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Reconfiguring the construction value chain: Analysing key sources of friction in the business model archetypes of AEC companies in strategic partnerships

Lack of innovation and productivity in the construction industry compared to other industries is often explained by the institutionalized roles and fragmented nature of the construction value chain. Closer connections and collaboration (such as strategic partnerships) among architecture, engineering and construction (AEC) companies and across the values chain is often prescribed as a strategy to improve the performance of the construction industry. However, the institutional roles of AEC companies serve as important reference points for the sector. They have over time been translated into business practices in companies giving rise to a number of archetypical business models. How these business models interact, and the friction created when they come in close contact is not well researched and understood. This paper identifies business models archetypes for architect, engineer, contractor and materials supplier based on workshops and interviews with practitioners. Friction is identified in and between the business models of AEC companies engaging in strategic partnerships. The analysis shows that architect archetypes face friction with regard to their profit formula and could benefit from profit sharing. The engineering archetypes face friction in their processes since they have to coordinate with specialists from other companies. Contractor and supplier archetypes face friction in their profit formula since the open books force them to alter business practices.

Keywords: business model; friction; archetypes; architecture, engineering and construction sector; AEC; value chain;

Introduction

One of the key criticisms levied against the construction industry is the fragmented nature of the architecture, engineering, and construction (AEC) value chain (Gottlieb et al., 2020, Staykova & Underwood, 2017, Fellows & Liu, 2012). This has prompted proposals to make the industry more efficient by reducing this fragmentation and have

closer collaboration, e.g. in strategic partnerships (Costa & Tavares, 2012, Lahdenperä, 2012a Frederiksen et al., 2019). From an economic, business and risk perspective this is an optimal solution, however the fragmentation persists. Whenever an economic system does not default to the most optimal configuration it is often due to friction. In the AEC industry one of the key sources of friction come from the institutionalized roles and their business models.

The AEC sector's low productivity and systemic challenges have been the subject of political scrutiny (e.g. Egan, 1998 and Nielsen *et al.* 2010) and research for decades (Gadde & Dubois, 2010, Bygballe et al., 2010, Badi & Murtagh, 2019). Part of the challenges can be traced back to the fragmented nature of the value chain organized around well-rehearsed institutional roles. The AEC sector is a classic case of project-based organisations (Chinowsky, 2011), working in dynamic environments and collaboration patterns that favour short-term goals. Eriksson (2013) argued that due to the project-based nature of the sector, project teams tend to focus on short-term results and move on to the next project without the opportunity for reflection, thus resulting in discontinuities in the knowledge flows and learning. After construction projects are terminated project teams usually dissolve (Bower, 2003) and therefore the transfer of the valuable experience gained during the project execution is limited. Consequently, the learning in the industry is more organised around playing certain archetypical roles rather than specializing within a certain market (Thomassen, 2004). These roles constitute important reference points in the AEC industry, where few processes are standardised and few projects are repeated (Hall et al., 2020, Katila et al., 2018). To be a part of the construction value chain companies find themselves organized in similar ways according to the institutionalized role. They offer similar value propositions, use the same type of resources organised in the similar processes and rely on the same way

of creating profit. In other words, each institutionalized role should exhibit a similar business model.

To overcome the systemic challenges, calls have been made to reconfigure the supply chain changing the ways companies do business. Under agendas like Digitalization, Industry 4.0 and relational contracting, initiatives promise to transform the businesses and subsequently the industry. A specific example of relational contracting practices in the AEC industry is Strategic Partnering/Partnerships (Eriksson, 2010), Integrated Project Delivery (Lahdenperä, 2012), and Alliancing (Laan et al., 2011). Changes like these have implications for the configuration and coordination of the underlying business models. The close proximity e.g. making a joint venture, may force changes in business model or several business models may be mismatched and have conflicting goals. When a company changes its business model or there is a mismatch between business models this is associated with friction (Williamson, 1989, Johnson et al., 2008). There is thus a need to analyse how changing business models create frictions across the value chain and within a company.

Research on the business models of AEC companies have tended to focus on only one part of the value chain. Previous research on coordinating business models in the AEC sector, has an emphasis on searching for integrated models that span the entire construction value chain (Brady *et al.* 2005, Brege et al., 2014). However little research exists on how close collaboration in the value chain transforms business models connected to the institutionalised roles and general organisation of the AEC industry. This leads to the research questions posed in this paper:

What are the points of friction in and between business model archetypes when they are subject to transformation in the value chain in the form of strategic partnerships?

Practical research context and paper structure

The study has been conducted in Denmark, where there has recently been a strong interest among public building clients to establish strategic partnerships with delivery teams consisting of consortia of private companies. A strategic partnership is a long-term collaboration covering a portfolio of building projects, which are developed and executed in close collaboration between the building client and the companies in the delivery team based on mutual trust (Gottlieb et al., 2020). The study was related to a large R&D initiative concerning sustainable building renovation in a societal partnership called REnovating BUildings Sustainably (REBUS) with participants from the whole construction value chain in the Danish AEC sector representing the institutional roles such as building clients, architects, consulting engineers, contractors, material suppliers and knowledge institutions.

Strategic partnership is a relational contracting scheme, which is fairly new in the Danish construction industry. In a strategic partnership several companies in the construction value chain come together to create a joint venture to tender a bid on a framework agreement. The building client then evaluates the tenders based on MEAT (Most Economically Advantageous Tender) criteria, with a heavy emphasis on collaboration and understanding both between the companies in the joint venture and their understanding of the building client's needs, vision and goals (Gottlieb et al., 2020). This type of contract is in close relation to strategic partnering which was first described in the 1990'ies (Latham, 1994, Egan, 1998). The strategic partnership sees the joint venture bid on a four-year framework contract created by a single building client organization. The delivery team in the joint venture consists of a least an architect company, an engineering consulting company and a contractor, but often also a consultant acting as facilitator of collaboration in the team and possibly material supplier and other specialized companies. The use of conflict mitigation, open books

and collaboration are some of the hallmarks of a strategic partnership and the first in the Danish construction industry was seen in 2016 (Frederiksen & Gottlieb, 2019). Similar relational contracts have been used in the UK and Sweden (Kadefors, Thomassen, & Jørgensen, 2013).

