (1) prefabrication of modular elements combined with (2) a main contractor role in the building process combined with (3) a turnkey offering that focused on (4) volume market segments and with (5) a high degree of complementary resources. Another business model was considered as viable: the 'in-house developer and system supplier' (no. 3). Three additional business models were considered as 'reasonably' viable:

- the 'frame system supplier with free factory' (no. 5);
- the 'component system supplier with technical support' (no. 6);
- the 'component system supplier' (no. 7).

However, at least two business models appeared as unviable; one case, the 'systems supplier with free factory' (no. 2), as a consequence of unclear responsibilities and another, the 'frame system supplier' (no. 4), as a result of a significant risk in the relationship between investment and control.

The starting point of this article was industrialized building (of wooden-framed multi-storey houses in the Swedish market) and how prefabrication at different value-added levels could be expanded to entire business models. This approach differs from most research related to business models within the construction sector, which primarily has focused on integrating industrialized building and other MMC into already established business models (Pan and Goodier, 2012). Because the availability of land is often viewed as the most important issue, the rationale is to define most business models from other perspectives related to the acquisition of land and financing rather than the use of MMC (Pan and Goodier, 2012). Industrialized building and other types of MMC are not at the top of the priority list. In contrast, negative perceptions in terms of the barriers to offsite manufacturing seem to be in the majority (Pan *et al.*, 2007, 2008).

Following this line of reasoning, proposing that the successful implementation of industrialized building depends on business models with industrialized building as a basis or starting point comes naturally. Consequently, the other important business model elements need to be adapted to fit industrialized building (in one or many configurations with a good fit). In this study, all of the dominant industrial builders in the Swedish market viewed themselves primarily as producers of prefabricated building systems. To do business successfully, they had to design entire business models to 'complement' their prefabrication mode.

In marketing, successful companies often manage to create a combination of push and pull effects (Kotler, 1997). Push effects are built through effective sales and distribution and a high degree of availability when the customer is willing to buy. Pull effects come from customers' own demand for a company's offering, which could result from a high degree of brand awareness and brand loyalty. By transforming this line of thinking into the push and pull mechanisms that promote industrialized building, one could argue that only weak pull mechanisms exist at the institutional level. Regulatory changes are creating opportunities for MMC in the UK (financial government support) and Sweden (function-based codes and government support for pilot projects), but these changes are comparatively weak (cf. Mahapatra *et al.*, 2012; Pan and Goodier, 2012). Strong pull mechanisms are also lacking at the corporate level, partly because of mental barriers and a lack of knowledge among architects and other decision makers in the building process. Therefore, a need exists for strong push effects when introducing industrialized building as an innovation. And as a consequence, a second and very important business model element to promote industrialized building was the role taken in the building process. The empirical data show that, in four out of the five cases, the industrialized builder also took the main contractor role in the building process. Such a role is particularly important for volume element prefabrication, which is specifically required for early involvement in the design process. A long-term perspective and a more mature market for the use of industrialized building of multi-storey houses may result in stronger pull mechanisms at the institutional and company levels, which reduce the need for the main contractor role to execute such strong push mechanisms. However, Sweden seems to have a long way to go.

Important barriers to industrialized building are high capital costs and lack of economies of scale and scope (Pan *et al.*, 2008). The challenge lies in the ability to combine a standardized offering from the operational platform with a relatively homogeneous demand from the customer base. Industrialized builders of module elements have the greatest need for high volume market segments, whereas producers of component systems could achieve economies of scale and scope by selling a standardized product range to a large and more heterogeneous customer base. In both cases, lean thinking and development of standardized modules are important tools to achieve operational effectiveness (Björnfot and Stehn, 2007; Höök and Stehn, 2008).

Different conclusions can be drawn depending on the risk perspective (cf. Buehler *et al.*, 2008). Viewing risk in absolute figures shows that the developer and main contractor positions are the most vulnerable (of course, this statement also depends on how risk is shared in the supply chain). However, if risk is viewed as probability multiplied by value in absolute figures, greater risks appear at the sub-system level. The subcontractor has greater responsibility than control and could have less qualified in-house capabilities to handle these enhanced responsibilities. Consequently, the frame system supplier in this study began to sell free factory, which means going down the value chain toward a materials supplier business model.

Generalization and suggestions for further research

This study reviewed five case companies that have dominated the Swedish market for multi-storey houses during the past 15 years in the industrialized building with wooden frames segment. During this period, this segment was considered still in its pilot phase with respect to family housing, but in a volume phase regarding housing for students and the elderly. Can these results be generalized to other countries with immature markets for MMC solutions in the multi-storey housing segment, to other segments within the construction industry, and to immature markets in general? As always, one must be extremely careful when generalizing.

That the modified business model construct for multi-storey housing will be relevant for the years to come is a fairly certain belief, also when a market (or market segment) goes from immaturity to maturity. However, viable (empirically identified) business models could be different. A mature market has stronger demand pull, which loosens up the present requirement on a very strong marketing push (which is built into business models no. 1 and no. 3). Immature markets within the construction sector, in other countries and in other construction segments, are also believed to need strong push mechanisms to successfully promote the introduction of new technologies and business models need to be adapted to this new technology.

To better understand the pros and cons of industrialized building and its extension into viable business models, conducting comparative studies between different housing and construction segments and between different countries with different institutional structures would be fruitful.

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