The paper opens with a theoretical framing in order to establish two key concepts; business models and friction. The current state of business model research of the AEC industry is also elucidated. Subsequently the methodology presents the details of the empirical data gathering efforts from workshops and interviews. The empirical data is then used to develop business model archetypes for the institutionalized roles in the AEC industry; architect, engineer, contractor and supplier. Using workshop participant interviews the business model archetypes are validated and the archetypes are compared to AEC business models in literature. The archetypes and practitioner interviews are used to evaluate friction in and between these business models in the implementation of strategic partnerships. The paper is concluded by a discussion connecting the findings to the broader development of the AEC industry, AEC business model research and finally a conclusion.

Theoretical framing

This section outlines the theoretical framing of the paper on business models and friction. The business model section is split into two parts; defining the term business model and an overview of AEC business model research.

Business models: Understanding how companies work

A business model is a model of how a business operate to create value. As with other scientific models, a business model seeks to make a simplified description of a phenomenon, in this case a business, to enable description and analysis. As such the

business model does not describe the myriad of social, organizational or economic interactions which the company consists of; it describes the logic behind these interactions (Richardson, 2008).

There are in the literature many definitions of business models. Fielt (2013) analysed many such definitions and concluded:

“We define a business model as a representation of the value logic of an organization in terms of how it creates value and captures customer value” (Fielt, 2013, page 85).

A value proposition is the central dimension of a business model. Teece (2010) claims that a business model is more generic than a business strategy. However, it is necessary to couple strategy and business model analysis to protect competitive advantage resulting from new business model design.

The use of business models as an academic tool has its roots at the turn of the millennium (Richardson, 2008). At its core a business model is a conceptual model which simplifies the day-to-day operation of a company into pre-defined dimensions of the business model framework. An example of a widely used business model framework, that has also been used to analyse the AEC industry, is the Business Model Canvas (BMC) developed by Osterwalder (2004). The BMC has nine dimensions: Value Propositions, Customer Segments, Customer Relationships, Channels, Revenue Streams, Cost Structure, Key Resources, Key Partners and Key Activities. The dimensions serve to simplify the description of the business and at the same time limit the business model framework, since it cannot describe behaviour outside the predefined dimensions.

The scientific community has developed business models as a scientific tool, and developed business model frameworks suitable for scientific analysis (Amit & Zott

2001, Osterwalder 2004, Sommer 2012, Christensen et al., 2016). Each framework is focused on different aspects of a business and as such the business model developed using the four dimensions of Amit & Zott (2001) (Efficiency, Complementarities, Lock-in and Novelty) will be substantially different compared to a business model made using the nine dimensions of the BMC. As with other scientific research it is important to use an appropriate framework and thus in the following section business model frameworks used in AEC business model research is detailed.

Business models in the AEC industry

The study has used a broad literature review on business models covering both scientific papers and industry reports and 14 AEC business model studies were identified as seen in table 1. Of the 14 business models, seven were developed with a bespoke business model frameworks. Of the seven remaining four used BMC and the remaining three business model frameworks used were developed by Teece (2010), Sommer (2012) and Amit & Zott (2001).

Table 1 Business model types and analysis on construction companies from literature.

Business model framework	Scope	Analysis	Reference
Green Business models	Multinational enterprises (MNEs)	Barriers	(Hart et al., 2019)
Business Model Canvas (modified)	Business network	Business model change	(Mokhlesian & Holmén, 2012)
Bespoke Business model framework NICE	Zero Carbon Buildings Developer, Contractor, FM Service provider	Business model innovation Value drivers and value appropriation	(Zhao et al., 2016) (Rajakallio et al., 2017)
Bespoke Business model framework	International construction companies	Firm performance	(Jang et al., 2019)
Bespoke Business model framework	Consultancy	Business model reconditions	(Ling & Li, 2016)

Bespoke Business model framework	Manufacturer of prefabricated buildings	Development of business model framework	(Brege et al., 2014) (Lessing & Brege, 2018)
Business Model Canvas (modified)	Manufacturer of building materials	Description of business model	(Nußholz, Nygaard Rasmussen, & Milios, 2019)
Teece Business model framework	Building client and AEC companies	Sustainable renovation	(Jonsson et al., 2017)
Business model Canvas	Building client and AEC companies	Energy efficiency Conservation Retrofit	(Dunphy et al., 2016)
Business model Canvas	Sub-contractor	Ecosystem business model	(Laine et al, 2017)
Bespoke Business model framework	Architect	Business models for architectural service delivery	(Bos-De Vos et al., 2016)
Bespoke Business model framework	Building client and AEC companies	Sustainable Innovation	(Romero et al., 2016)
Bespoke Business model framework	Zero Carbon Buildings	Typology of business model innovations	(Zhao et al., 2018)

When looking at existing research in business model in construction a few trends can be discerned. Firstly, when research is done on AEC business models there is a tendency to develop bespoke business model frameworks, see Table 1. This bespoke approach is however problematic since this makes it difficult to assess the conclusions made using these bespoke frameworks, and makes it very difficult to compare business models. Existing research on business models in the AEC sector has also only looked at a single company type or variations of business models within a single segment (Pekuri et al., 2013, Jang et al., 2019, Laine et al., 2017, Höök et al., 2015, Abuzeinab et al., 2017, Bos-de Vos et al., 2016). The focus on a single segment of the AEC value chain misses the complexity of business models interaction across the construction value chain.

The business model framework is also important when interacting with practitioners who can have varying levels of knowledge of business model terminology.

In a study about business models in the Finnish construction industry Pekuri et al. (2013) concluded:

“The interviewees had significant problems describing their companies’ business models and value creation logic, pointing out the lack of analysis and understanding of customer values and needs in the project delivery process.”

Studying the business models of architecture firms Bos-De Vos (2017) noted:

“... participants, for example, often seem not aware of what a revenue model exactly is or what different types of revenue models can be used.”

When choosing a business model framework, it should therefore be of suitable complexity for the practitioners to give valid responses. In choosing an appropriate business model framework it can function as a sense-making tool for the practitioners (Weick, 1995 p. 412, Holzer, 2009).

Looking at the existing AEC business model literature there is a research gap in describing the existing business models in the AEC sector using established business model frameworks. It also highlights the lack of research making cross value chain assessments of business models when working with business model innovation and business model transformation that involve a large part of the AEC value chain.

Friction: Understanding changing business models

The traditional description of what today is thought of as economic friction was physical in nature, e.g. the distance a good has to travel to make an exchange (Aristotle [350 BCE] B. Jowett, 1999). In modern economics most forms of friction are related to information in one form or another (Hardt, 2009). When it comes to the friction associated with the interaction of companies, Transaction Cost Economics (TCE) has

been dominant in the last decades. Oliver E. Williamson, who received his Nobel Prize for creating TCE, has described TCE's relationship with friction this way:

“In mechanical systems we look for frictions: do the gears mesh, are the parts lubricated, is there needless slippage or other loss of energy? The economic counterpart of friction is transaction cost: for that subset of transactions where it is important to elicit cooperation, do the parties to the exchange operate harmoniously, or are there frequent misunderstandings and conflicts that lead to delays, breakdowns, and other malfunctions?” (Williamson, 1989, page 142)

When it comes to analysing business model change inside companies, this change is also associated with friction. When a business model changes internal conflict over resources can make it hard for a company to effectively change (Kim & Min, 2015).

“...previous studies have assumed away the performance implications of conflicting assets by taking for granted that a new and superior technology replaces incumbent firms' old technology with little friction. Yet, this implicit assumption misses the important quandary an incumbent faces when attempting to manage its old business model and new business model simultaneously” (Kim & Min, 2015, page 35)

From an analysis of the dimensions in of AEC business models and the potential for friction it is possible to make a number of recommendations when integrating the construction value chain, e.g. in strategic partnerships.

Methodology

In this study an abductive approach has been used (Awuzie & McDermott, 2017, Tavory & Timmermans, 2014). The empirical research included four workshops and interviews with four interviewees. Three of the workshops were exploratory and helped to establish an appropriate business model framework. From the literature review the BMC framework was identified as the most used business model framework in AEC business model research. In the three exploratory workshops we used several forms and subsets of BMC to see how best to have a discussion with practitioners. The goal was to find a business model framework to describe the business models in the AEC sector and facilitate dialogue. For the fourth workshop we used the Four Block Business Model (FBBM) framework developed by Christensen et al., (2016), see Figure 1, and this facilitated dialogue and could be used by the practitioners.



Figure 1 A simplified version of the FBBM framework (Christensen et al., 2016)

The FBBM framework has two main categories, Priorities and Capabilities each with two dimensions; Value Proposition, Profit formula, Resources and Processes. Attributes of the business are sorted into the dimensions to create the business model.

The business model archetypes were identified by the researchers using data gathered from workshop number four with practitioners representing the whole value chain of the AEC sector. The data from the fourth workshop was triangulated using the data obtained in the three exploratory workshops. To validate the archetypes participants in the fourth workshop representing the different company types were interviewed and asked to comment on the archetypes. To connect the archetypes to existing AEC business model literature, each archetype was compared to AEC business models identified in the literature.

The AEC business model archetypes were then used by the authors to analyse the friction, when these are brought together in a strategic partnerships. The analysis was augmented by interviews with practitioners. The research workflow can be seen in Figure 2.

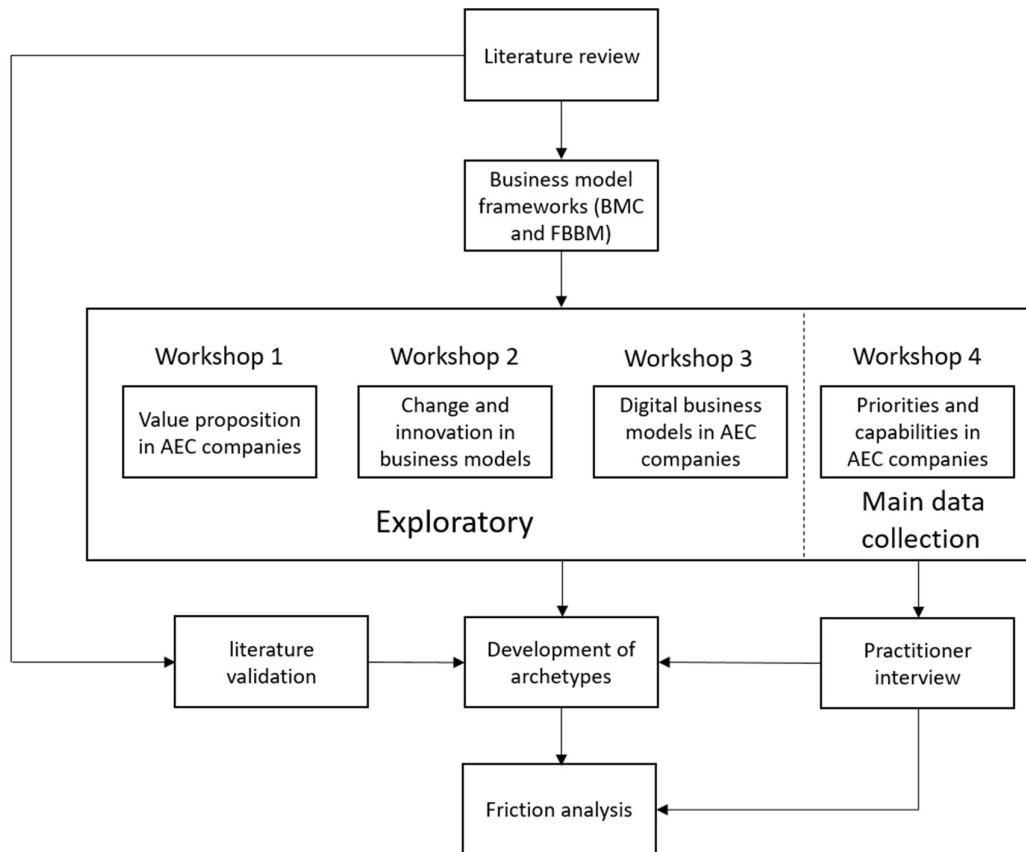


Figure 2 Research flow of the study

Workshops on business models

The participants were representatives from companies in the REBUS societal partnership and represented the whole value chain in the Danish AEC sector, including two building clients, an architect, a consulting engineer, a contractor, a material supplier and university researchers. The first exploratory workshop, see figure 2, was about identifying the value proposition of the individual companies. In the second exploratory workshop, we sought to get the participants to make a cohesive business model for a part of the AEC value chain with a focus on innovation. The third exploratory workshop was focused on digital business models, how to understand them and how to translate them into a company in the AEC value chain. Based on the experiences we had at the previous three workshops, the full nine-dimensional BMC was replaced by the simpler

and intuitive FBBM framework, which the participants could interact with, with less instruction.

Workshop structure and analysis

In all four workshops, the general structure was the same. They started with an introduction of the framework for the workshop; BMC framework with Value Proposition Canvas, a subdivided BMC framework or the FBBM framework. The participants were asked to use the framework, supported by facilitators. The frameworks were printed on A3 paper and post-it notes were supplied to write input for the framework. Depending on the number of participants, the inputs were generated by the participants individually or in groups. After approximately two thirds of the time had been used on the first two parts of the workshop, the third and final part was presentation and evaluation of the input. All participants were asked to present their work, and this was then commented on by the rest of the participants. At this stage post-its were added, cumulated or removed according to the participants input.

After conclusion of the workshop, all the A3 frameworks with post-its were collected and photographed by the facilitators of the workshop. This became the primary data collection together with researcher notes to document the discussions during the input and discussion phase of the workshop. In Table 2 general information about the workshops can be seen.

Table 2 General information about the four workshops used for data collection.

Workshop no.	Date	Duration	Participants	Type
1	23-05-2017	2 hours	10	Exploratory
2	16-04-2018	3 hours	12	Exploratory
3	07-05-2018	3 hours	7	Exploratory

4	26-11-2018	2 hours	10	Main data gathering
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Development of the business model archetypes

In the fourth workshop data was collected to develop of the business model archetypes.

As an example, the data for the architect archetype can be seen in table 3.

Table 3 Data from workshop and the corresponding archetype

	Data from workshop	Architect archetype	
Priorities	Economy, Art, To be/become famous (reputation), high architectonic quality, win architect competitions, Get projects, participate in competitions, prestige/reputation, make prestigious buildings, Create the framework and inspire the client	<ul style="list-style-type: none"> • High architectural quality • Art • Prestige (reputation) • Development • Advise the client • Listen to the users 	Value propositions
In between	Presentation of proposals	<ul style="list-style-type: none"> • Selling hours to cover high variable costs 	Profit formula
Capabilities	Transform idea/need into design, create the foundation for the building project, collect input and wishes from the users, "sell the building", Creative and competent employees, skill full employees – architects – projects, make esthetics and functionality coexist, put together the right teams, develop cities (create diversity), Strong BIM tools, create drawings that reflect real needs, create esthetically pleasing buildings, construction management, represent overall cohesion – in case of a plan for the area, translate vision into practice,	<ul style="list-style-type: none"> • Creative and competent employees • Strong digital tools • Communication resources • Commercial relations • Project management and control 	Resources
		<ul style="list-style-type: none"> • Integrate aesthetics and function • Set the right teams • Convert ideas / needs into design • Create a basis for construction, • Win competitions • Continuous development 	Processes

To get from the data collection in the workshops, which were made on post-it notes, all the notes were transcribed. Subsequently they were translated and grouped in to the

FBBM framework. All of the attributes were then triangulated with other data from the exploratory workshops to make sure that the statements were consistent and coordinated. Statements or descriptions that could not be triangulated were discarded.

Practitioner and literature validation of the archetypes

After gathering data from the workshops, it was important to make sure that the analysis and synthesis of the business model archetypes developed from the workshop data represented a reality that the participants could recognize. Therefore, subsequent interviews were conducted with participants from the fourth workshop representing the four archetypes.

The interviews were conducted as semi-structured elite research interviews as defined by Kvale & Brinkmann (2014). Due to the semi-structured nature of the interview, a theme for the interview had been agreed, before the interview was scheduled, and the researcher had prepared a number of questions. These were grouped into introduction questions serving to create meta-data on the interviewee; Name, position, company name, educational background and experience in the construction industry. The interview then continued with three sub-sections under the main theme of business models. First, the use of business models and other similar frameworks was explored, and the interviewee was asked if he/she has experience in making such and how/if they impacted their daily work. The second sub-section focused on how strategic partnerships would impact the company business model and the potential for creating new business models. Finally, the third and last sub-section was a direct conversation about the business model archetypes developed from the workshops, and if they could recognize their own company in the relevant business model archetype. In table 4 the general information about the interviews can be seen. The interviews were conducted and transcribed in Danish and selected citations were translated to English.

Table 4 General information about the interviews used for archetype validation.

Interview no.	Date	Duration	Education/field
1	18-06-2019	59 min. 48 sec.	Contractor
2	18-06-2019	1 hour 30 min.	Supplier
3	19-06-2019	1 hour 6 min.	Engineer Architect

The interviews together with comparing business models from AEC companies from literature served to validate the findings (Saunders et al., 2008, Eisenhardt, 1989). This is an established method for developing business models (Lessing & Brege, 2018).

Identification of friction

To identify sources of friction the archetypes were used together with data from the interviews. The participants were asked to describe which changes participating in a strategic partnership would create for their company. The responses from the practitioners were then used together with the frictions identified using the archetypes to make the final friction analysis.

Description and validation of the Business model archetypes

Through the workshops, interviews and analysis, we identified four business model archetypes, which utilise three distinct profit formulas illustrated in Table 3. Each business model is sustained through unique capabilities in the form of resources and processes, which support a specific value proposition for each archetype.

Table 3 The four archetypical business models of AEC companies and building material supplier.

	Architect	Engineer	Contractor	Supplier
Value propositions	<ul style="list-style-type: none"> • High architectural quality • Art • Prestige (reputation) • Development • Advise the client • Listen to the users 	<ul style="list-style-type: none"> • Advise the client • Prestige (reputation) • Ensure the building's durability • Innovative solutions • Trustworthy solutions 	<ul style="list-style-type: none"> • Convert project material to buildings -> buildability • Give the client what is economical possible in the project 	<ul style="list-style-type: none"> • Products with few flaws and complaints • Sustainability & Comfort • Materials are delivered on time
Profit formula	<ul style="list-style-type: none"> • Selling hours to cover high variable costs 	<ul style="list-style-type: none"> • Selling hours to cover high variable costs 	<ul style="list-style-type: none"> • Ensure constant cash flow to cover variable costs and contractual risks 	<ul style="list-style-type: none"> • Sales of products and systems
Resources	<ul style="list-style-type: none"> • Creative and competent employees • Strong digital tools • Communication resources • Commercial relations • Project management and control 	<ul style="list-style-type: none"> • Strong professional skills especially on technology • Strong digital tools • Commercial relations and project alliances • Project management and control 	<ul style="list-style-type: none"> • Construction skills specially trained employees • Special equipment • Purchasing Competencies • Project and construction management 	<ul style="list-style-type: none"> • Production facilities • Manufacturing expertise • Good relationship with customers / contractors
Processes	<ul style="list-style-type: none"> • Integrate aesthetics and function • Set the right teams • Convert ideas / needs into design • Create a basis for construction, • Win competitions • Continuous development 	<ul style="list-style-type: none"> • In-depth technical studies • Keep the balance between unique and standard • Make "good enough" solutions • Quality assurance / review • Secure realizable solutions (buildability, architecture, price) 	<ul style="list-style-type: none"> • Calculate expenses • Read the market (expenses, capacity, etc.) • Adhere to schedule and flexibility • Manage purchasing and logistics 	<ul style="list-style-type: none"> • Understand the market on the short and long term (10, 20, 30 years) • Develop new products / new markets • Optimize production • Advertise products

The Architects and Engineers

The professional consulting service providers, like architects and engineering businesses, build on a profit formula concentrating on selling hours to cover high variable costs. It is important to note that the way to classify costs can depend on the boundary conditions that a company has in a given market. Since professional consulting service providers are knowledge firms, the fixed cost (e.g. office space leases, insurance and office equipment) is negligible when compared to the variable cost of wages to highly skilled specialists. Both architect and engineering businesses have a strong focus on advising the clients as a central part of their value proposition by using e.g. references to previous projects. However, their underlying capabilities differ, and while a typical architect's competences concentrate on integrating aesthetics and functionality, a typical engineer focus on in-depth technical studies and quality assurance. Architects and engineers share a strong emphasis on digital tools and the ability to win competitions. They primarily differ with regards to competencies and, to some extent, the scale of projects. Participation in competitions and bidding processes represent a significant upfront cost, which every competing company must recuperate through overhead on other projects. Consequently, many professional service providers prefer making framework agreements with building clients to avoid the extra cost and risk of competitions. This requires competences in managing long-term relationships with building clients and creating the trust necessary for the building client to be willing to commit to such an agreement.

Practitioner validation

In the interview with practitioners from an engineer company the response to the process point of, "Make 'good enough' solutions" (see table 5), was that this term would be framed differently in the organization.

[Interviewee 1] "Officially we wouldn't say that we make "Good enough" solutions."

[Interviewee 2] "Good enough solutions, yes. I do understand what it is you are saying because we would not put it like that."

They were more comfortable talking about economic constraints and proven methods, instead of solutions as "good enough". It was agreed that this ability to make solutions, which are fit for purpose and not over engineered, or needlessly complicated or bespoke, is very important when it comes to making a building process run smoothly. In the same interview the architect commented that a similar principle could be applied to the architect's business model. In some cases, architects will purposefully reduce the number of new elements in a project to reduce the risk of several solutions not working, or having adverse interactions between several novel elements. It is important for an architect to be able to decide where it is important to innovate and where it is important to stick to a proven technology, method or design.

Literature validation

As found in the literature review, prior research has been done on the business models of architects. Research by Bos-De Vos et al. (2016) about the business model of architects use a bespoke three dimension business model framework. The first is *Value Proposition* and shows similarities with the archetype in terms of architects having "Development" as part of their business model. Bos-De Vos et al. (2016) differentiates between "Product development" and "Business case development". The architect both listens to the client and offers advice as part of the value proposition. An architect strives to have close contact to the client in order to keep a central role in the construction project.

The second dimension is *Resources* where “Commercial relations” with developers or contractors are considered essential to an architect. They also have low fixed costs and do not in general own land or physical assets.

The third and final dimension is *Value Capture*. It is highlighted that strong “Project management and control” capabilities are essential to capture value. Negotiation of fee from developers or other partners was seen as problematic and that not all architecture firms had a focus on monetary compensation.

Due to the significant differences in the underlying frameworks of the archetype and the Bos-De Vos et al. (2016) it is not possible to say if the discrepancies between the two are due to the frameworks or actual differences. The similarities are nevertheless present in all of the dimensions and more than half of the elements in the Value Proposition of the architect archetype are found in the Bos-De Vos et al. (2016) paper.

Regarding construction consultancy research from Ling & Li (2016) show that “Innovative solutions” and “Project management and control” should be a core focus. High quality and “Trustworthy solutions” are essential to create competitive differentiation. Since the paper has a clear target in terms of the Chinese market and do not differentiate engineering firms from other construction consultancy firms it is not possible to make a very close examination and comparison to the archetypes.

The Contractor

The profit formula of general contractors builds on a sustained cash-flow model to cover high variable costs and contractual risks. Sustained cash flow is needed to cover the often-long span of time between an expense being paid by the contractor and the building client reimbursing the contractor. The high variable cost of contractors comes from wages to employees (in-house production) as well as from building materials, hiring equipment and sub-contractors. The sustained cash flow is achieved by carefully following the market and shaping projects in a way that fits the capabilities and capacity of the company. Depending on the contractor, some of the turnover is secured through tendering processes - but in all cases the ability to document the capabilities and capacities is important e.g. through references.

The key value proposition of the contractor is to convert project drawings and other specifications to physical buildings, delivering the project within the economical boundaries of the project. This requires contractors to be capable of ensuring buildability of design, calculating for realistic estimates on costs and time, managing purchase and sub-contractors, assessing and handling risk through the project life cycle, monitoring and controlling project progress and handling the various stakeholders in and around the project. The capabilities of the contractor first and foremost consist of human resources and include technical construction skills and project management competences.

Practitioner validation

The very experienced contractor who was interviewed did find that the archetype in the form it was presented was comprehensible, and wished for further development as to what changed in the archetypes under new market forces or when new collaboration schemes were introduced. A point of clarification, which was made and could expand

the value proposition of the contractor in the model, is explained by the following quote:

“If you want to show what the turn-key contractor can do for the client, which none of the others [in the supply chain] can do, it is to guarantee the client a fixed price early in the design phase.”

This value proposition that essentially removes a big part of the risk of construction from the construction client and transfers it to the contractor, is a value proposition which is valid for a segment of the market where the tolerance of budget risk is low.

Literature validation

Business models have been developed for contractors and published in the academic literature. In these there are a number of similarities to the business model archetype of a contractor. In Rajakallio et al., (2017) the researchers use the Amit & Zott (2001) business model framework modified with a fifth dimension; Novelty, Efficiency, Complementarity, Lock-in and adding the dimension Risk. In the Novelty dimension the element “...optimising buildability of solutions” is very close to the Value Proposition of the construction client archetype “Convert project material to buildings - > buildability”. In the dimension Complementarity the element “Creating value for the client (developer) through solutions that lower investment costs” mirror the Value proposition of the contractor archetype “Give the client what is economical possible in the project”.

Since the Rajakallio et al., (2017) business model description is of contractors who are using Design & Build (DB) contracts there are specific attributes to this type of contractor which is not in the archetype. The Risk dimension has an attribute of

“Creating value for the client (developer) through lowering developer’s risk position” which is typical of a DB or a turnkey contractor. This is not in the archetype since this value proposition while valid is not true for contractors in general.

The Supplier

The profit formula of material suppliers is based on selling products and systems. Typically, they strive to optimise the capacity of their production facilities to cover high fixed costs. Compared to the other institutional roles, the suppliers usually have large fixed costs based on investments in production facilities. This makes them less agile in terms of scaling the organisation to the market and thus they work with longer time horizons - up to 30 years. The value proposition of the supplier centres around providing products on time with a minimum of flaws. Consequently, material suppliers have capabilities within supply chain logistics and strive to avoid legal responsibilities for erroneous handling of their products during the construction process.

The suppliers focus intensively on developing good relationships with their customers, which typically include large contractors and wholesalers. Although architects are not direct customers, material suppliers tend to prioritise showcasing products to architects to influence purchasing decisions derived from the early design phases. Thus, architectural offices often include a substantial amount of demo products to increase visibility of suppliers' products. To stay competitive, suppliers focus on utilizing their production capacity. This includes sustaining and developing capabilities within automation, lean production and digitalization. In addition, suppliers emphasise the importance of new product development to respond to changing user requirements. However, given the high cost of production facilities, the innovation and variance of products tend to be constrained by the capabilities of the production system.

Furthermore, many suppliers struggle to remove products from the market although new products are launched, resulting in a high degree of product variance and high complexity costs.

Practitioner validation

In the interview with the practitioner from a major supplier of construction materials and systems, it became apparent that the use of business models to understand business practices were an established practice. This was both in terms of formalized company systems put in place around developing business models as well as several useful models to analyse the company, new markets or products the interviewee had gathered from past experience. While the interviewee found the supplier archetype to be adequate for the present state of the general case for a material supplier, the future of the value proposition was likely to expand.

“We supply the people on the building site with calculation tools where they can evaluate if they need a 2.7 meter element or if it is a better solution with a 1.2 meter element which then requires a joint. As part of the tool there are sustainability parameters and comfort parameters which are on peoples’ minds, but they mostly consider these for when the building is finished and the subsequent users. We expand these sustainability parameters so they also include the people on the worksite, so we can reduce the number of people who need to go into early retirement due to for instance handling heavy components.”

This expansion of the sustainability agenda into social sustainability with regard to worker health and safety is a parameter, which traditionally has been handled by regulations and unions. These value propositions are not targeting the traditional customer groups like the end user or the building client but other parts of the construction value chain.

Literature validation

In Lessing & Brege (2018) study of ten Swedish and North American suppliers of building components there are a number of general attributes of the companies that closely resemble the attributes found in the archetype of a supplier. The Lessing & Brege (2018) study uses a bespoke business model framework with three dimensions; Offering, Market position and Operational platform. In the Offering dimension for the companies there are listed attributes such as “Frame and shell product platform for single family houses”, “Automated production of structural frame.” and “Supply of complete parts kit for these [prefabricated] buildings”. These are mirrored the archetype for the supplier in the profit formula attribute “Sales of products and systems”. In the Operational platform dimension eight out of ten have “In-house product development” or “In-house design”, which mirror the Process in the archetype of “Develop new products / new markets”.

Since the study is of vertically integrated suppliers there are also the business model deviates from the archetype in the Market Position category. Six of the ten companies have a “Design and build contractor” strategy of their own products.

Identifying friction using the archetypes

Following the development of the four business model archetypes, frictions between the business model archetypes can be identified when boundaries change. There are two types of friction identified in the transition from an archetypical way of doing business to a strategic partnership; internal company friction from business model change and friction between business models in the value chain. The points of friction identified between the AEC archetypical business models and the AEC business models in a strategic partnership can be seen in Table 4.

Table 4 Identified points of friction between archetypes and strategic partnership AEC business models (Grey cells are internal friction and white are external friction)

Friction with Archetype	SP Architect	SP Engineer	SP Contractor	SP Supplier
Architect	Value proposition: <ul style="list-style-type: none"> Sufficient focus on aesthetics Profit formula: <ul style="list-style-type: none"> Replicated solutions Resources: <ul style="list-style-type: none"> Competences for integrated teams and portfolio management 	Process: <ul style="list-style-type: none"> Engineer has influence on architectural design Dividing project management responsibility 	Process: <ul style="list-style-type: none"> Contractor has influence on architectural design 	Process: <ul style="list-style-type: none"> Supplier may have influence architectural design
Engineer	Process: <ul style="list-style-type: none"> Architect has an influence on engineering design Dividing project management responsibility 	Resources: <ul style="list-style-type: none"> Competences for integrated teams and portfolio management Process: <ul style="list-style-type: none"> Using in-house resources effectively 	Process: <ul style="list-style-type: none"> Contractor has influence on engineering design Deliver the right level of documentation 	Process: <ul style="list-style-type: none"> Supplier may have influence on engineering design
Contractor	Resources: <ul style="list-style-type: none"> Employees for competent early involvement 	Resources: <ul style="list-style-type: none"> Employees for competent early involvement Process: <ul style="list-style-type: none"> Define the right level of documentation 	Profit formula: <ul style="list-style-type: none"> Consultancy as a revenue stream Open books Resources: <ul style="list-style-type: none"> Competences for integrated teams, portfolio management and consultancy 	Process: <ul style="list-style-type: none"> Supplier may have influence on choice of materials
Supplier	Resources: <ul style="list-style-type: none"> Employees for competent early involvement 	Resources: <ul style="list-style-type: none"> Employees for competent early involvement 	Resources: <ul style="list-style-type: none"> Employees for competent early involvement 	Profit formula: <ul style="list-style-type: none"> Consultancy to be included Open books Resources: <ul style="list-style-type: none"> Competences for integrated teams and portfolio management and consultancy

The architect archetype

As an architectural firm enters into a strategic partnership this will bring a number of friction points in terms of the archetypical business model. Especially in the value proposition category and getting sufficient focus on “high architectural quality” and “art”. Where the early design phase of a typical construction project sees fairly few interests represented, in a strategic partnership project as a minimum both the engineering and contractor have direct influence as well as the building client. There is also the role of project management that needs to be settled with the other participants in the strategic partnership.

These long-term contracts are however very conducive to the value proposition of “advising the client” and in an interview with an architect there was an example given where a private company used long-term agreements because this was a key value.

“A large pharmaceutical company had a long-term agreement with an architectural firm. They had had this contract in... let’s say forever [laughter]. They knew very well that this long-term agreement meant that there were sometimes problems with low performance of the architecture firm, but the pharmaceutical company had some other values that they could not get fulfilled if they changed architectural firm. The client wanted transparency and if there were any problems with a project they wanted to know. They wanted loyalty.”

There is potential friction associated with the archetypical architect profit formula. The possible friction issue in that as solutions in the portfolio are replicated, the need for designing new building elements may go down. When previous good designs are reused in future projects in the portfolio this means less hours for the design. This may be offset by profit sharing or other schemes put in place to incentivise efficiencies in the strategic partnership projects. There may occur friction in terms of getting people who

work well in diverse and integrated teams across companies and backgrounds; little other friction has been identified from the archetypes.

The engineer archetype

An engineering and consulting firm will have an unchanged value proposition in a strategic partnership project compared to a traditional building project. They will likely meet some friction when integrating the strong professionally skilled employees into cross-disciplinary teams. This may lead them to need new resources in terms of people who can work in this new context.

One of the interviewees said that the strategic partnership as with any other framework contract is valuable because it provides more certainty about future work, and thus the long-term planning of the company becomes easier. Another point can be summarised by the following quote:

As a big consulting firm with many specialities in-house, we are always looking to serve our clients in the best possible way. We strive to add value to our clients. They may ask for one thing and after a short conversation it becomes evident that what they actually need are different things. In a strategic partnership this type of additional sales is very attractive for us since we can use our size and that we have many in-house capabilities as an advantage for the partnership to create value to our clients.

To fulfil this potential, the consulting firm must have people with broad knowledge of which services the company provides and their availability. This person needs to be part of the active decision and planning process of the strategic partnership, to make recommendations at an appropriate time. If a department from the company must deliver services to the strategic partnership, they also need to understand the special circumstances and agreements that are in a strategic partnership.

Creating this understanding and processes to support it can be a source of friction and may be a challenge when maximizing the effectiveness of this business model change. A new process needs to be implemented in the business model where a capability to understand internal capacity and capability across the engineering disciplines needs to be coupled to an understanding of the capabilities of other organizations in the strategic partnership. This will cause friction due to higher initial costs, time in coordinating and may need new personnel to execute.

The contractor archetype

Most notably when a contractor enters into a strategic partnering project this changes the profit formula. The early involvement of personnel in the design phase means that a part of the income from the project will be paid as a consultant. Due to the open books, it is also not possible to use procurement practices to cover optimistic budget estimations. The friction from changing the profit formula can be significant.

In terms of resources the contractor needs people who can give productive feedback in the early design phase and this may require retraining or finding new employees. There is also the possibility to make more strategic decisions and have more long-term strategy in the portfolio planning, exemplified with this quote from an interview with a contractor:

“[In a strategic partnership] together with a consultant, together with a building client we can say; how can we do urban development? How can we get most value for money? Etc. Which projects should be promoted first because we then utilize our capacity and the knowledge that the contractor and consultant have together? Which also may mean that a project may actually have to lie on ice for two years but then we have that resource back and then we give it full throttle. In the mean time we can do some other projects now because there we have those people in-house. It provides a completely different access to know-how and capacity.”

The value proposition will in all likelihood change significantly in a strategic partnership and as such will be the source of internal friction. When the contractor in the early design phase needs to have skilled employees who are compensated as a consultant this is very different from what an archetypical contractor does.

The supplier archetype

For a supplier of building materials to enter into a strategic partnership setup requires the company to make the largest change from its archetypical place in the construction value chain. They like the contractor will see a significant friction when it comes to changing the profit formula of the company. From a profit formula focused on “sales of products and systems” the early design process requires a change to a consultant role and a focus away from own products. This also requires new resources in terms of having personal who have knowledge of the company’s products and capabilities and at the same time can make honest recommendations based on what is good for the project.

In terms of value proposition this remains fairly unchanged but it may require some investigation into what value propositions can additionally be created to serve the whole project and all the stakeholders.

Discussion

According to Teece (2010) a business model is more generic than a business strategy. He advocates for thorough analysis of the value chain in order to design good business models. Since the design of AEC business models is largely role based following archetypical patterns there is a lot of potential for business model design to improve the AEC value chain. Changing business models in a company is however a very difficult task but it starts with knowing where the problem or friction is. We have in this paper connected business models research with the institutional roles of the AEC industry and

their transformation when entering strategic partnerships. The results are four archetypical business models and framework for exploring frictions in and among AEC businesses.

Through the literature study, workshops and interviews the study has found a large number of business model frameworks being used in the AEC business model research. While diversity has a quality, the bespoke nature of many frameworks makes comparison and evaluation of business models hard. If the field of AEC business models research is to develop there needs to be some kind of consensus and consolidation in the business model frameworks used in AEC business model research. This should be a topic of further study and research.

The study confirms the difficulty in dialogue with practitioners using complex business models experienced by Pekuri et al. (2013), Abuzeinab et al. (2014) and Bos-De Vos (2017). The use of the simple FBBM framework by Christensen et al. (2016) was found to make the dialogue easier than using the more complex BMC framework, but business models is still a fairly abstract concept, which most practitioners are unfamiliar with.

The construction client can by the way they formulate tendering conditions promote specific forms of strategic partnerships, which requires new integrated business models, where companies from different parts of the value chain must engage in long-term collaboration on a project portfolio. This paper does not describe the archetypical business model of construction clients. This is a limitation, which should be addressed in further research on strategic partnerships.

The suggested framework of business model archetypes and concept of friction enables further analysis of the implication of transformational practices along the AEC value chain. Thereby we contribute to the ongoing debate and efforts on transforming

construction through new digital technologies, offsite manufacturing, contractual forms as suggested in the Construction sector deal (HM Government, 2018) and the resulting Transforming construction challenge (UKRI, 2021).

Another topic concerns the gradual development of business models.

Christensen et al. (2016) suggest that business models remain stable over time, but also that they can be developed through gradual experimentation. Thereby the framework can be used as a platform for development and maturation of new business models.

Conclusion

In answering the research question this paper contributes with guidance for which business model frameworks are appropriate for analysing the construction industry and engaging with practitioners. Four business model archetypes have been identified, described, and validated, which can be used for analysis. Points of friction have been identified when these business model archetypes encounter new cross value chain interactions in strategic partnerships. Understanding the different business model archetypes in the construction industry will not directly solve these challenges and points of friction, but business models can be a tool to understand and develop the construction industry.

Friction was analysed as the business model archetypes interact in new ways in strategic partnerships. The archetypes were developed using the FBBM framework developed by Christensen et al., (2016) with four dimensions; Value proposition, Profit formula, Resources and Processes. Architect archetypes face internal friction with regard to the value proposition “Sufficient focus on aesthetics”, profit formula “Replicated solutions” and resources “Competences for integrated teams and portfolio management”. The external friction with other business models were in processes where engineers, contractors and material suppliers have influence on design decisions. To

remedy the friction in the profit formula for the architect archetype a form of profit sharing could be introduced in the strategic partnership. The engineering archetypes has internal friction is in resources “Competences for integrated teams and portfolio management” and the process “Using in-house resources effectively”. As external frictions are in the engineer archetype processes since they have to coordinate with specialists from other companies. A contractor archetype has internal friction in a strategic partnership in the profit formula with “Consultancy as a revenue stream” and “open books” and in resources with “Competences for integrated teams, portfolio management and consultancy”. The external friction is resources “Employees for competent early involvement” and supplier having influence on building material selection. Supplier archetypes faces internal friction in a strategic partnership similar to the contractor and external friction is in resources “Employees for competent early involvement”.

Further research can use the four archetypes as a starting point, e.g. in the alignment of business models in a business network context or business model innovation. Knowing the current starting point is paramount in our understanding and development of the business models in the AEC industry.

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Data availability

The data generated during workshops and interviews, which the analysis and business models are based on, are of a personal and sensitive nature and can only be accessed by directly contacting the corresponding author and subsequently obtaining written consent from the participant(s).

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